July 4, 1939. L. FILBERICH ET AL 2,165,041

CONTROL SYSTEM FOR CONVERTERS

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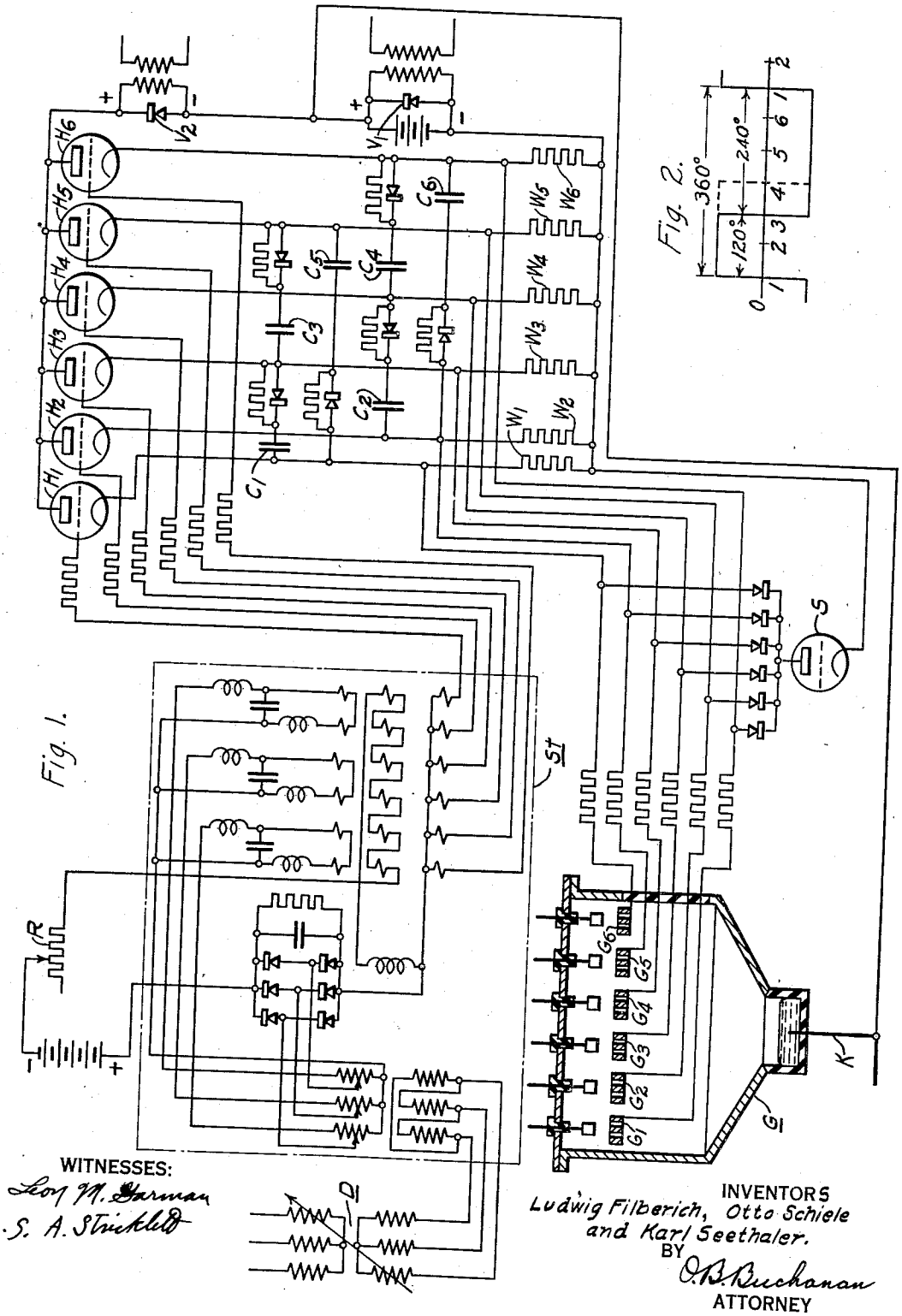


Fig. 1.

Fig. 2.

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CONTROL SYSTEM FOR CONVERTERS

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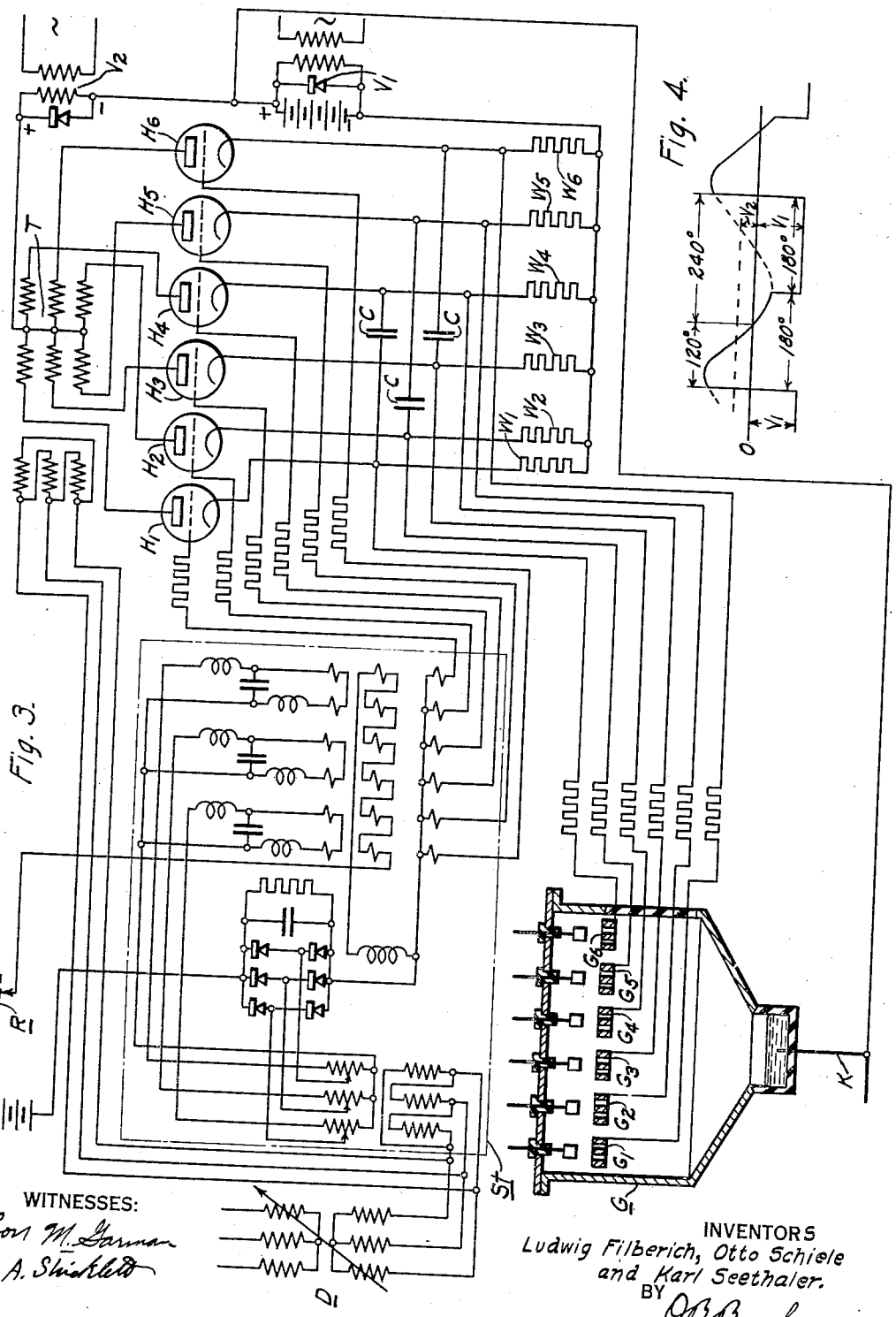


Fig. 4.

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CONTROL SYSTEM FOR CONVERTERS

Filed Oct. 27, 1937 3 Sheets-Sheet 3

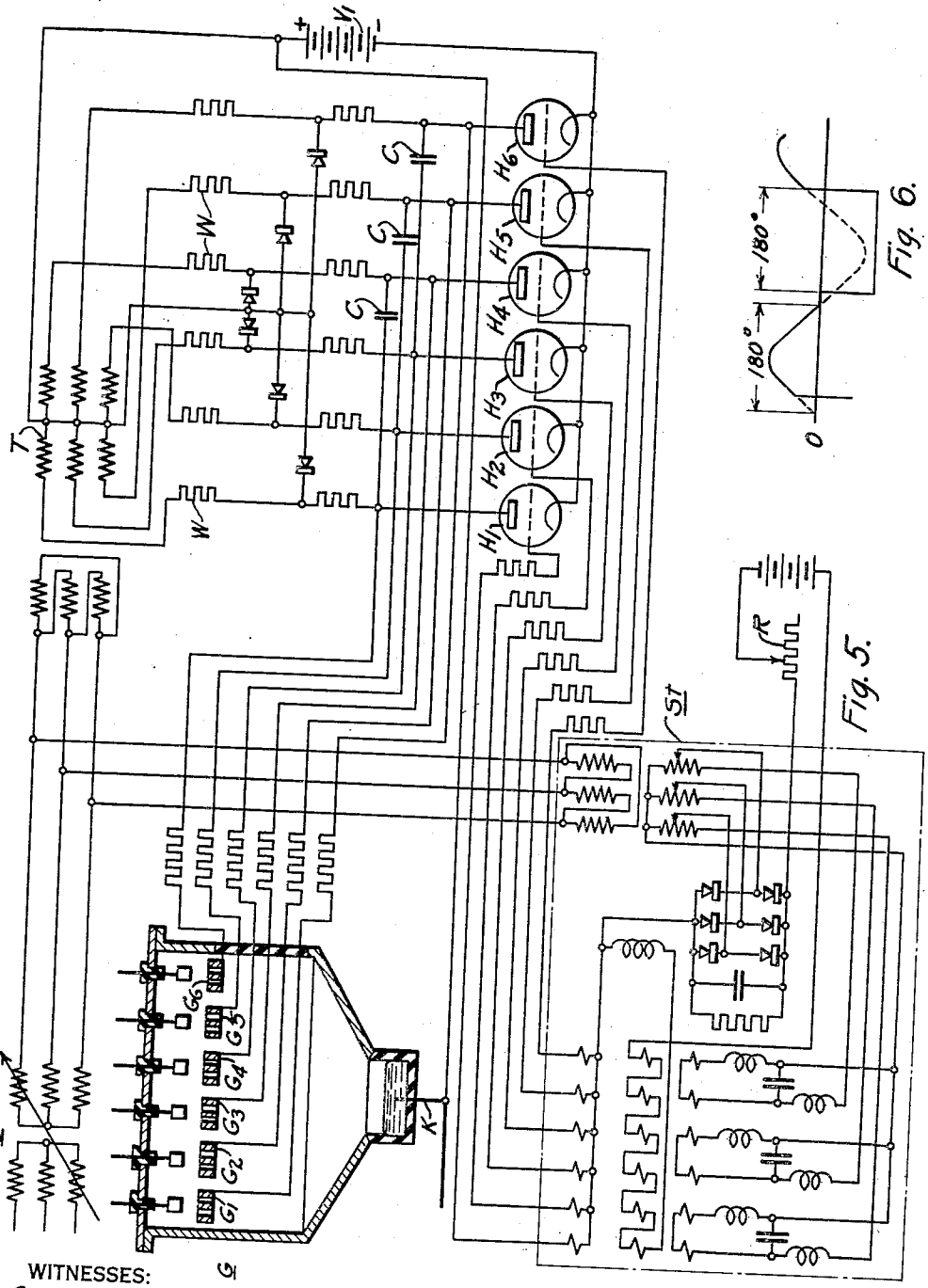


Fig. 5.

Fig. 6.

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Patented July 4, 1939 2,165,041

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2,165,041

CONTROL SYSTEM FOR CONVERTERS

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Application October 27, 1937, Serial No. 171,380
In Germany July 13, 1936

10 Claims. (Cl. 175—363)

Our invention relates to control systems for converters and particularly to an arrangement for controlling the moment of starting of gas- or vapor-filled discharge devices as are employed in converters, preferably in rectifiers, inverters and static frequency changers. The control is of particular importance for grid-controlled mercury vapor discharge devices with arc-like discharge. To this end, various control arrangements have been proposed having the common feature that auxiliary discharge devices, i. e., discharge devices which likewise operate with gas or vapor filling and an arc-like discharge are employed for interrupting control voltages. To this end, grid-controlled hot cathode mercury vapor rectifiers are, as a rule, employed. The auxiliary discharge devices operate partly as switches instead of rotary contact devices or their valve effect is also utilized, not only if direct-current voltages but also alternating voltages are effective in the control circuit.

The invention relates to a particular type of control arrangements operating with gas- or vapor-filled auxiliary discharge devices, that is control arrangements in which a discharge device is extinguished by the ignition of another discharge device which is provided in the same control arrangement. The auxiliary discharge devices thus allotted to each other are connected in the form of known inverter connections through condensers in such a manner that the charge liberated during the ignition of a device extinguishes the other device.

In the case of such grid control arrangements operating with auxiliary discharge devices it has been proposed to allot to each control grid of the main discharge device to be controlled or to each grid group to which equal control voltages are simultaneously supplied, two grid-controlled auxiliary discharge devices, one of which serves as an extinguishing device for the other. A six-anode rectifier is provided in this control arrangement at least wtih twelve auxiliary discharge devices.

According to the invention the number of the auxiliary discharge devices necessary for a multi-anode discharge device is decreased in this type of control to the half by the fact that the auxiliary discharge device of an anode is connected in such a manner to the auxiliary discharge device of a second anode in the form of an inverter connection that the ignition of one auxiliary discharge device causes the extinction of the other. Consequently, according to the invention no particular extinguishing discharge devices are employed. On the contrary by a particular mutual arrangement and connection of the discharge devices of all control grids of the main discharge device it is made possible that in the cyclic control of the auxiliary discharge devices allotted to the main discharge device the ignition of one of these auxiliary discharge devices may always be simultaneously employed for extinguishing another auxiliary discharge device likewise allotted to a control grid.

Further details and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings, in which similar characters of reference denote similar part.

Figure 1 is a schematic illustration of a control system according to our invention;

Fig. 2 is a diagrammatic representation of the control potential supplied by the system of Fig. 1;

Fig. 3 is a view similar to Fig. 1 showing a modification according to our invention;

Fig. 4 is a diagrammatic representation of the control potential according to Fig. 3;

Fig. 5 is a schematic illustration of a further modification according to our invention; and

Fig. 6 is a diagrammatic representation of the control potential according to Fig. 5.

G denotes the multi-anode mercury vapor rectifier to be controlled, K the cathode thereof and G_1 to G_6 denote the control grids or the control grid group of the anodes of the rectifier. H_1 to H_6 denote the auxiliary discharge devices allotted to the control grid and which are indicated in the connections as single-anode hot cathode mercury vapor rectifiers. It may be mentioned that also multi-anode auxiliary discharge devices may be employed, if the connection in question permits a directly conductive connection of various cathodes (cf. for instance the connection of Fig. 5). V denotes the direct-current voltage sources which partly feed the circuit of the auxiliary discharge devices and partly act only as a negative bias between cathode and circuit and partly also perform both functions. W_1 to W_6 are resistors which are provided at different points of the control circuit. Their function will be explained in detail by reference to the embodiments.

In the connection shown in Fig. 1 the auxiliary discharge devices H_1 to H_6 lie in a circuit which is closed through resistors W_1 to W_6 and two direct-current voltage sources V_1 and V_2. The control grids G_1 to G_6 are connected to the cathodes of the auxiliary discharge devices H_1 to H_6 cooperating therewith, whereas the cathode of the rectifier G to be controlled is inserted be-

tween the two direct-current voltage sources V_1 and V_2. When the auxiliary discharge device is not conducting each control grid is connected to the cathode K through one of the resistors W and the direct-current voltage source V_1. The control grid is impressed wtih a minus voltage whose magnitude is determined by the voltage of the voltage source V_1 and the magnitude of the resistor W_1. The positive voltage causing the ignition is supplied by the voltage source V_2 which is connected upon the ignition of the discharge device directly to the control grid through one of the auxiliary discharge devices. Any of the known devices for the variable determination of the moment of starting of a gas discharge device lies in the grid circuit of the auxiliary discharge device. In the embodiment shown it is assumed that an induction voltage regulator D be series-connected to the control device *St* which operates with direct-current biased transformers. The moment of starting of the auxiliary discharge devices H_1 to H_6 may be then varied both by the induction voltage regulator D and by a rheostat R which varies the direct-current magnetic bias of the transformers or reactors of the control device *St*. The control devices in the grid circuit of the auxiliary discharge devices are in themselves not essential to the invention, the main point being that they permit to determine the moment of starting at will.

The essential feature of the invention in the case of the connection according to Fig. 1 is the mutual connection of the auxiliary discharge devices H_1 to H_6. This connection depends upon the program according to which positive and negative potentials are to be supplied to the control grids G_1 to G_6 of the rectifier G. If it is assumed in the simplest case that the control grids are to be impressed during a control period of 360° 50% with positive and 50% with negative potential two auxiliary discharge devices are to be connected to each other at the cathode side thereof through a condenser and in the case of the embodiment in question these devices are the auxiliary discharge devices H_1, H_4; H_2, H_5 and H_3, H_6. In the control diagram shown in Fig. 2 the starting sequence is denoted by the numerals 1 to 6 and the dotted control curve holds good under the assumption that the positive potential of each anode be maintained during 180°.

The conditions are different, if the duration of the positive control voltage is differently chosen than the duration of the negative voltage. For reasons of reliability of service it is desirable particularly in the case of converters of great output to maintain the positive control voltage of the grid as long as the corresponding anode carries curent. In the case of a six-phase rectifier with simple current division this implies that the positive control voltage must be maintained during 120°. The inverter-like connection of the discharge devices is shown in Fig. 1 for this case. The cathodes of the auxiliary discharge devices H_1, H_3 and H_5 are connected to one another by condensers C_1, C_3 and C_5 so that a sort of a three-phase inverter connection results. In Fig. 2 is shown the corresponding control diagram in full lines. It shows that the ignition of the auxiliary discharge device H_3 must effect the extinction of the auxiliary discharge device H_1, since both corresponding moments of starting are shifted with respect to time 120°. The same applies also to the auxiliary discharge devices H_3 and H_5 or H_5 and H_1. Besides the condensers C, dry rectifiers with parallel resistors lie between the cathodes of the auxiliary discharge devices which operate alternately according to the contral cycle. This auxiliary connection is necessary, since otherwise one or more grids not concerned would be impressed with a positive voltage surge. By the rectifiers and the parallel resistances the charge of a condenser is on the one hand made possible within the interval between the ignition of both auxiliary discharge devices connected thereto, whereas on the other hand the sudden discharge towards an auxiliary discharge device not concerned is prevented. The connection shows that the dry rectifiers are series-connected according to their rectifying effect between the condensers C_1, C_3 and C_5.

The other three auxiliary discharge devices H_2, H_4 and H_6 are connected to one another in the same manner through condensers C_2, C_4 and C_6 to form an inverter connection or a three-phase inverter connection. The number of such inverter circuits in the circuit of the auxiliary discharge devices depends upon the number of the anodes of the main discharge devices to be controlled and upon the control cycle of the control grid as well as upon the ratio between the duration of the positive and negative voltage. At all events the invention has the advantage that each auxiliary discharge device may be employed at the same time as an ignition device and as an extinction device, that is to say that the smallest possible number of auxiliary discharge devices is required for the control of a large converter.

The circuit of the auxiliary discharge devices which consists of the three elements: Auxiliary discharge device, resistance and direct-current voltage source may also be connected in a different manner from that shown in Fig. 1 to the control grids on the one hand and to the cathode of the main discharge device on the other hand. For instance, in the connection shown in Fig. 1 the auxiliary discharge devices and the resistances may be exchanged. The control grids are then connected during the non-conductive period of the auxiliary discharge devices to the cathode through the resistances and the direct-current voltage V_2.

In the case of ignited discharge devices the control grids are directly connected to the negative voltage V_1. In this connection, the auxiliary discharge devices control therefore the minus potential, whereas in the connection shown in Fig. 1 they control the plus potential. The connection with controlled minus pole makes it possible that the auxiliary discharge devices may be combined to a multiple anode discharge device, since the cathodes may be connected to each other. To control the magnitude of the minus potential a particular resistance may be inserted in this connection between the auxiliary discharge device and the grid in order to attain a so-called soft minus.

It may be pointed out that the control must be further equipped with devices for protecting the rectifier against back-fires. To this end, in Fig. 1 an auxiliary discharge device S is employed whose cathode is connected to the minus pole of the direct-current voltage source V_1, whereas the anode is connected to the grid leads through dry rectifiers. As soon as a disturbance occurs the discharge vessel S is ignited and causes a negative inverse voltage to be applied at the same time to all control grids.

The further embodiments of the invention shown in Figs. 3 and 5 differ from the connection

shown in Fig. 1 insofar as an alternating voltage source is provided in the circuit of the auxiliary discharge device besides the direct-current voltage sources. The inventive idea consisting in a cyclically alternative ignition and extinction of the individual discharge devices is also applied in this case.

In Fig. 3 the resistors W_1—W_6 and both direct-current voltage sources V_1 and V_2 lie in the circuit of the auxiliary discharge devices H_1 to H_6 in the manner as shown in the connection of Fig. 1. The control grids G_1 to G_6 are likewise connected to the cathodes of the auxiliary discharge devices cooperating therewith and the cathode K of the rectifier G is connected to the point of connection of both direct-current voltage sources V_1 and V_2. The difference with respect to the connection shown in Fig. 1 lies in the transformer T whose phase windings are inserted in the anode circuit of the auxiliary discharge devices. The primary winding of this transformer is fed by an induction voltage regulator D to which is also connected the control circuit of the auxiliary discharge devices H_1 to H_6. The induction voltage regulator D therefore shifts at the same time the anode alternating voltage of the auxiliary discharge devices and the grid voltage of these discharge devices. A further possibility of control consists in varying the direct-current magnetic bias of saturated transformers or reactors of a control device *St* by the rheostat R as this is effected in the connection shown in Fig. 1.

The control diagram of the connection of Fig. 3 is shown in Fig. 4. In the case of non-ignited auxiliary discharge devices the negative voltage V_1 is applied to the control grids, for the control grids are connected to the cathode K through the resistors W and the direct-current voltage source V_1. As soon as a discharge device is ignited the grid voltage increases suddenly to a plus voltage which corresponds to the sum of the alternating voltage of the transformer T and that of the direct-current voltage source V_2. The instantaneous value of the alternating current concerned depends upon the position of phase of the grid voltage of the auxiliary discharge devices. The control voltage follows then as is shown in the diagram of Fig. 4 the sine curve of the alternating voltage of the transformer T up to the instant where the auxiliary discharge vessel phase displaced 180° in the control cycle is ignited. Every two auxiliary discharge devices are accordingly combined with each other through condensers C to an inverter connection, that is to say, the devices H_1, H_4; H_2, H_5 and H_3, H_6. By the ignition impulse, for instance, of the discharge device H_4 the discharge device H_1 is extinguished and the control grid G_1 is then again impressed with the negative voltage of the direct-current voltage source V_1.

From the diagram of Fig. 4 it follows that the amplitude of the alternating voltage of the transformer T must be so chosen that in the negative direction, i. e., referred to the voltage of the cathode K, the portion of the alternating voltage is always smaller than the portion of the negative bias V_1. Further, the diagram shows that the positive control voltage is maintained constant approximately over a range of 120° and that further at the moment of ignition a very steep increase of the plus voltage is attained and that finally the plus voltage changes gradually to the minus voltage. This latter property is as tests have shown advantageous, particularly to the operation of converters of large output. It is essential to the control according to Fig. 3 that a positive control voltage of 120° be attained, although the alternately operating auxiliary discharge devices lie at a distance of 180°. By a suitable selection of the amplitude of the alternating voltage of the transformer T and the direct-current voltage V_2 the duration of the positive potential may be increased or decreased in the case of an equal control distance of the auxiliary discharge devices. A limit case consists, for instance, in completely omitting the direct-current voltage V_2 so that the neutral point of the transformer T is directly connected to the cathode K of the converter.

It may be further pointed out that the control arrangement shown in Fig. 3 has the advantage that the voltage at which an auxiliary discharge device is ignited is considerably greater than the voltage applied to the auxiliary discharge device if it is to be extinguished by the ignition impulse of another device.

The form of the invention shown in Fig. 5 coincides with the connection of Fig. 3 to the effect that direct-current voltages and alternating voltages are effective in the circuit of the auxiliary discharge devices. The difference between both connections consists in the fact that in the case of Fig. 5 the negative inverse voltage is applied to the control grids through the auxiliary discharge devices. The auxiliary discharge devices are, consequently, ignited at the point of the control voltage curve (Fig. 6) where the grid voltage changes to the negative inverse voltage. The control distance of the auxiliary discharge devices amounts also in this case 180° so that only two discharge devices need be connected to each other through condensers C. Auxiliary rectifiers are furthermore parallel-connected to the phase windings of the transformer T in order to completely suppress the negative half wave of the alternating voltage. In this manner a horizontal portion of the curve indicating the cathode voltage results instantaneously in the control diagram of the Fig. 6. The advantage thereby obtained consists in that the voltage is increased at which the auxiliary discharge devices are ignited.

The means for varying the moment of starting of the main discharge device are similar to those employed in the other two connections. Controls within greater ranges are effected by the induction voltage regulator D, whereas by the control device *St* the moment of starting may be additionally shifted by varying the ignition of the auxiliary discharge devices with respect to the voltage of the transformer T.

As to the connections shown in Figs. 3 and 5 it may be further pointed out that direct-current voltages may also be inserted in the connecting wire between the cathode K and the circuit of the auxiliary discharge device in order to shift the curve diagram in the one or the other direction.

We claim as our invention:

1. An arrangement for controlling multi-anode converters in which controllable auxiliary discharge devices are employed for interrupting the control voltages, comprising control electrodes in said multi-anode converter, a source of control potential, connections including a controllable auxiliary discharge device for supplying control voltage from said source to each of said control electrodes, characterized in that the auxiliary discharge device of one anode is connected to the auxiliary discharge device of a second

anode in the form of an inverter connection in such a manner that the ignition of one auxiliary discharge device causes the extinction of the other.

2. An arrangement as set forth in claim 1, characterized in that more than two, preferably three, auxiliary discharge devices are combined to an inverter connection with corresponding cyclic sequence of the ignition impulses and extinction impulses.

3. An arrangement for controlling multi-anode converters in which controllable auxiliary discharge devices are employed for applying and interrupting the control voltages comprising control grids associated with the anodes of the multi-anode converter, a source of control potential, means including controllable auxiliary discharge devices corresponding in number to the anodes of the multi-anode device for supplying control impulses in cyclic sequence to said control grids, condensers connected between said auxiliary discharge devices to provide an inverter connection with corresponding cyclic sequence of the ignition and extinguishing impulses, characterized in that the condensers serving to extinguish the impulses are connected to parallel resistances through valves in such a manner that the sudden discharge of a condenser is only possible in one direction, but that the charge of the condensers is nevertheless attained with certainty.

4. An arrangement as set forth in claim 1, characterized in that only direct-current voltages are effective in the circuit of the auxiliary discharge devices.

5. An arrangement as set forth in claim 1, characterized in that direct-current voltages and alternating voltages are effective in the circuit of the auxiliary discharge devices.

6. An arrangement for controlling multi-anode converters in which controllable auxiliary discharge devices are employed for applying and interrupting the control voltages comprising control grids associated with the anodes of the multi-anode converter, a source of direct-current control potential, means including controllable auxiliary discharge devices corresponding in number to the anodes of the multi-anode device for supplying control impulses in cyclic sequence to said control grids, condensers connected between said auxiliary discharge devices to provide an inverter connection with corresponding cyclic sequence of the ignition and extinguishing impulses, characterized in that the circuit formed of the auxiliary discharge device, the resistor and the direct-current voltage source is connected to the control grids at the cathode of the auxiliary discharge devices, whereas the cathode of the main discharge devices is connected to the resistor by the insertion of a portion of the direct-current voltage.

7. An arrangement for controlling multi-anode converters in which controllable auxiliary discharge devices are employed for applying and interrupting the control voltages comprising control grids associated with the anodes of the multi-anode converter, a source of direct-current control potential, means including controllable auxiliary discharge devices corresponding in number to the anodes of the multi-anode device for supplying control impulses in cyclic sequence to said control grids, condensers connected between said auxiliary discharge devices to provide an inverter connection with corresponding cyclic sequence of the ignition and extinguishing impulses, characterized in that the circuit formed of the auxiliary discharge device, the resistor and the direct-current voltage source is connected to the control grid at the anode of the auxiliary discharge device and that the cathode of the main discharge devices is connected to the cathode of the auxiliary discharge devices by the insertion of a portion of the direct-current voltage.

8. An arrangement as set forth in claim 7, characterized in that series-resistances are inserted between the control grid and the anode of the auxiliary discharge devices for weakening the minus potential.

9. An arrangement for controlling multi-anode converters in which controllable auxiliary discharge devices are employed for applying and interrupting the control voltages comprising control grids associated with the anodes of the multi-anode converter, a source of control potential including a source of direct current connected in series with a source of alternating current, means including controllable auxiliary discharge devices corresponding in number to the anodes of the multi-anode device for supplying control impulses in cyclic sequence to said control grids, condensers connected between said auxiliary discharge devices to provide an inverter connection with corresponding cyclic sequence of the ignition and extinguishing impulses, characterized in that the circuit of the auxiliary discharge devices formed of the resistance, the auxiliary discharge device, the alternating voltage and the direct-current voltage is connected with the cathode of the auxiliary discharge device to the control grid, whereas the cathode of the main discharge devices is connected to the resistance through at least a portion of the direct-current voltage.

10. An arrangement for controlling multi-anode converters in which controllable auxiliary discharge devices are employed for applying and interrupting the control voltages comprising control grids associated with the anodes of the multi-anode converter, a source of control potential including a source of direct current connected in series with a source of alternating current, means including controllable auxiliary discharge devices corresponding in number to the anodes of the multi-anode device for supplying control impulses in cyclic sequence to said control grids, condensers connected between said auxiliary discharge devices to provide an inverter connection with corresponding cyclic sequence of the ignition and extinguishing impulses, characterized in that the circuit formed of the resistance, the auxiliary discharge device, the alternating voltage and the direct-current voltage is connected to the control grid at the anode of the auxiliary discharge device, whereas the cathode of the main discharge device is connected to the cathode of the auxiliary discharge device through at least a portion of the direct-current voltage.

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