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REGULATING APPARATUS

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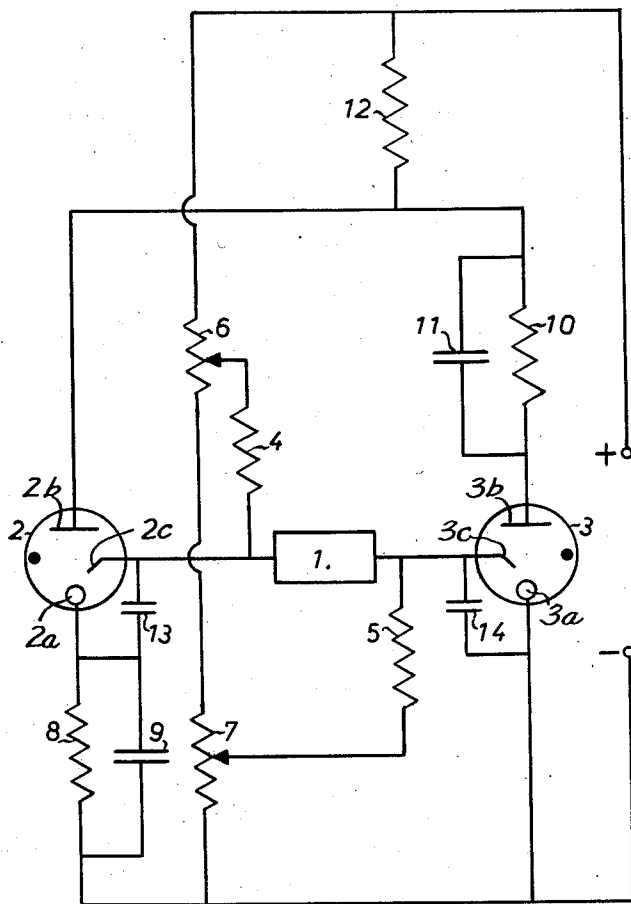


Fig. 1

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REGULATING APPARATUS

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4 Claims. (Cl. 317-142)

This invention relates to a regulating apparatus and more particularly to a regulating apparatus using gas relay tubes for controlling an external load circuit in dependence of very small electric currents flowing through an electric measuring element according to the level of a measured magnitude.

Objects of the invention are to improve a regulating apparatus of the type stated with respect to its sensitivity to extremely small currents and its stability over very long periods of operation, to simplify the circuit and reduce the number of circuit elements of such an extremely sensitive apparatus and to improve its speed of operation and ease of adjustment.

The improvements are obtained, in accordance with the invention, by the use of a pair of cold cathode gas tubes each of which has a main cathode, a main anode and a starter electrode and by the use of one electric condition responsive element. This electric condition responsive element is connected between the starter electrodes of said gas relay tubes, biasing means of high internal resistance are connected to each of said starter anodes and both tubes are coupled in a so-called multi-vibrator-circuit, in which, on the firing of one tube, the other will become non-conductive. The coil of an electromechanical relay or some other indicating element is connected to one of the main electrodes of said tubes and it will be operated by the firing of the corresponding tube. The whole circuit is connected to a direct-current supply, which, if a high precision of indication is required, may be stabilized by voltage reference tubes or other stabilizing means.

These and other objects and the advantages of the invention will best be understood from the following description of specific embodiments when read in connection with the accompanying drawing in which:

Fig. 1 shows a simplified diagram explaining the principle of the mode of operation of the regulating apparatus; and

Fig. 2 shows a more detailed diagram of a regulating apparatus, which preferably serves as an automatic photo-electric control.

In the diagram of Figure 1 the measuring or condition responsive element 1 can be a photo-electric cell, an ionisation chamber, or a resistance depending on light, radiation, temperature, pressure, etc. The apparatus includes gas relay tubes 2 and 3 of the glow-discharge type, each having a cold cathode, a main-anode and a starter-anode. The main-discharge between the cold cathode and the main-anode of these gas relay tubes is fired by means of their starter-anode in a per se known manner. Both relay tubes 2 and 3 are fed from a direct-current source which, however, is not shown in Figure 1. The condition responsive element 1 is connected directly between the two starter-anodes of the relay tubes 2 and 3. The load into which the condition responsive element 1 is working, is built up of high-resistance elements 4 and 5, each of which connects one of the starter-anodes to a tap on a voltage divider comprising the potentiometers 6 and 7 of

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conventional design and has a resistance of about 10^5 to 10^6 ohms. The high-resistance elements 4 and 5 can be high-ohmic resistances, ionisation chambers or other elements having a high internal resistance of about 10^7 to 10^{10} ohms. By means of the potentiometers 6 and 7 connected across the above mentioned direct-current source adjustable biasing-voltages for the starter-anodes of the gas relay tubes 2 and 3 are supplied. The cold cathode 2a of the gas relay tube 2 is connected, through the resistance 8 with the condenser 9 connected in parallel, to the negative terminal of the direct-current source, while the cold cathode 3a of the gas relay tube 3 is connected directly to the negative terminal. The main-anode 3b of the gas relay tube 3 is connected, through a resistance 10 with condenser 11 connected in parallel, to the main-anode 2b of the gas relay tube 2. The resistances 8 and 10 serve as current limiting resistors according to the ratings of the gas relay tubes 2 and 3. The main-anode 2b of the gas relay tube 2 is connected through the coupling resistance 12 to the positive terminal of the direct-current source. The resistance 12 is a voltage dropping or coupling resistance producing a coupling between the two circuits containing the cold cathode and the main-anode of the gas relay tubes 2 and 3. From the diagram it may be seen, that the biasing-voltages for the starter-anodes 2c, 3c of the gas relay tubes 2 and 3 respectively, are positive with respect to the negative terminal of the direct-current source, the biasing-voltage for the starter-anode 3c of the gas relay-tube 3 having its cold cathode connected directly to the negative terminal of the direct-current source being lower than the biasing-voltage for the starter-anode 2c of the other gas relay tube 2. The circuit is supplemented by the condensers 13 and 14, which are interposed between the starter-anode and the cold cathode of the two gas relay tubes 2 and 3.

In order to explain the mode of operation, let it be assumed that the condition responsive element 1 is a high-vacuum photo-electric cell, the cathode of which is exposed to intense illumination. Let it further be assumed that the glow discharge of the gas relay tube 3 burns, while the glow discharge of the relay tube 2 is extinguished. The starter-anode 3c, immersed in the discharge, of the relay tube 3 will in these circumstances assume in relation to the negative terminal of the direct-current source a positive potential which is approximately equal to the cathode drop of the glow discharge of the relay tube 3. Given a normal construction for the gas relay tubes 2 and 3, the cathode drop is only slightly smaller than the burning voltage between the cold cathode and the main-anode. The current flowing from the positive terminal of the supply through a part of potentiometer 6, through the high ohmic resistance 4 and through the photo-electric cell 1 to the starter electrode and into discharge of tube 3 produces at the high-ohmic resistance 4 a voltage drop of such magnitude that the starter-anode 2c of the gas relay tube 2 has not yet quite attained the potential necessary for the firing of the main-discharge of the gas relay tube 2. If now the exposure to light of the photo-electric cell 1 is reduced, the voltage drop at the resistance 4 is reduced, and the starter-anode 2c of the relay tube 2 receives the potential necessary for firing the glow discharge of the relay tube 2. On the occurrence of the main-discharge current of the gas relay tube 2, an additional voltage drop is produced at the resistance 12 which together with the charge stored in the capacitor 11 has the effect that the voltage of the main-anode 3b of the relay tube 3 temporarily falls beneath the necessary minimum burning voltage. On the firing of the relay tube 2, the relay tube 3 is consequently extinguished. The starter-anode 2c of the relay tube 2 will now in corresponding manner assume in relation to the

negative terminal of the direct-current source a potential which is composed of the voltage drop at the resistance 8 and the cathode drop of the relay tube 2. On the other hand, the photo-electric cell current produces at the resistance 5 a voltage drop which is just no longer sufficient to fire the main-discharge of the relay tube 3. If the exposure to light of the photo-electric cell 1 is again increased, the potential of the starter-anode 3c of the relay tube 3 is then increased until the latter is fired. The additional voltage drop at the resistance 12 on the firing of the relay tube 3 now extinguishes the relay tube 2, because the capacitor 9 temporarily retains its potential and in consequence the voltage between the main-anode 2b and the cold cathode 2a of the relay tube 2 falls for a short time below the extinguishing voltage.

By a suitable adjustment on the potentiometer 7, the photo-electric cell current, on the exceeding of which the relay tube 3 is fired, can be adjusted. On the other hand, the photo-electric cell current below the relay tube 2 is fired, is adjusted with the potentiometer 6. The capacitors 13 and 14 permit the firing of the relay tubes 2 and 3 even with very small control currents. By suitable dimensioning, a retardation of response of the regulating apparatus can at the same time be effected with them, so that short-timed alterations of the measured magnitude do not initiate control operations in the regulating apparatus. If the regulating apparatus having glow discharge relay tubes 2 and 3 of the cold cathode starter-anode type is operated in the manner described, then control currents in the condition responsive element 1 of 10^{-8} to 10^{-10} amperes are sufficient for perfect working of the regulating apparatus. A voltage controlled by the condition responsive element 1 is available at the cold cathode 2a of the relay tube 2 or at the main-anode 3b of the relay tube 3 and can for example be used to control thyatron tubes which close or open an external load circuit. Controlled currents are available in the main discharge circuits containing the cold cathode and the main-anode of the relay tubes 2 and 3 and can for example serve to operate electromechanical relays, the exiter windings of which take place of the resistances 8 or 10 and the relay contacts of which close or open an external load circuit containing a load which is to be connected to or disconnected from the power supply according to the level of the electric currents flowing through the condition responsive element 1. In Figure 1, however, such external load circuits are not specially shown.

The condition responsive element 1 used in the circuit is preferably one, the current of which in the normal operating range depends practically only on the magnitude of the condition to which it is responsive, but not on the voltage applied, as in the case, for example, with a high-vacuum photo-electric cell, with an ionisation chamber operated in the saturation zone, or the like. The condition responsive element 1 can, however, also be a resistance, which steadily varies its value as a function of the magnitude of the condition such as light, radiation, temperature, pressure, etc. Very sensitive, practically not loadable contacts, which for example close or open as a function of the magnitude of the condition, can also be used as the condition responsive element 1. The use of the regulating apparatus is indicated wherever larger powers must be reliably controlled with powers of about 10^{-8} watts obtained at a condition responsive element 1 of very high internal resistance.

A particularly suitable field of application of the regulating apparatus described with reference to Figure 1 comprises photo-electric controls of all kind.

Figure 2 shows diagrammatically the example of an automatic light control, which is used to switch on and off lightings of roads, airfields, shop-windows, factory premises, and so on, in dependence on the brightness of daylight. The regulating apparatus, and the external load circuit to be controlled, are fed from the same alternating current line 15. The load circuit contains a

load to be connected to the terminals 16, and also the contacts 17 of an electromechanical relay 18, by means of which the load is connected to or separated from the power supply line 15 depending on the switching state of the relay 18. The load can for example consist of a large number of illumination lamps, and is not shown in Figure 2. The regulating apparatus itself is fed by a source of direct current, which is illustrated by the full-wave rectifier 19 and the filter capacitor 20. Two series connected gaseous voltage reference tubes 22 and 23 are fed through a common series resistor 21 from the rectifier 19, 20. Two potentiometers 6 and 7 are connected across the gaseous voltage reference tubes for feeding adjustable biasing voltages for the starter-anodes 2c, 3c of the gas relay tubes 2 and 3. The regulating apparatus itself is constructed in accordance with the diagram illustrated in Figure 1, the resistance designated there by 8 in the main discharge circuit of the gas relay tube 2 being replaced by the exiter winding 24 of the electromechanical relay 19. The condition responsive element 1 is a photo-electric cell preferably of the high-vacuum type for measuring the brightness at a given moment. The values of the different circuit elements depend much on the type of relay tubes used in a particular design and on the characteristics of the measuring element as well as on the desired sensitivity and speed of operation in each case. For the example of an automatic light control with a commercial vacuum type photoelectric cell as a light-measuring element the circuit elements of Figs. 1 and 2 may have the following values:

D. C.-voltage: 280 v.

High-ohmic resistors 4 and 5: 10^7 – 10^{10} ohms, depending on desired light sensitivity.

Potentiometers 6 and 7: 10^5 ohms.

Resistors 8 and 10 or resistance of the exciting winding of an electromechanical relay: 10^4 ohms.

Condensers 9 and 11: 1 microfarad.

Resistor 12: 5.10^3 ohms.

Condensers 13 and 14: 10^{-4} to 1 microfarad, depending on desired response delay.

The invention is not limited to the particular embodiments here shown and described. Various modifications may be made in the regulating apparatus without departing from the spirit and scope of the invention as set forth in the following claims.

We claim:

1. A regulating apparatus comprising a pair of gas relay tubes each of which includes a main cold cathode, a main-anode and a starter-anode, a first current limiting resistor shunted by a first condenser and connected between the cold cathodes of said relay tubes, a second current limiting resistor shunted by a second condenser and connected between the main-anodes of said relay tubes, a direct-current source and a coupling resistor arranged in series therewith, one end of said series arranged direct-current source and coupling resistor being connected to the cold cathode of one of said relay tubes and the other end of said series arranged direct-current source and coupling resistor being connected to the main-anode of the other of said relay tubes, a pair of high resistance elements each of which connects one of said starter-anodes to biasing voltage supply means, and an electric condition responsive element connected between said high resistance elements for controlling the respective biasing voltages applied to said starter anodes and thereby firing said two relay tubes in an alternative manner determined by the magnitude of the condition to which said electric element is responsive.

2. The invention as recited in claim 1, wherein said biasing voltage supply means deliver positive voltages with respect to the negative terminal of said direct-current source, the biasing voltage for the starter-anode of one relay tube having its cold cathode connected to

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the negative terminal of said direct-current source being lower than the biasing-voltage for the starter-anode of the other relay tube.

3. A regulating apparatus comprising a pair of gas relay tubes each of which includes a main cold cathode, a main-anode and a starter-anode, a first current limiting resistor shunted by a first condenser and connected between the cold cathodes of said relay tubes, a second current limiting resistor shunted by a second condenser and connected between the main-anodes of said relay tubes, a direct-current source and a coupling resistor arranged in series therewith, one end of said series arranged direct-current source and coupling resistor being connected to the cold cathode of one of said relay tubes and the other end of said series arranged direct-current source and coupling resistor being connected to the main-anode of the other of said relay tubes, a pair of high resistance elements each of which connects one of said starter-anodes to a voltage-divider connected between the terminals of said direct-current source, an electric condition responsive element connected between said high resistance elements for controlling the respective biasing voltages applied to said starter anodes by said voltage divider and thereby firing said relay tubes in an alternative manner in dependence upon the electric currents flowing through said condition responsive element as determined by the magnitude of the condition to which said electric element is responsive, a third condenser connected in the starter-anode circuit of one of said relay tubes and a fourth condenser connected in the starter-anode circuit of the other of said relay tubes, said third and fourth condensers serving for the storage of electrical charges required for the firing of said relay tubes.

4. A regulating apparatus comprising a pair of gas relay tubes each of which includes a main cold cathode, a

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main-anode and a starter-anode, a first current limiting resistor shunted by a first condenser and connected between the cold cathodes of said relay tubes, a second current limiting resistor shunted by a second condenser and connected between the two main-anodes of said relay tubes, a direct-current source the negative terminal of which is connected to the cold cathode of one of said relay tubes, the positive terminal of said direct-current source being connected through a coupling resistor to the main-anode of the other of said relay tubes, a pair of high resistance elements each of which connects one of said starter-anodes to a voltage divider arranged between the terminals of said direct-current source, an electric condition responsive element connected between said high resistance elements for controlling the respective biasing voltages applied to said starter anodes by said voltage divider and thereby firing said relay tubes in an alternative manner in dependence upon the electric currents flowing through said condition responsive element as determined by the magnitude of the condition to which said electric element is responsive, a third condenser connected in the starter-anode circuit of one of said relay tubes and a fourth condenser connected in the starter-anode circuit of the other of said relay tubes, said third and fourth condensers serving for the storage of electrical charges required for the firing of said relay tubes.

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