April 4, 1939. R. C. KELTING 2,152,998

CIRCUIT FOR GASEOUS ELECTRIC DISCHARGE DEVICES

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Fig. 1

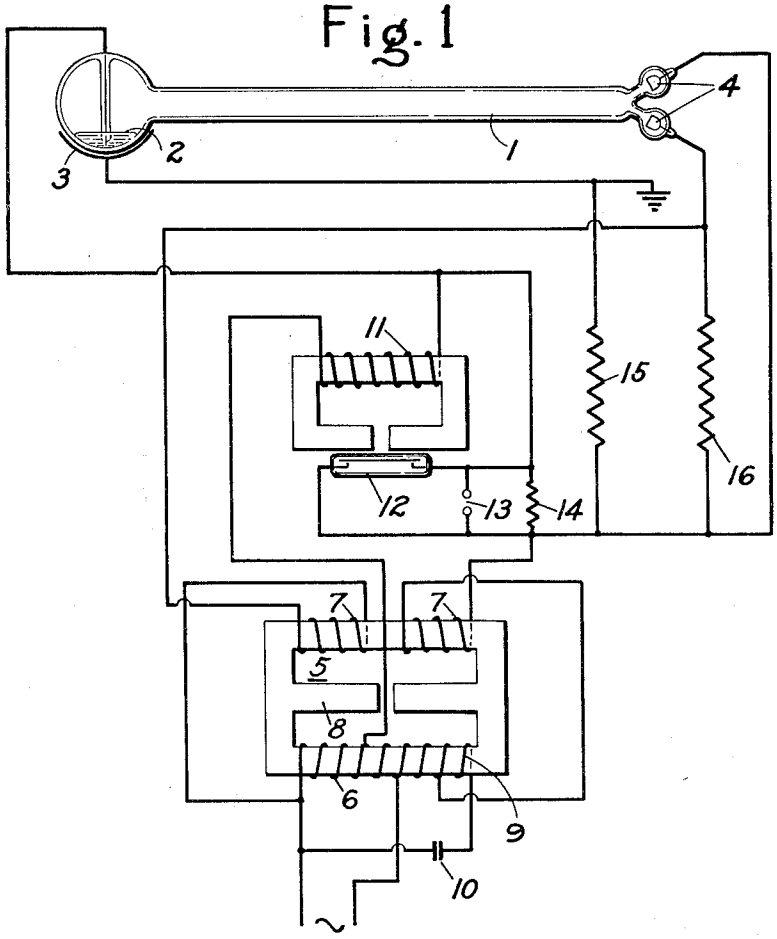
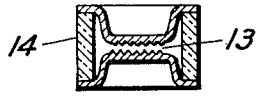


Fig. 2



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CIRCUIT FOR GASEOUS ELECTRIC DISCHARGE DEVICES

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4 Claims. (Cl. 176—45)

The present invention relates to electric gaseous discharge devices and particularly to starting and operating circuits therefor.

A particular object of the invention is to provide apparatus which will be extremely effective to start and operate gas or vapor discharge devices. A further object of the invention is to provide means to protect this apparatus against abnormal voltage surges which might damage the insulation. Various other objects and advantages of the invention will appear from the following detailed description or from an inspection of the accompanying drawing.

The invention consists in the novel combination of elements hereinafter set forth and claimed.

During the past few years many improvements have been made in the circuits used for starting and operating lamps of the gaseous discharge type, such as the well known Cooper Hewitt lamp, for instance. Thus the efficiency of these lamps has been markedly increased by the substitution of reactive ballasting for the series resistances which have been long in use, and the starting has been improved by the use of a newly developed evacuated switch. These changes in circuit design have brought in their wake new problems which have now been successfully solved by the present invention.

Thus with the advent of reactive ballasting it was found that occasional unexplained insulation failures occurred in use. After considerable study I discovered that these failures were caused by the inductive surge produced in the rectifier circuit when the current flowing through the discharge device did not carry over for any reason from one half cycle to the next, such as occasionally occurs during starting. Having thus discovered the cause of this trouble, I found that the difficulty was entirely eliminated by the novel use of a special resistance connecting the anodes. Since this resistance is permanently connected across the anodes a resistance of constant value is unsuitable, since if low enough to be of value in dissipating such a surge, excessive energy would flow therethrough during normal operation. Consequently I found it to be necessary to use a resistance of the type whose value sharply decreases as the impressed voltage rises. In the preferred case I use the material known to the trade as "Thyrite", which consists essentially of silicon carbide, carbon and clay, in which this characteristic is very marked. A resistance of this material limits the current flow therethrough during normal operation, with 250 volts impressed thereacross, to but a few milliamperes, whereas under the conditions which tend to produce a voltage surge which it is desired to control, this resistance will pass the entire normal discharge current of several amperes at a controlled elevation in voltage, making it impossible for the voltage surge to reach a peak value sufficient to puncture the usual insulation.

The use of a vacuum metal to metal contact type switch brought with it the use of a spark gap across the terminals thereof to prevent occasional starting surges from exceeding a predetermined maximum potential, and also to increase the effectiveness of the starting circuit, as described in Patent 2,135,776, granted November 8, 1938, to Warren R. Walker. Where an air gap type of by-pass gap was used it was found that under certain conditions an unforseen difficulty arose. Thus if a lamp failed to start for any reason when the potential was applied thereto the vacuum switch remained in continuous operation so that frequently repeated spark-overs thereupon occurred in the by-pass gap, and oxide deposits were built up by these discharges which after a period of a day or so of continued sparking eventually produced a resistance path in parallel to the switch. The current which thereupon flowed through these deposits produced a localized heating which in some cases destroyed the starting unit. I have now discovered that this difficulty is entirely overcome by the novel use of another resistance of particular characteristics in parallel with the vacuum switch and the by-pass gap previously used. According to my invention this resistance must have two special characteristics. Thus it must have a negative temperature-resistance characteristic, and a negative potential - resistance characteristic. "Globar", Type B, a resistance material readily available on the market, and consisting essentially of silicon carbide is an example of a material having these essential characteristics to a high degree, although "Thyrite" can also be used where desired. The latter, however, has a somewhat less marked negative temperature-resistance characteristic, while its potential-resistance characteristic is somewhat more marked than that of the "Globar". The value of this resistance is so chosen that when cold the surge built up by the opening of the vacuum switch will build up sufficient potential thereacross to break down the associated spark gap, since it has been found that definitely superior starting of the discharge occurs when there is sparking at this gap. If these surges are continued, however, the resistor

is gradually heated by the current passing therethrough and its resistance thus gradually diminished until, after several minutes have elapsed, the entire current being opened by the vacuum switch passes through the resistance at a potential less than that required to break down the air gap. Thereafter there will obviously be no further sparking in the gap, regardless of how long the device is left unattended. As soon as the circuit is deenergized, however, and the resistance allowed to cool, normal starting conditions are automatically restored. During normal operation of the lamp 1, however, the value of this resistance is so high that less than a milliampere will flow therethrough, since the voltage then impressed thereon is only of the order of 130 volts, so that the wattage consumed therein is limited to a fraction of a watt.

It has been proposed heretofore in U. S. Patent 2,076,755 to Warren R. Walker, granted April 13, 1937, to connect the starting band of the discharge device to an anode lead through a high resistance. This resistance serves the purpose of limiting the peak value of the surges, and also provides effective insulation between the anode lead and the starting band during operation. In addition it also serves to prevent the welding of the contacts of the vacuum switch by condenser discharge. I have now found that the starting of the device is materially improved if this resistance is made of a material similar to that of the resistances previously described, namely one having a decidedly negative potential-resistance characteristic. Under these conditions this resistance, of the order of 80,000 ohms under impressed potentials of the order of 130 volts, offers a much lower resistance to the starting surge whereby good starting is permitted without the establishment of a correspondingly good electrical path to the starting band at normal operating potentials.

These new features all cooperate in a novel manner to provide positive starting plus complete freedom from circuit failure regardless of adverse operating conditions.

For the purpose of illustrating my invention I have shown a preferred embodiment thereof in the accompanying drawing, in which

Fig. 1 is a schematic diagram of the circuit arrangements as applied to a standard Cooper Hewitt lamp, and

Fig. 2 is a sectional elevational view of the novel combined spark gap and resistance which is used in this circuit.

As shown in this drawing the lamp 1 has a mercury cathode 2, external starting band 3, and a pair of anodes 4. As is customary in this type of device the lamp 1 is highly evacuated, containing only vapor from the cathode 2.

Said lamp is supplied with energy from a suitable alternating current source through a leaky autotransformer 5. Said autotransformer has a coil 6 which has a suitable number of turns connected to said source, while the same or a different number of turns are connected through a pair of secondary coils 7 to the anodes 4. A magnetic shunt 8 having a suitable air gap therein provides the desired leakage reactance between the coils 6 and 7, this reactance being used to ballast the lamp 1. An extended winding 9 is connected in series with the winding 6 across a condenser 10 which is used to counteract the lagging effect of these reactances on the power factor of the unit. The midpoint of the coil 6 is connected through an inductance 11 to the cathode 2, said inductance serving the usual function of smoothing and stabilizing the discharge, and to provide the starting surge. A vacuum metal-to-metal contact switch 12 of the type disclosed in Patent 2,076,162 to J. P. Ruth, granted April 6, 1937, is arranged opposite the air gap of the inductance 11 so that said inductance when energized will open the circuit through said switch, which is connected between the lead to the cathode 2 and the lead to an anode 4. A spark gap 13 is connected across the switch 12 as taught by the Walker application, referred to hereinbefore, this gap having a breakdown potential well below the tolerance of the insulation of the associated circuit. According to my invention this spark gap is supplemented by a resistance 14 of "Globar", Type B, or any other material having a highly negative potential-resistance characteristic and also a markedly negative temperature-resistance characteristic. As shown in Fig. 2 this spark-gap and resistance are conveniently formed into a single unit, in which the resistance 14 forms a tubular housing and separator for the elements of the spark gap 13. The starting band 3 is connected to ground and also to the same anode lead as the switch 12 through a resistance 15 of a material such as "Globar", Type B, which has a markedly negative potential-resistance characteristic. "Thyrite" may also be used for this purpose where desired. A third resistance 16 of similar material having a strongly negative potential-resistance characteristic is connected between the anodes 4. The invention resides in the use of these three resistors 14, 15 and 16, and in their novel cooperation with the rest of the circuit, which will appear more fully from the description of the mode of operation of this novel lamp circuit.

Thus, as is usual in these Cooper Hewitt circuits, upon energization of the transformer 5 the lamp 1 does not immediately start into operation, due to its relatively high breakdown potential. Current immediately flows, however, from the midpoint of the coil 6 through the inductance 11, switch 12 and a coil 7 back to the end of the coil 6. The inductance 11 thus energized causes the switch 12 to open this circuit, whereupon the magnetic field about said inductance collapses and produces a high voltage surge which depresses the cathode potential to a value several thousand volts below that of the starting band 3, whereby the condenser formed by the mercury and the starting band, together with the intervening glass wall, is charged. In most cases this potential causes a disruptive discharge to occur to the mercury pool which ionizes the mercury vapor and establishes the main arc discharge to the anodes 4. The resistance 15 permits the flow of the requisite energy during this operation, during which its resistance is reduced, due to the high potential, to a value of the order of 10,000 ohms, but immediately after the surge its value goes back to 80,000 ohms or more, thus effectively protecting the apparatus against damage upon the accidental grounding of any portion of the circuit. This resistance likewise protects the switch 12 from fusion of the contacts by a condenser discharge current, as described in the Walker Patent 2,076,756, granted April 13, 1937.

In case the discharge is not started immediately by one of these surges, however, the potential of the surge sometimes, depending upon the moment in the A. C. cycle when the interruption occurs, builds up to a value such that the spark gap 13 will break down, despite the presence of

the shunt 14. In fact the resistance 14 is purposely designed to permit, when cold, the building up of enough voltage to cause breakdown of the gap, since it has been found that this spark sets up a disturbance in the circuit which is extremely effective in starting the discharge in the lamp 1, as pointed out in the Walker Patent 2,076,755, referred to hereinbefore. If the lamp 1 has been damaged so that it will not start the switch 12 will obviously continue to operate until the circuit is deenergized, which means that repeated spark-overs occur in the gap 13. Each surge, however, causes a momentary current flow through the resistance 14 which heats this resistance and thus causes a material drop in the resistance thereof due to its negative thermal characteristic. By design of the resistor this decrease becomes sufficient after a period of two or three minutes continuous operation of the switch 12 to permit the passage of the current which said switch is interrupting without building up a potential which would break down the gap 13, and hence under continued operation of the switch 12 the surge is harmlessly dissipated in this resistance 14. As soon as the circuit is deenergized this resistance cools and resumes its original value, ready for operation anew.

In the starting of the lamp 1 it occasionally happens that the surge produced in the inductance 11 starts a discharge in the lamp 1, as intended, but that this discharge for some unexplained reason fails to carry over from one half cycle to the next. In such a case the lamp 1 acts as a switch in the inductive circuit including the reactive transformer 5, producing a high voltage surge, which is magnified by transformer action between the coils 5, 6 and 7, between the anodes 4. If left uncontrolled this surge might have disastrous effects upon the insulation, but the resistance 16 effectively dissipates these surges and thus avoids this possible difficulty. Due to its strongly negative potential-resistance characteristic this resistance allows the full lamp current to flow therethrough momentarily at a voltage well within the tolerance of the insulation, and yet under normal operating conditions limits the current flow therethrough to a value of the order of 2 or 3 milliamperes.

Thus due to the novel cooperation of these resistances with the rest of the circuit the circuit is protected against all conceivable hazards of operation while at the same time the starting of the lamp 1 is made positive.

While I have illustrated my invention by reference to a specific embodiment thereof it is to be understood that various omissions, substitutions and changes, within the scope of the appended claims, may be made therein without departing from the spirit of the invention. Thus while I have particularly described my invention by reference to a device having a liquid cathode, certain features thereof are also useful in devices having other types of cathode, including those of the activated thermionic type, as will readily appear to those skilled in the art.

I claim:

1. In combination, an electric gaseous discharge device having a liquid cathode, a plurality of anodes, and a conducting sheath in electrostatic relation to said cathode, means to connect said anodes to a source of alternating current potential and said cathode to a point of intermediate potential, an inductance in the lead to said cathode, a connection from said cathode to the lead to one of said anodes, said connection including an evacuated metal to metal contact switch, said switch being responsive to energization of said inductance to open said connection, a spark gap and a high resistance having a negative temperature-resistance and a negative potential-resistance characteristic connected in parallel across the terminals of said switch, said spark gap and said resistance being so adjusted that the voltage built up there across by the flow of current induced by the maximum voltage surges produced by the opening of said switch exceeds the breakdown potential of said gap when said resistance is cold but is less than said breakdown potential after said resistance has been heated by recurrent flow of said current for a predetermined time, a high resistance of the type having a strongly negative potential-resistance characteristic connected between said sheath and said anode lead, and another high resistance having a similar potential-resistance characteristic connected between a pair of said anodes.

2. In combination, an electric gaseous discharge device having a liquid cathode, an anode, and a conducting sheath in electrostatic relation to said cathode, means to connect a source of potential between said anode and said cathode, an inductance in the lead to said cathode, a connection from said cathode to said anode, said connection including an evacuated metal to metal contact switch, said switch being responsive to energization of said inductance to open said connection, and a spark gap and a high resistance having a negative temperature-resistance and a negative potential-resistance characteristic connected in parallel across the terminals of said switch, said spark gap and said resistance being so adjusted that the voltage built up thereacross by the flow of current induced by the maximum voltage surges produced by the opening of said switch exceeds the breakdown potential of said gap when said resistance is cold but is less than said breakdown potential after said resistance has been heated by recurrent flow of said current for a predetermined time.

3. In combination, a mercury vapor arc device having a mercury cathode, at least one anode, and a conducting sheath in electrostatic relation to said cathode, an inductance in the lead to said cathode, a connection from said cathode to said anode, said connection including an evacuated metal to metal contact switch, and a high resistance connection to said sheath from the side of said switch which is connected to said anode lead, said high resistance connection having a strongly negative potential-resistance characteristic.

4. In combination, an electric gaseous discharge device having a cathode and a plurality of anodes, means to connect said anodes to a source of alternating current through a reactive circuit, means to connect said cathode to an intermediate point on said source, and a high resistance connection between a pair of said anodes, said resistance having a strongly negative potential-resistance characteristic.

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