June 27, 1967 J. H. HOLLIDAY 3,328,545

ELECTRICAL DEVICE HAVING SEALED ENVELOPE AND ELECTRODES CONTAINING AN ABSORBED GAS

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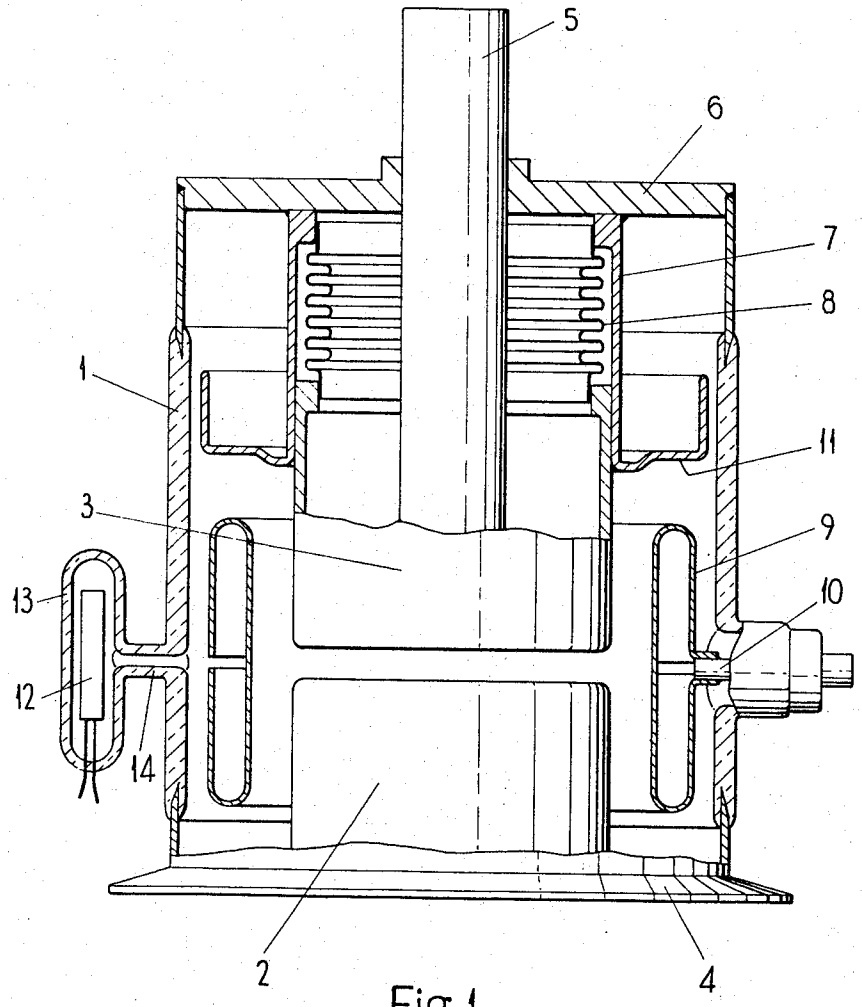


Fig.1

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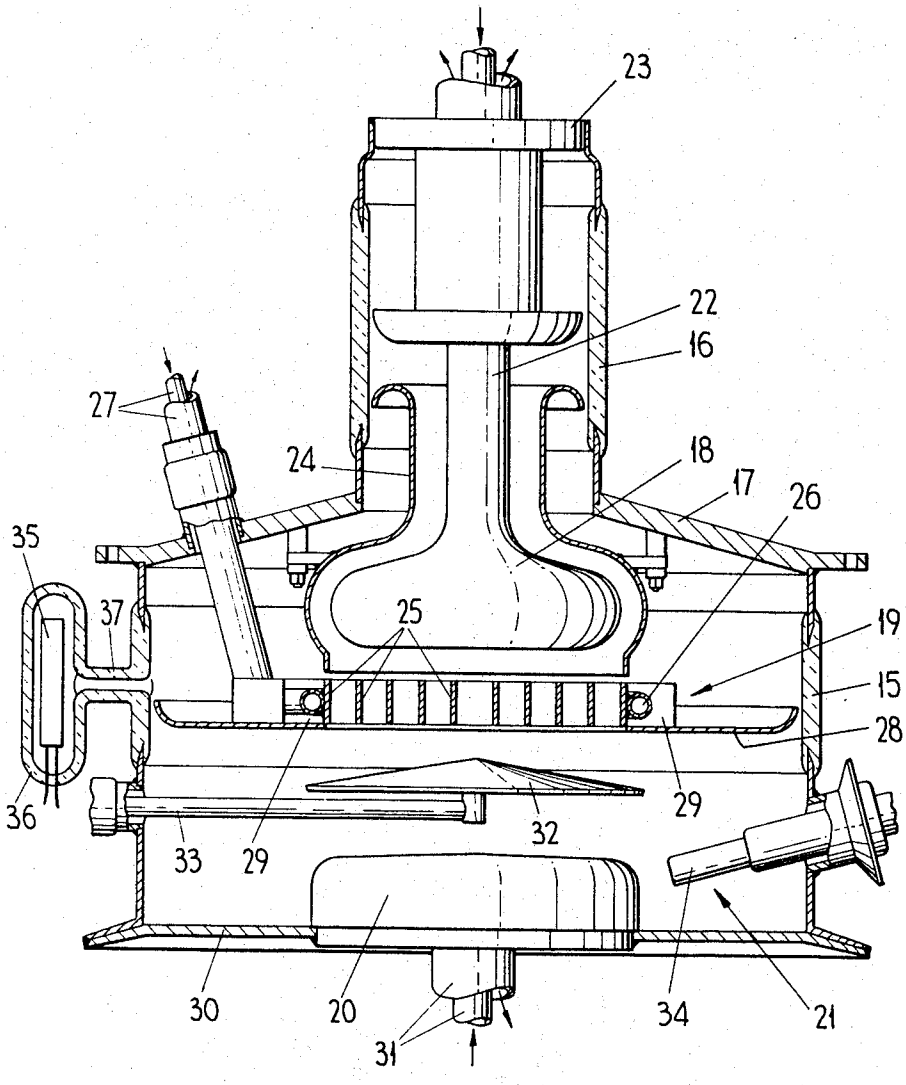


Fig. 2

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ELECTRICAL DEVICE HAVING SEALED ENVELOPE AND ELECTRODES CONTAINING AN ABSORBED GAS

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4 Claims. (Cl. 200—144)

This invention relates to electrical devices wherein an electric arc may be produced in operation.

The high conductance of an electric arc is attributable to the presence of ions in the gap between the electrodes supporting the arc, these ions being derived primarily from a cloud of material derived from the cathode which forms close to the surface of the cathode. As a result two difficulties may arise. Firstly, the cathode may be subject to severe erosion by the action of the arc. Secondly, the ions may take an appreciable time to neutralize when the arc is extinguished; in consequence, if the voltage between the electrodes rises again soon after the arc is extinguished, there is a possibility that a new, undesired arc may form between the electrodes.

It is an object of the present invention to provide an electrical device in which an arc may be produced in operation, wherein at least one of the above-mentioned difficulties is alleviated.

According to the present invention there is provided an electrical device having a sealed envelope and a pair of electrodes respectively having surfaces within the envelope between which an arc may be formed in operation of the device, at least one of said pair of electrodes containing an absorbed gas which, upon initiation of a discharge between said pair of electrodes with said one electrode operating as a cathode, is liberated from said one electrode more readily than the basic material of that electrode, said gas when liberated being capable of being ionised to provide an arc of high conductance between said pair of electrodes.

Preferably said gas has a lower molecular weight than that of the vapour of the basic material of said one electrode, thereby ensuring that, when the arc is extinguished, relatively rapid neutralization of the ions will occur.

Two electrical devices in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a sectional view of a switch adapted for use in high voltage alternating current circuits; and

FIGURE 2 is a sectional view of a gas-filled electric discharge device adapted for use as a switch in unidirectional high voltage pulse circuits.

Referring now to FIGURE 1, the switch has a sealed, evacuated, hollow cylindrical envelope **1**, the side wall of which has a glass center portion and metal end portions. The envelope **1** houses a fixed electrode **2** and a movable electrode **3**, each electrode **2** and **3** comprising a titanium cup-shaped member. Prior to assembly of the switch, hydrogen is absorbed in each electrode **2** or **3** up to saturation point by heating the electrode **2** or **3** to a temperature above 800° C., and allowing it to cool in an atmosphere of hydrogen.

At its open end the fixed electrode **2** is secured centrally to a metal plate **4** which is sealed across one end of the envelope **1** so that the outer surface of the closed end of the electrode **2** lies within the envelope **1** in a plane perpendicular to the axis of the envelope **1**.

The movable electrode **3** is disposed within the envelope **1** with the outer surface of its closed end facing and parallel to the corresponding surface of the fixed electrode **2**,

and the electrode **3** is supported at the end of a metal rod **5** which extends coaxially along the envelope **1** and fits slidingly through a circular aperture formed centrally in a metal plate **6**, the plate **6** being sealed into the other end of the envelope **1**. At its open end the electrode **3** fits slidingly within one end of a tubular metal member **7** which at its other end is brazed to the plate **6** so as to coaxially surround the rod **5**. In addition, the open end of the electrode **3** is brazed to one end of a length of copper tubing **8** which at its other end is brazed to the member **7** adjacent the plate **6**. The intermediate portion of the tubing **8** is thin-walled and corrugated, so that the tubing **8** is extendable, the length of the tubing **8** when extended being such that the facing surfaces of the electrodes **2** and **3** are in contact.

The gap between the electrodes **2** and **3** is coaxially surrounded by an anti-sputter screen **9** which is supported on a metal rod **10** sealed through the side wall of the envelope **1**, and further screening against sputtering is provided by an outwardly extending flange **11** formed at the end of the member **7** remote from the plate **6**.

An electrically heated hydrogen getter **12** is housed in a compartment **13** which communicates with the main body of the envelope via a glass tube **14**.

In operation the switch is opened and closed by causing the electrodes **2** and **3** to move out of and into contact with one another by means of the rod **5**. If at the moment the electrodes **2** and **3** part, the applied voltage is other than zero, an arc will form between the electrodes **2** and **3**, one or other of the electrodes **2** or **3** serving as the cathode for the arc depending on the polarity of the applied voltage at the moment the electrodes **2** and **3** part. The heat produced in the region of the cathode spot causes a cloud of hydrogen liberated from the relevant electrode **2** or **3** to form adjacent the cathode, some of this hydrogen being ionised to provide an arc of high conductance. The arc extinguishes as the applied voltage passes through zero and the hydrogen ions present rapidly neutralize, thus preventing a new arc forming between the electrodes **2** and **3** when the applied voltage rises again.

The major part of the hydrogen liberated from an electrode **2** or **3** is reabsorbed by that electrode **2** or **3** after the arc has extinguished, and any remaining hydrogen is absorbed by the getter **12**, thereby restoring the envelope **1** to the evacuated condition.

Referring now to FIGURE 2, the gas-filled electric discharge device includes a hollow generally cylindrical sealed envelope comprising two coaxial sections **15** and **16** of different diameters joined by an intermediate frusto-conical section **17**, the envelope being filled with hydrogen at a pressure of 100 millitorrs. The frusto-conical section **17** is made of metal and each of the sections **15** and **16** comprises a glass central portion and metal end portions. The electrode structure of the gas-filled electric discharge device is housed in the wider section **15** of the envelope and comprises an anode **18**, a control grid **19**, a cathode **20** and a trigger electrode **21**.

The anode **18** is of the hollow, water-cooled type and is mounted adjacent the frusto-conical section **17** at the end of a tubular metal stem **22**. The stem **22** serves as an electrical lead to the anode **18**, and also for the passage of cooling water to and from the anode **18**, the stem **22** passing coaxially through the narrower section **16** of the envelope and being sealed through a metal plate **23** sealed into the narrower end of the envelope.

The side wall of the anode **18** and the adjacent portion of the stem **22** are closely surrounded by a metal baffle **24** mounted on the section **17** of the envelope.

The control grid **19** comprises a number of short tubular metal members **25** of equal lengths but different diameters, the members **25** being secured together coaxially,

one within the other. The control grid **19** is disposed coaxially within the envelope with the plane of one end of the members **25** parallel to the anode **18**. The grid **19** is supported within a ring of metal tubing **26** brazed around the outside of the largest member **25**, the ends of the tubing **26** being respectively joined to a pair of coaxial metal pipes **27** sealed insulatingly through the section **17** of the envelope. The pipes **27** and tubing **26** serve as an electrical connection to the grid **19** and for the passage of cooling water for the grid **19** in operation.

A second metal baffle **28** in the form of an apertured metal disc having an upturned outer edge is supported at its inner edge of flanges **29** extending radially outwards from the largest member **25**, the baffle **28** lying substantially in the plane of the end of the grid **19** remote from the anode **18** and extending almost to the side wall of the envelope.

The cathode **20** comprises a substantially cup-shaped titanium member in which hydrogen has been absorbed in the manner described above with reference to the electrodes **2** and **3** shown in FIGURE 1. At its open end the cathode **20** is secured centrally to a metal plate **30** sealed across the wider end of the envelope so that the closed end of the cathode **20** lies within the envelope approximately in a plane perpendicular to the axis of the envelope. Cooling water is passed in and out of the interior of the cathode **20** via a pair of coaxial pipes **31** sealed through a metal disc (not visible) sealed into the open end of the cathode **20**.

A third baffle **32** in the form of a shallow conical metal member is disposed between the grid **19** and cathode **20**, the open end of the baffle **32** being nearer the cathode **20** and the baffle **32** being supported at the end of a metal rod **33** sealed insulatingly through the side wall of the envelope.

The trigger electrode **21** comprises a metal rod **34** sealed insulatingly through the side wall of the envelope, the end of the rod **34** within the envelope being adjacent the end of the side wall of the cathode **20** nearest the baffle **32**.

The gas pressure within the envelope is maintained by means of an electrically heated reservoir **35** housed in a compartment **36** communicating with the wider section of the envelope via a glass tube **37**.

In a typical application the gas-filled electric discharge device may be utilised to produce high voltage pulses by connecting the anode-cathode path of the gas-filled electric discharge device in series with a resistive load across a high voltage supply derived from a bank of capacitors. An output pulse is then produced across the load on application of suitable voltage pulses to the grid **19** and trigger electrode **21**. The voltage applied to the trigger electrode serves to produce a low current arc between the trigger electrode **21** and the cathode **20**, thus producing hydrogen ions in a similar manner to that described above with reference to the switch shown in FIGURE 1. A high current arc is then produced between the anode **18** and cathode **20** on application of a voltage pulse to the control grid **19**, thus producing an output pulse across the load. The hydrogen ions produced in the device rapidly neutralize on extinction of the arcs, thus preventing reformation of the arc between the anode and cathode when the voltage across the capacitor bank builds up again and until further control pulses are applied to the grid and trigger electrodes **19** and **21**. On extinction of the arc the cathode **20** reabsorbs an amount of hydrogen substantially equal to the amount emitted during the arc.

In both the devices described above, by way of example, it is found that erosion of the electrodes acting as cathodes is appreciably reduced compared with similar devices having metal cathodes in which no hydrogen has been absorbed prior to assembly.

It will be appreciated that in other arrangements in accordance with the invention, the basic material of the electrode containing an absorbed gas may be other than titanium, for example it may be zirconium or an alloy consisting primarily of titanium and/or zirconium. Similarly, the absorbed gas may be other than hydrogen. In relation to gas filled devices it is pointed out that the absorbed gas need not be the same as the gas constituting the filling.

It will be understood that in other arrangements in accordance with the invention gas may also be liberated during the presence of an arc from electrodes other than that operating as a cathode. However, the major part of the gas liberated is derived from the electrode operating as a cathode.

I claim:

1. An electrical device for controlling a flow of electric current, said device including a sealed envelope and a pair of solid metal main electrodes respectively having surfaces within the envelope between which the current to be controlled passes in operation of the device and between which an arc may be formed in normal operation of the device, at least one of said pair of main electrodes, which acts as a cathode in operation of the device, containing hydrogen which, upon initiation of a discharge between said pair of main electrodes, is liberated from said cathode more readily than the basic material of said cathode, said hydrogen when liberated being capable of being ionised to provide an arc of high conductance between said pair of main electrodes so that the arc is supported by the hydrogen liberated from the cathode rather than the basic material of the cathode.

2. A device according to claim **1** wherein the basic material of said one electrode comprises at least one metal selected from the group consisting of titanium and zirconium.

3. A device according to claim **1** wherein said pair of electrodes are movable into and out of contact with one another.

4. A device according to claim **1** wherein said pair of electrodes have a fixed gap between them.

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