United States Patent

Baker

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[54] **GAS-DISCHARGE DEVICE WITH MAGNETIC MEANS FOR EXTINGUISHING THE DISCHARGE**

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[51] **Int. Cl.**....................................**H05b 37/00,** H05b 39/00

[58] **Field of Search**..................313/156, 160, 161, 162, 203, 313/204; 315/218, 344; 328/8, 9, 10, 11, 250, 251, 253

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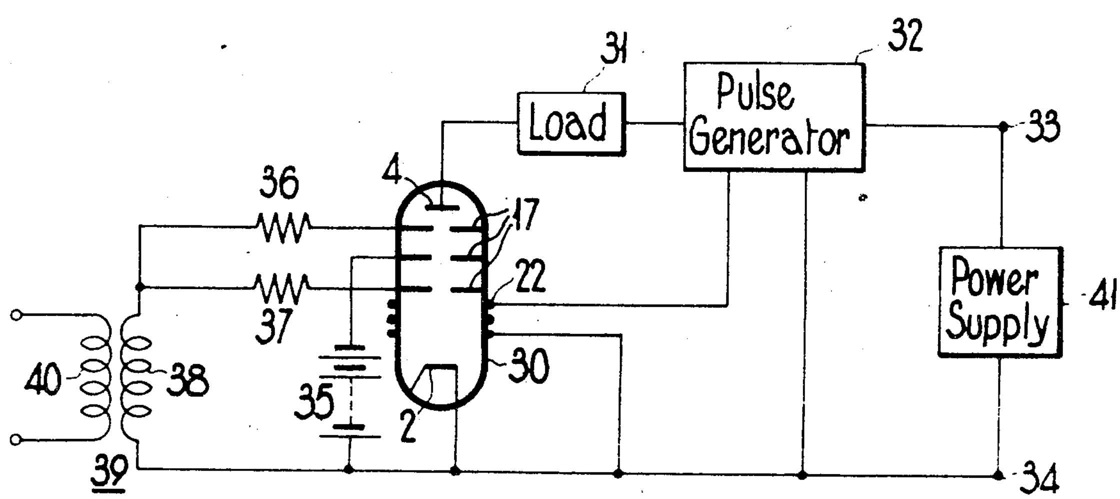
[57] **ABSTRACT**

An electric circuit interrupting device comprising a gas-filled envelope containing an anode and a cathode, and between them a screen with an aperture through which a discharge can pass between anode and cathode. Means are provided for producing a magnetic field adjacent the aperture, and directed parallel to the path of the discharge, the maximum transverse dimension of the aperture being sufficiently small so that, when a discharge is passing, the presence of the magnetic field causes the discharge to be quenched.

9 Claims, 2 Drawing Figures



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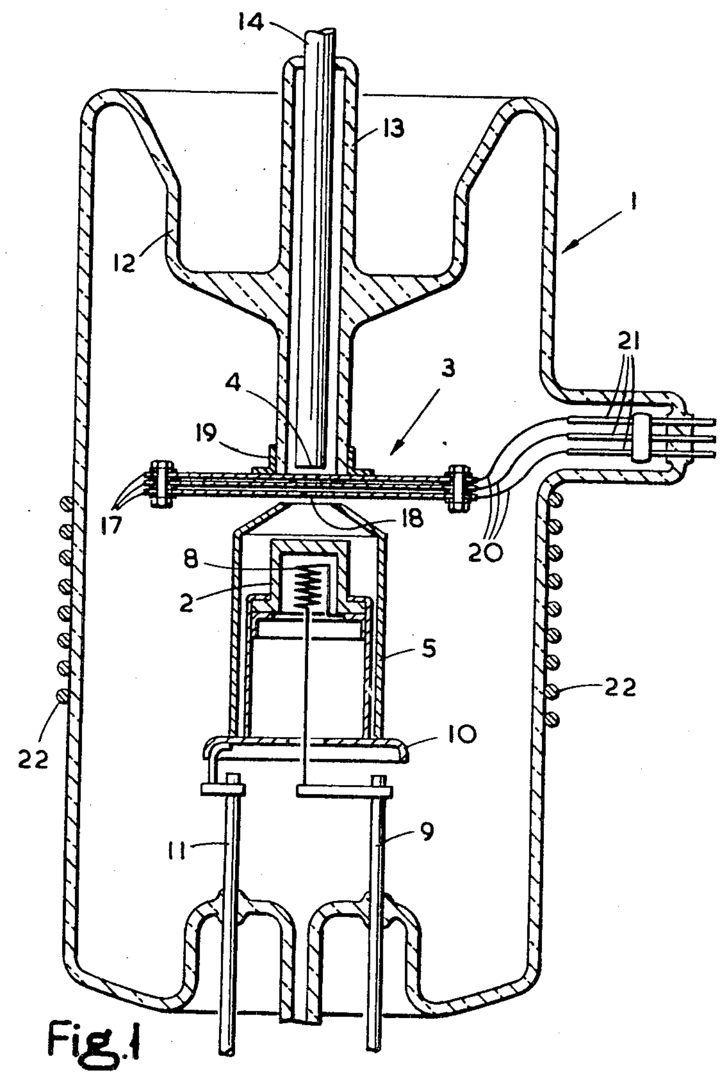

Fig.1

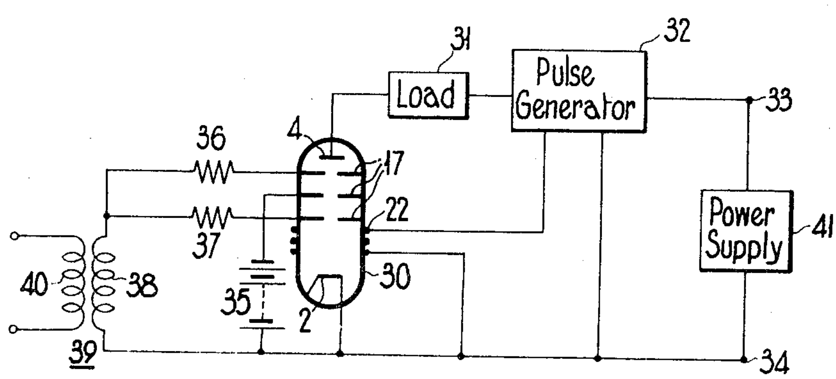

Fig.2

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GAS-DISCHARGE DEVICE WITH MAGNETIC MEANS FOR EXTINGUISHING THE DISCHARGE

This invention relates to electric circuit interrupting devices.

Known electric circuit-interrupting devices operate relatively slowly and are therefore not suitable in applications where rapid operation is required, for example, for the protection of radiofrequency oscillating valves in the event of the occurrence of a flash arc in the valve.

One way of overcoming this difficulty is to connect a so-called "crowbar" device, typically a gas-discharge device, in parallel with the device to be protected, which bypasses overload current around the device being protected until an associated interrupting device has had time to operate. However, this method has the disadvantage that the magnitude of the current to be bypassed may be very high, and where there are several devices to be protected operating from a common power supply failure of one device results in all the other devices being bypassed as well.

Thus there is a need for an electric circuit-interrupting device capable of operating at a higher speed than known devices, and it is an object of the present invention to provide such a device.

According to the present invention, an electric circuit-interrupting device comprises: an anode and a cathode housed within the envelope; a screen member housed within the envelope between the anode and cathode and having an aperture through which in operation an electrical discharge can pass from the cathode to the anode, the discharge passing through the aperture along a predetermined direction; and magnetic field-producing means mounted in fixed relationship relative to the anode and cathode to produce in a region of the discharge adjacent said aperture and between said aperture and the cathode a magnetic field directed parallel to said predetermined direction; the maximum dimension of said aperture in a plane perpendicular to said predetermined direction being of small size whereby, in operation of the device and when a discharge is passing, application of said magnetic field causes the discharge to be quenched.

In a preferred circuit arrangement for utilizing a device in accordance with the invention the device has associated with it pulse-generating means for energizing said means for producing a magnetic field so as to produce a pulse of magnetic field in said region.

In operation of a device in accordance with the invention, in regions of the device where the magnetic field is present the holdoff voltage between facing metal parts of the device may be reduced due to electrons being constrained to follow paths which are longer than they would be in the absence of the magnetic field.

To alleviate this difficulty, in a preferred embodiment of the invention, including facing metal parts which in normal operation of the device are maintained at different potentials, a member of insulating material is disposed between said metal parts, thereby increasing the holdoff voltage between said metal parts.

Such facing metal parts are typically members which are respectively at the potentials of the anode and of a control electrode of the device and may, for example, form supports for such electrodes.

In the present specification, the term "gas-filling" is intended to cover vapor fillings.

One electric circuit interrupting device in accordance with the invention will now be described, by way of example with reference to the accompanying drawings, of which:

FIG. 1 is a sectional elevation of the device; and

FIG. 2 is a circuit diagram of a circuit arrangement for utilizing the device shown in FIG. 1.

Referring to FIG. 1, the device comprises a sealed, hollow, generally cylindrical glass envelope 1 in which is housed an electrode structure including an indirectly heated cathode 2, a control electrode arrangement 3, and an anode 4.

The cathode 2 is of hollow cylindrical form and is disposed coaxially within the envelope 1 with a tubular heat shield 5 coaxially surrounding and electrically connected to it, the heat shield being of uniform diameter over the major part of its length but narrowing in diameter towards its end nearer the anode 4.

A cathode heater 8 is housed within the body of the cathode 4 and is in the form of a wire helix, one end of which is connected to the cathode 4 and the other end of which is connected to a metal rod 9 which is sealed through the nearer end of the envelope 1 and serves as a connector for the heater 8.

The cathode assembly is mounted on a support member 10 in the form of an inverted shallow metal cup, the member 10 in turn being mounted on a second metal rod 11 which is sealed through the nearer end of the envelope 1 and serves as a second connector for the heater 8 and as a connector for the cathode 2.

At its end further from the cathode 2 the envelope 1 is provided with a reentrant portion 12, through which is sealed, coaxial with the envelope 1, a glass tube 13. A tungsten rod 14 is disposed coaxially within the tube 13 and is sealed at a point near its outer end to the outer end of the tube 13, the inner end of the tube 13 projecting slightly beyond the inner end of the rod 14. The inner end of the rod 14 constitutes the anode 4 of the device, while the remainder of the rod 14 constitutes a connector for the anode 4.

The control electrode arrangement 3 comprises three similar disc-shaped metal control electrodes 17 which are bolted together in parallel spaced-apart relationship so as to be electrically insulated from one another, and are disposed between the anode and cathode in planes perpendicular to the axis of the envelope 1. Each electrode 17 has a small circular aperture 18 formed in it centrally, 3 millimeters in diameter, the apertures 18 being in register so that in operation of the device a discharge can pass along the axis of the envelope 1 in a direct straight line between the cathode 2 and the anode 4.

To support the control electrode arrangement the outer face of the electrode 17 nearest the anode 4 is sealed to the face of a flange formed at one end of a short metal sleeve 19 which is secured around the inner end of the glass tube 13.

The three control electrodes 17 are respectively connected via three metal rods 21 which are sealed through the sidewall of the envelope 1 and serve as connectors for the control electrode arrangement 3.

The electrode structure is not designed that the device has forward and reverse holdoff voltages in the order of 10 kilovolts between the anode and cathode.

The envelope is surrounded coaxially by a coil 22 of wire which, when a suitable pulse of current is passed through it, produces in the path of the discharge between the cathode 2 and the control electrodes 17 a pulse of magnetic field, the field being directed, in the region of the apertures 18 along the axis of the envelope 2, and thus being parallel to the direction of the discharge in that region.

Referring now to FIG. 2, a typical application of the device 30 is in a circuit breaker arrangement for protection of a load 31 in the event of the load drawing excess current from a power supply 41.

The anode 4 of the device 30 is connected via the load 31, and via a path through a pulse generator 32 to the positive terminal 33 of the power supply, the negative terminal 34 of which is earthed, as is the cathode 2 of the device. The pulse generator 32 is arranged to produce an output pulse of current in the event of the current passing to the load 31 from the terminal 33 exceeding a predetermined value, this output pulse being applied to the coil 22 of the device 30.

The middle control electrode 17 is maintained at a potential of 100 volts negative with respect to the cathode 2, by means of a direct voltage supply 35. The two outer control electrodes 17, however, are connected via separate resistors 36 and 37 to one end of the secondary winding 38 of a transformer 39, the other end of the winding 38 being earthed.

In operation of the arrangement, after the power supply has been turned on, the supply of current to the load 31 from the terminals 33, 34 can be initiated by application of a pulse of voltage to the primary winding 40 of the transformer 39, thereby momentarily driving the outer control electrodes 17 positive with respect to the cathode 2, and then causing a discharge to pass between the cathode and anode.

Typically, the amplitude of the triggering pulse applied to the control electrodes 17 in the order of 500 to 2,000 volts.

In the event of the current passing through the lead 31 exceeding the predetermined value, the pulse generator 32 produces a pulse of current in the coil 22, the pulse being of sufficient magnitude and duration to produce, in the region of the apertures 18, a pulse of magnetic field having an amplitude of 2 kilogauss, and a rate of rise of approximately 0.2 kilogauss per microsecond. This pulse of magnetic field causes the discharge in the device 30 to be quenched, so that current ceases to be supplied to the lead 31.

The supply of current to the lead 31 may subsequently be reestablished by the application of a further pulse to the primary winding 40.

In the arrangement described above with reference to FIG. 1, unwanted long-path breakdown between the rod 14 and the metal sleeve 19, which would otherwise be induced by the presence of the magnetic field, is prevented by the glass tube 13, which extends between the curved surface of the rod 14 and the inner curved surface of the sleeve 19. Thus the breakdown voltage between the anode 4 and the control electrode 17 for a given gas-filling pressure is higher than it would be if the glass tube 13 did not extend between the rod 14 and the sleeve 19. This means that higher gas-filling pressures may be used, thus giving the device a higher current rating.

I claim:

1. An electric circuit-interrupting device comprising:
a. an envelope containing a gas filling;
b. an anode and a cathode housing within the envelope;
c. a screen member housed within the envelope between the anode and cathode and having an aperture through which in operation an electrical discharge can pass from the cathode to the anode, the discharge passing through the aperture along a predetermined direction;
d. and magnetic field-producing means mounted in fixed relationship relative to the anode and cathode to produce in a region of the discharge adjacent said aperture and between said aperture and the cathode a magnetic field directed parallel to said predetermined direction;
e. the maximum dimension of said aperture in a plane perpendicular to said predetermined direction being of small size whereby, in operation of the device and when a discharge is passing, application of said magnetic field causes the discharge to be quenched.

2. A device according to claim 1 wherein said means for producing a magnetic field comprises a coil.

3. A device according to claim 1 wherein said screen member comprises a control electrode of the device.

4. A device according to claim 1 including facing metal parts which in normal operation of the device are maintained at different potentials, and a member of insulating material disposed between said metal parts thereby increasing the hol-doff voltage between said metal parts.

5. A device according to claim 4 wherein said facing metal parts are members which in normal operation of the device are respectively at the potentials of the anode and of a control electrode of the device.

6. A device according to claim 5 wherein said facing metal parts are support members for the anode and a control electrode respectively.

7. A device according to claim 1 wherein the aperture is aligned with the anode and cathode so that in operation of the device a said discharge can pass in a direct line between the cathode and anode.

8. An electric circuit-interrupting arrangement comprising a circuit-interrupting device according to claim 1, and pulse-generating means for energizing said means for producing a magnetic field so as to produce a pulse of magnetic field in said region.

9. An electrical circuit comprising a load, a power supply, and an electric circuit-interrupting arrangement according to claim 8, electrically connected with the load and power supply so that, when a discharge is passing in said device, current is supplied from the supply to the load, said pulse-generating means being arranged to energize said means for producing a magnetic field, to produce a pulse of magnetic field, in the vent of the current passing to the load exceeding a predetermined value.

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