

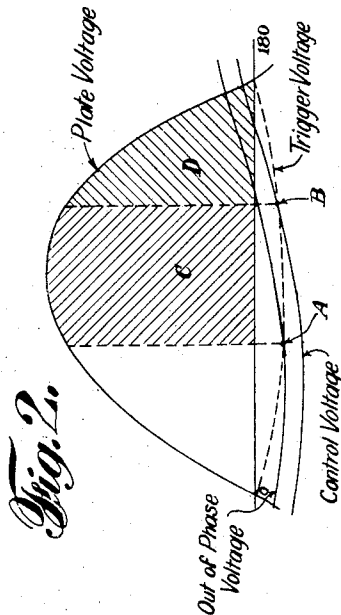
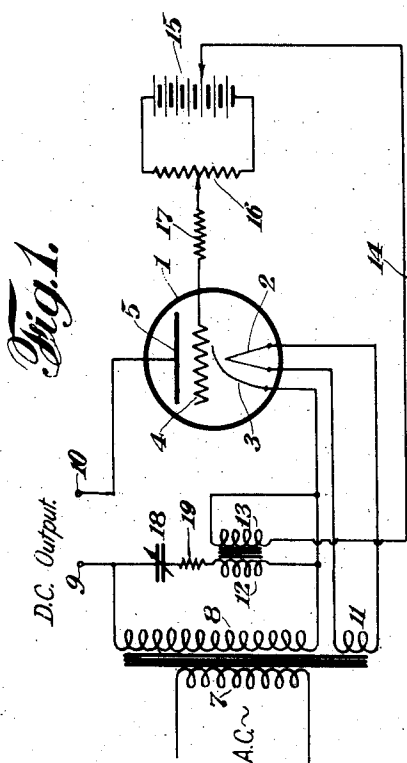
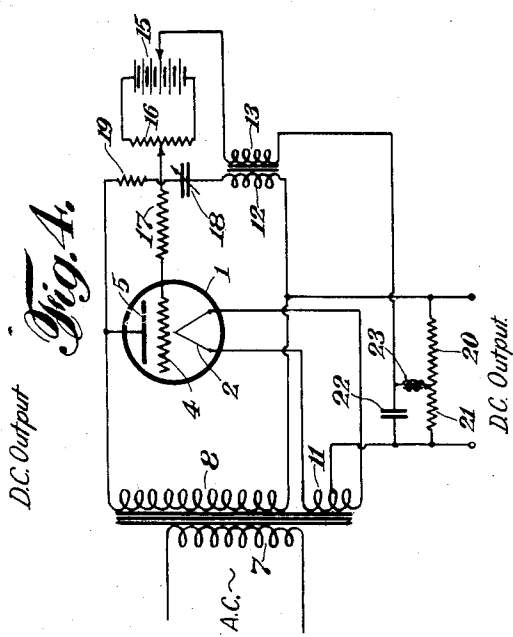
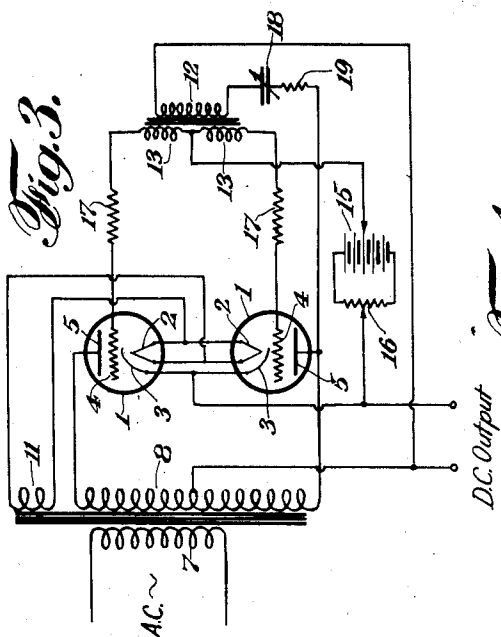
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CONTROL MEANS FOR GAS FILLED RECTIFIERS

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CONTROL MEANS FOR GAS FILLED
RECTIFIERS

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The invention relates to control means for gas filled rectifiers.

The object of the invention is to provide a method and means for controlling the starting of such a tube at any time during its entire active period, or at any point on the positive half cycle of the current to be rectified.

The principle and mode of operation of the invention will be apparent from the following description and the accompanying drawing, in which the invention is applied to an alternating current rectifier. In the drawing,

Fig. 1 shows a half wave rectifier embodying the invention,

Fig. 2 illustrates graphically the characteristics of various control voltages employed in the arrangement of Fig. 1,

Fig. 3 shows the invention applied to a full wave rectifier, and

Fig. 4 is a modification of the invention.

Referring to Fig. 1, there is shown a half wave rectifier 1 preferably of the indirect heated type having a heating filament 2, an electron emitting cathode 3, a control grid 4 and plate 5. The plate supply current for the rectifier is obtained from a source of alternating current connected to the primary winding 7 of a supply transformer, the secondary winding 8 of which is connected at one end to a plate output terminal 9 and the other end to the cathode 3 to impress the supply current upon the plate circuit. The other side of the plate circuit is completed by a connection between plate 5 and the remaining plate output terminal 10. The filament is heated by alternating current from a winding 11 of the supply transformer, and heats the cathode 3 to cause the latter to become electronically emissive.

Tube 1 is preferably filled with argon or other inert gas, although mercury or other metallic vapor may also be used. If a sufficient stream of electrons is emitted by the cathode the gas will become ionized thereby and will become conductive, and a main discharge between the plate and cathode will take place during the active periods of the tube, that is, during each half cycle of the supply current when the plate is positive with respect to the cathode. During the blocking periods of the tube when the plate is negative with respect to the cathode no plate current will flow, and therefore a unidirectional current only will be impressed upon the output terminals 9 and 10.

The grid 4 is used to control the starting point of the tube during its active periods by impress-

ing a proper potential upon the grid, thereby controlling the electron flow from the cathode, and thus control the ionization of the gas necessary to induce the main discharge between plate and cathode. The means for impressing the proper potential upon the grid at the desired time are as follows. A sinusoidal control voltage is applied to the grid circuit by a transformer whose primary winding 12 is connected across the winding 8 of the current supply transformer, and whose secondary winding 13 is connected at one end to the cathode 3 and at the other end through conductor 14, battery 15, potentiometer 16 and current limiting resistance 17 to the grid 4. The phase of the potential thus applied to the grid is shifted with respect to that of the plate supply current by a phase shifting condenser 18 and preferably a resistance 19 inserted in series with the transformer winding 12, a reverse potential being obtained from winding 13, and in this manner the potential on the grid will rise and fall in a predetermined relation with respect to the supply current to control the starting of the tube. As the grid potential rises and the grid becomes relatively more positive, the electrons emitted increase until they cause ionization of a sufficient number of gas molecules to render the tube conducting, at which time the main discharge will start. This discharge will continue during the remainder of the positive half cycle, or until the plate supply current again passes through zero, when the discharge will cease, and the tube will remain inactive during the negative half cycle. Once the discharge occurs the grid is no longer effective to control the same for the remainder of that period, but on the next positive half cycle the grid will again function in the same manner to determine the time of starting.

A source of auxiliary control potential is connected to the grid circuit so that such potential is impressed thereon in addition to the out of phase potential as to give a different resultant potential, and in this manner the time of starting of the tube may be adjusted or may be varied at will, and it is possible to start the tube at any point between zero and 180° on the positive half cycle of the supply current, without shifting the phase of the out of phase potential. In the arrangement shown a direct current potential is obtained from battery 15 inserted in the grid circuit, and a potentiometer 16 is used to impress either positive or negative potential to the grid circuit. Thus, by moving the potentiometer arm so that the battery will impress a

negative potential upon the grid circuit, the potential on the grid due to the out of phase voltage will be made more negative and the resultant potential will cause the tube to start later. If the potentiometer arm is moved in the opposite direction so that a positive potential will be impressed upon the grid circuit, this will make the out of phase potential less negative and the resultant potential will cause the tube to start earlier.

The characteristics of the various control potentials are shown graphically by Fig. 2. During the active periods of the tube the plate supply voltage is shown by the sinusoidal curve in which the plate voltage is represented by values along the ordinate, and the time during the cycle is represented by the abscissa. The dotted line represents the "trigger voltage" of the tube, that is, it represents the most positive value which the grid can have at any instant without allowing the tube to start. The voltage induced in the phase shifting circuit is designated as the "out of phase" voltage, and the auxiliary voltage impressed upon the grid circuit by the battery and potentiometer is referred to as the "control voltage."

Assuming that the arm of potentiometer 16 is adjusted so that battery 15 impresses no voltage upon the grid circuit, then the grid voltage will be that of the out of phase voltage. Under this condition the tube will start at the point where the out of phase voltage when rising crosses the line representing the trigger voltage, as for example at point A, because at that point the out of phase voltage has a value which will govern the electronic emission so as to cause ionization to occur to induce the main discharge through the tube. The plate current will then pass for the remainder of the half cycle or active period of the tube, the average value of direct current potential across terminals 9, 10 for this plate current being determined by the area to the right of the vertical line at A, that is, the sum of areas C and D.

When the auxiliary control potential is impressed upon the grid circuit, however, the starting point of the tube is changed. If this potential is negative, it will make the out of phase potential on the grid more negative, and the tube will start later as, for example, at point B. The average value of the direct current potential would then be determined by the area to the right of the vertical line at B, or that determined by the area of D only.

Fig. 3 shows the invention applied to a full wave rectifier employing two tubes 1, on the grid circuits of each of which is impressed the proper potential during the active period of the tube to control the time of starting. The out of phase voltage is obtained by shifting the phase of the supply voltage in the primary circuit of transformer 12, and providing two secondaries 13 to impress the out of phase voltage upon the respective grids. The auxiliary control voltage from battery 15 and the potentiometer 16 are common to both grids. The circuit operates upon the same principle as that of Fig. 1.

Fig. 4 shows a circuit according to the invention and also having compensating means to maintain the output or direct current voltage constant irrespective of fluctuations in either the work circuit or the alternating current supply source. This is accomplished by inserting a resistance 20 across the output circuit and connecting the grid control circuit at a point

along the resistance so that the IR drop across that portion 21 connected to the grid circuit gives a desired potential difference. If for any reason the output current should rise, the IR drop across the resistance will increase, and this will impress a negative voltage upon the grid control circuit. Under this condition it will cause the grid to be more negative and will cause the tube to start later on the next cycle, thereby bringing the output voltage back to its original value. A storage circuit, represented by condenser 22, and choke coil 23, is preferably provided to retain the negative voltage during the blocking period of the tube and to improve the stability.

The necessary degree of phase shift or displacement of the out of phase potential will depend upon the characteristics of the tube, and may be either leading or lagging, and may vary or be varied within relatively wide limits since the tube may be caused to start at any desired time by the application of the proper auxiliary control potential.

Various other phase shifting means, either fixed or variable, may be used instead of the means shown. Thus, it has been found that an inductance which gives a lagging potential may be used instead of the condenser 18 which gives a leading potential, and such inductance may be connected in series with a resistance having a variable potential tap connected to the grid circuit without the necessity of providing a transformer to give a reverse potential. Also, the condenser or other phase shifting means may be located in the circuit of the secondary winding 13 of the transformer, if desired. In practice, it has been found that the potentials of the out of phase voltage and the control voltage may be relatively small with respect to the plate supply voltage.

The control potential may be obtained from any suitable source other than that of the battery shown, and it may comprise the algebraic sum of several sources. The control potential may also be discontinuous or alternating in character, and in practice an alternating current voltage of the same frequency as the plate supply voltage has been employed. Also, a high frequency control potential may be used, or its frequency may be such as to cause the control potential to operate on certain cycles of the plate supply current and not on others. It is only necessary that the control potential be impressed upon the out of phase potential to give a resultant potential on the grid at the desired point to induce the main discharge.

We claim:—

1. A rectifier system comprising a gas filled discharge tube having main discharge and control electrodes including an electron emissive cathode, a source of alternating current supply connected to the main electrodes, means for impressing upon the control electrode an alternating potential of the same frequency but out of phase with the potential of said supply current, means for impressing an auxiliary control current upon said control electrode to give a resultant potential for determining the time of starting during the discharge periods, means for changing the potential of said control current to shift the time of starting at will, impedance means connected in the output circuit of the rectifier to provide an additional potential which varies with the potential of the output current, and means for impressing said ad-

ditional potential directly upon the control electrode circuit to automatically compensate for fluctuations and to maintain the average output voltage constant.

2. The method of controlling the operation of a gas filled discharge valve having an electron emitting cathode and a control electrode, which consists in impressing upon the control electrode a varying potential having a constant phase displacement with respect to the potential of the plate supply current, impressing an auxiliary potential upon the control electrode, varying the said auxiliary potential through a continuous range to obtain any desired portion, between zero and maximum, of the possible output of said rectifier, and directly impressing upon the control electrode an additional potential obtained from the output current to compensate for fluctuations and to maintain the average output voltage substantially constant.

3. Means for controlling the output of a gas filled alternating current rectifier having an electron emitting cathode and a control electrode, comprising means for impressing upon the control electrode an alternating potential having a constant degree of phase displacement with respect to the potential of the supply current, means for impressing a direct current potential upon said control electrode to give a resultant potential which will determine the time of starting of the rectifier during the discharge periods, means for changing the direct current potential from positive to negative relative to the alternating potential to determine the time of starting at any desired point in a positive half cycle of the supply potential and means for simultaneously and directly impressing upon the control electrode a potential obtained from said output current which varies directly with the output current, to automatically shift the time of starting and thereby maintain the average output voltage substantially constant.

4. The method of controlling the operation of a gaseous discharge tube having an electron emissive cathode and a starting-control electrode, which consists in impressing upon the control electrode a varying potential having a constant phase displacement with respect to the potential of the supply current and adapted to start the discharge at an intermediate point in the active period of said tube, impressing an auxiliary potential upon the control electrode, and making the auxiliary potential variable through a continuous range to give resultant control potentials for starting earlier or later in the cycle than the said intermediate point and throughout the entire active period.

5. The method of controlling the output of a gas filled alternating current rectifier having an electron emitting cathode and a control electrode, which consists in impressing upon the control electrode an alternating potential having a constant out of phase relation with respect to the potential of the supply current and adapted to start the gaseous discharge at an intermediate point in the active period of said rectifier, impressing a direct current potential upon said control electrode and making the latter potential variable through a continuous range from negative to positive to give resultant control potentials for starting earlier or later in the cycle than the said intermediate point and throughout the entire active period.

6. A rectifier system comprising a gaseous discharge tube having main discharge electrodes and a starting-control electrode, a source of alternating current supply connected to the main electrodes, means for impressing upon the control electrode an alternating potential of the same frequency but out of phase with the potential of said supply current, means for impressing the algebraic sum of two independent direct current potentials upon said control electrode, and means for varying at least one of said direct current potentials through a continuous range from positive to negative relative to said alternating potential to control the starting of said tube over its entire active period.

7. In combination with a grid-controlled gaseous discharge tube, connections for energizing the main electrodes of said tube from a single-phase source, a grid circuit for said tube also energized from said source and including a fixed single-phase impedance having reactance to shift the phase of grid potential a fixed amount relative to the anode potential of said tube and thereby start the discharge at an intermediate point in the active period of said tube, a source of auxiliary potential in said grid circuit, and means for varying the auxiliary potential to make the resultant grid potential more positive than the out-of-phase grid potential for that portion of the active period prior to said intermediate point, and more negative than said out-of-phase potential for that portion of the active period subsequent to said intermediate point, and thereby give resultant control potentials for starting the tube throughout its entire active period.

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