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REMOTE-CONTROL SYSTEM

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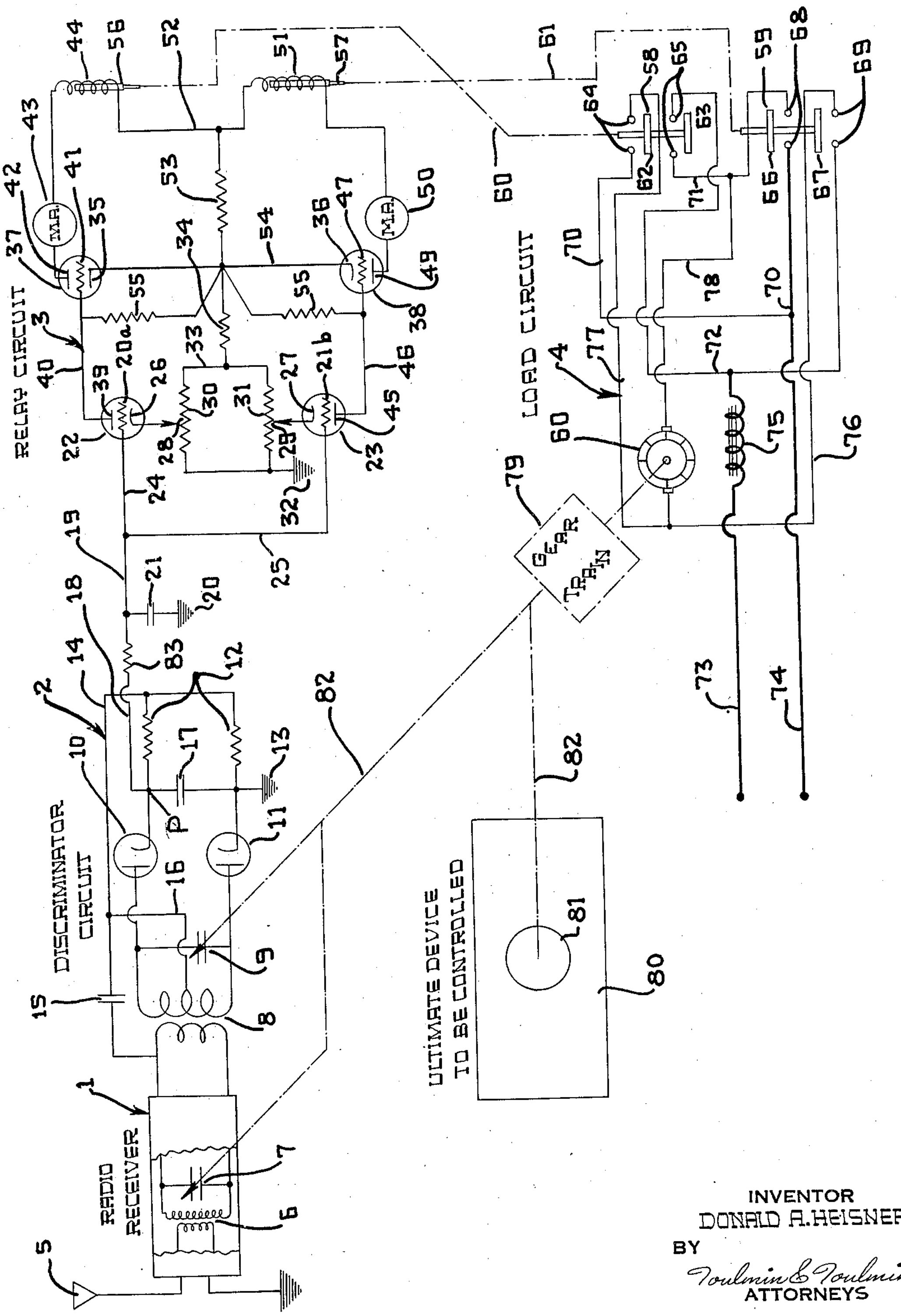

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REMOTE-CONTROL SYSTEM

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The present invention relates to control apparatus, more particularly to radio and wired systems for controlling the movement of a device positioned at a considerable distance from the controlling or transmitting position.

In the electrical control art there is a definite need for an electrical system or apparatus which can positively control other apparatus through a wired or radio link. For example, in automatic sub-stations which are usually run without an attendant it may be necessary to operate certain switches to start and stop electrical apparatus and controlled from a master station many miles away. Power rheostats may also be advantageously operated by an attendant at a remote position and in the art of robot airplanes, the rudder, elevator, ailerons and the motive power may be controlled from a transmitter located on the ground. It is sometimes desirable to simultaneously operate from a single control station a large number of electrical devices or appliances which are not only located a considerable distance from the master station but also long distances from one another. A radio system load provides many opportunities for remote control, as for example, when it is desired to adjust variable condensers contained in a remotely positioned radio transmitter or receiver.

The primary object of the invention is to provide an improved system for controlling in a positive and direct manner one or more remotely positioned electrical devices or loads. Another object is to provide a control and a controlled system by which an angular movement initiated at the controlling station is reproduced at the controlled station which may be positioned many miles away.

Still another object is to provide apparatus which produces a simultaneous movement at a distant station corresponding to a certain movement of apparatus at the master or control station.

Another object is to provide apparatus by which to initiate and stop an electrical motor from a remote position spanned by a radio or wire link. Still another object is to provide apparatus for controlling a remotely positioned rotary device through either a radio or wire link and in which the rotary device can be stopped or required to take a predetermined position strictly in accordance with the final position of the controlling device at the transmitter station. The final object is to provide apparatus at a receiving station which will respond to impulses propagated through a wire or a radio link for operating parts of a radio device or other power-operated unit in forward and reverse directions without any appreciable over-run in either direction.

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The invention will be better understood when reference is made to the following description and the accompanying drawing which shows diagrammatically an improved receiving station in which the device to be controlled responds to radio impulses initiated at a distant transmitter station.

In general, the improved system comprises four units, electrically or electromagnetically connected together, the first unit being a radio receiver generally designated 1 feeding into a so-called discriminator circuit generally indicated at 2. The output of the latter circuit is received by direct current amplifier, generally designated 3 and having an output circuit in which there is a pair of electromagnetic actuators which constitute the third unit of the system. These actuators cause the operation of switches for initiating the rotary movement of electric motors or other source of power which is to be controlled from the transmitter or sending station. The motor unit is indicated by reference character 4.

Referring to these various units in order, the radio receiver 1 may comprise an impulse receiving conductor exemplified as an antenna 5. The received impulses pass through an input radio frequency transformer the secondary of which can be tuned by a variable condenser 7. The receiver may comprise any number of amplifier stages of the tuned radio frequency type. The output of the receiver as represented by the transformer 8 comprises radio frequency impulses derived from the carrier and these impulses are passed into the discriminator circuit 2. The latter consists of one or more tuned circuits as indicated by the variable condenser 9 which is adapted to produce resonance with the transformer secondary 8, and two or more rectifiers 10, 11 connected in parallel across the terminals of the transformer secondary. The rectifiers 10, 11 are preferably constituted of high vacuum diodes with the plates connected to the transformer 8 and the cathodes, which may be directly or indirectly heated, connected to an output resistance network indicated at 12. The extreme ends of the resistors 12 are grounded as indicated at 13 and there is a conductor 14 passing from the resistors through a fixed condenser 15 to the primary of the transformer. The mid-tap of the secondary of the transformer is electrically connected through a conductor 16 to the conductor 14. A by-pass condenser 17 is shunted across the two cathodes. Conductor 18 is taken from a tap positioned between the upper resistor 12 and the cathode 10 to an outgoing line 19, grounded at 20 through a fixed condenser 21.

The line 19 feeds the grids or control elements 20a, 21b of a pair of thermionic amplifiers 22, 23 through conductors 24, 25 respectively. The cathodes 26, 27 which may be directly or indirectly heated, are connected through adjustable taps 28, 29 to a pair of fixed resistors 30, 31. The latter are grounded at 32. The ungrounded ends of the resistors 30, 31 join together through a conductor 33 to which a resistor 34 is connected. This resistor leads to a pair of cathodes 35, 36, which may be directly or indirectly heated, and contained within amplifier tubes 37, 38. The plate 39 of the tube 22 is connected through a conductor 40 to a grid or control element 41 of the tube 37. The anode 42 of the said tube is connected through a current indicating device 43 to an electromagnetic actuator 44.

The anode 45 of the tube 23 is connected through a conductor 46 to the grid or control element 47 of the tube 38. The anode 49 of the last mentioned tube is taken through current indicating device 50 to an electromagnetic actutor 51. The inner terminals of the coils 54, 51 are connected together through a conductor 52, and a resistor 53 is connected between the conductor 52 and the cathode conductor 54. Gridleak resistors 55 may be connected between the grids 41, 47 and their respective cathodes.

The actuators 44, 51 have slidable armatures or cores 56, 57 respectively which are mechanically connected to the respective switch elements 58, 59 as indicated by the dot-dash lines 60, 61. These switches constitute part of the work or load circuit indicated at 4 which includes a D. C. motor indicated by the showing of its commutator-armature 60.

The switches 58, 59 may comprise any form of reversing switch mechanism so designed that when the armature or core 56 is pulled up into its solenoid, the motor 60 is rotated in one direction and when the armature core 57 is allowed to drop due to de-energization of its solenoid the motor is caused to rotate in the opposite direction. As shown, the switch 58 is provided with a pair of contact plates 62, 63 which are adapted to bridge the two pairs of terminals 64, 65 respectively.

The switch 59 is also provided with two pairs of plates 66, 67 which are adapted to bridge two pairs of terminals 68, 69 respectively. The left-hand terminal 64 is connected through a conductor 70 to the left-hand terminal 68 and the left-hand terminal 65 is electrically connected through a conductor 71 to the right-hand terminal 68. Conductor 72 connects the right-hand terminal 65 with the left-hand terminal 69. The power for the motor 60 is brought in through mains 73, 74 the latter being connected to the conductor 70 and therefore to the left-hand terminal 64, 68. The wire 73 is taken through a filter exemplified by a choke coil 75 to the conductor 72, thus being connected to the right-hand terminal 65 and the left-hand terminal 69. The right-hand terminal 69 is connected through a conductor 76 to one side of the motor 60 and this conductor extends through a conductor 77 to the right-hand terminal 64. The remaining side of the motor 60 is electrically connected through wire 78 to conductor 71 and is therefore connected to the left-hand terminal 65 and the right-hand terminal 68.

The motor 60 may be of the shunt field type. The armature is preferably geared through a train of gears indicated at 79 to the rotor of the condensers 7, 9 of the radio receiver 1 and discriminator circuit 2 respectively. Devices other than the variable condensers 7, 9 can be mechanically controlled by the motor 60 so that a device 80 having a rotary element 81 has been generically indicated to represent any and all of such devices. The rotary element 81 and the rotor of the condensers 7, 9 have been indicated as being mechanically connected to the motor 60, with or without the gear train 79, by means of dot-dash lines 82.

Operation

Let us assume that high frequency impulses are being received by the antenna 5 and after being amplified finally pass through the transformer 8. The discriminator circuit 2 will develop a positive voltage at the cathode of tube 10 (point P) when the incoming signal is off resonance to the tuned circuits 6, 7 and 8, 9 in one direction and a negative voltage at point P when the incoming signal is off resonance in the opposite direction. Any voltage which appears at the point P is fed through the filter circuit 83, 21 to the grids 20a, 21b which are the first stage amplifier tubes in the two stage D. C. amplifier circuit.

The cathode voltage of tube 22 is adjusted by means of the potentiometer 30 so that the tube draws sufficient current through resistor 55 to produce a grid-bias voltage on tube 37 which will effectively block current in the plate circuit of tube 37. The relay 44 will normally rest with its contacts open and there is no current in its winding which is in series with the plate of tube 37. The cathode voltage of tube 23 is adjusted at the potentiometer 31 in such a manner that no plate current flows in the tube and there is no grid-bias developed in resistor 55 for the grid 47 of the tube 38. A current of several milliamperes will therefore flow in the plate circuit of tube 38 and relay 51 which is in series with the circuit and the relay will normally be pulled up. Since the contacts of relay 59 are break contacts, the circuit through them will be open under this normal condition as shown in the drawings.

When a positive voltage appears at the point P, it will increase the plate current in tube 22 which will in turn increase the grid-bias in tube 37. Since there is no plate current flowing in tube 37, relay 44 will not be affected. The positive voltage applied to the grid of tube 23 will counteract the cathode voltage developed in resistor 31 and permit plate current to flow through the lower resistor 55. This current will produce a voltage drop which is applied to the grid of tube 38 to reduce or eliminate the plate current flowing through relay 51. This reduction or absence of plate current will allow relay 51 to drop, closing the motor circuit. The motor, through its geared train 79 will revolve the tuning controls at 7, 9 of the radio receiver and the discriminator circuit until the positive voltage at point P disappears because the circuits 6, 7 and 8, 9 have been made resonant to the incoming carrier.

If the carrier is off resonance in the opposite direction, a negative voltage will appear at point P. This negative voltage applied to the grid of tube 22 will reduce the current flowing through the upper resistor 55 and the bias applied to the grid 41. Reduced bias on tube 37 will result in current flowing through relay 44. The negative voltage applied to the grid of tube 23 will serve to decrease the possibility of current flow in the lower resistor 55 so that no bias will appear on tube 38 and relay 51 will remain in its normal position. With relay 44 operated, its contacts 64, 65 will close the motor circuit so that it will run in the opposite direction to that originally described.

A circuit for energizing the motor 60 in one direction can be traced from the conductor 73, choke coil 75, conductor 72, contacts 65, conductor 78, through the motor armature, conductor 77, contacts 64, conductor 70 back to the other side of the line 74. When the relay 44 is thus energized, voltage is applied to the motor 60 to cause the latter to run in one direction. When the relay 51 is de-energized, allowing the core 57 to drop, a circuit for the motor is established through main 74, terminals 68, conductor 78, through the motor (in the opposite direction from that traced immediately above), conductor 76, terminals 69, choke 75, back to the other side of the line 73.

As the motor 60 is moved in one or the other direction depending on the condition of the relays 44, 51, and its motion is transmitted through the mechanical links 79, 82 to the condensers 7, 9 or the rotary element 81, the result is that the motor 60 continues to operate in one direction or the other as long as positive or negative impulses appear at the point P. These impulses will disappear at the point P when the two circuits 6, 7 and 8, 9 are made resonant to the received carried and/or its detected frequency. The motor will therefore run continuously in a given direction in an attempt to bring these two circuits into resonance with the transmitter frequency. The motor can be reversed by shifting the transmitter frequency in the opposite direction and the only limit to the amount of movement at the motor is the tuning range of the radio receiver.

It is apparent that by using different gear ratios at 79 or different types of mechanical linkage, any conceivable type of mechanical control could be achieved in this manner. The motor 60 may be caused to operate power rheostats, variable condensers in remotely controlled radio transmitters or receivers, rotating or mechanical switches and circuit selecting devices. In the airplane field, the directional motion of a plane or an aero-bomb can be readily controlled by operating on the rudder, elevator or ailerons.

It is apparent that instead of coupling the motor 60 to a pair of variable condensers 7, 9 which serve to produce a state of resonance in the circuit and to cause the motor to stop, I may disconnect the motor from these condensers and employ fixed condensers. The operator at the transmitting station, knowing the resonance frequency of the circuits 6, 7 and 8, 9 would transmit a frequency out of resonance with these circuits, either above or below, causing the motor 60 to continuously rotate in one direction or the other. Thus work would be performed at the distant station, controlled by the operator at the transmitter. Even with a mechanical link between the motor 60 and the condensers 7, 9 a continuous operation of the motor could be obtained by continuously varying the frequency at the transmitter station so that the motor and its condensers can never catch up with the changing frequencies. Such a scheme has the advantage of not only initiating the operation of the motor 60 but also of determining the direction in which the motor shall run and when it shall stop.

There is little or no overrun to the motor 60 in either direction of movement because as the frequency resonance of the turns 6, 7 and 8, 9 approaches closer and closer the frequency of the received radio signals, the potential of the positive and negative impulses at point P become less and less. This in turn determines the duration of time over which the relays 44, 51 are energized and therefore determines precisely the time over which the motor 60 shall run and the precise moment that it shall stop. Thus, considerable accuracy can be obtained in the starting and stopping of a movement and the period of time over which such movement extends which factors may be very important in certain applications of the improved remote control system.

While I have illustrated my improved control system in connection with a radio station, this system could be operated equally well over a wired link in which the carrier frequencies are transmitted or guided by wire cables. However, the system lends itself particularly to the transmission of radio or ultra high frequencies, the upper range of which is determined solely by the electrical characteristics of the tubes 10, 11 and their ability to provide plus and minus polarity impulses at the point P when their input circuits are out of resonance with the incoming impulses.

It will be understood that I desire to comprehend within my invention such modifications as come within the scope of the claims and the invention.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. An electrical control system comprising a radio receiver, a frequency discriminating circuit connected thereto, a relay system including a pair of thermionic tubes A, B having input and output circuits, the respective output circuits containing individually operable electro-magnetic actuators, switching mechanism controlled by said actuators and a reversible load device operated in pre-determined directions by said mechanism, a pair of thermionic tubes C, D having grid and plate circuits, said grid circuits being connected in parallel to said discriminating circuit and said plate circuits being connected respectively to the input circuits of tubes A, B through biasing resistors whereby when potentials of different amounts appear across the grid circuits of tubes C, D, one of the tubes A, B will be rendered inoperative and the other operative to selectively cause the operation of the respective actuators and thereby control the operation of said load device.

2. An electrical control system comprising a radio receiver, a frequency discriminating circuit connected thereto, a variable condenser in said radio receiver, a relay system including a pair of thermionic tubes A, B having input and output circuits, the respective output circuits containing individually operable electro-magnetic actuators, switching mechanism controlled by said actuators, and a reversible load device operated at predetermined directions by said mechanism, said load device being mechanically connected to said condenser to tune the receiving circuit to the incoming frequency, a pair of thermionic tubes C, D having grid and plate circuits, said grid circuits being connected in parallel to said discriminating circuit and said plate circuits being connected

respectively to the input circuits of tubes A, B through biasing resistors, whereby when potentials of different polarities appear across the grid circuits of tubes C, D one of the tubes A, B will be rendered inoperative and the other operative to selectively cause the operation of the respective actuators and thereby control the direction of operation of said load device.

3. An electrical control system comprising a radio receiver, a tuning device therefor, a frequency discriminating circuit connected to said receiver and containing a tuning device, a relay system including a pair of thermionic tubes A, B having input and output circuits, the respective output circuits containing individually operable electro-magnetic actuators, switching mechanism controlled by said actuators, and a reversible load device operated in predetermined directions by said mechanism, a pair of thermionic tubes C, D having grid and plate circuits, said grid circuits being connected in parallel to said discriminating circuit and said plate circuit being connected respectively to the input circuits of tubes A, B through biasing resistors, whereby when potentials of different polarities appear across the grid circuits of tubes C, D, one of the tubes A, B will be rendered inoperative and the other operative to selectively cause the operation of the respective actuators and thereby control the direction of operation of said load device, and a mechanical connection between the last mentioned device and each of said tuning devices, whereby the radio receiver and the discriminating circuit are simultaneously tuned in resonance with the received frequency and the different polarities across the grid circuits of tubes C, D no longer appear so that the load device comes to rest.

4. An electrical control system comprising a radio receiver feeding into a frequency discriminating circuit, a relay circuit controlled by said discriminating circuit and a motor connected to said relay circuit, a tuning condenser in each of the radio receiver and frequency discriminating circuit and a mechanical connection between said motor and said tuning condensers for adjusting the condensers in accordance with the movements of said motor, and an electrical network interposed between the frequency discriminating circuit and the relay circuit, which network is selectively responsive to differences of potential that appear in the discriminating circuit in order to control the operation of the relay circuit and the direction of movement of the motor which, in turn, controls the direction of movement of the tuning condensers.

5. An electrical control sysetem comprising a radio receiver feeding into a frequency discriminating circuit, a relay circuit controlled by said discriminating circuit and a motor connected to said relay circuit, a tuning condenser in each of

the radio receiver and frequency discriminating circuit and a mechanical connection between said motor and said tuning condensers for adjusting the condensers in accordance with the movements of said motor, and an electrical network interposed between the frequency discriminating circuit and the relay circuit, which network is selectively responsive to differences of potential that appear in the discriminating circuit in order to control the operation of the relay circuit and the direction of movement of the motor which, in turn, controls the direction of movement of the tuning condensers, said electrical network including a pair of multi-electrode thermionic devices having grid and plate circuits connected in parallel to the frequency discriminating circuit and the plate circuits being connected in an opposed relation to the relay circuit.

6. An electrical control system comprising a radio receiver feeding into a frequency discriminating circuit, a relay circuit controlled by said discriminating circuit and a motor connected to said relay circuit, a tuning condenser in each of the radio receiver and frequency discriminating circuit and a mechanical connection between said motor and said tuning condensers for adjusting the condensers in accordance with the movements of said motor, and an electrical network interposed between the frequency discriminating circuit and the relay circuit, which network is selectively responsive to differences of potential that appear in the discriminating circuit in order to control the operation of the relay circuit and the direction of movement of the motor which, in turn, controls the direction of movement of the tuning condensers, said electrical network including a pair of multi-electrode thermionic devices having grid and plate circuits connected in parallel to the frequency discriminating circuit and the plate circuits being connected in an opposed relation to the relay circuit, said relay circuit including a pair of multi-electrode thermionic devices and a plurality of biasing resistors interposed between the two pair sets of multi-electrode devices.

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