

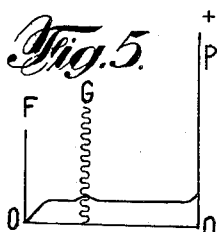
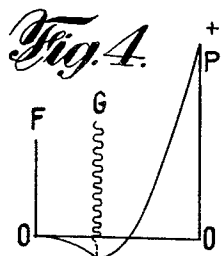
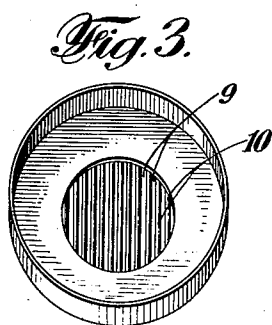
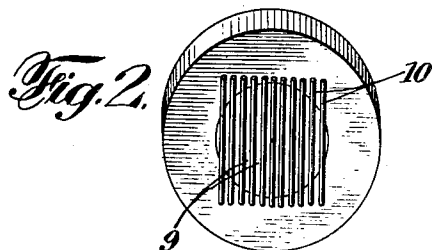
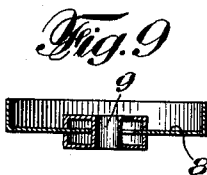
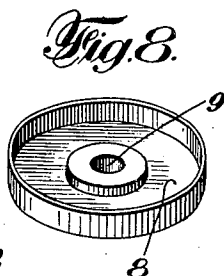
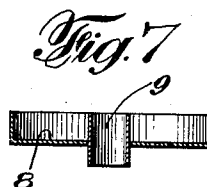
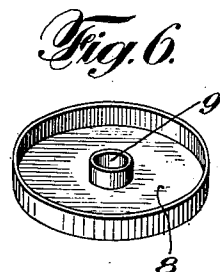
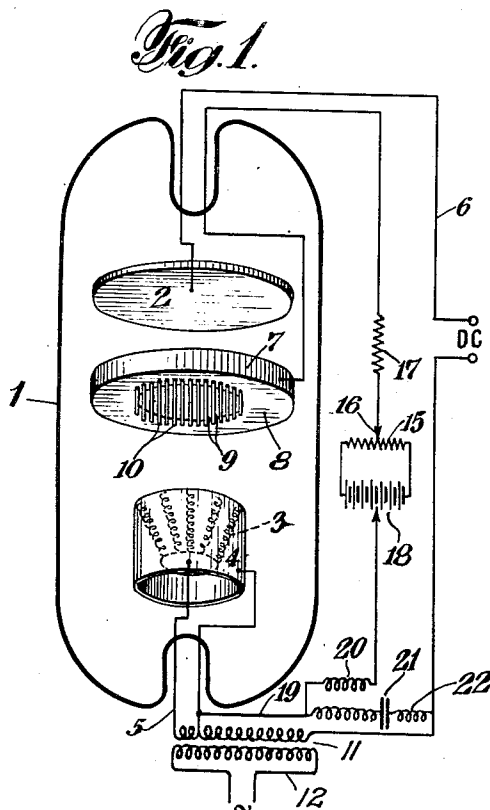
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D. V. EDWARDS ET AL

1,905,692

RECTIFIER

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RECTIFIER

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This invention relates to discharge tubes and has especial usefulness in that type of gaseous discharge tubes known as "controlled rectifiers", in which tube an alternating voltage is applied between plate and filament, and the starting point of the tube is controlled by the grid voltage.

The object of the invention is to provide means for starting the tube certainly and easily, without sacrificing control ratio or the negative bias required on the grid.

The invention will be described with respect to the form thereof shown in the accompanying drawing, in which

Fig. 1 is a view partly in perspective of a rectifier tube embodying our invention.

Fig. 2 is a detail perspective view showing the grid viewed from the bottom.

Fig. 3 is a similar view of the grid viewed from the top.

Fig. 4 is a diagram illustrating approximately the voltage distribution in the tube before the main discharge occurs.

Fig. 5 is a diagram illustrating approximately the voltage distribution in the tube after the main discharge has started.

Figs. 6, 7, 8 and 9 illustrate modified forms of grid.

Tubes of this type, when used for industrial purposes, are often subjected to long periods of lighted filament and no load, and under these circumstances the filament tends to lose its activity. Nevertheless, it is essential that when a demand for current comes the filament must be activated quickly, i. e. within a few cycles. The only practical way for this to occur is by ionic bombardment and the speed of activation will depend on the amount of ions bombarding the filament. If there is general ionization between filament and grid produced by the first few ions passing through the grid moving in the direction of plate to filament, the ions will bombard the filament and bring out a copious flow of electrons.

If there is not general ionization in this space there is a tendency for the filament to emit less electrons. We do not offer any theory in explanation of this action but merely observe that it appears to be attend-

ant upon the complex nature of oxide coated filaments. Under this condition the tube flickers a bit at the peak of one or two cycles and may go on or go off depending on which way the coating reacts, this being a complicated reaction which cannot be predicted.

Likewise on surges, a condition met with in industrial uses, but to which radio tubes are not subjected, the duration of the transient period during which the filament is being activated can be cut down if a copious supply of ions is available.

We have found that to insure a certain and easy start of the main discharge it is essential that that portion of the path between filament and grid be ionized, and to attain this result without sacrifice of control ratio, as well as to attain other advantages hereinafter referred to, the grid should be such that the opening shall be so large that the distance between adjacent walls or wires thereof shall be approximately as great or greater than the mean free path distance of the gas in the tube.

In order not to sacrifice the control ratio the screening effect of the grid must be maintained constant by increasing the surface, as by increasing the diameter of the grid wires in proportion to the increase in space between the wires. In practice there are limits to increasing both wire diameter and grid openings, since these must be proportioned for any given configuration of plate, filament, position of the grid between the two, and gas pressure, to give the shielding value of electrostatic field desired from the grid for the determined control ratio. Consequently there is a limit beyond which increase in the distance between grid wires results in rapid decrease in the control ratio.

The tube 1 is filled with gas, preferably an inert gas such as argon, although other gases may be employed, such as mercury, or a mixture of mercury and argon. In the form shown, 2 is the plate and 4 is the cathode, the latter being shown in this instance as a hollow can containing a plurality of heater filaments 3, the upper ends of which are connected to the upper end of the can and the lower ends being connected together. The can and

lower end of the filaments are connected to opposite ends of the supply circuit 5. Preferably the filament or interior of the can, or both, are coated with an emissive alkaline earth oxide coating which may be of any suitable emissive character. A good coating is the resultant compound from a mixture of an alkaline earth metal such as barium, calcium or strontium oxide and an oxide of a metal capable of forming amphoteric compounds less acid than titanous acid, such as aluminum oxide, zirconium oxide, the whole heated in vacuum. The plate 2 is connected to the usual supply circuit 6 deriving power from an alternating current source 12 through the transformer 11. The plate and cathode may be of any suitable form and arrangement, although we prefer the arrangement as shown in which the electron stream is directed from the cathode in a straight axial line through the grid opening to the plate.

The tube may be employed in any suitable circuit. As shown, the potential on the grid 7 is controlled by potentiometer 15 connected across the terminals of a battery 18 through a limiting resistance 17, and a variable pointer 16 whereby battery voltage upon the grid may be adjusted. The battery 18 is connected to the cathode through the secondary 20 of a transformer connected across the plate-cathode and thence through wire 19 to the cathode. Thereby an alternating potential, which may be made out of phase by the insertion of a condenser 21 or an inductance 22, or both, is also applied to the grid. In this manner the tube may be made to start throughout the entire alternating current cycle.

In the form shown in the drawing, the grid 7 comprises a plate 8 having an annular strengthening wall and an opening 9 the size of which may be determined by the desired cross sectional area to which the electron stream is to be confined. Across the opening 9 are the wires 10, separated from each other a distance approximately equal to or greater than the mean free path of the gas atoms in the tube. In order that the separation of the wires 10, to such a distance may not diminish the screening effect of the grid, the wires 10, are made of sufficiently large area by increasing the diameter of the wires in proportion to the increase in space between the wires. It will be understood that the size of the openings and surfaces of the grid wires will vary in different types of tubes and therefore numerical limits cannot be assigned for each. However, there are well defined functional limits from which the dimensions may be determined readily in each type. Having once determined the value of the electrostatic field necessary to give the desired control ratio, the diameter of the wires and the distance between wires

will be calculated to give the desired surface for electrostatic effect with distances between wires greater than the mean free path. We have obtained satisfactory results with about ten times the mean free path distance between wires and wire diameter calculated accordingly to give the proper electrostatic control. The practical limit appears to be about fifty times the mean free path distance. Above this distance the grid wires become unnecessarily thick and clumsy to maintain the control ratio and there are no compensating improvements in starting characteristics.

The grid may be controlled in any suitable manner, although I prefer the control illustrated in which a voltage out of phase with the main voltage is derived from a transformer 11 and a direct current voltage is also impressed upon the grid, whereby the control is retained over the entire a. c. cycle.

In a tube of this type the grid is normally of negative potential in order to prevent flow of current, and under this condition the drop in potential from filament to plate, assuming a positive voltage on the plate less than sufficient to cause a discharge may be represented by Fig. 4 in which the horizontal line represents zero voltage, the vertical lines F, G and P respectively represent filament, grid and plate and the vertical dimension as represented by full and dotted lines, represent positive and minus voltages. As shown, the grid G, being relatively negative to the filament, repels electrons from the filament, and so tends to prevent the tube from starting. When the grid is made less negative than a determined value for any plate voltage, which determined value is usually known as a trigger voltage, electron flow from the filament to the grid is permitted and the electrostatic field from the plate draws the electrons from the grid to the plate at sufficient speed to cause ionization of the gas and thereupon the main discharge starts.

In the construction above described, when the grid and plate voltages reach the proper values to start the tube, the ionization which normally occurs in the space between the grid and the plate by reason of the electrons having reached ionization speed, is not confined to the grid plate space but the ions will move freely through the grid toward the filament and thus ionize the space between grid and filament, and so provide a conductive path for the main discharge. There is no tendency for the ions around the grid wires to block the passage of electrons toward the plate and ions to the filament as is customary in tightly woven grids, such as have been commonly used heretofore. Moreover, by reason of the herein specified spacing between the wires of the grid, a larger percentage of the total electrons will pass through the grid rather than impinge upon it, and

ionization in the immediate neighborhood of the grid and consequent accumulations of ions upon the grid will be lessened. Likewise, ionic bombardment of the grid will also be lessened. We have also found that the arc drop in the tube is materially lessened.

A further advantage of the construction above referred to is that the large cross-section of the individual wires of the grid aids in carrying away the heat from the grid and thus tends to prevent the grid from becoming an emitter.

When the tube is filled with mercury, or other gas variable with temperature, the definite starting point of the tube will be reached when the temperature is increased enough to reduce the mean free path to the distance between the grid wires.

It is not necessary to use a wire grid to come within the scope of our invention; for instance, as illustrated in Figs. 6, 7, 8 and 9, for low control ratios a relatively thick plate with one or more holes in it may be used, the diameter of the hole being of greater dimensions than the mean free path. For higher control ratios a tube may be inserted in the plate, as illustrated in Figs. 7 and 8. In this case the tube diameter should be well over the mean free path.

We claim:—

1. A discharge tube enclosing a gaseous conducting medium, an anode, a cathode and a grid adapted to control the starting of said tube, said grid having open spaces therein formed by conductive elements separated a distance approximately as great as the mean free path of the gas in the tube under starting conditions.

2. A discharge tube having plate, cathode and control electrodes, the cathode having an electron emissive coating thereon, and an inert gas in said tube, said control electrode having an opening through it, the dimensions of which are greater than the mean free path of the gas in the tube under normal starting conditions.

3. A discharge tube, having a gaseous medium therein, an open ended hollow cathode, a plate opposite the open end of the cathode, and an interposed grid having an opening through which the electron stream from the cathode may pass, and having a plurality of grid wires across said opening, said wires being separated a distance and having a diameter approximately as great as the mean free path of the gas in said tube under starting conditions.

4. A discharge tube comprising a gaseous conducting medium, a cathode, anode and grid, the wires of the grid being separated from each other a distance equal to from ten to fifty times the mean free path of the gas, under starting conditions of the tube.

5. A controlled grid rectifier tube comprising an anode, a cathode, a gaseous con-

ductive filling and a grid capable of blocking the electron flow from said cathode to said anode, said grid having an opening the minimum dimension of which is greater than the mean free path in said filling, the surface surrounding said opening having a dimension in the direction of the electron path between said anode and cathode approximately equal to said minimum dimension of the opening.

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