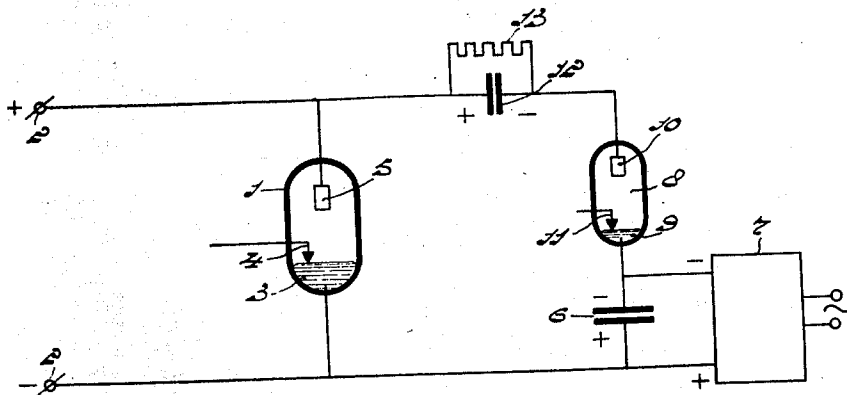


Jan. 9, 1951

A. C. VAN DORSTEN
DEVICE FOR EXTINGUISHING A DISCHARGE
TUBE HAVING A MERCURY CATHODE
Filed April 19, 1946

2,537,383



INVENTOR.
ADRIANUS C. VAN DORSTEN

BY

Charles H. ...

ATTORNEY

UNITED STATES PATENT OFFICE

2,537,383

DEVICE FOR EXTINGUISHING A DISCHARGE
TUBE HAVING A MERCURY CATHODE

Adrianus Cornelis van Dorsten, Eindhoven, Netherlands, assignor, by mesne assignments, to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

Application April 19, 1946, Serial No. 663,292
In the Netherlands March 31, 1942

Section 1, Public Law 690, August 8, 1946
Patent expires March 31, 1962

6 Claims. (Cl. 315-234)

1

This invention relates to a device for extinguishing a gas- or vapor-filled discharge tube having a mercury cathode, more particularly for use in installations designed for high voltages and large powers and fed with direct current.

The invention has for its object to provide an improved extinguishing device wherein the extinction is effected by means of a voltage impulse obtained from a previously charged condenser, which at the moment of extinction delivers a discharge impulse through the discharge tube and/or on one or more auxiliary electrodes thereof. As a rule this method of extinction is very suitable for extinguishing tubes having a mercury cathode in conjunction with the fact that during the extremely short time available for the extinction the cathode spot can be caused to disappear so that the discharge is interrupted.

However, this method often entails the drawback that the voltage, which is reapplied to the discharge tube after extinction and is usually much higher than the operating voltage across the tube before the extinction, also exists across the parallel branch consisting of the series-connection of the above-mentioned switching member and the extinguishing condenser. For this reason the extinguishing condenser must be designed for a much higher voltage than is necessary in view of its function during the period of extinction. This drawback particularly occurs when discharge tubes having a mercury cathode are used, in view of their fundamental fitness for this purpose, for the passage of comparatively large currents of the order of magnitude of hundreds of amperes at very high voltages, for instance of the order of magnitude of tens of kilovolts. Moreover, it may then occur that immediately after extinction the switching member, the condenser and the feed apparatus connected in parallel therewith have to take up a current impulse which may be a multiple of the extinction current, for instance 100 times as large. This drawback may be avoided in regard to the feed apparatus by switching it off temporarily, it is true, but this requires an additional manipulation. Furthermore, this entails the drawback that the extinguishing condenser is discharged to a higher or smaller degree, its charge being even reversed under certain conditions, and is not available again in time for a next extinction. The latter drawback is particularly objectionable if the discharge tube, by virtue of its function in a definite circuit arrangement, has to be ignited and extinguished periodically.

The improvement according to the invention

2

consists in connecting in series with the extinguishing condenser and the switching member another (auxiliary) condenser, whose capacity in proportion to the capacity of the extinguishing condenser is so chosen as to take up or absorb substantially the voltage applied to the discharge tube after extinction. It will be obvious from what has been said above that in the present case the expression substantially is to be understood to mean such a part of the voltage that the above-mentioned drawbacks cannot occur.

If, for instance, the voltage returning to the discharge tube upon extinction amounts to several kilovolts, which may occur in transmitting energy by means of direct current having a high voltage, and the voltage available for extinction at the extinguishing condenser is of the order of magnitude of several hundreds of volts, for instance 500 volts, the voltage applied to the extinguishing condenser will at the utmost be of the same order of magnitude after extinction. As a rule it may be said that the ratio between the capacities of the extinguishing condenser and the auxiliary condenser amounts to 50 or 100, the capacity of the extinguishing condenser being determined, of course, by the quantity of energy required for the extinction. Although the auxiliary condenser must be insulated against the high voltage this does not constitute a drawback at all in view of the low capacity relatively to that of the extinguishing condenser. On the contrary, this is advantageous in comparison with operation without such an auxiliary condenser in which case the comparatively large extinguishing condenser must be insulated against the same high voltage, since in order to obtain the required insulation the volume of the condenser is substantially proportional to the square of the voltage.

In order to prevent re-ignition of the tube in special cases on account of oscillation phenomena (instability) of the discharge, which occur if, after extinction, the voltage returning to the tube would remain at the condensers connected in parallel therewith, it is advisable that the switching member should be open circuited, as soon as the auxiliary condenser has been charged by the reapplied voltage and charging current has substantially ceased to flow. Although, in principle, any suitable switch may be used to constitute the switching member it is advisable to use a controllable (auxiliary) discharge tube having a gas- or vapor-filling, which tube may be blocked by means of an auxiliary electrode if required, since oscillations can be prevented at any rate by the valve action.

In many cases the auxiliary condenser, after extinction, will require some time to discharge to such a degree that the main tube, after re-ignition, can be extinguished again by causing the recharged extinguishing condenser to discharge again through the tube by means of the switching member through the intermediary of the auxiliary condenser. If the moments of extinction are sufficiently spaced apart, no difficulties will be experienced in regard to the extinction. However, it often occurs that the tube must be rapidly ignited and extinguished successively at such a rate that the discharge of the auxiliary condenser takes place too slowly. In such cases the condenser in the device according to the invention is shunted by a variable resistance, which may or may not be disconnected by switching means and has such a value as to permit the discharge to take place within an adjustable time. This is of importance more particularly if the main tube must be periodically ignited and extinguished automatically, for instance 50 times per sec. In this case the desired effect can be secured by connecting in parallel with the auxiliary condenser a resistance having such a value that the discharge of the condenser has sufficiently proceeded within the time of the period. To this end the time constant RC must be of the same order of magnitude as the duration between two succeeding extinctions.

It is to be remarked that owing to the presence of the resistance, after extinction of the main tube, a high voltage will be set up also at the auxiliary tube, which might unexpectedly produce again an arc discharge in the auxiliary tube. However, when making use of an auxiliary tube having a mercury cathode this drawback is avoided with certainty by such a choice of the resistance value that the current if any, would lie far below the minimum current of a mercury cathode. Owing to this, disturbances in the extinguishing process due to a breakdown of the auxiliary discharge tube, cannot occur. When using other switching members, for instance an auxiliary tube having an incandescent cathode, the shunt-resistance should not be switched on before termination of the extinguishing process and interruption of the parallel branch. In this case the voltage set up at the tube through the resistance does not appear before the passage of current through the tube has been interrupted. This step is necessary in conjunction with the well known fact that for a gas-discharge tube having an incandescent cathode there is no minimum current strength at which the discharge is interrupted. The step is also advisable with a tube having a mercury cathode if, under the action of gas pressure and voltage there would not occur an arc discharge but a glow discharge under certain conditions.

The principles of the invention are applicable to circuits for both alternating voltage and direct voltage.

The circuit according to the invention has proved to be particularly effective in switching off large powers at a high direct voltage of some tens of kilovolts.

In switching off these large direct current powers the best form of construction of the device according to the invention comprises an auxiliary tube having a mercury cathode, since re-ignition of the tube after extinction of the main tube can be avoided with certainty owing to the extremely short time of 10^{-9} sec. in which the cathode spot disappears, even if the auxiliary

condenser is permanently shunted by the resistance. Consequently, oscillation phenomena in the main tube due to capacity in parallel with the tube can be avoided automatically even at the highest voltages.

In order that the importance of the invention for switching off direct current having high voltages by means of an extinction impulse from a condenser on a discharge tube connected in parallel with the switch may be made better understood, it is remarked in this respect that one of the causes of the fact that in the strong current technique currents having such voltages could not be switched off up till now, so that corresponding switching devices were not sold in commerce, resides in the oscillation problem which could not be avoided hitherto. The use of an auxiliary condenser according to the invention yields a solution which, in the combination with a mercury cathode auxiliary tube as a switching member in the manner described, yields a substantially perfect solution to the problem. When using a resistance having a suitable value in parallel with the auxiliary condenser it is also possible, in principle and also for the first time to switch off direct currents of hundreds of amperes having a high voltage even with a periodicity of 50 times per sec. The latter has proved to be of much importance for the cascade circuit described in French Pat. Spec. 847,401 of applicant for converting direct current having a high voltage into alternating current having a lower voltage for the transmission of energy over a long distance, since in this case the periodical extinction of the discharge tubes used in conversion plays an important part.

The invention will be more fully explained by reference to the accompanying drawing, given by way of example.

The reference number 1 designates the main discharge tube which must be extinguished periodically, for instance 50 times per sec. and may, for instance, be connected to a source of direct voltage of some tens of kilovolts through the intermediary of a load. The tube, for example a so-called "Ignitron," is periodically ignited in a common manner by applying a voltage impulse between the mercury cathode 3 and the ignition electrode 4 which consists of semi-conductive material and is plunged into the said mercury cathode.

The extinguishing device according to the invention is connected in parallel with the discharge tube, i. e. in series between the cathode 3 and the anode 5. It comprises the extinguishing condenser 6 which is charged with the polarity indicated in the drawing, from a direct current supply 7.

In series connection with the extinguishing condenser are an auxiliary condenser 12 shunted by the resistance 13, and an (auxiliary) discharge tube 8 having a mercury cathode 9 and an anode 10 for which a tube of the "Ignitron" type having an ignition electrode 11 is chosen in the present case. As has been set out above, the resistance 13 may, in principle, be omitted if no periodical extinction is required.

The operation of the device referred to above without resistance 13 is as follows. If the tube 8 is made conductive by means of the ignition electrode 11 thereof and it is assumed that at this moment tube 1 is conductive and the condenser 12 uncharged, whilst the extinguishing condenser 6 is charged in the manner referred to, the extinguishing condenser will partly dis-

5

charge abruptly, the uncharged condenser 12 being in a position to transmit this impulse to the anode of the tube 1, between whose anode and cathode prevails at this moment the comparatively low operating voltage of some tens of volts. The auxiliary discharge tube 8 conveys current only for the extremely short time required for charging the condenser 12. After that the current is interrupted.

The current impulse thus obtained from the main condenser produces a short voltage drop at the anode 5 of the tube 1 (sometimes a negative voltage), whereby the tube 1 is extinguished. As is well known a voltage drop during 10^{-9} sec. is sufficient to extinguish the cathode spot of a discharge tube having a mercury cathode.

As this moment a voltage is reapplied between cathode and anode of tube 1 which may attain, say, some tens of kilovolts. The ratio between the capacities of the condensers 6, 12 is so chosen that this voltage exists mainly across the condenser 12.

In the case referred to without resistance 13 a next extinction after re-ignition of the tube 1 by means of the ignition electrode 4 cannot take place before the condenser 12 has been discharged in some way. Without resistance 13 this is rather impractical if the extinction has to take place periodically, for instance 50 times per sec. The value of the resistance 13 is now so chosen that the product RC is of the order of magnitude of the duration of one period or smaller, and consequently the discharge of the condenser 12, after an extinction, will have proceeded to a sufficient degree before the next extinction to permit a recurrence thereof.

Owing to the presence of the resistance 13 a high voltage is applied to the tube 8 after extinction it is true, but on the other hand the value of the resistance is chosen such that, if the tube 8 should become conductive again, the current through the tube 8 would remain far below the minimum current of the mercury cathode so that disturbances due to an arc discharge in the tube 8 cannot occur.

After extinction of the tube 1 the extinguishing condenser 6 has meanwhile been charged again from the supply 7 to the full voltage and after re-ignition of the tube 1 a next extinction can take place periodically by igniting the tube 1 periodically.

If the tube 8 is replaced by another switching member, for instance a spark gap, the operation referred to is fundamentally the same. When using a spark gap the voltage of the condenser 6 must generally be higher to take into account the breakdown voltage of a spark gap, or means, for instance an inductance coil, must be available for bringing about the breakdown of the spark gap. Use may also be made of other switching elements capable of being switched on and off periodically at the required speed; however, a discharge tube having a mercury cathode is to be preferred also on account of its well-high inertia-free operation. As such any type of discharge tubes having a mercury cathode may be used. It is advisable to use tubes having a capacitative ignition electrode, since the ignition energy required therefor is very low with respect to the energy required for other discharge tubes. Such a tube may also be used as a main discharge tube.

In switching off direct current of 6 amp./20 kilovolts by means of the circuit represented in the drawing the capacity of the condenser 12

6

amounted to about 0.1 to 0.05 microfarad and that of the main condenser to several microfarads, the value of the resistance 13 being of the order of magnitude of 50,000 to 100,000 ohms. The voltage set up at the condenser 6 amounted to about 600 volts.

What I claim is:

1. A circuit arrangement for extinguishing a mercury vapor discharge tube including a mercury cathode electrode and an anode electrode, comprising a series circuit connected in parallel with the said tube and between said cathode and said anode and including an auxiliary condenser element, a switching element and an extinguishing condenser element, and means to apply to said extinguishing condenser element an extinguishing potential for said discharge tube, said auxiliary and extinguishing condenser elements having capacity values in a ratio at which voltage impulses applied to the said series circuit are substantially absorbed by said auxiliary condenser element.

2. A circuit arrangement for extinguishing a mercury vapor discharge tube including a mercury cathode electrode and an anode electrode, comprising a series circuit connected in parallel with the said tube and between said cathode and said anode and including a parallel connected auxiliary condenser element and resistance element, an extinguishing condenser element and a switching element, and means to apply to said extinguishing condenser element an extinguishing potential for said discharge tube, said auxiliary and extinguishing condenser elements having capacity values in a ratio at which voltage impulses applied to the said series circuit are substantially absorbed by said auxiliary condenser element.

3. A circuit arrangement for recurrently extinguishing in a predetermined period of time a mercury vapor discharge tube having a mercury cathode electrode and an anode electrode, comprising a series circuit connected in parallel with the said tube and between said cathode and said anode and including a parallel connected auxiliary condenser element and a resistance element, an extinguishing condenser element and a switching element, and means to apply to said extinguishing condenser element an extinguishing potential for said discharge tube, said auxiliary and extinguishing condenser elements having capacity values in a ratio at which voltage impulses applied to the said series circuit are substantially absorbed by said auxiliary condenser element, said parallel connected auxiliary condenser element and resistance element having a time constant less than about said predetermined period of time.

4. A circuit arrangement for recurrently extinguishing in a predetermined period of time a mercury vapor discharge tube including a mercury cathode electrode and an anode electrode, comprising a series circuit connected in parallel with the said tube and between said cathode and said anode and including a parallel connected auxiliary condenser element and resistance element, an extinguishing condenser element and a switching element having a threshold value of current passage therethrough below which conduction through said switching element is substantially zero, and means to apply an extinguishing potential for said discharge tube to said extinguishing condenser element, said auxiliary and extinguishing condenser elements hav-

7

ing capacity values in a ratio at which voltage impulses applied to the said series circuit are substantially absorbed by said auxiliary condenser element, said parallel connected auxiliary condenser element and resistance element having a time constant less than about said predetermined period of time, said resistance element having a resistance value at which the steady state current through said switching element is maintained below said threshold value.

5. A circuit arrangement for extinguishing a mercury vapor discharge tube including a mercury cathode electrode and an anode electrode, comprising a series circuit connected parallel with the said tube and between said cathode and said anode and including an auxiliary condenser element, an extinguishing condenser element and a second gaseous discharge tube having a control electrode, and means to apply to said extinguishing condenser element an extinguishing potential for said first named discharge tube, said auxiliary and extinguishing condenser elements having capacity values in a ratio at which voltage impulses applied to the said series circuit are substantially absorbed by said auxiliary condenser element.

6. A circuit arrangement for extinguishing a mercury vapor discharge tube including a mercury cathode electrode and an anode electrode, comprising a series circuit connected parallel

8

with said tube and between said cathode and said anode and including a parallel connected auxiliary condenser element and resistance element, an extinguishing condenser element and a second gaseous discharge tube having a minimum current carrying capacity, and means to apply to said extinguishing condenser element an extinguishing potential for said first named discharge tube, said auxiliary and extinguishing condenser elements having capacity values in a ratio at which voltage impulses applied to the said series circuit are substantially absorbed by said auxiliary condenser element, said resistance element having a resistance value at which the steady state current through said second discharge tube is maintained at a value less than the minimum current carrying capacity thereof.

ADRIANUS CORNELIS VAN DORSTEN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 21,697	Lord	Jan. 21, 1941
1,478,638	Cordes	Dec. 25, 1923
1,975,164	Ludwig	Oct. 2, 1934
2,113,011	White	Apr. 5, 1938