April 3, 1956 J. E. JENNINGS 2,740,868

VACUUM SWITCH

Filed March 2, 1953

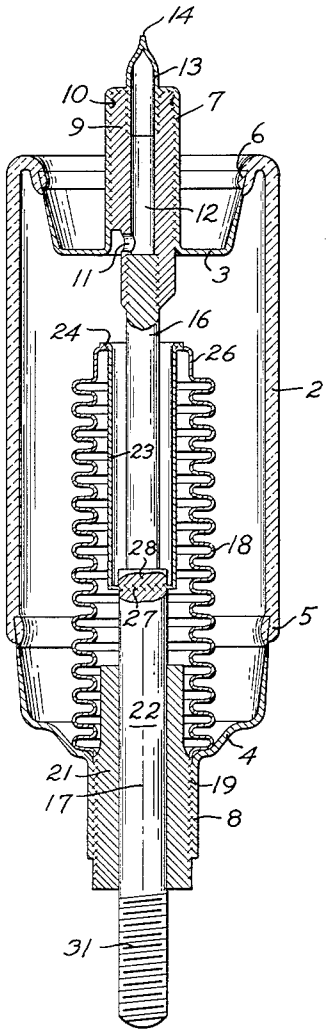


Fig-1

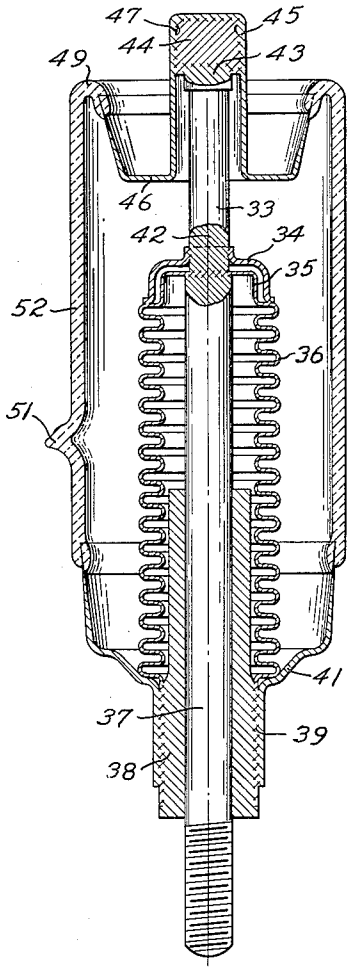


Fig-2

INVENTOR
JO EMMETT JENNINGS
BY Charles S. Evans
his ATTORNEY

United States Patent Office

2,740,868

Patented Apr. 3, 1956

2,740,868

VACUUM SWITCH

Jo Emmett Jennings, San Jose, Calif., assignor to Jennings Radio Manufacturing Corporation, San Jose, Calif., a corporation of California

Application March 2, 1953, Serial No. 339,697

6 Claims. (Cl. 200—144)

My invention relates to vacuum switches; and one of the objects of the invention is the provision of an electric switch having contact points surrounded by a vapor condensing shield or baffle so that a build-up of conducting metallic film on the interior of the vacuumized chamber is prevented.

Another object is the provision of a switch of the character described, having contact points within a vapor condensing shield which also functions as part of the terminal cap structure at either end, so that there may be a rapid dissemination of heat evolved at the contact points by direct conduction to the closely adjacent terminal cap.

Another object is the provision of a vacuumized switch in which the contact points may be engaged and held together resiliently in a normally closed position by pressure of the atmosphere.

Another object is the provision of a relatively short and small vacuum switch having a relatively high capacity.

Still another object is the provision of a switch in which the degree of movement of parts to interrupt or establish the circuit is greatly reduced, with a corresponding increase in speed of operation.

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 sectional view of my vacuum switch, the plane of section lying in the long axis of the switch. This view shows the contact points within the cap structure which includes the bellows or mobile end of the switch.

Fig. 2 is a sectional view similar to Fig. 1, but showing another embodiment of my invention in which the contact points are in the cap structure forming part of the fixed end of the switch.

Both views are drawn to a scale approximately one and one-half times larger than the actual switches described herein.

My vacuum switch comprises a vacuumized envelope in which metallic contact rods, one fixed and the other movable, are arranged in axial alignment. The interposition of a flexible metallic bellows between the mobile rod and the envelope wall permits operative movement of the mobile rod by means external to the envelope.

Since normal atmospheric pressure tends to expand the bellows into the envelope, the atmospheric pressure may be utilized to hold the contact points together in normally closed position, and to speedily close the gap between them upon release of separating pressure applied externally when the circuit through the switch is to be broken. In some uses, the contact points may be held in normally open position by interposition of a spring tensioned to overbalance atmospheric pressure, as shown in my copending application, Serial Number 317,184.

The range of movement of the mobile contact rod is very small and extremely rapid. With only 1/16" of separation between the contact points, the stand-off value exceeds 40,000 volts. A switch such as illustrated in the drawings will safely handle voltages up to 20,000 and is capable of conducting continuously current volumes up to 20 amperes.

Although arcing between the contact points is at a minimum in the vacuumized envelope, some vaporization of the metal contact points occurs. If this vapor is allowed to condense and gradually build up on the inside surface of the envelope, it forms a conducting path between the inside terminals, thus shorting the contact points and seriously limiting the useful life of the unit. My invention provides a surface on which substantially all but a negligible amount of the vaporized metal, condenses without providing a conducting path around the contact rods, so that the useful life of the device is extended indefinitely.

One of the many applications of my switch is that of an overload relay in high voltage direct or alternating current uses. Thus it may operate as a protective instrument in high voltage rectifiers where an external overload or an internal flash back of a tube may occur; and because of its extremely rapid action in opening the circuit, it prevents other damage. Also in low voltage alternating current lines, my relay provides protection against overloads and short circuits.

Another use of my relay is in the broadcasting field where energy is to be shifted from one antenna to another, or to effect a change in directivity characteristics of an antenna. Since my relay is capable of withstanding much higher voltages than those at which they are operated, they may be used in "hot" condition; that is, while the station is in full operation. So far as I am aware this has never before been possible.

My switch finds a useful application in electrical circuits known as "interlocks" in which it is operated to interrupt the controlled circuit by linkage to the actuating element.

Perhaps the most important application of my switch, at least in the field of accident preventing, is its use where explosion due to flame or spark is a hazard. The vacuum tight envelope, enclosing the contact points, insures complete immunity.

In each of the embodiments, I have shown a relay designed for use in a normally closed circuit where the pressure of the atmosphere tends to hold the contact rods together, and reestablishes contact after it has been broken. By proper designing of the end cap structure in which the contact rods are mounted, stresses may be distributed, so that when the contacts are closed, a balance of pressures on the end caps results, with a planned proportion of the atmospheric thrust upon the end cap structures carried by the engaged contact rods.

In detail my vacuum switch comprises a cylindrical glass shell **2**, closed at the ends with copper caps **3** and **4**, joined to the glass by the well known housekeeper seals **5** and **6**. The glass shell is continuous from the seal **5** to seal **6**, which is reversed in direction. This is done to increase the relative length of the glass path in a small instrument, so that a large safety factor in flash-over voltage is attained. The caps constitute the external terminals of the switch and also provide bosses **7** and **8** respectively by which the instrument may conveniently be mounted in suitable clips or brackets, usually in a horizontal position.

The boss **7** of cap **3** is formed as a cup opening into the vacuumized chamber, and is filled with a copper plug **9**, brazed in place by silver solder spreading from the groove **10**. The plug is flattened on one side at the inner end and is provided with a passage **11** leading from

inside the chamber into the central passage 12 in the plug and thence into the copper tube 13, the inner end of which is brazed in the plug and adjacent cup wall. The tube is for use in exhausting the envelope and after that is completed, its free end 14 is pinched together so tightly as to effect a sealed closure.

Seated in the end of the plug and integrally united therewith by brazing is a metallic rod 16 preferably of tungsten, forming one of the contact points of the switch. It is to be noted that all of this fixed end cap structure of terminal cap, plug, rod and tube are concentrically disposed about the long axis 17 of the structure, and integrally united into one continuous metallic body in axial alignment with the mobile contact rod 22 and its mounting structure.

At the opposite end of the glass shell 2, the copper terminal cap 4 provides a mounting for the mobile contact rod and the bellows by which the envelope is closed and which permits movement of the rod without breaking the extremely high vacuum in the envelope.

The bellows 18 preferably of bronze of a 95–5 composition terminates at one end in a cylindrical sleeve 19, fitting snugly into the cylindrical base flange 8 of the cap 4. Fitting snugly into the inside of the sleeve is a plug 21, extending well up into the bellows and providing a long journal bearing within which the mobile contact rod 22, preferably of stainless steel, may slide. Base flange, bellows sleeve and plug are brazed together so that the three are integrally united into one continuous metallic body.

The bellows is closed at its inner end by the inwardly opening concentric cup 23, the flanged rim 24 of which is brazed to the inwardly flanged end 26 of the bellows. The rod 22 extends to the bottom 27 of the cup and is brazed to it with high temperature silver solder fusing at about 1000° C. Axially aligned on the inside of the cup and brazed to the bottom 27 so that it is quite literally an integrally united axially aligned extension of the mobile rod 22 into the cup, is a short tungsten rod 28, forming the other contact point of the switch. The bellows folds are thus interposed between the rod 22 and the cap 4 and permit limited axial movement of the rod within its bearing plug into and out of contact with the fixed contact rod 16, without injury to the hermetic sealing of the envelope.

The outer end of the rod 22 is provided with threads 31 for connection to an operating means (not shown) of any desired type.

Tungsten is preferred for the engaging ends of the contact rods because it has the highest melting point and the lowest vapor pressure of the refractory metals available, in addition to low electrical resistance and a low temperature gradient.

Like the fixed end structure, the mobile end of terminal cap, bellows, bearing plug, and rod are concentrically arranged about the long axis 17 and integrally united into one continuous metallic body. The sizes and relation of parts are such that when the envelope is fully evacuated, the two contact rods are pressed together with the full force of atmospheric pressure. Under operating conditions, and when energized, a solenoid (or other operator) pulls the rod 22—28 outwardly, perhaps ⅛", thus separating the contacting points of the two rods and breaking the circuit.

Since the atmospheric pressure against the inside of the bellows is substantially constant, the contact points are again engaged when the solenoid is deenergized, to reestablish the circuit through the contact rods. It is to be noted that by making the seals or end cap structures of the same diameter, atmospheric pressure inwardly against the seals may be equalized, so that in the open position of the switch unnecessary stresses in the end cap structures are avoided; and in the normally closed position, the inward pressures on the cap structures largely balance each other because of the intervening engaged contact rods.

The interruption of the circuit in the vacuumized envelope is attended with a minimum of arcing between the separating tungsten points of contact. This minimum is strongly influenced by the speed of separation; and use of a properly designed solenoid effects an almost instantaneous break and resultingly, there is a very minimum of sparking. However, it is impossible to wholly prevent all arcing and to the extent it occurs, tungsten at the points of separation is vaporized. Without a baffle or barrier of some kind, the vaporized metal condenses on the inside surface of the glass shell, and builds up thereon a conducting layer which eventually shorts across the rods, and of course ruins the switch.

I prevent this result, although I cannot wholly prevent the cause, by placing the arcing points near the bottom of the cup 23 well within the bellows, the cup acting as a baffle or barrier tube on the inside surface of which the vaporized tungsten is caught and deposited. No significant quantity of metal vapor escapes from the tube into the interior of the envelope, and no appreciable deposit on the interior surface of the glass envelope occurs to create a short circuiting film thereon.

Copper is particularly suitable for the end cap structures since electric current is to be conducted, as well as the heat from the contact points carried to the external parts of the unit where it is dissipated into the air. The copper or bronze bellows 18 which is in parallel electrically with the rod 22 is a major conductor for both current and heat; and the copper cup 23, also functions in helping to dissipate heat generated at the contact points.

Tungsten is preferred for the contact rods or the major proportion thereof because it has the highest melting point and the lowest vapor pressure of available refractory metals, in addition to a low thermal and electrical resistance. The external portion of the contact rod 22 is of course exposed to the influence of the atmosphere with possibly a corrosive gas component. It may therefore be made of stainless steel or bronze.

In Fig. 2, I have shown a different embodiment of my invention, in which the interior of the boss of the terminal cap at the fixed end of the switch forms a cup to serve as a vapor condensing shield.

The mobile end of the switch is the same as that shown and described in detail in my copending application Serial No. 317,184, but briefly comprises a tungsten contact rod 33 integrally united by brazing, both directly and through the nickel cap 34 with the closed end 35 of the bellows 36 and the inner end of the stainless steel rod 37, constituting an operating stem for the switch. The rod 37 is slidably journaled in the bearing plug 38, integrally united by brazing with the bellows sleeve 39 and the terminal cap 41. This structure concentrically arranged about the long axis 42 of the switch, permits a limited axial movement of the contact rod 33.

The opposing contact is a short tungsten rod 43, brazed into a recess in the short plug 44, in turn brazed into the extreme inner end of the cup 45 within the boss of the terminal cap 46. A ring of solder in the annular groove 47 insures a complete union of the plug and cap parts.

Atmospheric pressure of course exerts an inward pressure on the rod 33, which holds the contact points firmly together. It will be noted that in the terminal cap structure including the reversed seal or inwardly turned rim 49 of the glass shell, the pressure of the contact rod 33 is exerted outwardly against the terminal cap 46, contrary to the inward pressure of the atmosphere against the cap. This partial balancing of opposing pressures effects a material lessening of stress tending to break the metal-to-glass seal at this end of the switch.

The envelope is exhausted through the usual tubulation 51 formed on the glass shell 52.

In operation, the minute quantity of metallic vapor produced between the breaking contacts condenses on the adjacent inside surface of the cup **23**, Fig. 1, and the inside surface of the cup **45**, Fig. 2; and so is never deposited on the inside surface of the glass shell where it would eventually build up a conducting layer.

I claim:

1. A vacuum switch comprising a vacuumized envelope having metal end caps constituting terminals, a cup integrally united with each end cap and opening into the envelope toward the other end cap, a separate contact rod extending from each cup and engaging the other rod inside one of the cups, means external the envelope for moving one of the rods and its associated cup relative to the other rod, and means interposed between the mobile rod and its associated end cap for preserving the vacuum of the envelope while allowing movement of the mobile rod.

2. A vacuum switch comprising a vacuumized envelope having metal end caps constituting terminals, a contact rod fixed in one of the end caps and lying within the envelope, a mobile contact rod aligned with the fixed rod and slidably journaled in the other end cap and extending from outside the envelope into the envelope, a vapor condensing shield surrounding the contact rods on each side of their adjacent ends and integrally united with one of said end caps, and vacuum tight flexible means interposed between the mobile contact rod and its associated end cap and allowing axial movement of the mobile rod.

3. A vacuum switch comprising a vacuumized envelope having metal end caps constituting terminals arranged on the long axis of the envelope, a contact rod fixed in one of the end caps and extending axially into the envelope, a mobile contact rod extending into the envelope and slidably journaled in the other end cap and aligned with and adjacent to the fixed rod, a bellows surrounding the mobile rod adjacent its bearing, and a cup seated in the inner end of the bellows and opening into the envelope and enclosing the contact rods on both sides of their adjacent ends and having its rim integrally united with the inner end of the bellows.

4. A vacuum switch comprising a vacuumized envelope having metal end caps constituting terminals arranged on the long axis of the envelope, one of said caps including an inwardly opening cup, a contact rod fixed in the cup

and ending intermediate the bottom and rim thereof, a mobile contact rod extending into the cup and slidably journaled in the other terminal and aligned with and adjacent to the fixed rod, and means interposed between the mobile contact rod and its associated terminal for preserving the vacuum of the envelope while allowing limited axial movement of the mobile rod in its terminal.

5. In a vacuum switch, a vacuumized envelope comprising a cylindrical glass shell closed at one end by a metal end cap extending beyond the shell and at the other end by a metal end cap extending into the shell, the last named end cap having an outwardly extending integral cup opening into the envelope, a fixed contact rod rigidly supported in the cup and extending into the envelope, a slide bearing fixed in the first named end cap, a mobile contact rod slidably journaled in the bearing and in alignment with the fixed contact rod, a cylindrical cup fixed on the mobile rod near its inner end and surrounding the free end of the fixed contact rod, and a metallic bellows integrally united with and interposed between the rim of the cup and the first named end cap.

6. In a vacuum switch, a vacuumized envelope comprising a cylindrical glass shell having at one end a reentrant portion; a metal end cap extending into the shell and closing the reentrant end thereof, said shell being closed at the opposite end by a metal end cap extending beyond the shell; a contact rod fixed in one of the end caps and lying within the envelope; a mobile contact rod aligned with the fixed rod and slidably journaled in the other end cap and extending from outside the envelope into the envelope; a vapor condensing shell surrounding the contact rods on each side of their adjacent ends and supported on and integrally united with one of said end caps; and metallic bellows means between the mobile contact rod and its associated end cap for providing therebetween an integral, thermal, electrical, and vacuum tight connection.

References Cited in the file of this patent

UNITED STATES PATENTS

1,784,302	Millikan et al.	Dec. 9, 1930
1,875,765	Scherbius	Sept. 6, 1932
2,027,835	Rankin et al.	Jan. 14, 1936
2,121,180	Vatter	June 21, 1938
2,156,974	Doan	May 2, 1939
2,181,586	Perryman et al.	Nov. 28, 1939