Nov. 21, 1939. W. L. MEIER 2,180,815

GAS DISCHARGE TUBE AND CIRCUIT

Filed May 8, 1937

Fig. 1

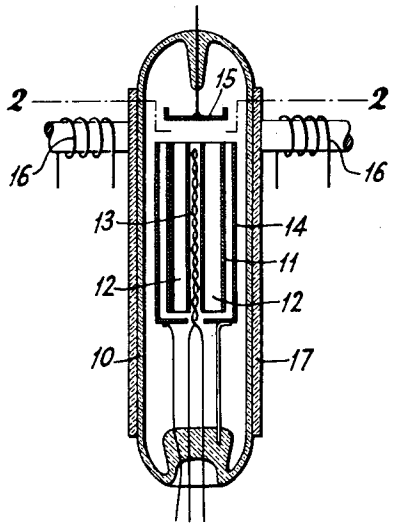



Fig. 2

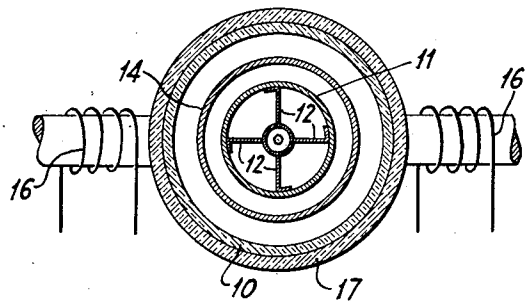



Fig. 3

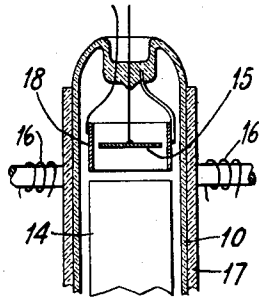



Fig. 4

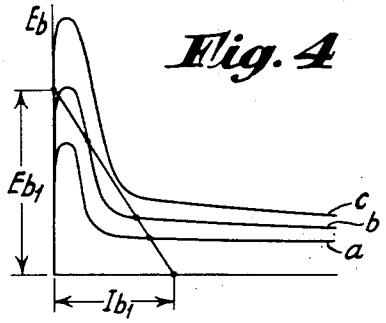



Fig. 5

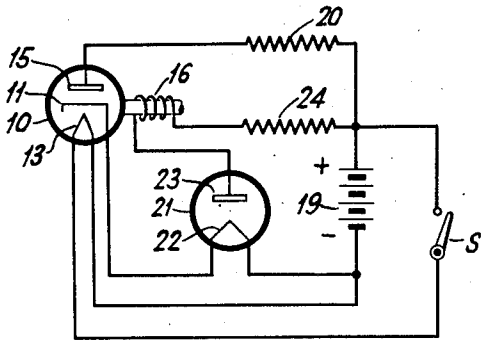
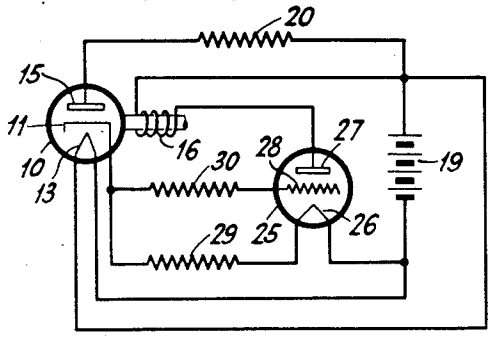



Fig. 6




INVENTOR
WILBER L. MEIER

BY Charles McClair
ATTORNEY

Patented Nov. 21, 1939

2,180,815

# UNITED STATES PATENT OFFICE

2,180,815

## GAS DISCHARGE TUBE AND CIRCUIT

Wilbur L. Meier, North Arlington, N. J., assignor, by mesne assignments, to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application May 8, 1937, Serial No. 141,411

6 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.

It is therefore an object of my invention to provide a gas discharge tube in which the discharge can be easily controlled and the discharge started and stopped at will. More specifically, it is an object of my invention to provide such a tube making use of a magnetic field for shutting off the discharge.

While a tube of the type embodying my invention is applicable to many uses it is particularly suitable for convertor 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, etc., 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 another 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 gas discharge tube, particularly the type of tube embodying my invention in which vibrating contacts and the other objectionable features noted in this kind of device are eliminated.

The tube embodying my invention 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 includes a tube made according to my invention having connected to its output a load which may include the primary of a transformer. The current for energizing the electromagnet to intermittently shut off the discharge in the tube is controlled by means of a second gas discharge tube connected in the output of the first tube and responsive to the load current. The magnetic field shuts off the current in the output of the first tube and hence through the second tube. This de-energizes the electromagnet so that the magnetic field collapses and the first tube again becomes conductive. This process is repeated to produce a pulsating current in the output of the first tube.

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 embodying my invention, Figure 2 is a transverse section taken along line 2—2 of Figure 1, Figure 3 is a partial section of a modification of a tube shown in Figure 1 and embodying my invention, Figure 4 is a graph showing the plate voltage-plate current characteristics of a tube made according to my inventions, Figures 5 and 6 are diagrams 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 embodying my invention and 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 cathode 11 is provided with the coated fins 12 and heater 13, the cathode being surrounded by heat shield 14. The anode 15 receives the electrons emitted from the cath-

ode 11. 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.

In Figure 3 I show a modification in which the tube is provided with a control electrode in the form of cylinder 18 surrounding the anode and extending toward the cathode. The tube is otherwise the same as that shown in Figures 1 and 2.

The anode voltage-anode current characteristics of a tube made according to my invention are shown in Figure 4. 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 re-combine 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 a tube made according to my invention.

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 140–250° 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 the converter arrangement according to my invention is shown in Figure 5 and includes in addition to tube 10 made according to my invention, a source of anode potential 19 which serves also as the heating source for 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 electromagnet 16 for producing the extinguishing magnetic field has one side connected with the source of voltage supply 19 and is in series with a gas discharge tube 21, the filament cathode 22 of which is connected in series with the cathode 11 of the tube 10, the anode 23 of tube 21 being connected to the other side of the electromagnet 16. A control switch 24 is connected into the cathode heater circuit of tube 10.

The operation of this circuit is as follows: The switch 24 is closed to heat the heater 13. When the cathode 11 comes up to temperature it will emit electrons so that there is a current through the load 20 and the filament 22 of the tube 21. This current will continue to flow until the temperature of the cathode 22 reaches a temperature at which it will emit, thus acting as an automatic switch to send current through the electromagnet 16 from the voltage supply 19. This produces a magnetic field between the cathode and anode of sufficient strength to extinguish the gas discharge between the electrodes 11 and 15. The current through the load 20 and through the cathode filament 22 is then cut off. As a result the cathode filament 22 cools off and emission ceases stopping the current through the electromagnet 16 so that it is no longer energized. When the magnetic field drops to a low or zero value, the tube 10 again breaks down so that a discharge takes place between the cathode 11 and anode 15 repeating the operation just described. In this way the current through the output is made pulsating, and a transformer in the output will be able to convert this pulsating current into alternating current at a higher voltage.

In Figure 6 I have shown an improved circuit which guards against the establishing of a stable condition which would prevent the intermittent operation described in connection with Figure 5. In this arrangement I use a grid controlled gas discharge tube 25 for controlling the current through the electromagnet. This tube is provided with a filament cathode 26, anode 27 and grid 28. Connected in series with the filament is a low resistance 29, preferably of tungsten wire. This resistance in operation affects the bias on grid 28 with respect to cathode 26. A resistor 30 may be connected in series with the grid 28.

With no current flowing through tube 10 and hence no current flowing through cathode 26 and resistor 29, the grid 28 is at the same potential as the cathode 26. When switch 24 is closed the cathode of tube 10 becomes heated and current flows through tube 10 and resistor 29 and the filament cathode of tube 25. The tube 25 is so designed that under these conditions the tube 25 remains non-conducting. As the resistor 29 becomes heated due to the flow of current therethrough the drop across this resistor increases and since the resistor is between the positive side of the voltage supply and tube 25 the grid becomes more positive with respect to the cathode 26. At a certain positive bias the tube breaks down and passes current. In this way the discharge is delayed until the cathode has had a sufficient time to attain a predetermined emit-

ting temperature. The operation of the circuit is otherwise the same as that of the circuit shown in Figure 5.

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 at a low voltage to provide a gaseous discharge, and enclosing a cathode and an anode, a load circuit including a source of low 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 including a second electron discharge device having its cathode in said load circuit for energizing the magnetic field producing means.

2. An electron discharge device including an envelope containing a gaseous atmosphere ionizable at a low voltage to provide a gaseous discharge and enclosing a cathode and an anode, a load circuit including a source of low 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 including a second electron discharge device having its cathode in said load circuit for energizing the electromagnet.

3. An electron discharge device including an envelope containing a gaseous atmosphere ionizable at low voltage 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 low 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 in said load circuit responsive to the current in said load circuit and including a second electron discharge device having a cathode filament in series with said load circuit for controlling energization of the means for producing the magnetic field to extinguish the discharge.

4. An electron discharge device including an envelope containing a gaseous atmosphere ionizable at low voltage 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 low voltage for producing a gaseous discharge between said cathode and anode, an electromagnet for producing a magnetic field transverse to said gaseous discharge and of sufficient strength to extinguish said discharge, a second electron discharge device having a cathode filament connected in series with said load circuit and connected to said electromagnet for energizing said electromagnet to extinguish the gas discharge between the cathode and anode of the first tube when said cathode filament reaches a predetermined emitting temperature.

5. An electron discharge device including an envelope containing a gaseous atmosphere ionizable at low voltage 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 low voltage not substantially higher than neecssary for producing a gaseous discharge between said cathode and anode, an electromagnet for producing a magnetic field transverse to said gaseous discharge and of sufficient strength to extinguish said discharge, and means including a second electron discharge device having an anode and a cathode filament, said cathode filament being connected in series with the cathode of the first electron discharge device and said source of voltage and its anode connected to one side of said electromagnet, the other side of said electromagnet being connected to said source of low voltage whereby the load current through said cathode filament raises said cathode filament to emitting temperature to produce a current through the electromagnet to extinguish the discharge through the first electron discharge device.

6. An electron discharge device including an envelope containing a gaseous atmosphere ionizable at low voltage 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 low voltage not substantially higher than necessary for producing a gaseous discharge between said cathode and anode, an electromagnet for producing a magnetic field transverse to said gaseous discharge and of sufficient strength to extinguish said discharge, a second electron discharge device containing gas and having an anode and a cathode filament, said cathode filament being connected in series with the cathode of the first electron discharge device and said source of low voltage and its anode connected to one side of said electromagnet, the other side of said electromagnet being connected to said source of low voltage, and a grid in said second electron discharge device and a resistor in series with the cathode filament, said grid being connected to the opposite side of the resistor from said cathode filament whereby a flow of current through said resistor increases the voltage drop across said resistor to control the bias voltage applied to said grid for controlling a discharge through said second tube.

WILBER L. MEIER.