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METHOD OF AND MEANS FOR CONTROLLING ELECTRICAL ENERGY.

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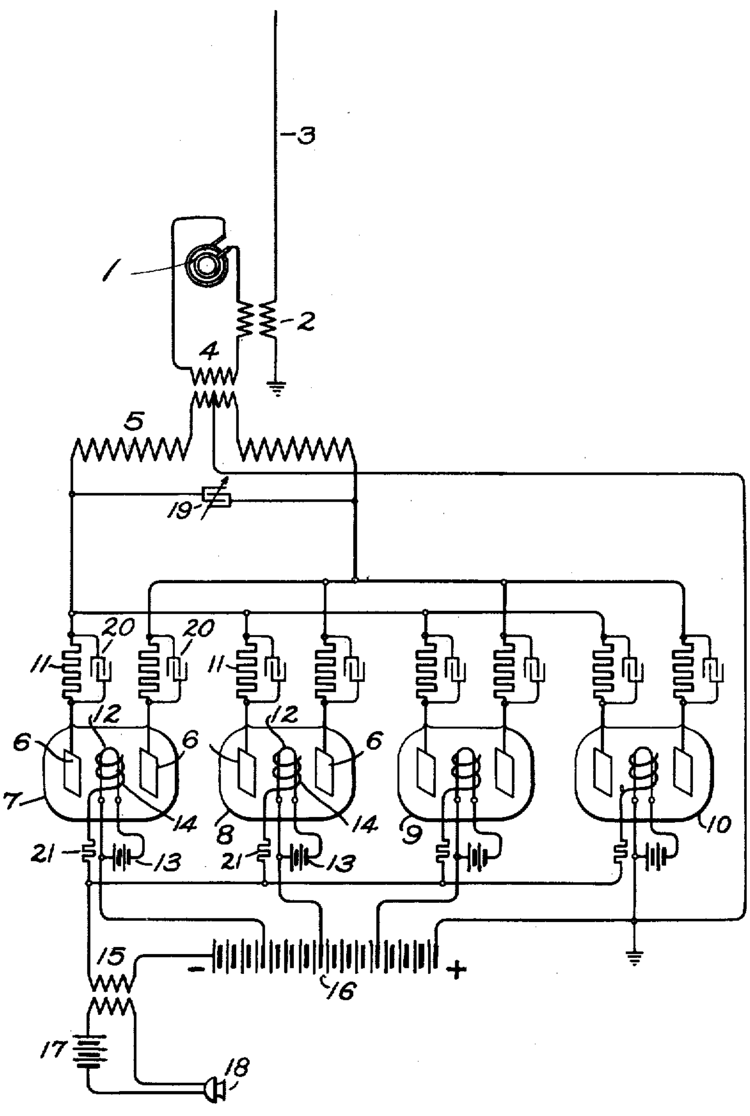

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UNITED STATES PATENT OFFICE.

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METHOD OF AND MEANS FOR CONTROLLING ELECTRICAL ENERGY.

1,340,101. Specification of Letters Patent. **Patented May 11, 1920.**

Application filed June 15, 1914, Serial No. 845,115. Renewed September 24, 1919. Serial No. 325,969.

To all whom it may concern:

Be it known that I, Ernst F. W. Alexanderson, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Methods of and Means for Controlling Electrical Energy, of which the following is a specification.

My present invention relates to a method of and means for controlling electrical energy and more particularly to the control of energy used for transmitting signals through space. While in the description which follows I have illustrated its utility when applied to wireless telephony, it is capable of use for other purposes as well.

In a copending application, Serial No. 835,433, filed April 30, 1914, I have described and claimed a system of wireless signaling in which a comparatively large amount of energy may be controlled by means of the feeble current set up in an ordinary telephone transmitter. In this case the amount of energy transmitted to the antenna from a local source of high frequency current is varied by means of a relay or electron discharge device which is controlled by the current from a telephone transmitter in such a way as to vary its conductivity. With this arrangement, in order to produce the desired variation in the antenna current, it is necessary that a considerable amount of the total energy of the local source shall be absorbed in the relay circuit. In all of the modifications shown in my prior application the greater part of the energy is absorbed in the relay itself. Hence the amount of energy which may be effectively communicated to the antenna is limited by the absorptive capacity of the relay used. At the present time this capacity is limited by difficulties which appear to be inherent in the manufacture of apparatus of this type.

The energy which may be controlled in such a system might be increased by connecting several relays in parallel, in which case the amount which could be controlled would vary directly as the number of relays used. By connecting the relays in parallel with resistance in series therewith according to my invention however the amount of energy which can be controlled will vary substantially as the square of the number of relays used.

My invention will best be understood by reference to the following description taken in connection with the accompanying drawing in which I have shown diagrammatically a system of connections whereby the desired result may be accomplished. As here indicated a source of high frequency energy 1 is connected through the usual transformer 2 with the antenna 3. The primary 4 of an oscillation transformer is also connected in series with the source 1 and the primary of transformer 2. The terminals of the secondary 5 of the oscillation transformer are connected to the anodes 6 of a series of electron discharge devices or relays 7, 8, 9, 10 through resistances 11 as shown. These relays also comprise filamentary cathodes 12 with local sources of current 13 for heating the same. The cathodes are surrounded by grid-shaped conducting bodies 14. The grids are all connected to one terminal of the secondary of transformer 15, to the other terminal of which is connected a battery 16 and the cathodes are connected to various points in the battery. One end of the battery is preferably grounded as shown. The primary circuit of transformer 15 includes a source of direct current 17 and a telephone transmitter 18. The cathodes are also connected to the middle point of the secondary 5 of the oscillation transformer. An adjustable condenser 19 is preferably connected across the terminals of the secondary of the oscillation transformer 5, although in some cases the capacity of the relays may be great enough so that this will not be required.

With the arrangement here shown it will be seen that the current in the antenna will vary in accordance with the current through the primary 4 of the oscillation transformer. The amplitude of the current in the primary 4 will in turn depend upon the current flowing in the secondary circuit. It will be apparent that a certain proportion of the energy from the source 1 will be diverted to the secondary circuit and absorbed in the resistances and the relay devices therein. The system may be so designed and adjusted that the energy thus absorbed will in general bear a certain ratio to the total amount of energy derived from the source 1, hence by varying the amount of energy absorbed in the secondary circuit the amplitude of the antenna current will be varied in substantially the same proportion.

The relays used may assume a great variety of forms. In the form of relay indicated in the present case there will normally be a flow of negative electricity from the cathode to the anodes but no flow of current in the opposite direction. The amplitude of the current flow through the relay may be varied by varying the potential impressed upon the grids 14. If a large enough negative potential is impressed thereon the flow of current may be stopped altogether. If a positive potential is impressed upon the grids the current flow will be increased. For convenience of description let it be assumed that the potential of the grid 14 is such that little or no current will flow through the relay 7 when the high frequency potential of the secondary 5 of the oscillation transformer is applied to the electrodes. The negative potential of the grids of the relays 8, 9 and 10 with respect to their cathodes will be progressively greater. If now a current wave is produced in the transformer 15 of such a direction as to overcome the negative potential of the grids 14, current will begin to flow first through the relay 7 and will gradually increase to a maximum value. If the potential of the current wave is great enough it will gradually overcome the negative potential of all of the grids and current will begin to flow successively in relays 8, 9 and 10. It will of course be understood that when the voltage impressed upon the grids from the transformer 15 begins to decrease the reverse action will take place, that is, current will cease to flow first in relay 10, next in relay 9 and so on until the impressed potential falls to zero and no current will flow as in the begining. The relays may be so designed and the potentials applied thereto so chosen that when the current in relay 7 reaches its maximum, current will begin to flow in relay 8 and when the current in relay 8 reaches its maximum, current will begin to flow in relay 9 and so on.

Relay devices of the general type shown herein vary somewhat in their characteristics and in some cases the proportionality between the current flow and the voltage impressed upon the grid is constant only over a somewhat limited range. In such cases it may be desirable to so choose the potentials applied to the grids that before the current in one relay has reached its maximum, current will begin to build up in the next relay and so on. In this way the system may be so designed that the current flow therein will be substantially proportional to the voltage variation in the transformer 15 throughout the entire range.

When current first begins to flow in the relay circuit the greater part of the drop in potential will occur in the relay itself and hence the relay will be called upon to absorb most of the energy of the secondary circuit. As the current increases however the drop through the resistances 11 will increase and the proportionate amount of energy absorbed by the relay will decrease. The maximum energy which the relay will be required to absorb will be when the current has reached one-half of its maximum value and the relay is consuming one-half of the voltage. When the current reaches its maximum value in the relay the amount of energy which the relay will be required to absorb will be practically negligible, the principal drop being in the resistance.

Suppose, for example, that it is desired to control in the secondary circuit a maximum of 10 kilowatts of energy which may be represented by .5 ampere at 20,000 volts. If we do this with a single relay and secure a gradual regulation of the energy from no load to full load, the relay will be called on to consume a maximum of .25 ampere at 10,000 volts or 2.5 kilowatts. It will also be required to absorb energy during the entire period during which the change from minimum to a maximum takes place.

Suppose now it is desired to control a maximum of 160 kilowatts of energy which is represented by 8 amperes at 20,000 volts. If we use four relays as indicated in the drawing each relay will be called upon to take 2 amperes. The maximum amount of energy which any one relay will be called upon to absorb will be 1 ampere at 10,000 volts or 10 kilowatts. The change from minimum to maximum in each relay however will occur in one-quarter of the time required in the case where a single relay was used. Hence the average amount of energy absorbed will be only one-quarter of 10 or 2.5 kilowatts. Thus it will be seen that four relays of the same capacity will be able to control 16 times as much energy as the single relay.

In the type of relay here shown there is an appreciable capacity between the anodes. This results in considerable current flowing through the relay between the anodes when the system is not being used for transmitting signals. As a result a large amount of energy is needlessly wasted in the resistances 11. In order to avoid this it may be desirable to shunt each of these resistances by a condenser 20. This will cut down the high frequency alternating current but will not interfere with the unidirectional flow of current through the relay between the cathode and anodes. It will of course be understood that the resistance 11 may equally well be inserted in series with the cathode instead of in series with the anodes.

In order to prevent the grids 14 from consuming an unnecessary amount of current when they become highly positive, resistances 21 may be inserted in series therewith.

While in the preceding description I have described the application of my system with high vacuum relays which are especially adapted for use with high voltages and low currents, my invention is by no means limited to use with this type of relay. It is equally applicable with relays adapted for lower voltages and larger currents and in which there are appreciable amounts of gas or vapor present.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. The method of varying the amplitude of the current flow in a circuit comprising a plurality of parallel paths, each of which contains a relay device, which consists in gradually varying the conductivity of each one of the paths in succession by varying the electrical field of the relay device therein.

2. The method of varying the amplitude of the current flow in a circuit comprising a plurality of parallel paths each of which contains a resistance and a relay device, which consists in gradually varying the conductivity of each one of the paths in succession by varying the electrical field of the relay device therein.

3. The method of varying the amplitude of the current flow in a circuit which comprises a plurality of parallel paths each of which contains a relay device, which consists in gradually varying the conductivity of each one of the relay devices in succession.

4. The method of transmitting signals by varying the amplitude of the current flow in a circuit which comprises a plurality of parallel paths, which consists in gradually varying the conductivity of each one of the paths in succession between minimum and maximum values and maintaining the maximum value in at least one of the paths while varying the conductivity of the others.

5. The method of varying, in accordance with signals to be transmitted, the amplitude of current low in an antenna having a source of energy connected thereto, which consists in diverting a certain proportion of the energy from said source through a circuit containing a plurality of parallel paths and gradually varying the conductivity of each one of said paths in succession in accordance with the signals to be transmitted.

6. The method of varying the amplitude of current flow in an antenna having a source of energy connected thereto, which consists in diverting a certain proportion of energy from said source through a circuit containing a plurality of parallel paths and gradually varying the conductivity of each one of said paths in succession.

7. The method of varying the flow of current in a circuit connected to a source of energy and having a series of relay devices connected thereto in parallel, which consists in so varying the electrical field in the relay devices that the current flow therein will vary successively in the entire series from a minimum to a maximum.

8. The combination in a wireless signaling system of a source of high frequency electrical energy, an oscillation transformer in series therewith, a plurality of relay devices connected in parallel to the secondary of said transformer and means for varying the electrical field in said relay devices to successively vary the current flow therethrough from a minimum to a maximum.

9. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, a relay device in each of said parallel paths and means for varying the conductivity of each of said paths in succession.

10. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, a relay device in each of said parallel paths, and means for successively varying the electrical field in each of said relay devices in accordance with the signals to be transmitted.

11. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, and means for varying the conductivity of each of said paths in succession in accordance with the signals to be transmitted.

12. The combination in a wireless signaling system of an antenna, a source of energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of energy from said source, a relay device comprising a plurality of electrodes in each of said parallel paths, a conducting body interposed between the electrodes in each of said relay devices, means for normally impressing a different potential upon each of said conducting bodies, and means for varying the potential impressed upon said conducting bodies.

13. The combination in a wireless signaling system of an antenna, a source of high frequency electrical energy connected thereto, a secondary circuit comprising a plurality of parallel paths for diverting a certain proportion of the energy from said source, a relay device comprising a plurality of

electrodes in each of said parallel paths, a conducting body interposed between the electrodes of each of said relay devices, and means for successively varying the potential of said conducting bodies in such a way as to successively vary the current flow through said relay devices from a minimum to a maximum.

14. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto comprising a plurality of parallel paths each of which contains a relay device, and means for gradually varying the conductivity of each one of the relay devices in succession.

15. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto comprising a plurality of parallel paths each of which contains an electron discharge device, and means for varying the conductivity of each one of said electron discharge devices in succession.

16. The combination in a high frequency signaling system of a signaling circuit, a source of high frequency energy connected thereto, a secondary circuit for diverting a portion of the energy from said source, a relay device in said circuit for varying the amount of energy diverted and a resistance in series with said relay device for absorbing a portion of the energy diverted.

17. The combination in a high frequency signaling system of a signaling circuit, a source of high frequency energy connected thereto, a secondary circuit for diverting a portion of the energy from said source, a relay device comprising a plurality of electrodes interposed in said secondary circuit, a conducting body interposed between the electrodes of said relay, means for impressing a variable potential upon said conducting body to vary the amount of energy diverted from said source and a resistance in series with said relay device for absorbing a portion of the energy diverted.

18. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto for diverting a variable amount of energy from said source, an electron discharge device in said circuit, means for varying the conductivity of said electron discharge device to vary the amount of energy diverted and a resistance in series with said electron discharge device for absorbing a portion of the energy diverted.

19. The combination in an electrical distribution system of a source of high frequency alternating current, a circuit connected thereto comprising a plurality of parallel paths each of which contains an electron discharge device, means for varying the conductivity of each one of said electron discharge devices in succession and resistances in series with said electron discharge devices for absorbing a portion of the energy in the circuit.

20. Means for controlling the flow of high frequency alternating current in a circuit comprising a plurality of parallel paths comprising a relay device having a cathode and an anode in each of said paths, a current controlling member interposed between said cathode and anode in each of said devices, for gradually varying the current flow therethrough, means for impressing a variable potential upon said controlling members and resistances in series with said relay devices for absorbing a portion of the energy in the circuit.

In witness whereof I have hereunto set my hand this 12th day of June, 1914.

ERNST F. W. ALEXANDERSON.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.

Correction in Letters Patent No. 1,340,101.

It is hereby certified that in Letters Patent No. 1,340,101, granted May 11, 1920, upon the application of Ernst F. W. Alexanderson, of Schenectady, New York, for an improvement in "Methods of and Means for Controlling Electrical Energy," an error appears in the printed specification requiring correction as follows: Page 3, line 49, claim 5, for the word "low" read *flow;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of July, A. D., 1920.

[SEAL.]

M. H. COULSTON,
Acting Commissioner of Patents.

Cl. 250—6.