Jan. 4, 1949. A. G. THOMAS 2,457,948

ELECTRON DISCHARGE DEVICE

Filed Feb. 16, 1945

FIG. 1

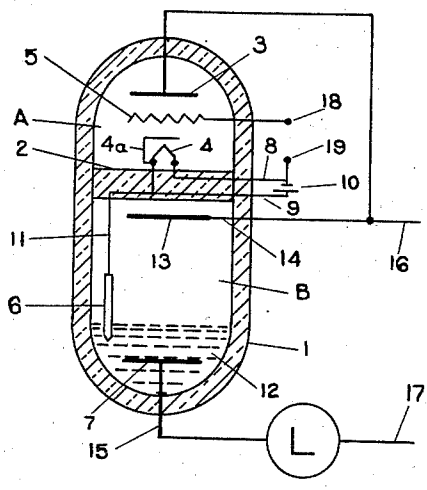
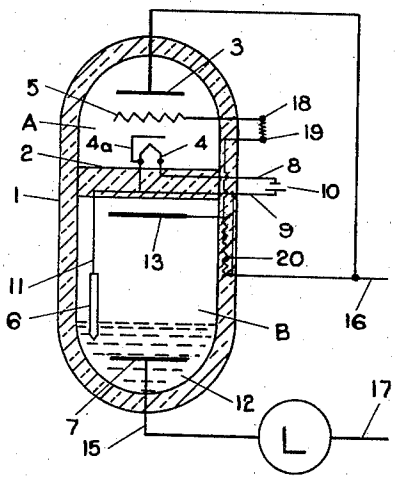


FIG. 2



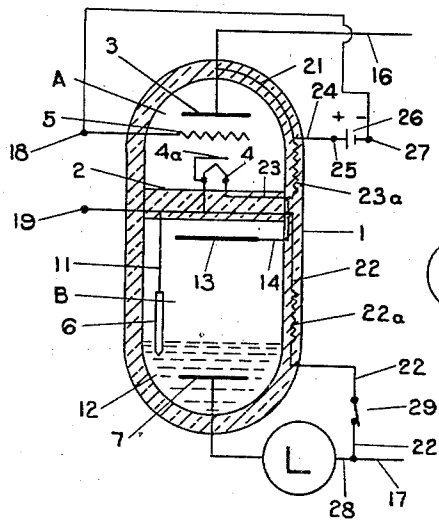


FIG. 3

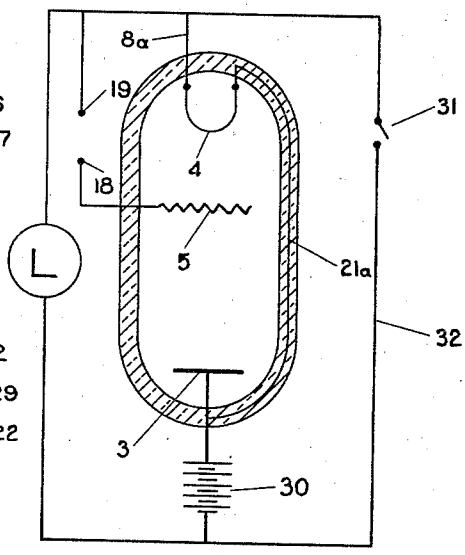


FIG. 4

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ELECTRON DISCHARGE DEVICE

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9 Claims. (Cl. 250—27.5)

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This invention relates to electronic devices and has particular reference to electronic valves or relays.

Electronic valves or relays containing gas or vapor are often used to control currents in circuits but much apparatus is usually required in order to operate the relays, particularly if complicated or sequential operations are involved.

It is an object of this invention to provide an electronic relay or switch that can be controlled with a minimum of auxiliary apparatus.

Another object is to provide an electronic relay in which a principal pool cathode type relay is combined with the controlling electronic tube.

A further object is the provision of an electronic relay for large currents combined with a control electronic tube or relay for relatively small currents, in one envelope.

An additional object is to provide an electronic relay for large currents combined with an electronic control relay for smaller currents so that the smaller relay is effectively cut out of circuit automatically when the larger relay conducts appreciable current.

Another object is the provision of an electronic relay combined with a control tube which automatically determines the firing point of the voltage cycle.

Other objects will appear in the following description:

In the drawings:

Figure 1 is a part sectional elevation of an electronic relay with pool type cathode combined in the same envelope with a gaseous or other electronic control relay or tube.

Figure 2 is a part sectional elevation of a device similar to that shown in Figure 1 but with in-built means for effectively removing the control relay from the circuit when the pool cathode relay conducts sufficient current.

Figure 3 is a part sectional elevation of a combination pool cathode relay and hot filament relay, the filament being in series with the line.

Figure 4 is a part sectional elevation of an electronic relay or tube shown connected in a circuit. The filament of this tube is connected in series with the anode voltage source.

In Figure 1, envelope 1 of glass or other suitable material has sealed cross partition 2 of similar material forming chambers A and B. Chamber A has anode 3 of any well known construction such as of nickel, and filament cathode 4 and grid 3 are provided. Suitable leads from the anode and grid are sealed in envelope 1 in known manner and the leads 8—9 to cathode 4 are preferably sealed in partition 2 and are brought out of the envelope as shown so that

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they may be connected to battery or other current source 10 which may be the secondary of a transformer.

Rod 6 which may be of graphite or other suitable material, is supported by connected lead 11, or in any other manner. Lead 11 connects rod 6 to cathode 4 which may have connected heater element 4a adapted to emit electrons freely. Element 4a is preferably coated with barium oxide or other suitable material of relatively low work function. If desired, hot wire cathode 4 alone may be used.

Rod 6 dips into cathode pool 12 of mercury or suitable material and preferably nickel or graphite anode 13 is fastened in chamber B to lead 14 sealed in envelope 1. Other means of support such as glass stems could be used.

Electrically conducting plate 7 of suitable material such as metals or the like, is placed in contact with pool 12 and is connected with lead 15 sealed in envelope 1. The device is preferably positioned vertically as indicated.

Anodes 3 and 13 are connected to line conductor 16 and lead 15 from cathode 12 for chamber B is connected to line 17 through load L which may be a motor or any other current operated device.

Grid 5 is connected with terminal 18 and terminal 19 is connected with cathode 4—4a.

Rod 6 may be composed of graphite or of material which changes its resistance markedly with variation of current passing through the material. Various compounds or mixtures of silicon carbide, carbon, zinc oxide, boron or the like, have such characteristics. If rod 6 is made of a suitable material of this type it will normally offer a relatively high resistance which can be greatly reduced to facilitate forming an arc when current is passed through the rod to mercury or other material 12.

Rod 6 may also consist of graphite mixed with carborundum crystals, silica, or other finely divided or cystalline particles in order to facilitate the forming of spots of high potential gradient. If desired, the rod may comprise a metal rod coated with graphite or other material for better conductivity through the graphite. A smaller unit can be made in this way. Semi conducting material such as selenium, copper oxide, aluminum oxide or the equivalent may also be effective as means for producing a high potential gradient between the rod and the cathode material 12.

In operation line 16 is connected to a positive terminal of a potential source and line 17 to the negative terminal of the same source. No current, or negligible current will flow through chamber B from anode 13 to pool cathode 12 if grid

5 is kept sufficiently negative by connecting a battery or other source of potential between terminals 18 and 19. This is true even if cathode 4 is heated by source 10. If, however, grid 5 is made sufficiently positive with respect to cathode 4, then current will pass from anode 3 to cathode 4 and through lead 11 to rod 6 from which it passes to pool 12. If this current and the potential drop across the rod 6—pool 12 junction are of sufficient magnitude, the vapor from mercury pool 12, for instance, will then become ionized so that relatively heavy current passes from line 16 through anode 13 and chamber B to cathode 12 and so through load L.

If pulsating direct current is applied in lines 16 and 17 or alternating current, then grid 5 may be made negative to stop the current flow in chamber B when the potential difference between lines 16 and 17 falls below a critical value.

Chamber A preferably contains gas such as argon, or argon and mercury in order to provide sufficient current flow. This chamber may be placed to the side of chamber B, within that chamber, or below it as desired.

This combined heavy duty electronic valve and relatively small current control valve is much more convenient to use than prior devices which have to be assembled in various groups.

Envelope 1 may be of metal which may have cooling fins if desired. Conductors 15 and 16 would be suitably insulated from the metal envelope.

In Figure 2 the construction is the same as in Figure 1, as indicated by like numerals, except that in this modification grid 5 is connected to cathode 4—4*a* through resistor or impedance element 20 when the grid circuit is closed by connecting a source of potential between terminals 18—19. This source can be a battery, generator, a current-carrying resistor, or a condenser or inductance which could also be wound to have considerable reactance. Anode 13 is connected to the grid-connected end of resistor 20 the other end of which is connected to line 16 as well as to cathode 4—4*a*.

By means of the above described arrangement chamber A conducts current to rod 6 until current conduction between anode 13 and cathode 12 occurs at which time the current passing through resistor 20 from line 16 causes a potential drop in resistor 20 which biases grid 5 negatively with respect to cathode 4—4*a* so that current conduction from anode 3 to that cathode is stopped or reduced when current is passed from anode 13 to cathode 12. In this way the starting relay is automatically cut out of circuit or increased in effective resistance when the power or larger relay passes current.

In case sufficient gas is contained in chamber A, then alternating current or pulsating direct current potential should be applied between positive line 16 and negative line 17. Resistor 20 can be of sufficiently high value so that it will cut off current flow in chamber A at a relatively low value of current in chamber B. The resistor is preferably sealed in the envelope 1 but may be placed outside if desired, or in any other suitable location.

This form of the invention may be changed from a non-conducting to conducting state by increasing the voltage between lines 16 and 17 if terminals 18 and 19 are connected or by connecting these terminals together directly or through a potential source which biases grid 5 positively with respect to cathode 4—4*a*, if necessary. The negative potential drop across resistor 20 can then be sufficient to overcome the positive bias.

An advantage of this modification is that the starting relay is cut on and off by one operation instead of by two as before, if the relay in chamber A is normally non-conducting. By varying the bias of grid 5 or the value of resistor 20 the point in the line cycle at which cut off in chamber B occurs can be regulated.

In Figure 3, like parts are designated by the same numerals as before. In this form of the invention line 16 is connected to anode 3, as before, but cathode filament 4 is connected in series with lines 16 and 17 by means of conductors 21, 22, and 23 wholly or partially sealed in envelope 1. Conductor 22 is connected to line 17 on the line side of load L the other terminal of which is connected to cathode plate or other element 7. Resistor 23a is preferably connected in series with conductors 21, 22, cathode 4, and conductor 22. If this resistor is used then lead 24 from conductor 21 is brought out as shown and connects with terminal 25 which may be connected to the positive terminal of biasing battery 26 the negative terminal of which may be connected to terminal 27. Conductor 14 is connected with conductor 23 or filament 4 as indicated. A switch 29 can be provided for opening and closing the filament circuit.

In operation, if switch 29 is closed and line 16 is connected to anode 3 and line 17 is connected to the junction of conductor 22 and conductor 28 from load L, then current will pass through resistor 23*a* and filament 4 to heat that cathode. No appreciable current will pass through chamber B and load L however if grid 5 is biased sufficiently negatively with respect to cathode 4—4*a*. Grid 5 may be biased by a potential source suitably connected between terminals 18 and 19. If then, grid 5 is made positive or sufficiently less negative, current will pass from anode 3 to cathode 4—4*a* and through rod 6 to produce electrons so that mercury vapor in chamber B will become ionized and current conduction from line 16 to line 17 will take place through conductor 21, resistor 23*a*, conductor 14, anode 13, chamber B, cathode 12, load L and conductor 28. If fluctuating or alternating potential occurs between lines 16 and 17 then current flow through chamber B and load L can be stopped by making grid 5 sufficiently negative with respect to cathode 4—4*a* so that the starting current in chamber A will be prevented by a relatively low anode potential point.

Another mode of operation is to connect grid terminal 18 to terminal 27 as indicated. Then grid 5 is normally negatively biased by battery or other potential source 26 so that there is no appreciable current conduction in chambers A and B when the potential between lines 16 and 17 is below a predetermined value. At some point in the cycle, however, this potential will rise to the critical value so that sufficient current flows through resistor 23*a* to bias grid 5 positively or sufficiently less negatively with respect to cathode 4—4*a* to allow current conduction in chamber A from anode 3 to cathode 4—4*a* with the result that current conduction in chamber B and through load L occurs. The point in the line potetial cycle at which current conduction through chamber B and load L occurs can then be regulated by varying the potential of source 26 or by varying the value of resistance 23*a* which may be tapped or placed outside envelope 1. In this way

the average magnitude of current through load L can be varied.

This modification is very useful and convenient since it can be connected directly in the line, only a few connections being necessary. This device is therefore much simpler to use than prior gaseous relays which require numerous connections and circuits. It will be observed that no current passes through the load until chamber B conducts, but if the current through filament 4 is not objectionable, conductor 22 can be connected on the opposite side of load L.

The bias of grid 5 can be adjusted to compensate for the potential drop across resistor 23*a*, due to normal filament drain. The current through this resistor is increased when chamber B is fired.

Resistor 22*a* is placed in series with conductor 22 to insure a potential difference between anode 13 and cathode 12.

A circuit showing a relay tube similar to the upper relay of Figure 3 is illustrated in Figure 4. The filament 4 can be supplied with current from anode potential source 30 through both the load L and line 32 if switch 31 is closed and through load L if the switch is open. The resistance of cathode filament 4 or its connected lead may be sufficient to keep the initial current flow through the load to relatively low values, if load L requires considerable current in proportion to that supplied to the filament. Load L will then receive its full current when grid 5 is of proper polarity and potential.

Various other modifications can be readily made without departing from the general principles I have disclosed.

What I claim is:

1. In an electron discharge tube, means forming two chambers, a first cathode, a grid, and a first anode in one said chamber; a pool type cathode, a second anode, and a control element in the other said chamber; an impedance element connecting said first anode and one terminal of said first cathode, and another impedance element connecting the other terminal of said first cathode and said pool type cathode.

2. In an electron discharge tube, means forming two chambers, a first cathode, a grid, and a first anode in one said chamber; a pool type cathode, a second anode, and a control element in the other said chamber; an impedance element connecting said first anode and one terminal of said first cathode, another impedance element connecting the other terminal of said first cathode and said pool type cathode, said grid being electrically connected with said first anode.

3. In an electron discharge tube, means forming two chambers, a first cathode, a grid, and a first anode in one said chamber, a pool type cathode, a second anode, and a control element in the other said chamber; an impedance element connecting said first anode and one terminal of said first cathode, another impedance element connecting the other terminal of said first cathode and said pool type cathode, and a source of potential connecting said grid and said first anode.

4. In an electron discharge tube, means forming two chambers, a first cathode, a grid, and a first anode in one said chamber; a pool type cathode, a second anode, and a control element in the other said chamber; an impedance element connecting said first anode to one of the terminals of said first cathode, another impedance element connecting the other terminal of said first cathode and said pool type cathode, means connecting said grid and said first anode, and means connecting said control element and said first cathode.

5. In an electron discharge tube, means forming two chambers, a first cathode, a grid, and a first anode in one said chamber; a pool type cathode, a second anode, and a control element in the other said chamber; an impedance element connecting said first anode and one terminal of said first cathode, another impedance element connecting the other terminal of said first cathode and said pool type cathode, and means connecting said second anode and said control element to said first cathode.

6. In an electron discharge tube, means forming two chambers, a first cathode, a grid, and a first anode in one said chamber; a pool type cathode, a second anode, and a control element in the other said chamber; an impedance element connecting said first anode and one terminal of said first cathode, another impedance element connecting the other terminal of said cathode and said pool type cathode, means connecting said second anode and said control element to said first cathode, and means connecting said grid with said first anode.

7. In an electron discharge tube system, a cathode having a pair of terminals for supplying heating current to said cathode, an anode, a grid, an impedance element connecting said anode and one terminal of said cathode, the other terminal of said cathode being connected with the negative terminal of a source of current, and said anode being connected with the positive terminal of said source for passing current from said source through said impedance element and said cathode in series.

8. In an electron discharge tube, means forming two chambers, a first cathode, a grid, and a first anode in one said chamber; a pool type cathode, a second anode, and a control element in the other said chamber; an impedance element connected in circuit with at least one of said anodes, and means connecting said grid with said impedance element to cause biasing of said grid as a result of current flow through said impedance element.

9. In an electron discharge tube, an anode and a positive terminal connected thereto, a thermionic cathode and a negative terminal connected thereto, an impedance element connected in series with said cathode between said terminals, and grid means for controlling electron flow between said cathode and said anode.

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