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SIGNALING

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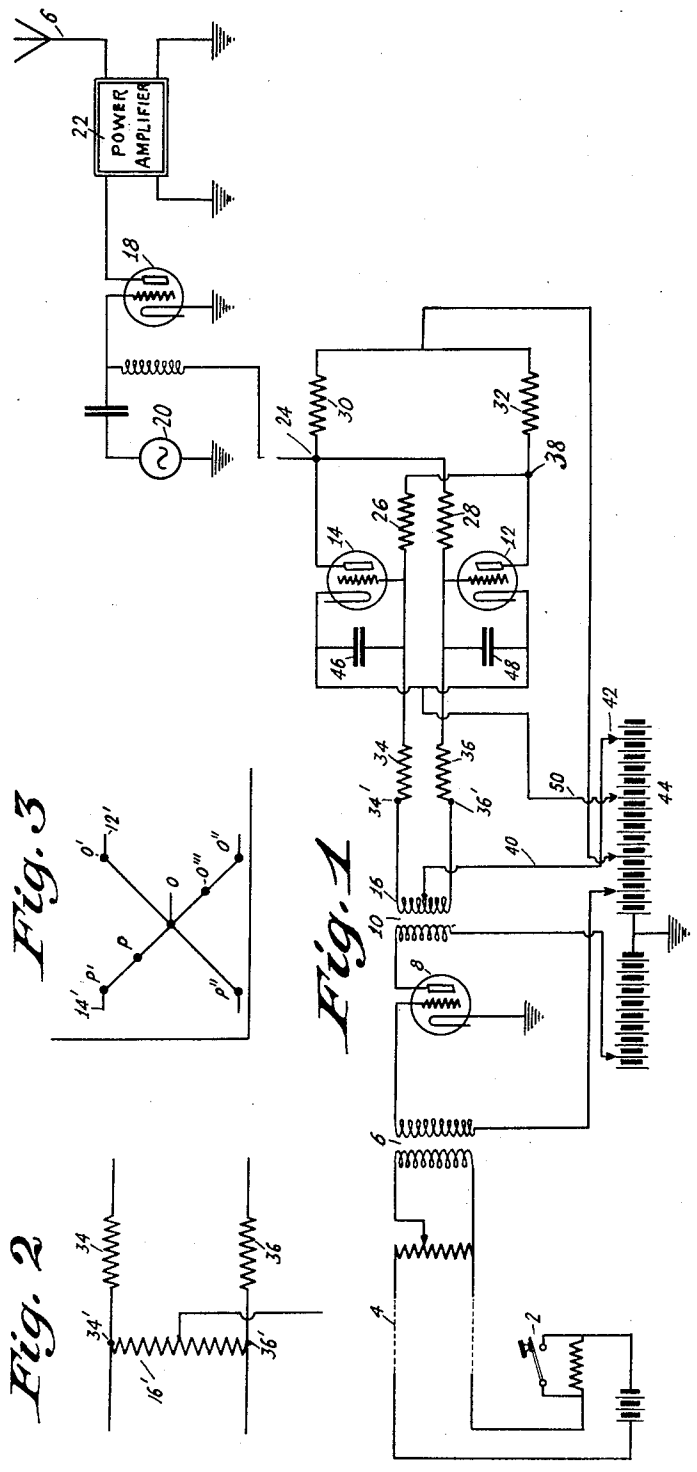

Fig. 1

Fig. 3

Fig. 2

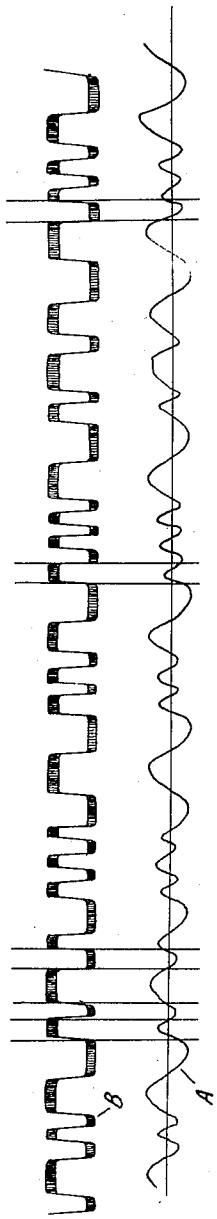

Fig. 4

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SIGNALING

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This invention deals with keying and has for one of its objects the provision of a new and useful method and means for code signaling.

Heretofore relaying or repeating of signals over, for example wire lines, or for the controlling of a radio transmitter, has been accomplished by the use of mechanical relays. Such relays are objectionable in that, because of the inertia of the various moving parts, the speed of signaling is limited; and, with this in view, another object of my invention is to increase the speed of signaling and this I do by avoiding the use of mechanical relays and providing a practically instantaneously acting inertialess relay.

Still another object of my invention is to improve the transmitting or relaying of signals regardless of poor form of signal control waves.

As already indicated to some degree, the accomplishment of the foregoing objects involves, according to my invention, the use of a practically instantaneously acting electrical relay. The relay which I provide, according to this invention, includes a plurality of electron discharge devices so coupled that they present two positions, conditions, or degrees of electrical stability, the conditions of stability being upset only by control signal energy of predetermined values. This relay or device having the two degrees of electrical stability necessitates the use of at least two electron discharge devices so connected that when one is blocking the other is conducting, or the reverse, the change being made by control signal energy. The effects of the changes in electrical stability are then caused to affect the flow in repeater apparatus, of a working current, for example, the flow of energy in the antenna of a radio transmitter.

In order to cause the electron discharge devices to operate in the manner described it is necessary to interconnect the control electrodes and anodes thereof. To prevent the application of anode potentials to the control electrodes or grids, it is possible, of course, to insert batteries to oppose a portion of the anode potentials. However, such batteries would be "floating" and not only would the care and expense incident to their maintenance be objectionable; but, because of their floating position their capacities to ground would prove detrimental to good operation of my invention. Accordingly another object of my invention is to avoid the use of floating batteries and yet allow of desired connections. Briefly, I do this by purely resistively interconnecting the control electrodes and anodes of my device having two degrees of electrical stability.

Although this invention is readily applicable to straight relaying of signals over wire lines or cables, it is, as stated before, extremely advantageous for use in radio signaling where the energization of a radiating antenna, which broadly may be considered a repeater, is controlled by means of signal control currents sent over land lines. As the apparatus included in my invention may often be placed in close proximity to high frequency radiating apparatus, undesirable potentials may be built up upon the grids of the apparatus. Hence, still another object of my invention is to avoid building up, by virtue of ambient radio frequency fields, such potentials, and this I do by providing reactive paths for the grids of my apparatus to relieve them of potentials so built up.

My invention may best be understood both as to its structure and method of operation by referring to the accompanying drawing, which, of course, is given by way of example only, for, after understanding the operation thereof, many minor changes will readily suggest themselves to one skilled in the art, and accordingly, the invention is not to be limited thereby.

In the accompanying drawing, Figure 1 is a wiring diagram of a keying system for controlling the energization of a radiating antenna, or, in a broad sense, a repeater, the energization being varied by the rate of change of a signal control current.

Figure 2 indicates a group of electrical elements to be substituted for certain elements of Figure 1 to make the energization of the antenna depend upon a quantity of control current rather than rate of change thereof,

Figure 3 is a graph given for the explanation of a device having two degrees of electrical stability which forms part of the apparatus illustrated in Figure 1, and

Figure 4 is an oscillogram showing how well formed characters are transmitted by the use of my invention, even though the received wave is of poor form.

Turning to Figure 1 I have illustrated at 2, diagrammatically, a keying device for sending over a land line 4, control or signal currents. If necessary, of course, the control currents may be amplified as desired so as to be of proper strength at the transmitting station where they are to control the flow of a working current in antenna 6; or in other words, the energization thereof. The line 4 may be supplied with tone signals, but in that case, in order to carry out this invention, it would be necessary at the re-

ceiving end of the line to provide a rectifier for transforming the alternating tone signal into unidirectional energy.

The received control currents or signals are fed through transformer 6 into an amplifier 8 of any suitable number of stages.

From this arrangement, it will be clear that in the secondary 16 of the transformer 10 coupled to the output of amplifier 8, there will appear potentials of different algebraic sign, dependent, at given times, upon whether or not the current in line 4 is increasing or decreasing.

Coupled to the secondary of transformer 10 in a manner which will be more fully described hereinafter, are a plurality, in this case two, electron discharge devices 12, 14. These devices form part of my instantaneously acting electrical relay or device having two conditions of electrical stability. The electron devices or tubes 12, 14 are so connected that they are unstable when both are drawing current but stable when one is blocking and the other is conducting. The change from one condition of stable equilibrium to another or, for example, from the condition when 14 is blocking and 12 is conducting, to the condition when 14 is conducting and 12 blocking, or the reverse, is only possible by the presence of a suitable predetermined potential in the secondary 16 of transformer 10. From this it should be clear that the change from one condition of stable equilibrium to another is accomplished in the apparatus shown by a suitable rate of change of signal control current.

By coupling a low power amplifier 18 to the output circuit of one of the tubes 12, 14, presence of high frequency energy from source 20 in high power amplifier 22, and thus the presence of working current or energization of antenna or repeater 6 may be varied according to the flow of signal control current. This should be clear from the connections shown; for, when tube 14 is blocking, point 24 is at a relatively high potential allowing energy to be fed from generator 20 into the high power amplifier 22; whereas, when tube 14 is conducting, the potential at point 24 drops to such a point that amplifier 18 blocks, thereby preventing the presence of high frequency energy in high power amplifier 22.

As I have already indicated, my instantaneously acting electrical relay device having two conditions or degrees of electrical stability includes tubes 12 and 14. The control electrode or grid of tube 14 is connected through resistance 26 to the anode of tube 12; and similarly, the grid of tube 12 is connected through a resistance 28 to the anode of tube 14. Resistances 30 and 32 are merely anode impedances. In series with resistance 26 there is a resistance 34 and in series with resistance 28 there is a resistance 36, which resistances, together with secondary 16, form conductive paths from points 34' and 36' through conductor 40 to point 42 on the source of anode potential 44.

Because of the continuous current flowing in resistances 26, 28, 34 and 36, voltage drops occur thereacross and the grids of tubes 12 and 14 do not have imparted to them high anode potentials. Of course, the same result could be accomplished by replacing the resistances with batteries or sources of potential having polarities such as to give correct grid potentials. However, not only would these batteries require attention; but, because they would not have terminals connected directly to ground, they would prove detrimental to good operation because of capacity effects to ground. By the use of simple resistances these capacity effects are materially eliminated, thus fulfilling one of the objects of my invention, allowing of, incidentally, higher operation speeds.

Stray potentials built up upon the grids of tubes 12, 14 by ambient radio frequency fields are shunted to ground through capacities 46, 48 through conductor 50 and battery 44. It will be found that capacities can be used, for this purpose, with values so low that they will not materially affect keying speed.

As connected the characteristic grid potential plate current curves of tubes 12, 14 would be as shown in Figure 3 by curves 12', 14'. There may be a time when both tubes are drawing, because of their symmetrical connection, the same current, corresponding to point O of Figure 3. However, this point is one of unstable equilibrium; for, if there is a slight increase in current through tube 12, because of the additonal voltage drop across resistance 32, point 38 will decrease in potential causing tube 14 to become less conductive. When tube 14 becomes less conductive point 24 because of the lessened drop in potential across resistance 30, rises in potential causing an increased current to flow through tube 12. This action will continue until tube 12 operates at point O' and tube 14 at point O'' at which time tube 14 is blocking and tube 12 conducting. This corresponds to one position of stable equilibrium, and is reached, after point O is passed, practically instantaneously, for, the circuits are substantially reactionless.

In order to give rise to the other condition of stable equilibrium, namely, that wherein tube 14 is conducting and tube 12 blocking, it will be necessary to apply to the grid of tube 14 a potential sufficient to carry the operating points of the tubes beyond point O. This can be done, of course, by inducing in secondary 16 the necessary potential. If, for example, point O'' is not moved past point O but, say to some intermediate position such as O''', the device will not, because of the mode of connection thereof, move over to its other position of stable equilibrium; but, when the potential moving the operating point of tube 14 to O''' is removed, O''' will slide back to position O''.

When, however, a potential is applied or induced across secondary 16 such that point O'' is moved to some point such as P beyond point O, then the action referred to will take place in an opposite manner resulting in the other position of stable equilibrium where the operating point of tube 14 will be P' and of tube 12, P''. The potential to change the last mentioned condition of stable equilibrium of the two tubes to the one started with in this discussion, will be some potential which will, of course, move point P' or P'' past point O.

The necessary moving potential, as shown in Figure 1, by the choice of suitable constants for the electrical elements involved, may be made a predetermined value; and, as shown in Figure 1, the potential induced in 16 is dependent upon the rate of change of control current. However, matters may be made so that the moving potential can be caused by a quantity of control current rather than by a rate of change thereof. Thus, as shown in Figure 2, by inserting a resistance 16' in place of reactance 16, the change over from one position of stable equilibrium to another is made dependent upon the quantity of current flowing through resistance 16'. Points 34' and 36' for spacing would have

positive and negative polarities respectively; whereas, for marking they must have reversed polarities. Such a system, using quantity of current to initiate the change over, is more fully described in my United States Patent No. 1,844,950, issued February 16, 1932.

Because of the choice of resistive interconnecting elements for my device or relay having two degrees of stable equilibrium, the action, wherein one tube becomes conducting and the other blocking, occurs practically instantaneously, which, of course, is highly desirable.

The arrangement also offers another advantage in that the energization of the transmitter is made substantially independent of the wave form received, say, at point 6. In apparatus set up according to this invention, an oscillogram was taken of the control current at point 6 simultaneously with potential variations at point 24. Figure 4 is an exact copy of that oscillogram, and curve A thereof indicates the received line current and curve B potential variations at point 24. It is apparent that sudden and complete energization or deenergization of the antenna 6 was had despite the poor wave form of the received signal,—a highly desirable result.

To sum up the operation of the apparatus shown in Figure 1, when key 2 is depressed, by suitable arrangement of the intermediate apparatus, tube 14 is caused to block and tube 12 is caused to become conductive. This results in an increased potential at point 24 which increases the bias on the grid of tube 18 thereby allowing passage of high frequency energy from generator 20 to amplifier 22 and hence radiation from antenna or repeater 6. For spacing, when key 2 is opened, the decrease in line current causes a relatively reversed potential to be induced in secondary 16 whereby tube 12 becomes blocking and tube 14 conducting; and, because of the conductivity of tube 14, point 24 is decreased in potential to such an extent that tube 18 blocks stopping radiation suddenly from antenna 6.

The electron discharge devices 14, 12 together with the resistance interconnecting their grids and anodes is, of course, a device having two degrees of electrical stability. The change over from one positon or degree of stability to the other is caused by the rate of change of current in reactance 16 of such a value to cause the operating points of the tubes to move past their point of unstable equilibrium.

I claim as my invention:

1. An electrical circuit comprising a pair of electron discharge devices, a resistance connecting the control electrode of one device to the anode of the other device, another resistance connecting the control electrode of the other device to the anode of said one device, a resistance in series with the anodes of each device, a source of anode potential, said source of potential and resistances being connected together at a common point, and, an inductance connected between the control electrodes of said devices and to the cathodes thereof for applying controlling potentials to the control electrodes of said devices.

2. In combination, a source of signaling current, a thermionic tube having its input electrodes coupled to said source and an inductance connected with its output electrodes, an inductance coupled to said last named inductance, a pair of thermionic tubes having their grid electrodes connected to the terminals of said inductance and their filaments connected to a point on said inductance, an output circuit including resistances connected between the anodes of said tubes, and a connection between the anode of each tube and the grid of the other tube.

3. In combination, a source of signaling current, a thermionic tube having its input circuit connected to said source, an inductance in the output circuit of said tube, a second inductance coupled to said first named inductance, a pair of thermionic relays having their control electrodes connected to the terminal of said last named inductance and their filaments connected to a point on said last named inductance, a pair of resistances connected between the output electrodes of said last named tubes, means for connecting a terminal of each of said resistances to a source of potential, and means for imparting two conditions of electrical stability to said tubes and associated circuits comprising a connection between the anode of each of said tubes and the grid of the other of said tubes.

4. An arrangement as claimed in claim 3 in which each of said last named connections includes a resistance.

5. An arrangement as claimed in claim 3 in which a resistance is inserted between the terminals of said inductance and the control electrodes of said tubes and in which a source of potential is inserted in the connection between a point on said inductance and the filaments of said tubes, and in which a resistance is inserted in each of the connections between the anode of each of said tubes and the control electrode of the other of said tubes.

6. Signaling means comprising a source of high frequency oscillations, a source of signaling potentials, means for converting said signaling potentials into electrical currents the polarity of which changes, and means for modulating said high frequency oscillations in accordance with the rate of change of polarity in said currents comprising, a thermionic relay tube having its input electrodes connected to said source of signaling potentials and its output electrodes connected with the primary winding of a transformer having a secondary winding, a pair of thermionic tubes having their control grid electrodes connected by way of resistances to the terminals of said secondary winding and their cathodes connected together and to a point intermediate the terminals of said secondary winding, a capacity connected between the control electrode and cathode of each of said last named tubes, a resistance connecting the anode of each of said tubes to the cathode of each of said tubes by way of a source of potential, a resistance connecting the anode of each of said tubes to the control grid of the other of said tubes, and a connection between the anode of one of said tubes and said source of high frequency oscillations.

7. In combination, a plurality of electron discharge devices, each having a cathode, a control electrode and an anode, a source of varying potentials, a transformer having its primary winding coupled to said source of varying potentials, the secondary winding of said transformer having one terminal connected to the control electrode of one of said tubes and the other terminal connected to the control electrode of the other of said tubes and a point intermediate its terminals connected to the cathodes of said tubes, resistances for interconnecting the control electrodes and anodes of said tubes, a continuous flow of current through the resistances preventing high anode potential from being applied from the anodes of said tubes

to the control electrodes of said tubes, and a reactance between the cathode and control electrode of each device for preventing the building up of relatively high potentials at the control electrodes by ambient radio frequency fields.

8. In combination, a source of signaling current, a thermionic tube having its input electrodes coupled to said source and an inductance connected with its output electrodes, an inductance coupled to said last named inductance, a pair of thermionic tubes having their grid electrodes connected to the terminals of said inductance and their filaments connected to a point on said inductance, an output circuit including resistances connected between the anodes of said tubes and to a source of anode potential, and a resistance connected between the anode of each tube and the grid of the other tube.

9. An electrical circuit having two degrees of electrical stability which comprises, a pair of thermionic tubes, each having anode, cathode and control grid electrodes, a pair of resistances connecting the anodes of said tubes together and to a source of charging potential, a work circuit connected with said resistances, a resistance connecting the anode of one tube to the grid of the other tube and the grid of the latter tube to the anode of said one tube, whereby an increase of current in the anode of one tube causes a decrease of current in the anode of the other tube and vice versa, an inductance having one terminal connected to the control grid of one tube and the other terminal connected to the control grid of the other tube and a point intermediate its terminals connected to the cathodes of said tubes, and means for applying alernating current potentials to said inductance to produce current flows therein, the polarity of the rate of change of which determines the bias of the control electrodes of said tubes and thereby the state of electrical stability taken by said system.

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