H. GERDIEN.

CURRENT RELAYING APPARATUS.

APPLICATION FILED JAN. 7, 1911.

1,004,012. Patented Sept. 26, 1911.

2 SHEETS—SHEET 1.

Fig. 1

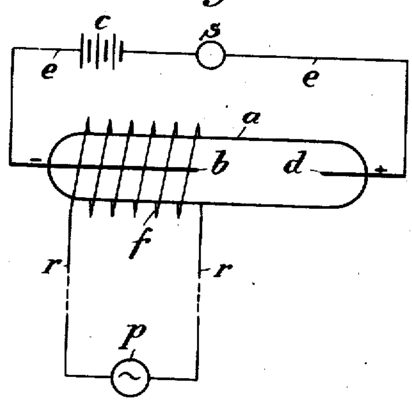


Fig. 1a

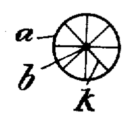


Fig. 1b

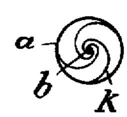


Fig. 1c

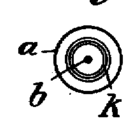


Fig. 2

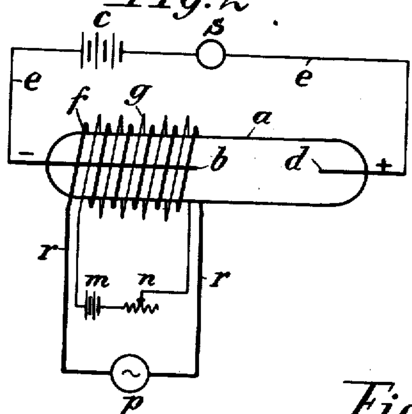


Fig. 3

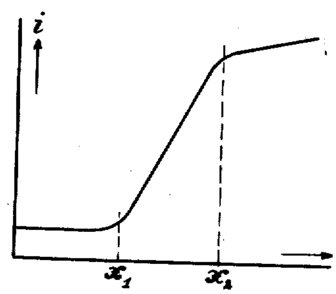
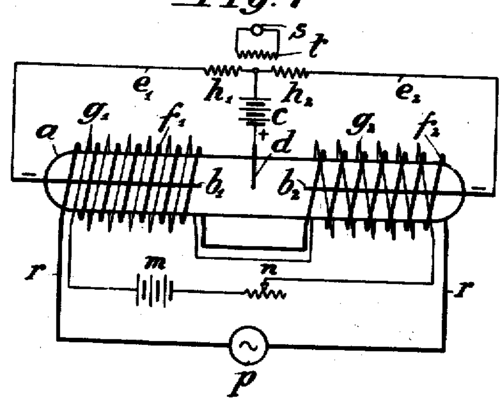


Fig. 4



WITNESSES

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2 SHEETS—SHEET 2.

Fig.5

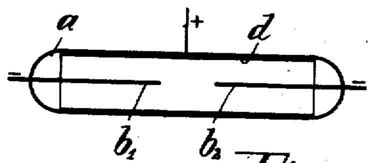


Fig.5a

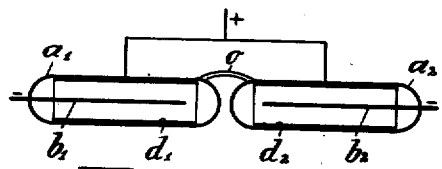


Fig.5b

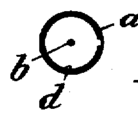


Fig.6

Fig.7

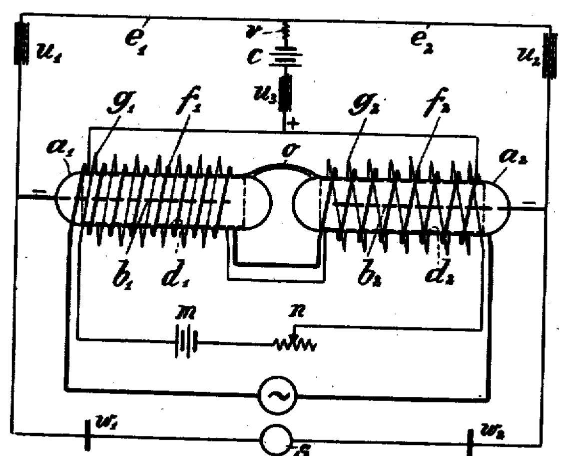
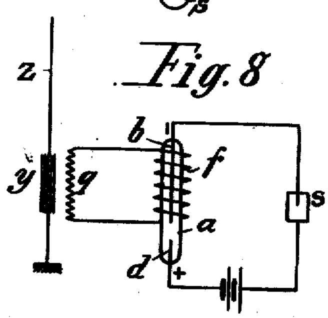


Fig.8



WITNESSES

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UNITED STATES PATENT OFFICE.

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CURRENT-RELAYING APPARATUS.

1,004,012. Specification of Letters Patent. Patented Sept. 26, 1911.

Application filed January 7, 1911. Serial No. 601,443.

To all whom it may concern:

Be it known that I, HANS GERDIEN, a subject of the German Emperor, and residing at Halensee, near Berlin, Germany, have invented certain new and useful Improvements in Current-Relaying Apparatus, of which the following is a specification.

The subject-matter of my invention is means for producing great changes of energy in dependence on smaller changes of energy, the great changes of energy being to a certain extent proportional to the smaller changes of energy. Such means may be designated a quantitative relay in contradistinction to customary relays, in which the secondary changes of energy brought about by primary changes of energy are in no definite relation one to the other.

My means are particularly suitable for increasing the action of arriving waves in radiotelegraphy, for increasing the action of telephones, the action of telegraphs in cable telegraphy, for signaling, and for controlling machines from a distance, and the like.

According to my invention, for producing the great changes of energy a luminous discharge is used, whose strength is influenced by a magnetic field varied by small primary changes of energy. By luminous discharge is to be understood the electric current in a gas, in which the material of which the cathode is composed is not vaporized by the current and does not participate in the transmission of the current. In contradistinction thereto an arc is formed only when the material of which the cathode is composed is vaporized by the current.

Cathode rays are a constant accompanying phenomenon of luminous discharge. They are the carriers of a certain fraction of the luminous discharge and are that part of the whole luminous discharge which can be magnetically or electrically most readily influenced in its position and direction. In my present invention, however, the energy of the total luminous discharge, and not only the position and direction of the cathode rays, is directly influenced by a magnetic field.

Several illustrative embodiments of my invention are diagrammatically represented by way of example in the accompanying drawing, wherein:—

Figure 1 shows the simplest form of my invention; Figs. 1ᵃ, 1ᵇ and 1ᶜ are sections through various vacuum tubes showing the course of the cathode rays under various conditions; Fig. 2 shows an embodiment similar to that shown in Fig. 1 but with the addition of an auxiliary circuit; Fig. 3 is a diagram; Fig. 4 shows another embodiment of my invention; Figs. 5 and 5ᵃ show modified forms of vacuum tubes in sectional elevation; Figs. 5ᵇ and 6 are sections through the tube shown in Fig. 5ᵃ, and through a modified form of tube, respectively; Fig. 7 shows another embodiment of my invention, and Fig. 8 shows how my invention may be used in connection with radiotelegraphy.

Referring firstly to Fig. 1, *a* designates a closed glass tube containing a highly rarefied gas; *b* designates the cathode, *c* the source of current, *d* the anode, *e* the conductor connecting the electrodes to the source of current, and *s* a receiving apparatus, *e. g.* a telephone, interpolated in this conductor. These members form the secondary circuit. The primary circuit consists of the coil *f* mounted concentrically relatively to the cathode *b*, a sender *p*, *e. g.* an alternating current generator, and the conductors *r* connecting the sender with the coil *f*. By showing part of the conductors *r* in dotted lines it is intended to indicate that the sender *p* may be at a great distance from the coil *f*. When the coil *f* is currentless, cathode rays will go from the cathode *b* at right angles to the surface of the rod, *i. e.* radially, to the wall of the tube, as shown in Fig. 1ᵃ. In this figure *a* designates the tube, *b* the cathode rod and *k* the cathode rays. If, on the contrary, a current traverses the coil *f*, the cathode rays are deflected and arranged curved around the cathode rod *b*, as shown in Fig. 1ᵇ. When the field of the coil *f* is increased still more, the cathode rays no longer arrive at the wall of the tube at all, but are caused to arrange themselves in circles about the cathode, as represented in Fig. 1ᶜ. As soon as the cathode rays are curved, the intensity of the total luminous discharge is simultaneously changed. To what this is due, is very difficult to determine; probably it is due to the cathode rays traversing within the tube a longer path in consequence of their being curved around the rod so that the gas in the tube is consequently more highly ironized, whereby an increase of strength of the total luminous discharge is caused. To every change of current in the coil f there corresponds, therefore, a certain change of current in the luminous discharge maintained by the source of current c. Now it has been found that the sensitiveness of this arrangement is very variable, according to the strength for the time being of the magnetic field influencing the cathode rays, or in other words, according in each instance to the form which the cathode rays assume in the tube. Indeed, when fields of variable, gradually increasing intensity are employed, ranges of variable sensitiveness can be found. Therefore, in order to obtain as favorable sensitiveness as possible, it is preferable to arrange in addition to the coil f, which is traversed by the primary current, an auxiliary coil concentric with the coil f, said auxiliary coil being fed by an auxiliary source of current. I then regulate the current in the auxiliary coil, for example by a series resistance, in such manner that as great sensitiveness of the apparatus as possible is obtained. Fig. 2 shows such an arrangement. In addition to the means shown in Fig. 1, I provide the auxiliary coil g, the source of current m and a variable resistance n. When the current in the auxiliary coil is varied by varying the resistance, it is found that between the magnetic field of the auxiliary coil determined by the number of ampere turns per centimeter length of the coil and the luminous discharge in the tube there exists a relation represented by the curve in Fig. 3. It is seen from this curve that the strength i of the luminous discharge is very small as long as the number of ampere turns per centimeter length of coil equals zero, *i. e.* as long as no current traverses the auxiliary coil. As the current in the auxiliary coil increases, the luminous discharge at first increases very slowly, then very rapidly between the points x_1 and x_2, and then slowly again after the point x_2. The part of the curve which rises very rapidly represents the range of greatest sensitiveness of the tube. If the tube is adjusted to this sensitiveness by regulating the current in the auxiliary coil, to small changes of energy in the primary curcuit there will correspond very large changes of energy in the secondary circuit, as will be readily understood from Fig. 3.

The above described arrangements have the defect that their action is somewhat impaired by the sluggishness of the operations at the anode. This defect is particularly noticeable when periodical changes of energy of very high frequency occur. Now this defect can be avoided by dividing the current supplied by the secondary source of current c to the negative pole into two portions and conducting them to two cathodes, as represented in Fig. 4. Each of the two cathodes b_1, b_2 is coaxially or concentrically surrounded by coils f_1, f_2 fed by the primary source of current p. g_1 and g_2 are two auxiliary coils for regulating the sensitiveness of the apparatus. m designates the source of current and n the variable resistance. The coils f_1, g_1 and f_2, g_2 are so connected that the magnetic fields of the two appertaining coils are added together on the one side, whereas one is subtracted from the other on the other side, so that when the field on the one side is weakened the field on the other side is correspondingly strengthened. This can be brought about in a simple manner by, *e. g.* winding the coils f_1, g_1 and f_2 in the same direction and the coil g_2 in the opposite direction. The consequence is that the undivided current at the anode d flows, when the change of energy takes place in the primary circuit, in one direction mostly by way of the one cathode, for example by way of the cathode b_1 and the conductor e_1, but, on the contrary, when the change of current in the primary circuit takes place, in the other direction by way of the other cathode, *i. e.* by way of the cathode b_2 and the conductor e_2. The transference of the luminous discharge from the one cathode to the other takes place in this arrangement with exceedingly great rapidity, so that this arrangement is very particularly suitable for transmitting high-frequency currents. In this arrangement the receiving apparatus is not directly connected in the secondary circuit, but two transformer coils h_1 and h_2 influencing a secondary coil t, in whose circuit the receiving apparatus s is interpolated, are interposed in the secondary circuit. In order to avoid losses of energy and to bring the anode quite into the range of the highly ionized gases surrounding the cathodes so that absolutely no parts of the luminous discharge having appreciable inertia can arrive, I preferably form the anode in such manner that it surrounds the cathode like a tube, as represented in Figs. 5, 5a, 5b and 6. In these arrangements the anode most simply consists of a metallic coating on the inside of the tube. In Fig. 5a two tubes a_1, and a_2 are employed having the cathodes b_1, b_2 and the anodes d_1, d_2. The connecting branch or tube c between the tubes is for equalizing the pressure of the gases in the tubes. In order to avoid a damping action, particularly in the case of high frequency currents, the anode is slit longitudinally, as shown in Figs. 5b and 6. Obviously, the reverse arrangement may be made when the cathode will concentrically surround the anode, as will be readily understood, this arrangement being most simply brought about by connecting the positive pole to the former cathode and the negative pole to the former anode. As it is advantageous to make the strength of cur rent in the tube as great as possible and thereby to obtain great changes in the strength of the luminous discharge, I may enlarge the superficial area of the cathode for this purpose by, for example, making it stellar as shown in Fig. 6.

Fig. 7 shows an arrangement in which the receiving apparatus *s* is connected in parallel to the secondary, high-tension circuit. a_1 and a_2 designate two connected tubes similar to those shown in Fig. 5ᵃ. A choking coil u_3, a battery *c* and a resistance *v* are connected to the tubular anodes d_1 and d_2. The conductors e_1, e_2 connected to the resistance *v*, go by way of the choking coils u_1, u_2 to the cathodes b_1, b_2. The receiving apparatus *s*, comprising *e. g.* a telephone actuated by alternating current, is connected in parallel with this circuit condensers w_1, w_2 being interpolated in the circuit of the receiving apparatus. Owing to the symmetrical arrangement of the apparatus fluctuations in the primary source of current are not transmitted to the receiving apparatus because they are kept back by the choking coils. In addition, owing to the parallel connection of the two luminous discharge tubes like changes in strength of the working tension in the two tubes are caused to take place simultaneously, whereby fluctuations of current in the receiving apparatus are likewise prevented. Therefore, a dynamo may be used as the primary source of current instead of the battery *c*.

Fig. 8 diagrammatically shows the invention as applied to radiotelegraphy. An antenna *z* is connected to earth by way of a choking coil *y*. The fluctuations of current in the choking coil are taken up by the coil *r* and sent into the coil *f* wound around the tube *a* having the cathode *b*. A receiving apparatus *s*, *e. g.* a detector, which reproduces fluctuations of current increased corresponding to the changes of the primary current is interposed in the secondary circuit.

I claim:—

1. In means for producing large changes of energy in dependence on small changes of energy, the combination, with a secondary circuit comprising a source of current, and a vacuum tube, of a receiver operatively connected with said circuit, a primary circuit comprising a coil wound around said tube concentrically with the cathode, and means for causing a current to flow in the primary circuit.

2. In means for producing large changes of energy in dependence on small changes of energy, the combination, with a secondary circuit comprising a source of current, and a vacuum tube, of a receiver operatively connected with said circuit, a primary circuit comprising a coil wound around said tube concentrically with the cathode, and means for causing a current to flow in the primary circuit; an auxiliary coil concentric or approximately concentric with the former coil, and means comprising an adjustable resistance for energizing the auxiliary coil.

3. In means for producing large changes of energy in dependence on small changes of energy, the combination of a secondary circuit comprising a vacuum tube having two rod-shaped cathodes and at least one anode arranged symmetrically relatively thereto, a source of current having one pole connected to said anode, and conductors connecting the other pole of the source of current to the cathodes; a primary circuit comprising a source of current and a coil concentric with each cathode; receiving apparatus operatively connected with the secondary circuit; and an auxiliary circuit comprising a source of current, a variable resistance and an auxiliary coil concentric with each cathode.

4. In means for producing large changes of energy in dependence on small changes of energy, the combination of a secondary circuit comprising a vacuum tube having two rod-shaped cathodes and at least one anode arranged symmetrically relatively thereto, a source of current having one pole connected to said anode, and conductors connecting the other pole of the source of current to the cathodes; a primary circuit comprising a source of current and a coil concentric with each cathode; receiving apparatus indirectly operatively connected with the secondary circuit; and an auxiliary circuit comprising a source of current, a variable resistance and an auxiliary coil concentric with each cathode.

5. In means for producing large changes of energy in dependence on small changes of energy, the combination of a secondary circuit comprising a vacuum tube having two rod-shaped cathodes and at least one anode arranged symmetrically relatively thereto, a source of current having one pole connected to said anode, and conductors connecting the other pole of the source of current to the cathodes; a primary circuit comprising a source of current and a coil concentric with each cathode; receiving apparatus operatively connected with the secondary circuit; and an auxiliary circuit comprising a source of current, a variable resistance and an auxiliary coil concentric with each cathode, the coils in the primary circuit around the cathodes and one auxiliary coil being wound in one direction and the other auxiliary coil being wound in the other direction.

6. In means for producing large changes of energy in dependence on small changes of energy, the combination of a secondary circuit comprising a vacuum tube having two

rod-shaped cathodes and at least one anode arranged symmetrically relatively thereto, a source of current having one pole connected to said anode, and conductors connecting the other pole of the source of current to the cathodes; a primary circuit comprising a source of current and a coil concentric with each cathode; a circuit comprising a receiver and a condenser on each side thereof connected in shunt with the secondary circuit; and a choking coil interpolated in each of said conductors connecting the cathodes with the source of current in the secondary circuit; and an auxiliary circuit comprising a source of current, a variable resistance and an auxiliary coil concentric with each cathode.

7. In means for producing large changes of energy in dependence on small changes of energy, the combination, with a secondary circuit comprising a source of current, and a vacuum tube having at least one rod-like cathode and a tubular anode surrounding the latter, of a receiver operatively connected with said circuit, a primary circuit comprising a coil wound around said tube concentrically with said cathode, and means for causing a current to flow in the primary circuit.

In testimony whereof I have signed my name to this specification in the presence of two witnesses.

HANS GERDIEN.

Witnesses:
HENRY HASPER,
WOLDEMAR HAUPT.