July 4, 1939. W. L. MEIER 2,164,538

GAS DISCHARGE TUBE AND CIRCUITS

Filed Dec. 29, 1937

Fig. 1

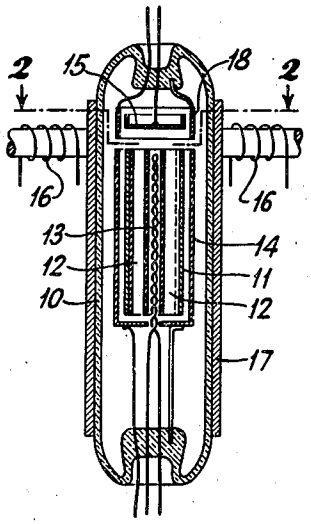


Fig. 2

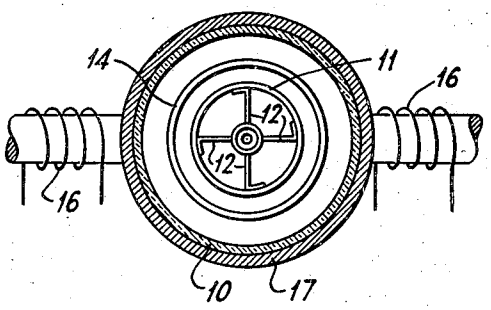


Fig. 3

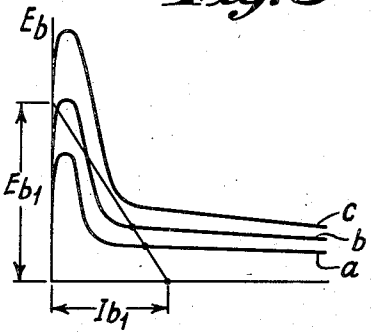
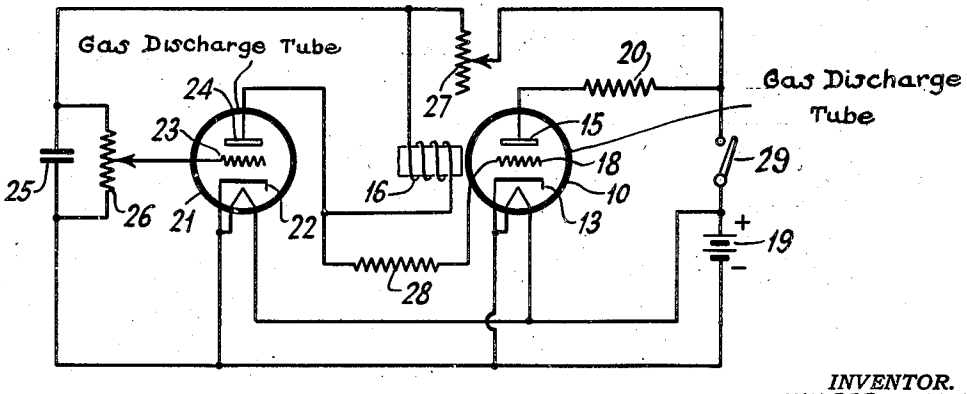


Fig. 4



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GAS DISCHARGE TUBE AND CIRCUITS

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Application December 29, 1937, Serial No. 182,188

8 Claims. (Cl. 250—27)

My invention relates to electron discharge devices, more particularly to such devices of the gaseous type and circuits therefor.

In certain conventional grid controlled gas discharge tubes, not only is a rather high voltage between plate and cathode necessary to cause the tube to break down and pass current, but also the grid though effective in controlling the initiation of the arc-like discharge, is ineffective after the discharge starts in stopping the discharge unless very high negative potentials are applied to the grid which for most purposes is impractical. The tube is usually shut off by removing the anode voltage. This of course limits the application of tubes of this kind.

In my co-pending application No. 141,411 filed May 8, 1937 and assigned to the same assignee as the present application, I describe and claim a gas discharge tube in which the discharge can be easily controlled and the discharge started and stopped at will. The described tube makes use of a magnetic field for controlling the discharge.

While the tube described in the above noted application is applicable to many uses it is particularly suitable for converter apparatus for transforming a low voltage direct current supply to a low or high voltage oscillatory or intermittent current supply. The transformation of a low voltage direct current source of supply to a low or high voltage oscillatory or intermittent current supply can be accomplished by the use of a vibrator, as in the power pack of automobile radio receivers. In many applications however, the vibrator is objectionable because of the short life of the contacts, sticking of the contacts, and the like, and because of the spark or arc that may occur. Gaseous tube oscillators may be used, but in the usual case, especially at low frequencies, expensive and bulky inductances and condensers are required.

It is therefore the principal object of my invention to provide a device for transforming or converting a low voltage direct current supply to a low or high voltage oscillatory or intermittent current supply efficiently by means of a circuit using a gas discharge tube, particularly the type of tube described in my co-pending application noted above, in which vibrating contacts and the other objectionable features noted in this kind of device are eliminated.

The tube described and claimed in my co-pending application comprises a cathode and anode, both contained within an envelope containing a gas which may be ionized at a very low voltage, for example caesium vapor, the caesium vapor being maintained ionized at voltages as low as 1.5 to 3 volts. The envelope closely surrounds the electrodes and positioned on the outside of the envelope is an electromagnet which produces a field transverse to the gas discharge between the cathode and anode. With the low voltages used between the cathode and anode, preferably not more than 15 volts, I am able with a moderate magnetic field to extinguish the gaseous or arc discharge between the electrodes. This tube lends itself particularly to a circuit which I have invented for converting low potential direct currents to pulsating or alternating currents of either high or low voltage.

Briefly the converter circuit made in accordance with my invention includes a tube of the type described in my copending application having in series with it a load and a source of low voltage supply. The electromagnet for controlling the discharge through the tube is connected in series with a second gas discharge tube and a condenser, thus forming an oscillatory circuit through the second gas discharge tube. One side of the condenser is directly connected to the negative side of the source of voltage supply and the other side of the condenser connected through a resistor to the positive side. The condenser and resistor arrangement provides a so-called time constant circuit which provides a pulsating or oscillating current output from a direct current supply in which the ratio of the time of current flow to the time of no current flow can be adjusted to any value. The discharging of the condenser through the electromagnet and the second gas discharge tube when the second gas discharge tube breaks down shuts off the current in the output of the first gas discharge tube and hence through the load. The condenser then charges up again and the process is repeated to produce a pulsating current in the output of the first tube of any desired low frequency within limits.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a vertical section of an electron discharge device described in my co-pending application noted above, Figure 2 is a transverse section taken along line 2—2 of Figure 1, Figure 3 is a graph showing the plate voltage—plate current characteristics of the tube shown in Figures 1 and 2, and Figure 4 is a diagram of a tube and circuit made according to my invention for converting low voltage direct current to alternating or pulsating current of high or low voltage in the output of the tube.

The tube shown in Figures 1 and 2 comprises an envelope 10 containing a gaseous atmosphere, for example caesium vapor, ionizable at low voltage to provide a gaseous discharge, and closely surrounding the enclosed electrodes. The cath-

ode 11 is provided with the coated fins 12 and heater 13, the cathode being surrounded by and connected to heat shield 14. The anode 15 receives the electrons emitted from the cathode 11. A control electrode 18 in the form of a cylinder surrounds the anode and extends toward the cathode. Voltages from 4 to 14 volts are applied between the electrodes, this voltage being preferably below that at which destructive cathode bombardment by ions takes place, but great enough to cause ionization and a gas discharge. Caesium vapor will ionize at very low voltages to permit a gas discharge between the electrodes within the tube. On the outside of the tube I place electromagnets 16 for producing a field transverse to the gas discharge. When the electromagnets 16 are energized to produce a moderate strength field the arc discharge can be easily extinguished so that the anode current can be readily reduced to zero. To conserve the heat which is necessary to maintain the caesium vaporized the envelope 10 may be surrounded by insulating coating 17. The tube may also be placed within an evacuated container.

The anode voltage-anode current characteristics of a tube made according to my invention are shown in Figure 3. As the magnetic field is increased in strength, as indicated by curves *a*, *b*, and *c*, the breakdown voltage and voltage required for maintaining the discharge increases. As indicated by curve *c*, if a magnetic field of sufficient intensity is produced transverse to the arc stream between the cathode and anode, for a given load, as represented by the straight line extending at an angle between the voltage and current axes, a condition can be produced whereby breakdown will not only not occur but that a discharge can be extinguished after it has once been started. Thus, if a voltage E_{b1} is applied between the cathode and anode so that there is a current of the value represented by the intersection of curve *a* and the load line, if a magnetic field, which will produce the characteristic line *c* is applied between the cathode and anode, the arc discharge will be extinguished. The magnetic field causes the electrons and the ions of the arc stream to be deflected out of the path between the cathode and anode and to recombine on the wall of the tube or on an auxiliary electrode provided for this purpose. This in effect increases the resistance of the tube so that the applied voltage cannot maintain the arc or gas discharge. This characteristic is made use of in the operation of circuits made according to my invention and using the tube described above.

An example of a tube made according to my invention includes a cathode having a diameter of about .250", which is also the diameter of an anode disc spaced 2 mm. away, the length of the cathode being .75". The diameter of the heat shield is .260". Voltages from 6 to 9 volts are applied between the cathode and anode and the tube is operated at a temperature ranging from 140 to 250° C. although wider temperature ranges are possible. The envelope closely surrounds the electrodes to keep the heat losses at a minimum and permit the magnetic field to be concentrated in the space between the electrodes. If it is desired to establish the magnetic field more easily, auxiliary electrodes made of magnetic material may be placed inside the envelope. Residual magnetism of the magnet may be neutralized by means of small neutralizing winding on the magnet so that the residual field is reduced to zero or an auxiliary electrode positioned close to the cathode may be used to establish a low current discharge.

A circuit embodying my invention is shown in Figure 4 and includes in addition to the first gas discharge tube 10 made according to Figure 1, a source of anode potential 19 which may also serve as the heating source for the heater 13 of cathode 11. The load 20 is connected between anode 15 and the positive side of the voltage source. It may be the primary of a transformer or some other load. The means for controlling the discharge through tube 10, and hence through the load 20, includes electromagnet 16 in series with the gas discharge tube 21, having a cathode 22, grid 23 and anode 24, and the condenser 25 bridged by the resistor 26. The condenser 25 and electromagnet 16 form an oscillatory circuit when a discharge takes place through the tube 21. One side of the condenser is connected to the cathodes of the tube and to the negative side of the voltage source 19. The other side of the condenser is connected through resistor 27 to the positive side of the source of voltage 19. The control electrode 18 of the first gaseous discharge tube is connected through a resistor 28 to a point between the anode of the second gas discharge tube and the electromagnet 16.

The circuit may be controlled by a switch 29. Closing of the switch 29 permits condenser 25 to charge up through resistor 27, the value of which may be adjusted to vary the time that it takes to charge condenser 25. At the same time tube 10 starts conducting, permitting current through load 20. As the condenser charges, the voltage on the anode 24 rises until the breakdown voltage on the tube is reached. The condenser then discharges through the tube through the electromagnet 16 energizing the magnet 16 to generate a magnetic field to shut off the discharge through the first gas tube 10. Due to oscillatory action of condenser 25 and electromagnet 16, which forms the inductance, the anode voltage of tube 21 at the end of the discharge period becomes negative with respect to the cathode. This of course stops the discharge through the tube 21 and at the same time causes the voltage on the grid 18 of tube 10 to be negative so that current cannot flow through the tube 10. The condenser at the end of this period, however, again becomes charged from a negative value to a positive value and at the same time the voltage on the grid rises to a point which permits tube 10 to breakdown, which point is determined by the tube construction and the amplification factor of the grid, and current is again through the tube 10 and the load 20. This current continues until tube 21 again breaks down, thus the cycle is repeated. Changing the resistance 27 varies the time that the tube 10 conducts and during which current flows through the load 20. The grid 23 of tube 21 is connected to resistor 26, the position changing the breakdown characteristic of the tube 21 so that a longer or shorter period elapses during which the condenser 25 may be charged. A gas tube which does not have a control grid could also be used in place of tube 21 in the circuit.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may

be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to provide a gaseous discharge, and enclosing a cathode and an anode, a source of voltage connected between said anode and cathode to produce a gaseous discharge between said cathode and anode, means for producing a magnetic field transverse to said gaseous discharge of sufficient strength to extinguish said discharge, and means for energizing the magnetic field producing means, including a condenser and a second electron discharge device in series with the magnetic field producing means.

2. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to provide a gaseous discharge and enclosing a cathode and an anode, a source of voltage connected between said anode and cathode to produce a gaseous discharge between said cathode and anode, an electromagnet for producing an electromagnetic field transverse to said gaseous discharge of sufficient strength to extinguish said discharge, and means for energizing the electromagnet, including a condenser and a second electron discharge device in series with the electromagnet.

3. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to produce a gaseous discharge, a cathode and an anode within said envelope, a load circuit connected between said cathode and anode and including a source of voltage for producing a gaseous discharge between said cathode and anode, means for producing a magnetic field transverse to said gaseous discharge and of sufficient strength to extinguish said discharge, and means for controlling energization of the means for producing the magnetic field to extinguish the discharge, and including a second electron discharge device having a cathode and an anode, and a condenser, said means for producing the magnetic field, the second electron discharge device and condenser being in series, one side of said condenser being connected to one side of the source of voltage and the other side of the condenser being connected through a resistor to the other side of the source of voltage.

4. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to provide a gaseous discharge and enclosing a cathode and an anode, a source of voltage connected between said anode and cathode to produce a gaseous discharge between said cathode and anode, an electromagnet for producing an electromagnetic field transverse to said gaseous discharge of sufficient strength to extinguish said discharge, and means for energizing the electromagnet including a second gas discharge device having a cathode and anode, and a condenser, said second electron discharge device and condenser being in series with said electromagnet.

5. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to provide a gaseous discharge and enclosing a cathode and an anode, a source of voltage supply connected between said anode and cathode to produce a gaseous discharge between said cathode and anode, an electromagnet for producing an electromagnetic field transverse to said gaseous discharge of sufficient strength to extinguish said discharge, and means for energizing the electromagnet including a second gas discharge tube having a cathode and anode and in series with said electromagnet, said second gas discharge device and said electromagnet being connected across the source of voltage supply, and a condenser having one side connected to one side of said source of voltage supply and the other side connected to the side of the electromagnet remote from the side connected to the second gas discharge device.

6. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to provide a gaseous discharge, and enclosing a cathode, control electrode and anode, a source of voltage supply connected between said anode and cathode to produce a gaseous discharge between said cathode and anode, an electromagnet for producing an electromagnetic field transverse to said gaseous discharge of sufficient strength to extinguish said discharge, and means for energizing the electromagnet including a second gas discharge tube and condenser in series with said electromagnet, one side of said condenser being connected to one side of said source of voltage supply, and a resistor connected between the other side of said condenser and the other side of said source of voltage supply, said control grid being connected to a point between said second gas discharge device and said electromagnet.

7. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to provide a gaseous discharge and enclosing a cathode, a control electrode and an anode, a source of voltage supply connected between said anode and cathode to produce a gaseous discharge between said cathode and anode, an electromagnet for producing an electromagnetic field transverse to said gaseous discharge of sufficient strength to extinguish said discharge, and means for energizing the electromagnet including a second gas discharge tube having an anode and cathode, and a condenser, said electromagnet, second electron discharge device and condenser being connected in series, the anode of the second gas discharge tube being connected to one side of the electromagnet, said control electrode being connected to a point between said anode and said electromagnet, one side of said condenser being connected to one side of the source of voltage supply, and a resistor, said resistor being connected between the other side of said condenser and the other side of said source of voltage supply.

8. An electron discharge device including an envelope containing a gaseous atmosphere ionizable to provide a gaseous discharge, and enclosing a cathode and an anode, a source of voltage connected between said anode and cathode to produce a gaseous discharge between said cathode and anode, means for producing a magnetic field transverse to said gaseous discharge of sufficient strength to extinguish said discharge, and means for energizing the magnetic field producing means and including a condenser and a second electron discharge device in series with said magnetic field producing means and having a cathode, anode and control electrode, and a resistor connected across said condenser, and a connection between said resistor and the control electrode of said second gaseous discharge device.

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