Oct. 25, 1938. G. MIERDEL 2,134,527

METHOD OF IGNITING GAS OR VAPOR DISCHARGE SPACES

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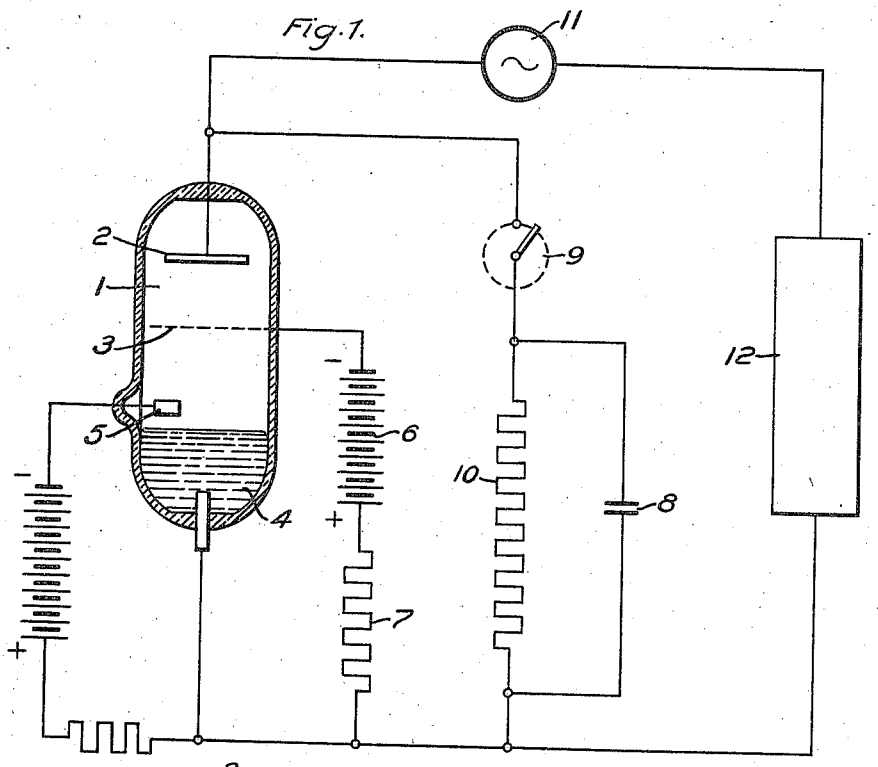
Fig. 1.



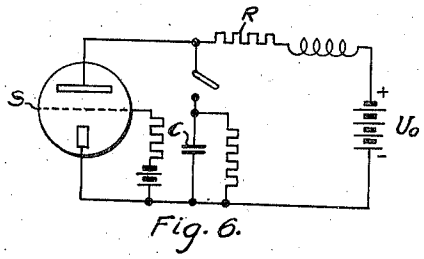


Fig. 6.

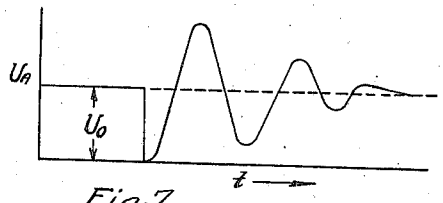


Fig. 7.

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Fig. 2.

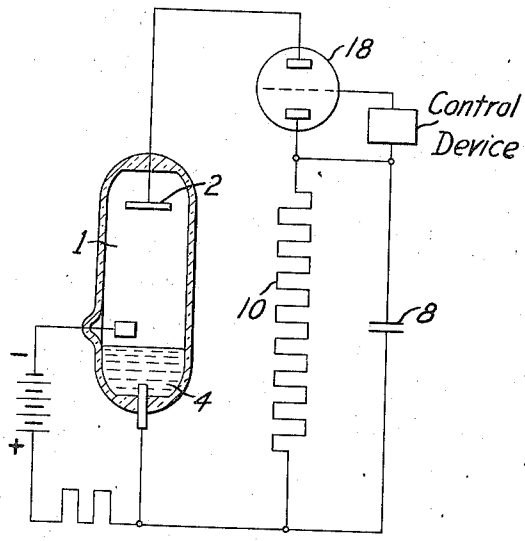


Fig. 3.

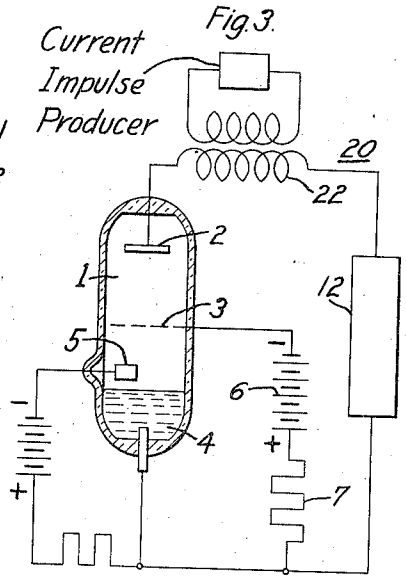


Fig. 4.

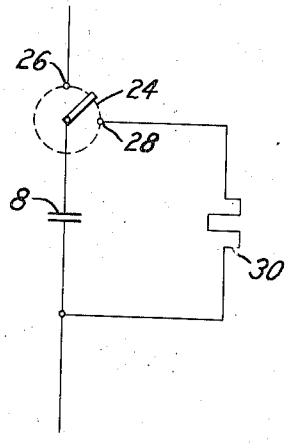
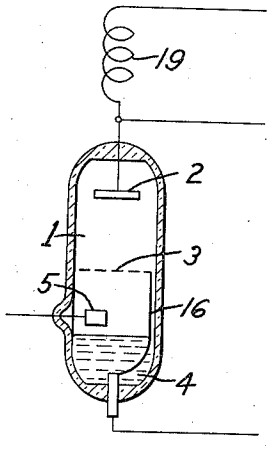


Fig. 5.



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Patented Oct. 25, 1938 2,134,527

UNITED STATES PATENT OFFICE

2,134,527

METHOD OF IGNITING GAS OR VAPOR DISCHARGE SPACES

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Application October 30, 1935, Serial No. 47,498
In Germany January 23, 1935

14 Claims. (Cl. 250—27.5)

The invention relates to a method for igniting gas and vapor discharge spaces which are preferably adapted for the control and regulation of rectifiers such as mercury vapor rectifiers, inverters, converters, or the like. According to the invention, the potential of the anode of the discharge space which is to be ignited and the grid of which is connected to a blocking potential, is for a short interval of time reduced at least approximately to the potential of the cathode. Accordingly, the discharge space is, as in the usual applications of controlled rectifiers, provided with an auxiliary electrode which operates on the discharge path between the anode and the cathode. The auxiliary electrode preferably has the form of a control grid and the control grid is permanently and without change connected to such a potential that the discharge space is blocked; that, accordingly, a potential connected to the anode cannot without further change ignite the discharge space. Other electrode structures than the usual control grids, for example, shells, which envelop the discharge path either within or without the container enclosing the discharge space, may be utilized. As to the magnitude of the blocking potential which is to be connected to the control grid, the dimensions of the discharge device utilized, and therefore particularly the dimensions of the control electrode and the geometric dimensions of the discharge space between the cathode and the anode, are determining. For this purpose a negative direct current potential in series with a resistor in accordance with the character of the discharge vessel utilized, is connected between the control electrode and the cathode. In many cases, however, the potential source may be dispensed with, i. e., the control grid may be connected to the cathode only through a resistor. The latter connection is utilized only for those vessels for which the so-called ignition characteristic line of the discharge vessel coincides with the cathode potential or lies in the positive region above it.

By experiment with the above characterized discharge spaces, it has been established that the discharge space, which on the application of an anode potential (that may be either a direct current or an alternating current potential) is under normal circumstances not ignited, may be ignited if by any means whatever the anode potential is for a short interval of time brought to the cathode potential or at least approximately to the cathode potential. For the purpose of changing the anode potential for a short interval of time, various means may be utilized. For example, a transformer may be connected in the anode circuit, in the secondary of which a short current impulse is produced. The transformer is so connected that the potential peak introduced thereby in the anode circuit is opposite to the anode potential. Control means of this type have, in the past, been utilized in rectifiers. Nevertheless the use has been heretofore in those rectifiers which, in contrast to the control method according to the invention, are not ignited by a potential decrease but by a momentary potential increase of the anode.

Another particularly advantageous means for reducing the anode to the cathode potential consists of a capacitor connected in parallel to the discharge space through a switch which is to be closed at the instant the discharge space is to be ignited. The working potential impressed across the discharge space is then short-circuited through the capacitor and by the charging current of the capacitor, the anode potential is for a short interval of time reduced to a potential which is approximately equal to the cathode potential. As the charge on the capacitor increases the anode potential rises immediately to its normal operating value. Preferably, means are provided in addition to again discharge the capacitor after the discharge space is ignited thus to prepare it for the next ignition, for example, in cases where the discharge space of a rectifier is to be periodically ignited. For this purpose, a resistor is connected in parallel with the capacitor. The magnitude of the resistor is such that it does not disturb the decrease of the anode potential at the instant that the capacitor circuit is connected in. The time constant of the capacitor circuit determined by the capacitor and the resistor, however, must be so gauged that the discharge period of the capacitor is small compared to the period of ignition of the discharge space. In place of a capacitor with a parallel connected resistor, a resistor having characteristic capacity (distributed capacity) of such magnitude that the parallel capacitor may be dispensed with, may be utilized.

The invention may be utilized for the most diverse purposes. For example, a direct current network may be connected by the operation of the control method according to the invention. The switch lying in the capacitor network is then preferably provided with two contacts which are operated in succession. By the operation of the first contact the capacitor is connected in parallel to the discharge space, while by the second contact the capacitor is short circuited for dis-

charge purposes, preferably through a properly dimensioned resistor. Particularly important is the new control method for conversion arrangements which operate with controlled rectifiers, accordingly, for controllable rectifiers, inverters and converters. In these conversion arrangements, the time point of the ignition of the discharge space is determined by the switching arrangement in the capacitor circuit. For this purpose rotating switch apparatus, for example, of the machine commutator type, are utilized as they have been utilized heretofore with the usual grid controlled discharge paths. Mechanical contacts may be entirely avoided if auxiliary discharge spaces, particularly gas or vapor discharge spaces which are ignited by the customary and well known means, are utilized in the capacitor circuit for switching purposes. Gas or vapor discharge spaces are preferable for the present use, to high vacuum electron tubes because the switching load is practically unlimited, and because the capacitor circuit must be switched in, above all else, without delay.

Fig. 1 is a diagrammatic view of an embodiment of my invention,

Fig. 2 is a diagrammatic view of a modification of my invention,

Fig. 3 is a diagrammatic view showing another modification of my invention,

Fig. 4 is a diagrammatic view showing a further modification of my invention,

Fig. 5 is a diagrammatic view showing a still further modification of my invention,

Fig. 6 is a diagrammatic view of a circuit which is electrically equivalent to the Fig. 1 circuit and which is used in explaining the operation of my invention, and

Fig. 7 is a graph illustrating the operation of the circuit shown in Fig. 6.

In Fig. 1, the connection for a controllable rectifier is illustrated as an embodiment of the invention. A mercury vapor discharge vessel **1** is in the known manner provided with an anode **2**, a control grid **3** and a mercury cathode **4**, and by the operation of an auxiliary electrode **5**, a permanently-burning excitation arc is maintained. The control grid **3** is connected to the cathode through a battery **6** and a resistor **7**. The battery **6** may be dispensed with, as has been mentioned before, if the discharge vessel is of such character that the connection between the control grid and the cathode suffices to block the discharge. This arrangement has the advantage that the connection conductors **16** (Fig. 5) between the control grid and the cathode may be disposed within the discharge vessel so that the separate bushings for the grids such as are necessary in the known grid controlled discharge devices may be eliminated.

A capacitor **8** is according to the invention connected in parallel with the discharge space of the discharge vessel. The capacitor may be connected and disconnected by a switching device **9** which is to be periodically actuated. The capacitor **8** is shunted by a discharge resistor **10**.

The alternating current source **11** is connected to the discharge vessel **1** through the current consumption load **12**. The discharge vessel operates as a rectifier, the current transmission of which or the mean potential delivered by which may be regulated with the aid of the switching apparatus **9**. In place of the switch **9**, an auxiliary discharge device **18** (Fig. 2) which is periodically ignited may be utilized as has been explained before.

The arrangement may, moreover, be improved by connecting an inductor **19** in the anode circuit as viewed from the load side before the connection of the capacitor parallel circuit. The inductor prevents the potential of the anode from being raised sooner than is desired by the current flowing out of the load circuit or out of the feeding source when the capacitor is connected in.

In Fig. 3 a transformer **20** in the secondary **22** of which a short current impulse is produced is shown as connected in the anode circuit. The transformer is so connected that the potential peak introduced thereby in the anode circuit is opposite to the anode potential.

In the Fig. 4 modification a switch **24** with two contacts **26** and **28** is shown in the capacitor circuit. The contacts **26** and **28** are operated in succession. By the operation of the first contact **26**, the capacitor is connected in parallel to the discharge space **1**, while by the second contact **28** the capacitor is short circuited, preferably through a properly dimensioned resistor **30**.

The theory of operation of the apparatus is illustrated in Figs. 6 and 7. A thyratron S may be regarded as connected through an ohmic resistor R and an inductor L (leakage inductance, inductance of the conductors, etc.), to a direct current source with the potential U_0. The grid potential may be assumed to be so low that the tube does not, itself, become ignited. According to the invention applied for, an ignition is to be effected by the actuation of a suitable switch mechanism by the operation of which the anode is connected to the capacitor C which is normally maintained without a difference of potential by a parallel connected resistor. The above method is based on the following theory:

By closing the above-mentioned switch, the anode potential is suddenly reduced to zero. However, this does not correspond to the equilibrium condition and furthermore in the final condition, the anode must again take on the potential U_0 of the potential source. This takes place in general, however, in the form of oscillations which, disregarding damping, increase the anode potential to twice its normal value, i. e., to $2U_0$ after the first half wave of the anode potential. By this means, an ignition may now be effected at least in the case in which the static grid potential no longer suffices to prevent the ignition for a substantial over-potential.

In addition to this possible explanation, there is another point which must be brought in particularly when, as may be realized experimentally, the method operates in the case in which the grid potential is low enough to block for double the anode potential. This point relates to the variation of the grid potential by reason of the capacitive effect of the anode potential. The measure of this is the time constant of the grid circuit given by the capacity between grid and cathode and the series resistor of the grid. If this time constant is very large, the grid potential varies in proportion with the anode potential and may, therefore, take on a value which is not sufficient for blocking the discharge when the anode potential rises. In general, however, the time constant of the grid circuit will be smaller than the oscillation period of the anode circuit. Also in such a case, the effective grid potential is greater than the static value, as simple consideration will show, during the rise of the anode potential and accordingly during the whole of the

first half wave of the circuit closing oscillation, so that in this case there is also the possibility of ignition.

The proposed explanation possibilities also naturally are applicable if the potential U_0 is an alternating current potential, as is the case for controlled discharge tubes.

The invention has a series of important advantages over the known controllable electric discharge spaces. All interlocking of the circuit by control electrodes of the discharge path disappears. The control grid may even, under certain circumstances, be connected with one of the other electrodes within the discharge container, so that no bushing leading to the outside is necessary. Compared to other control devices in which the anode potential is varied for purposes of ignition, the invention has the advantage that the potential is not increased but decreased. As the description of the invention shows, no additional auxiliary sources are necessary for operation.

I claim as my invention:

1. Method of igniting a gas or vapor discharge device connected in a circuit having distributed impedance particularly for the purpose of control of a rectifier which comprises reducing the potential of the anode of the discharge device, to the grid of which a blocking potential is connected, for a short interval of time, at least approximately to the potential of the cathode for producing an interelectrode potential impulse to ignite said device.

2. Method according to claim 1 characterized by the fact that a capacitor connected in parallel with the discharge space is connected in at the instant of ignition.

3. Apparatus according to claim 1 characterized by the fact that, by the operation of a transformer lying in the anode circuit a potential impulse opposite to the anode potential is produced at the instant of ignition.

4. Translating apparatus comprising an electric discharge device having a control electrode and a plurality of principal electrodes, said discharge device being connected in a circuit having distributed impedance, means for impressing a potential difference between said principal electrodes, means for maintaining a potential difference between said control electrode and one of said principal electrodes that is of such magnitude that said discharge device is normally deenergized and means for momentarily connecting said principal electrodes to produce an interelectrode impulse for energizing said discharge device.

5. Apparatus according to claim 4 characterized by the fact that the last means includes a capacitor, which is to be momentarily connected between the principal electrodes when the discharge device is to be energized, said capacitor being shunted by a resistor.

6. Apparatus according to claim 4, characterized by the fact that the last means includes a resistor with distributed capacity, which is to be momentarily connected between the principal electrodes when the discharge device is to be energized.

7. Apparatus according to claim 4, characterized by the fact that the last means includes a capacitor circuit, which is to be momentarily connected between the principal electrodes when the discharge device is to be energized and a rotating contact device constructed in the manner of a commutator for making the momentary connection.

8. Translating apparatus comprising an electric discharge device having a control electrode and a plurality of principal electrodes, said discharge device being connected in a circuit having distributed impedance, means for impressing a potential difference between said principal electrodes, means for maintaining a potential difference between said control electrode and one of said principal electrodes that is of such magnitude that said discharge device is normally deenergized and means including an auxiliary discharge device for momentarily connecting said principal electrodes to produce an interelectrode impulse for energizing said discharge device.

9. Apparatus according to claim 4, particularly for working circuits which are connected in for comparatively large time intervals by the discharge device which is to be ignited, characterized by the fact that the last means includes a capacitor circuit and a switch, with two contacts to be successively actuated in the capacitor circuit, the first of the switches connecting the capacitor in parallel to the discharge device while by the operation of the second of the switches the capacitor is short circuited for discharge purposes.

10. Apparatus according to claim 4, characterized by the fact that the potential difference between the control electrode and the one principal electrode is zero and the conductor connecting the control electrode to the one principal electrode is within the container of the discharge device.

11. Translating apparatus comprising an electric discharge device having a control electrode and a plurality of principal electrodes, said discharge device being connected in a circuit having distributed impedance, means for impressing a potential difference between said principal electrodes, means for maintaining a potential difference between said control electrode and one of said principal electrodes that is of such magnitude that said discharge device is normally deenergized, means including a capacitor circuit for momentarily connecting said principal electrodes to produce an interelectrode impulse for energizing said discharge device and an inductor connected in the anode circuit of said discharge device as viewed from the load circuit before the connection of the capacitor circuit.

12. Apparatus according to claim 4 characterized by that the last means includes a capacitor, which is to be momentarily connected between the principal electrodes when the discharge device is to be energized.

13. Apparatus according to claim 4 characterized by that the last means includes a capacitor, which is to be momentarily connected between the principal electrodes when the discharge device is to be energized, and a resistor shunting said capacitor, the time constant of the capacitor and resistor network being small compared to the periodicity of the difference of potential impressed between the principal electrodes.

14. Apparatus according to claim 4 characterized by that the last means includes a capacitor, and means for periodically connecting the capacitor between said principal electrodes for a short interval of time to energize the discharge device.

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