

Nov. 16, 1948.

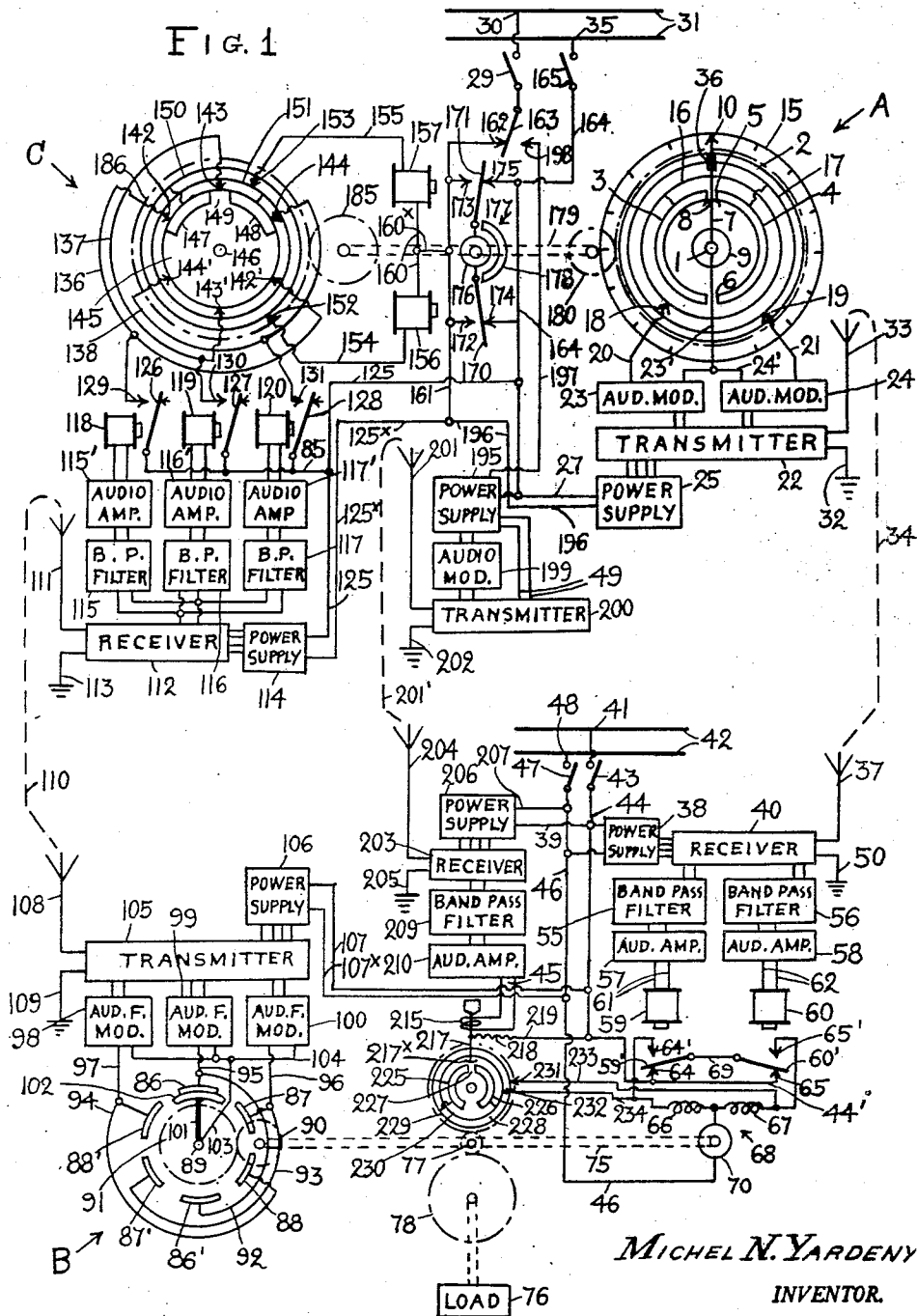
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2,454,022

RADIO REMOTE CONTROL APPARATUS

Filed Feb. 9, 1945

2 Sheets-Sheet 1



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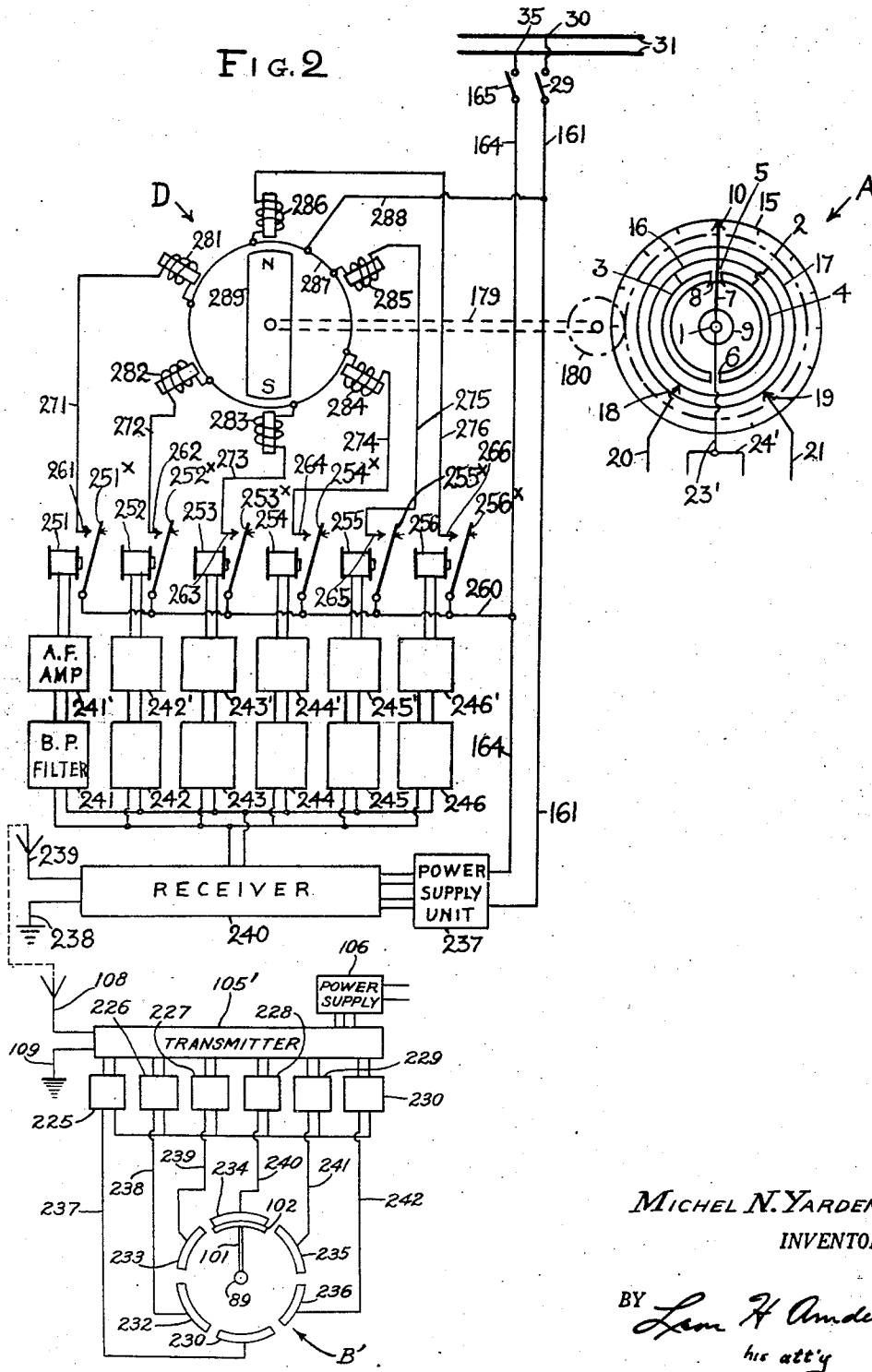
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FIG. 2



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RADIO REMOTE-CONTROL APPARATUS

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10 Claims. (Cl. 250—2)

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This invention relates to remote control systems for controlling or energizing from a control point, a motor located at a remote point to place an object or load at any desired position.

One of the principal objects of the invention is to provide a remote control system of the character described in which the link between the control point and the remote point shall be solely by radio waves. An allied object is to provide a remote control system by which the load at a remote point may be moved in correspondence with the movement of a control member at the control point, without the use of wires or other connecting medium other than the ether between the control and remote points. A further allied object is to provide a remote control system in which the load motor at the remote point is controlled by radio waves originating at a transmitter at the control point and under guidance of a selectively moved control member.

Another object of the invention is to provide a remote control system in which the said transmitter at the control point radiates two characteristically different radio waves, one for rotating the load motor at the remote point in one direction, and the other wave, for rotation in the opposite direction. An allied object is a remote control system in which the two said characteristically different radio waves differ in audio frequency.

Another object of the invention is to provide a remote control device in which the load motor at the remote point is controlled by radio waves originating at a primary control device at the control point, and in which the load motor, in turn, motivates a transmitter at the remote point to radiate radio waves (preferably characteristically different from the said motivating radio waves) which are sent back to the control point to energize instrumentalities for maintaining the movement of the primary control in precise correspondence of coordination with that of the load motor. An allied object is to provide a remote control system as just described in which the said characteristic difference between the motivating and coordinating radio waves resides in a predetermined difference in their radio frequency (so not to cause interference between the two types of radio radiations). Another allied object is to provide a remote control system as here described in which the said coordinating radio waves are varied or modulated in audio frequency with the changes in angular position of a member driven by the load motor, and the varying A. F. modulated waves received at the control point to turn

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an element of the primary control device in correspondence with the said load motor-driven member at the remote point.

Another object is to provide a remote control system as here described which in normal functioning transmits a motivating radio wave from the primary control device at the control point to the load motor at the remote point and transmits back to the control point a coordinating radio wave, but which system may be conditioned to transmit a zeroizing radio wave from the control to the remote point for the purpose of resetting or zeroizing the system to check any deviation of the parts of the system from true correspondence.

For the attainment of these and such other objects of invention as may appear or be pointed out herein I have shown an embodiment of my invention in the accompanying drawings, wherein:

Fig. 1 is a diagrammatic showing of the radio remote control system of this invention; and

Fig. 2 is a diagrammatic showing of a portion of the system of Fig. 1 in which the pilot motor and pilot motor control device are replaced by a single instrumentality.

The remote control apparatus according to the invention includes a primary control device (designated generally at A in Fig. 1) at a control point, comprising a pair of control members both rotatively mounted on a shaft 1. One of the pair of members is an insulated disc 2, which may have gear teeth on its periphery, and which mounts two metal conducting segments 3, 4 insulated from each other and separated by gaps 5, 6. The other member of the pair is a contact arm 7 provided with a contact 8 slidably engageable with individual ones of the segments 3, 4 and adapted to bridge gap 5 or 6 to engage both segments simultaneously. Arm 7 is provided with a knob 9 for manual operation and with a pointer 10 for indicating the position of the arm on a stationary scale 15. Disc 2 likewise may have a pointer or index mark 36 also indicative on scale 15.

Segments 3, 4 are connected to collector rings, respectively, 16, 17 which are engaged by respective brushes 18, 19, connected by leads 20, 21 to one of the input terminals of a pair of audio frequency modulators 23, 24, respectively, which are provided to modulate the radio frequency waves at two different predetermined audio frequencies. The output terminals of the pair of modulators are connected to a single radio transmitter 22, supplied with a current from a power supply unit

25. The other input terminals of the pair of modulators are connected by common leads 24', 23' to contact arm 7. Power supply unit 25 is connected to the two terminals 30 and 35 of a source of current 31, being connected to terminal 30 by leads 196 and 161 leading to a contact 162 engageable by a switch arm 163, and through a switch 29; connection to the other terminal 35 is through leads 27, 164 and switch 165. The transmitter 22 is grounded at 32 and is provided with an antenna 33 which radiates waves indicated by dashed line 34. The waves are picked up at the remote point by an antenna 37 of a receiver 40, grounded at 50, and tuned to the radio frequency carrier wave of transmitter 22. The receiver is connected to a power supply unit 38, which is connected through short leads to supply wires 44 and 46 leading to source of current 42.

Radio transmission units of the conventional type, such as are used in radio transmission of sound, may be employed in the improved remote control system of the invention, including audio frequency modulators which are also adaptable to the radio transmission of power impulses. The audio frequency modulation may vary either the intensity (amplitude) of the carrier—"AM" system—or the frequency of the carrier—"FM" system. Receiver 40 will pass both audio frequencies originating at modulators 23 and 24 at the control point. Two band pass filters 55 and 56 wired to receiver 40, are each adapted to pass only the particular predetermined audio frequency corresponding, respectively, to that of modulators 23 and 24. The filtered frequencies pass through audio frequency amplifiers, respectively, 57 and 58, the amplified output of which is conducted by paired leads 61, 62 to respective ones of a pair of relays 59 and 60.

The armatures 59' and 60' of the respective relays 59 and 60, joined by a common lead 63, normally engage contacts, 64, 65 on a lead 44' connected to supply wire 44 leading to terminal 41 of the source 42. Although the motor shown is of the series wound type, it is to be understood that any other type of motor may be used. Relay armatures 59', 60', upon the energization of their respective relays, engage contacts 64', 65', which are connected to the outer terminals of respective field windings 66, 67; the inner terminals of the windings have a common lead to motor armature 70, circuit being continued through supply wire 46 to the other supply terminal 43.

Motor 68 drives a load, diagrammatically represented at 76, through a shaft 75 and gears 77, 78. The primary control device A, load motor 68 and associated parts are preferably, though not necessarily, designed so that contact arm 7 is turned in the same direction in which it is desired to move the load. Also, the scale 15 may be marked in degrees of a circle, so that contact arm 7 may be turned to the particular angular position corresponding to the end position to which it is desired to move the load.

Supply switches 29, 165 are closed to place the system in operation, switch arm 163 being normally engaged with its contact 162 (as shown), furnishing current to power supply unit 25 from source 31 and causing transmitter 22 to radiate carrier waves of a predetermined radio frequency, which is adapted to be modulated by one or the other of the audio modulators 23 and 24 when their respective circuits are closed, as will now be described. Assuming that it is desired to rotate load motor 68 to move the load clockwise, through

a particular degree of a circle from a normal or zero position, to a desired end position, contact arm 7 of the primary control device is turned clockwise, by hand or other instrumentalities, to an angular position, as indicated by scale 15, corresponding to the desired end position of the load. Engagement of contact 8 of the contact arm with conducting segment 4 will complete the circuit associated with modulator 24, starting at lead 24' from the modulator and continuing through lead 23', contact arm 7, collector ring 17, brush 19, and through lead 21 back to modulator 24. This will cause the transmitter to radiate radio waves modulated by the predetermined audio frequency of audio modulator 24.

This wave will be picked up at the remote point by receiver 40, which is tuned to the radio frequency of transmitter 22 and will pass both audio frequencies originating at modulators 23, 24; the audio frequency modulation radiated by transmitter 22, in the operation being described, is blocked at band pass filter 55 but admitted by filter 56 which, as already described, is designed to pass frequencies of the predetermined audio frequency of modulator 24. Audio amplifier 58, associated with band pass filter 56, will amplify the admitted signal, using current from local source 42 for this purpose, more particularly, from power supply unit 38. The amplified current will energize relay 60 to attract its armature 60' into engagement with its contact 65' and thus to complete a circuit through motor field winding 66 which may be traced from the supply terminal 41, through leads 44, 44', contact 64' of deenergized relay 59, unattracted armature 59', short lead 69, armature 60' of the other relay 60 (energized as described) through relay contact 65' to winding 67, the circuit continuing through motor armature 70 and through lead 46 to the other supply terminal 43.

Concurrently with the rotation of motor 68, the insulated disc 2 of the primary control device A at the transmitting point is turned in a direction to cause the gap 5 separating the conducting segments 3, 4, to overtake contact arm 7. For this purpose there is provided at the transmitting point a pilot motor 177, shown of the type having a permanent field magnet 178, which drives insulated disc 2 through shaft 179 and pinion 180, which may be toothed or friction, meshing a gear (not shown) secured to rotate with disc 2. Pilot motor 177 is caused to rotate in correspondence with load motor 68 at the remote point by means of coordinating means which includes a commutator device (designated generally at B) at the remote point and a pilot motor device (designated generally at C) at the control point, the two being coupled via radio transmission, as will be described.

Commutator B at the remote or receiver point comprises a commutator arm 101 secured on shaft 89 and turned by load motor 68 by means of a gear 91 meshing with a pinion 90 secured on shaft 75 driven by motor 68. A contact 102 at the distal end of commutator arm 101 slidably engages a plurality of stationary contacts 86, 87, and 88: 86', 87' and 88' disposed concentrically about shaft 89. Only two sets of three contacts each, i. e., set 86, 87 and 88 and set 86', 87' and 88', are shown, for facility of illustration, although it will be clear that a greater number of sets may be employed and that the number of contacts in each set is not necessarily restricted to three. The respective contacts of each set are connected in groups; contacts 86, 86' are

connected by a lead 92; contacts 87, 87' by lead 93; contacts 88, 88', by lead 94. The said leads 92, 93, 94 are connected by leads, respectively, 95, 96, 97 to one input terminal of respective audio frequency modulators 98, 99 and 100. The other input terminals of the modulators are connected by a common lead 104 and a lead 103 to the commutator arm 101.

Modulators 98, 99 and 100 are adapted to modulate the generated radio waves at different predetermined audio frequencies—the radio frequency of which is different from that of the radio frequency radiating from transmitter 22 at the control point. The plurality of modulators are wired to a common transmitter 105 having antenna 108 and grounded at 109, and wired to power supply unit 106 which is connected by leads 107, 107^x to current supply wires 44, 46, respectively, leading to source 42.

The waves radiated from antenna 108, indicated by dashed line 110, are picked up at the control point by antenna 111 of a receiver 112, grounded at 113 and supplied with current from a power supply unit 114. Receiver 112 is tuned to the radio frequency of transmitter 105 at the remote point and will pass all three audio frequencies originating at modulators 98, 99 and 100 at the remote point. Three band pass filters 115, 116 and 117 wired to receiver 112, are each designed to pass only the audio frequency of the particular predetermined audio frequency corresponding, respectively, to that of modulators 98, 99 and 100 at the remote point transmitter 105. The band pass filters are individually wired to audio amplifiers 115', 116' and 117', which are individually connected to relays, respectively, 118, 119 and 120. Receiver 112 is wired to power supply unit 114 which is connected by leads 125, 125^x to supply wires 164 and 161, respectively, leading to source 31.

The armature 126 of relay 118, when the latter is energized, engages relay contact 129 which is connected to a lead 136 terminating in stationary contacts 142, 142'; armature 127 of relay 119, when energized, engages relay contact 130 connected to a lead 137 terminating in stationary contacts 143, 143'; armature 128 of relay 120 engages relay contact 131 connected to a lead 138 terminating in stationary contacts 144, 144'. The relay armatures 126, 127, 128 are connected by a common lead 85 to lead 125 connecting with supply wire 164 from supply terminal 35. The said stationary contacts are concentrically spaced about the shaft 145 of the pilot motor control C. Rotatively mounted on shaft 146 is an insulated disc 145 bearing a pair of conducting segments 147 and 148, the adjacent ends of which are separated by a gap 149, in sliding engagement with the aforesaid stationary contacts. Segment 147 is connected to a collector ring 150 engaged by a brush 152 connected by lead 154 to a relay 156; segment 148 is connected to a collector ring 151 engaged by a brush 153 connected by lead 155 to a relay 157. The other terminals of relays 156 and 157 are joined by wire 160 which is connected by short lead 160^x to wire 161 which, as previously described, is connected to one terminal 30 of the current source 31. Armature 170 of relay 156, when the latter is deenergized, engages a contact 174 connected to wire 164 which, as previously described, is connected to the other supply terminal 35, and, when the relay is energized, engages a contact 172 on supply wire 161. Armature 171 of relay 157, when the latter is deenergized, engages a contact 175 connected to supply

wire 164, and, when the relay is energized, engages a contact 173 on the other supply wire 161. The insulated disc 145 is turned by the pilot motor 177 by means of a gear 186 secured to turn with disc 145 and meshing with the pinion 185 on the pilot motor shaft 179.

As already described, load motor 68 at the remote point is caused to rotate in the desired direction by moving contact arm 7 of the primary control device A at the control point into engagement with one or the other of the segments 3, 4. Rotation of load motor 68 will cause commutator arm 101 of commutating device B to turn correspondingly to successively engage the stationary contacts 86, 87, 88, 86', 87', 88'. The circuit to a particular one of the plurality of modulators 98, 99, 100 will be completed by the engagement of contact 102 of commutator arm 101 with one or the other of the stationary contacts (i. e., 86 or 86', 87 or 87', 88 or 88') connected to that particular modulator. For example, if commutator arm 101 is at stationary contact 86, as shown in Fig. 1 (or at the companion contact 86'), a circuit will be completed to modulator 99 which may be traced from common modulator wire 104 through lead 103 to commutator arm 101, its distal contact 102, stationary contact 86 and through lead 95 to modulator 99. Modulator 99 will then modulate the carrier waves generated by transmitter 105 to the predetermined audio frequency assigned to 99. The modulated waves will be picked up by receiver 112 at the control point, and only that audio frequency will pass the band pass filter 116 which is designed to pass signals of the audio frequency originating at modulator 99. The amplified current from audio amplifier 116' associated with band pass filter 116 will operate its associated relay 119, attracting its armature 127 into engagement with relay contact 130, thus energizing the stationary contacts 143, 143' associated with relay 119 and band pass filter 116, the circuit being traced from supply terminal 35 through wires 164, 125 to the common armature lead 85 and to armature 127, engaged relay contact 130, lead 137 and finally to stationary contacts 143, 143'.

In the angular position of insulated disc 145 shown in Fig. 1, energization of stationary contacts 143, 143' will have no effect upon the pilot motor control relays 156 and 157 because both contacts engage, in the position of disc 145 shown, insulated portions of the disc; more particularly, stationary contact 143 will be at the insulated gap 149 between conducting segments 147, 148. Hence pilot motor 177 will not rotate when insulated disc 145 of the pilot motor control C and the contact arm 101 of the commutator B are in the position shown in Fig. 1. However, when commutator arm 101 is moved (by load motor 68, as already described) to engage its contact 102 with the next stationary contact 87 to energize the corresponding pair of stationary contacts 144, 144' of pilot motor control device C—by means of modulator 100 and transmitter 105 at the remote point and receiver 112 and band pass filter 117 and associated parts at the control point, as described above in connection with the energization of stationary contacts 143, 143' at C—a circuit will be completed through pilot motor control relay 157. This circuit is traced from the energized stationary contact 144, engaged conducting segment 148 (as shown in Fig. 1), its associated collector ring 151, brush 153, lead 155, to relay 157 and through common lead 160 and short lead 160^x to supply line 161 leading to the

other supply terminal 30. The other energized contact 144' of the pair 144, 144' will have no effect since it engages merely the insulated portion of disc 145.

Energization of relay 157 will attract its armature 171 into engagement with relay contact 173, thus establishing a circuit through pilot motor 177 from supply terminal 30, through supply wire 161, relay contact 173, attracted relay armature 171, motor armature 170, armature 170 of the other and deenergized relay 156 and relay contact 174 (in the position shown in Fig. 1), and to the supply wire 164 leading to the other supply terminal 35.

In the turning of commutator arm 101 from the first portion or station (shown in Fig. 1) in which its contact 102 engages only stationary contact 86 to the next station in which its contact 102 engages only stationary contact 87, the commutator contact 102 will, before fully reaching the next station at 87, engage both stationary contacts 86 and 87. This will cause energization of four stationary contacts at the pilot motor control device C, namely, contacts 143, 143' and 144, 144'. Energization of stationary contacts 143' and 144' will have no effect since they engage insulated portions of the disc 145; nor will the energization of brush 143 have any effect while disc 145 is in the position shown with brush 143 engaging insulated gap 149. However, in the turning of disc 145 from the first station with gap 149 at contact 143 (as shown in Fig. 1) by the now energized pilot motor 177, the other conducting segment 147 of the disc will become engaged by energized contact 143 (commutator contact 102 still bridging stationary contacts 86 and 87). The concurrent engaging of segments 148 and 147, with both energized contacts 144 and 143, respectively, will cause the energization of both relays 156, 157 with the result that their respective armatures 170, 171 will be attracted into engagement with relay contacts 172, 173, both of which are on the same supply wire 161, thus disconnecting the circuit to the motor armature 170. Pilot motor 177 will be stopped by dynamic braking in the field of the permanent magnet 178 and no further rotation will occur until commutator arm 101 is further turned (by the load motor, as described) to move its contact 102 out of engagement with stationary contact 86. Thereat, contact 143 at pilot motor control C will be deenergized, thus breaking the circuit to relay 156. Since relay 157 remains energized, the pilot motor will again start rotation, which will continue until gap 149 reaches contact 144, breaking the circuit to relay 156.

Current is continued to be supplied to the load motor 68 as the commutator arm 101 of commutating device B and insulated disc 145 of the pilot motor control C are turning successively from one stationary contact to the next. This stepped advance of commutator arm and pilot motor control disc continues as insulated disc 2 of the primary control A turns in a direction to overtake contact arm 7, until gap 5 separating conducting segments 3, 4 reaches the contact arm, at which time load motor 68 will be stopped (in the manner already described hereinbefore), thus stopping commutator arm 101 at the last engaged stationary contact and stopping pilot motor control disc 145 with the gap 149 separating its segments 147, 148, at the stationary contact corresponding to the last engaged stationary contact of the commutator.

Rotation of pilot motor 177 will also turn in-

insulated disc 2 of primary control A in a direction to cause gap 5 separating conducting segments 3, 4 to overtake contact arm 7. When this overtaking occurs and contact arm 7 bridges gap 5 to engage both conducting segments 3, 4, the load motor 68 at the remote point will be stopped, for the following reasons: Engagement of both segments 3 and 4 will complete the circuits to both audio frequency modulators 23 and 24 which will modulate the radio frequency at the two different predetermined frequencies assigned to the respective modulators. At the remote point, both band pass filters 55 and 56 will admit the two audio frequencies, that originating at modulator 23 being passed by filter 55 and the audio frequency originating at 24 being passed by filter 56. Hence both load motor control relays 59 and 60 will be energized to attract their respective armatures 59' and 60' into engagement with relay contacts 64' and 65'. The circuit (through the field windings 66, 67) to motor armature 70 will be broken and the load motor stopped. In Fig. 1, contact 8 of contact arm 7 is shown of sufficient width to bridge gap 5 and engage both segments 3, 4 simultaneously (resulting in energization of both relays 59 and 60 at the remote point, as just described). Similar results may be obtained by increasing the width of gap 5 and/or decreasing the width of contact 8, so that when the contact arm 7 is aligned with the gap, its contact 8 will engage neither one of segments 3, 4. In this case, the circuit to both audio frequency modulators 23 and 24 will be broken so that no modulation is imposed on the radiated waves. Hence there will be at the remote point no audio frequency waves to pass the band pass filters to energize load motor control relays 59, 60 which remain deenergized, their respective armatures 59', 60' engaging relay contacts 64, 65 (as shown in Fig. 1) to break the circuit to the load motor.

In the event that the concurrent movements of the load at the remote point and the contact arm 7 of primary control A are occasionally disarranged from true correspondence, an auxiliary coordinating load is provided for checking or resetting the position of the load to precisely correspond to a predetermined position of the contact arm 7, such for instance, as to the zero position of pointer 10 on scale 15. An independent auxiliary control system (which may be conveniently termed the "zeroizing" system in contradistinction to the main or "coordinating system") for this purpose comprises a separate transmitter at the control point and a separate receiver at the remote point for controlling the load motor independently of the main control system described above. The zeroizing transmitter at the control point, designated 200 in Fig. 1, provided with antenna 201 and grounded at 202, radiates waves of a predetermined radio frequency different from those of coordinating transmitters 22 associated with the primary control A at the control point and 105 associated with the commutating device B at the remote point, so not to cause interference therewith. Current is furnished to zeroizing transmitter 200 from power supply unit 195 through paired leads 49, and is wired to an audio frequency modulator 199 which is in turn wired to the power supply unit 195; audio frequency modulator 199 is adapted when the circuit thereto is completed, as will be described, to modulate the radio frequency waves. Power supply unit 195 is connected to supply wire 164 leading to supply ter-

minal 35 at current source 31; the other supply terminal 30, however, is not directly connected to power supply unit 195 but is normally broken at a "zeroizing" switch 163. Switch arm 163 normally engages contact 162 (shown in Fig. 1); to complete the supply circuit from terminal 30 to supply wire 161 which furnishes current to the various parts of the coordinating system (as already described), and is normally disengaged from its other contact 198 is at one end of wire 197 leading to power supply unit 195. Only when zeroizing switch 163 is moved from its normal position (shown in Fig. 1) into engagement with contact 198 are the zeroizing transmitter 200 and modulator 199 made operative to radiate the modulated radio wave, for purposes more fully described subsequently.

The modulated waves radiated by zeroizing transmitter 200, and diagrammatically indicated by dashed lines 201', are picked up by the antenna 204 of a zeroizing receiver 203 at the remote point, grounded at 205 and powered from a supply unit 226 connected by leads 207 and 39 to the supply terminals of local current source 42. Associated with receiver 203 is a band pass filter 209 to pass only the audio frequencies originating at A. F. modulator 199 of zeroizing transmitter 200 at the control point and picked up by zeroizing receiver 203 which is tuned to the predetermined radio frequency of the zeroizing transmitter 200. The A. F. signals are amplified at 210, the amplified current being conducted by paired leads 45 to the coil 215 of a solenoid, the armature 217 of which carries contact 217^x at its lower end. Contact 217^x is engageable when the solenoid is energized, with conducting segments 225, 226 mounted on an insulated disc 228 separated by gap 227. Segment 225 is connected to collector ring 229 engaged by brush 231 which is connected by a lead 233 to the outer terminal of field winding 67; segment 226 is connected to collector ring 230 engaged by brush 232 which is connected by a lead 234 to the outer terminal of the other field winding 66. Solenoid armature 217 is connected by a flexible lead 218 and lead 219 to the current supply line 44. Insulated disc 228 is provided with a gear (not designated) meshing with pinion 77 on shaft 75 of load motor 68, so that disc 228 is turned concurrently with rotation of the load motor.

The first step in zeroizing is to place contact arm 7 of primary control A in a position arbitrarily predetermined as the resetting or zeroizing position, preferably the zero position on scale 15. If insulated disc 2 is not already in a position with the gap 5 separating conducting segments 3, 4 in alignment with contact arm 3 at "zero" position, the engagement of contact 8 of arm 7 with one or the other of the segments will cause rotation of load motor 68, arm 101 of commutating device B, disc 145 of pilot motor control C, pilot motor 177 and disc 2 of primary control A (in the manner described above) until gap 5 is bridged by contact 8, both the contact arm 7 and disc 2 then being at the "zero" position. Rotation of load motor 68 will also turn insulated disc 228 of the zeroizing system. If the load is correctly coordinated with primary control A, insulated disc 228 will be in the position in Fig. 1 with gap 227 at solenoid contact 217^x, which is the "zero" position corresponding to "zero" position of primary control A; the load, being operatively connected to disc 223 (by the transmission gearing described above), will likewise be at "zero" position. To rectify the

coordination between zeroizing disc 228 (and load 76) and the primary control A, and to be certain that disc 228 is at "zero" position, zeroizing switch 163 is moved from its normal or coordinating position (as shown in Fig. 1) into engagement with contact 198 to motivate the zeroizing system. This will close the branch of the power lines to power supply unit 195 connected to supply terminal 30 via lead 197 and zeroizing switch 163. The other branch to power supply unit 195 via lead 164 already being completed, current will be thus furnished to transmitter 200 and A. F. modulator 199, resulting in the radiation of audio modulated waves of the predetermined radio frequency to be picked up at the remote point by zeroizing receiver 203 and of the predetermined audio frequency to be admitted by band pass filter 209.

The zeroizing radio transmission picked up at the remote point by receiver 203 and passed by filter 209 is amplified by audio amplifier 210. The amplified current is conducted by leads 45 to coil 215 of the solenoid causing its armature 217 to move towards the conducting segments 225, 226 of insulated disc 228 and engaging its contact 217^x therewith. If disc 228 happens to be in the "zero" position (as shown in Fig. 1) solenoid contact 217^x will engage both conducting segments 225 and 226, and will cause energization of both field windings 67 and 66, respectively. The circuit to field winding 67 may be traced from supply terminal 41 of the local source 42 via wire 44, lead 218, solenoid contact 217^x, segment 225, its collector ring 229 and brush 231, lead 233, to winding 67, through motor armature 70 and wire 46 back to the other supply terminal 48. The circuit to the other field winding 66 may be traced from its associated segment 226, collector ring 230 and brush 232; lead 234 to winding 66, and through motor armature 70 back to supply terminal 48 in the manner described above relative to its companion winding 67. By reason of the energization of both field windings 66 and 67, motor 70 will remain stationary and will not disturb the correct zero position of the load. If, on the other hand, gap 227 happens to be displaced from "zero" position (shown in Fig. 1) with solenoid contact 217^x engaging only one of the segments 225, 226, only that one of the windings 66, 67 associated with the engaged segment will be energized to cause the load motor to rotate and turn disc 228 in a direction to cause gap 227 to arrive at the solenoid contact 217^x ("zero" position) whereat motor 68 is stopped, as described above. Zeroizing switch 163 may then be restored to normal position (shown in Fig. 1) readying the system for regular coordinating operation.

In the arrangement of Fig. 1, pilot motor 177 is employed for turning insulated disc 2 of primary control A and insulated disc 145 of pilot motor control device C. Both the pilot motor and its control device C may be combined in a single unit which serves the dual purpose of turning disc 2 of primary control A and at the same time cooperating with commutator B in the coordinating operation. This is shown in Fig. 2 where the primary control A of Fig. 1 is duplicated, its component parts (and operation) being unchanged and bearing the identical reference characters of Fig. 1. The single unit, which is in effect a step-by-step actuator, designated generally at D, comprises a rotor 289 secured to shaft 179 which turns insulated disc 2 in the

manner, and for the purpose, described above in connection with Fig. 1. Rotor 289 has permanent "N" and "S" poles, as shown, and is caused to turn by the successive energization (in a manner subsequently described) of a plurality of magnet coils 281, 282, 283, 284, 285 and 286 concentrically spaced about rotor 289. One terminal of the coils is connected to a common lead 287 connected by lead 288 to supply wire 161 leading to supply terminal 30; the other ends of the coils are connected by individual leads, respectively, 271, 272, 273, 274, 275 and 276 to the respective contacts 261, 262, 263, 264, 265 of the plurality of relays 251 to 256. The armatures, designated 251^x, 252^x, 253^x, 254^x, 255^x, 256^x, of the relays are connected to a common lead 260 joined to supply wire 164 leading to supply terminal 35, and are normally, i. e., when their respective relays are deenergized, engaged with blind contacts (as shown). Hence in the deenergized condition of the relays (as shown in Fig. 2), the circuits to the plurality of magnet coils 281 to 286 will be broken at the relay armatures. For the purpose of energizing the relays 251 to 256, each is individually wired to respective ones of a plurality of audio frequency amplifiers 241', 242', etc. to 246' which are in turn individually wired to respective ones of a plurality of band pass filters 241, 242, etc. to 246. The plurality of filters are wired to a common receiver 240 provided with an antenna 239 and grounded at 238. Receiver 240 and the plurality of band pass filters and A.F. amplifiers are powered from power supply unit 237 connected by leads 164 and 161 to the current source 31.

Receiver 240 is tuned to the radio frequency of transmitter 105', at the remote point. Associated with the transmitter are a plurality of A.F. modulators 225 to 230, inclusive, equal in number to the number of band pass filters 241 to 246 at the control point. The plurality of modulators are controlled by a commutating device B' having a number of stationary contacts 231 to 236, inclusive, equal to the number of modulators (and band pass filters). The stationary contacts are not grouped or paired as is the case in Fig. 1, but each commutator contact is individual to a particular modulator. The plurality of modulators 225 to 230, inclusive, are arranged to modulate the radio frequency waves at different predetermined audio frequencies corresponding to the audio frequencies admitted by corresponding ones of the plurality of band pass filters 241 and 246 associated with step-by-step actuator D at the control point.

Commutator arm 101 of the commutator device B' is turned (by load motor 68 in the manner described in connection with Fig. 1) to successively engage the plurality of stationary contacts 231 to 236, inclusive, and thus to close the circuits to successive ones of the plurality of A. F. modulators 225 to 230, inclusive, resulting in the modulation of the radio wave generated by transmitter 105 at successively different predetermined audio frequencies. The modulated wave is picked up by receiver 240 but is blocked by the plurality of band pass filters 241 to 246 except the particular one assigned to the audio frequency of the modulator at the remote point associated with that particular stationary contact of commutator B which is engaged by commutator arm at the given instant. The audio frequency admitted by successive ones of the band pass filters 241—246, after being amplified, will energize relays 251—256 in succession. If, for example, the audio fre-

quency of the received wave at a given instant corresponds to that to which band pass filter 241 is assigned, the A. F. modulation will be admitted by 241, will be amplified by 241' and will energize relay 251, which will attract its arm 251^x into engagement with relay contact 261 to complete the circuit to magnet coil 281. This circuit may be traced from supply terminal 35, through supply wire 164 and common relay lead 260 to relay armature 251^x and engaged contact 261, through lead 271 and magnet coil 281 to common magnet coil lead 287 and by lead 288 to supply wire 161 leading to the other supply terminal 30. Energization of magnet coil 281 will attract rotor 289 towards it, in a counterclockwise sense as viewed in Fig. 2. As the magnet coils 281 to 286 (and 286 to 281, repeating the steps) are successively energized—in correspondence with the rotation, counter-clockwise, of commutator arm 101, Fig. 1—rotor 289 will turn counter-clockwise in correspondence with the successive energization of magnet coils 281—286 and likewise in correspondence with the commutator arm 101 and the load. Because of the drive connection 179, 180, between the step-by-step actuator D and insulated disc 2 of primary control A, disc 2 will turn in correspondence with the load.

The radio link between B at the remote point and the pilot motor control C at the control point is shown in Fig. 1, and has been described, as a radio frequency wave having interrupted or discontinuous modulation. This is occasioned by the fact that, for facility in illustration and exposition, the device at B was shown and described as a commutator. That is to say, the modulation will be interrupted during the time that the commutator arm disengages one stationary commutator contact and before it has engaged the next successive contact. The invention, however, is in no way limited to the employment of a radio frequency wave having discontinuous modulations linking B and C, but contemplates that the modulation may be continuous as well as discontinuous. The continuous modulated radio waves, like the discontinuous modulators imposed by the commutator, will be in repeated frequencies or patterns, originating at B and admitted by individual ones of the band pass filters 115, 116, 117 at C in succession, so that their respective relays 118, 119, 120 and associated stationary contacts 142, 143, 144, etc. will be successively energized in correspondence with the transmitting device at B (likewise with the load motor and load).

I claim:

1. In a remote control system controlled from a control point to move a load at a remote point to any desired end position, in combination, a primary control device at the control point comprising a pair of relatively movable members, one of the members having electrical conducting elements separated by a gap, the other member having a contact element slidably engageable with the said conducting elements, a radio transmitter adapted to radiate waves of a predetermined radio frequency, a pair of audio frequency modulators, each modulator being connected in a circuit with the transmitter and in a second circuit with a respective one of the said conducting elements each modulator being constructed and connected to modulate the said radiated waves to a different predetermined audio frequency, one of the said pair of members being selectively adjustable relative to the other member to cause displacement

between said gap and contact element and engagement thereof with one or the other of the said conducting elements to complete the second circuit to the respective one of the said pair of modulators depending upon said desired direction of load movement; a reversible motor at the remote point for moving the load, a radio receiver adapted to pick up the radiated waves of said predetermined radio frequency and to pass both said audio frequency modulations; a pair of band pass filters electrically connected to the receiver, each adapted to admit one of the two said predetermined different audio frequencies; a pair of relays controlling a circuit including the load motor, each relay being controlled by the corresponding filter to cause the load motor to rotate in the direction corresponding to the particular audio frequency being radiated; a commutating device comprising a pair of members one movable relatively to the other, one of the members having a plurality of contacts, the other member being a contactor slidably engageable with the said contacts, one of the said members being operatively connected with the load motor for causing successive engagement between the said member and said plurality of contacts, a second radio transmitter at the remote point adapted to radiate waves of a radio frequency different from that radiated by the said primary control transmitter at the control point, a plurality of audio frequency modulators connected in circuits with predetermined ones of the said commutator contacts and adapted to modulate the said radiated wave at predetermined audio frequencies, each modulator being energized by the engagement of the respective commutator contact by the said contactor; a secondary control device at the control point including a pilot motor for turning the other of the said pair of relatively movable members of the primary control device in a direction to cause alignment of contact element and the said gap to cause both first mentioned modulators to transmit simultaneously their respective frequencies for causing both relays to be simultaneously energized, thereby stopping the load motor, said secondary control device comprising a pair of members one movable relatively to the other, one of the members having a plurality of contacts, the other member having electrical conducting elements separated by a gap, a second radio receiver adapted to pick up waves of the said predetermined radio frequency radiated by the transmitter at the remote point and to pass said plurality of predeterminedly different audio frequencies, a plurality of band pass filters electrically connected to the second receiver, each filter being adapted to admit one of the audio frequencies transmitted by said plurality of modulators and connected in circuits with predetermined ones of the said pilot motor control device contacts to energize respective ones of the last-named contacts depending upon the particular audio frequency radiated by the commutator transmitter at the remote point, whereby the conducting element engaging one of the said last-named energized contacts causes the pilot motor to be energized, the pilot motor being operatively connected for turning one of the said pilot control members in a direction to cause alignment between said gap and energized contact to stop the pilot motor and the said member of the secondary control device with the gap at a position coordinated with the position of en-

gagement between commutator contactor and contact at the remote point.

2. In a remote control system controlled from a control point to move a load at a remote point to any desired end position, in combination, a primary control device at the control point comprising a pair of relatively movable members, a radio transmitter adapted to radiate waves of a predetermined radio frequency, a pair of audio frequency modulators connected in circuits with the transmitter and in second circuits with said members, each modulator being constructed and connected to modulate the said radiated waves to a different predetermined audio frequency, one of the said pair of members being selectively adjustable relative to the other member to complete one of the second circuits to one or the other of the said pair of modulators depending upon said desired direction of load movement; a reversible motor at the remote point for moving the load, a radio receiver adapted to pick up the radiated waves of said predetermined radio frequency and to pass both said audio frequency modulations, a pair of band pass filters electrically connected to the receiver, each filter being adapted to admit one of the two said predetermined different audio frequencies, a pair of relays controlling a circuit including the load motor, each relay being controlled by the corresponding filter to cause the load motor to rotate in a direction depending upon the particular audio frequency being radiated, a commutating device having a movable member driven by the load motor, a second radio transmitter at the remote point adapted to radiate waves of a radio frequency different from that radiated by the said primary control transmitter at the control point, a plurality of audio frequency modulators connected in circuits with the second transmitter and adapted to modulate the said radiated wave at predetermined audio frequencies depending upon the position of the said movable member of the commutator device; a secondary control device at the control point having a movable member and including a pilot motor for turning the other of the said pair of relatively movable members of the primary control device in a direction to cause both first mentioned modulators to function and stop the load motor, a second radio receiver adapted to pick up the waves of the predetermined radio frequency radiated by the transmitter at the remote point and to pass said plurality of predeterminedly different audio frequencies, a plurality of band pass filters electrically connected to the second receiver, each filter being adapted to admit one of the audio frequencies transmitted by said plurality of modulators, to control in cooperation with the movable member of the secondary control device rotation of the pilot motor, the pilot motor being operatively connected to the said movable member of said pilot control device to stop the pilot motor at a position coordinated with the position of the said movable member of the commutator device at the remote point.

3. In a remote control system controlled from a control point to move a load at a remote point to any desired end position, in combination, a primary control device at the control point, a radio transmitter adapted to radiate waves of a predetermined radio frequency, a pair of audio frequency modulators connected in a circuit with the transmitter and in a second circuit with the primary control device, each modulator being constructed and connected to modulate the said radiated waves to a different predetermined audio

frequency, the primary control device being selectively adjustable to complete the circuit to one or the other of the said pair of modulators, drive means including a motor at the remote point for moving the load, a radio receiver adapted to pick up the radiated waves of said predetermined radio frequency and to pass both said audio frequency modulations, a pair of band pass filters each adapted to admit one of the two said predetermined different audio frequencies and electrically connected to the receiver; a pair of relays controlling a circuit including the load motor, each relay being controlled by the corresponding filter, to cause the load motor to rotate in a direction depending upon the particular audio frequency being radiated; a commutator control device at the remote point operatively connected to the load motor, a radio transmitter at the remote point adapted to radiate waves of a radio frequency different from that radiated by the said primary control transmitter at the control point, a plurality of audio frequency modulators connected in circuits with the commutator control device and adapted to modulate the said radiated wave at predetermined audio frequencies depending upon the position of the commutator control device at the remote point; a pilot control device at the control point including a pilot motor, a second radio receiver at the control point adapted to pick up the waves of the predetermined radio frequency radiated by the transmitter at the remote point and to pass said plurality of predeterminedly different audio frequencies, a plurality of band pass filters electrically connected to the second receiver, each filter being adapted to admit one of the plurality of audio frequencies radiated by the said transmitter at the remote point to control rotation of the pilot motor, the pilot motor being operatively connected to the said pilot motor control device and to the said primary control device to stop the drive means at the remote point with the load in the desired end position.

4. A remote control system having coordinating instrumentalities according to claim 3, further provided with zeroizing instrumentalities comprising a radio transmitter at the control point adapted to radiate waves of a predetermined radio frequency different from that of the said primary control transmitter and the said transmitter at the remote point, an audio modulator connected in circuit with the transmitter and adapted to modulate the said radiated waves at a predetermined audio frequency, a switch at the control point for selectively connecting a source of current to the coordinating instrumentalities or to the said zeroizing transmitter and modulator, the said switch being manipulated preparatory to zeroizing to connect the source of current to the coordinating instrumentalities at the control point and the primary control device being adjusted to a predetermined zero position, whereby the motor at the remote point is caused to rotate for moving the load to reach the corresponding zero position, whereafter the switch is manipulated to supply current to the zeroizing transmitter and modulator, the said zeroizing instrumentalities further comprising a radio receiver and band pass filter connected in circuit thereto at the remote point adapted to pick up and pass waves radiated by the said zeroizing transmitter at the control point, a zeroizing device having a movable member provided with a pair of electrical conducting elements separated by a gap, the said conducting elements being connected in

circuit with the motor to cause rotation of the same in respectively opposite directions, a contact engageable with the said conducting elements, the load motor being operatively connected to the said movable member to move the same in a direction to cause alignment between said gap and contact, and electromagnetic means actuated by the said audio modulated waves to engage the said contact with the conducting elements to supply current to the load motor, whereby the load and the said movable member of the zeroizing device are turned until the said gap reaches the said engaged contact, thereby causing stopping of the load motor with the load at zero position.

5. A remote control system having coordinating instrumentalities according to claim 3, further provided with zeroizing instrumentalities comprising a radio transmitter at the control point adapted to radiate waves of a predetermined radio frequency different from that of the said primary control transmitter and the said transmitter at the remote point, an audio modulator connected in circuit with the transmitter and adapted to modulate the said radiated waves and band pass filter at the remote point adapted to pick up and admit waves radiated by the said zeroizing transmitter at the control point, and a zeroizing device having two relatively movable members electrically and operatively connected to the load motor and actuated by the said audio modulated waves, the relative position of said members causing the motor to move the load to the zero position and to stop the motor when the members reach a predetermined relative position.

6. In a remote control system controlled from a control point to move a load at a remote point to any desired end position, in combination, a primary control device at the control point, a radio transmitter adapted to radiate waves of a predetermined radio frequency, a pair of audio frequency modulators, each modulator being connected in a circuit with the transmitter and adapted to modulate the said radiated waves to a different predetermined audio frequency, the primary control device being selectively adjustable to complete the circuit to one or the other of the said pair of modulators; a reversible motor at the remote point for moving the load, a radio receiver adapted to pick up the radiated waves of said predetermined radio frequency and to pass both said audio frequency modulations, a pair of band pass filters electrically connected to the receiver and each adapted to admit one of the two said predetermined different audio frequencies, means controlled by the filters for causing the load motor to rotate in a direction depending upon the particular audio frequency being radiated; an adjustable secondary control device at the remote point operatively connected to the load motor, a second radio transmitter at the remote point adapted to radiate waves of a radio frequency different from that radiated by the said primary control transmitter at the control point, a plurality of audio frequency modulators connected in circuit with the second transmitter and in a second circuit with said secondary control device, said last-named modulators being adapted to modulate the said radiated wave at predetermined audio frequencies depending upon the position of said adjustable control device; a control motor at the control point for operating the said primary control device to cause both of its said pair of modulators to function and stop the load motor, said control motor having a magnetic rotor opera-

tively connected to the said primary control device and a plurality of coils spaced about the said rotor, a second radio receiver adapted to pick up the waves of the predetermined radio frequency radiated by the transmitter at the remote point and to pass said plurality of predeterminedly different audio frequencies, a plurality of band pass filters connected in circuit with the second receiver and each adapted to admit one of the plurality of audio frequencies radiated by the said transmitter at the remote point, a plurality of relays individually associated with respective ones of the said plurality of band pass filters and respective ones of the said plurality of coils, said coils being adapted upon functioning of their respective band pass filters and relays to create a rotating magnetic field to cause rotation of the said rotor in coordination with the rotation of the said load motor.

7. In a remote control system controlled from a control point to move a load at a remote point to any desired end position, in combination, a primary control device at the control point, a radio transmitter adapted to radiate waves of a predetermined radio frequency, a pair of audio frequency modulators, each modulator being connected in a circuit with the transmitter and adapted to modulate the said radiated waves to a different predetermined audio frequency, the primary control device being selectively adjustable to complete the circuit to one or the other of the said pair of modulators; a reversible motor at the remote point for moving the load, a radio receiver adapted to pick up the radiated waves of said predetermined radio frequency and to pass both said audio frequency modulations, a pair of band pass filters electrically connected to the receiver and each adapted to admit one of the two said predetermined different audio frequencies, means controlled by the filters for causing the load motor to rotate in a direction depending upon the particular audio frequency being radiated; and adjustable secondary control device at the remote point operatively connected to the load motor, a second radio transmitter at the remote point adapted to radiate waves of a radio frequency different from that radiated by the said primary control transmitter at the control point, a plurality of audio frequency modulators connected in circuit with the second transmitter and in a second circuit with said secondary control device, said last-named modulators being adapted to modulate the said radiated wave at predetermined audio frequencies depending upon the position of said adjustable control device; a control motor at the control point for operating the said primary control device to cause both of its said pair of modulators to function and stop the load motor, said control motor having a magnetic rotor operatively connected to the said primary control device and a plurality of coils spaced about the said rotor, a second radio receiver adapted to pick up the waves of the predetermined radio frequency radiated by the transmitter at the remote point and to pass said plurality of predeterminedly different audio frequencies, a plurality of band pass filters individually connected in circuits with respective ones of the said plurality of coils and each adapted to admit one of the plurality of audio frequencies radiated by the said transmitter at the remote point to create a rotating magnetic field at the said coil to cause rotation of the rotor in coordination with the rotation of the said load motor.

8. In a remote control system controlled from

a control point to move a load at a remote point to any desired end position, in combination, a radio transmitter at the control point adapted to radiate waves of a predetermined radio frequency and two predetermined audio frequencies, a primary control device at the control point electrically connected with the transmitter and selectively adjustable to modify the said radiated waves to one or the other of said audio frequencies, a motor at the remote point for moving the load, a radio receiver at the remote point adapted to pick up and selectively pass the radiated waves, means connected with said receiver and responsive to the passed audio and radio frequency wave for causing the load motor to rotate in a direction depending upon the said wave modification at the control point, a second radio transmitter at the remote point adapted to radiate waves of a radio frequency different from that radiated by the said primary control transmitter at the control point, and of predetermined audio frequencies, a movable control device at the remote point electrically connected with the second transmitter and operatively connected to the load motor, said movable control device being adapted to modify the said radiated wave, a second radio receiver at the control point adapted to pick up the waves radiated by the transmitter at the remote point, a pilot motor operatively connected with the primary control device for adjustment thereof, and means at the control point responsive to the output of the second receiver to energize the pilot motor to coordinate the said primary control device in accordance with the said wave modification at the remote point.

9. In a remote control system controlled from a control point to move a load at a remote point to any desired end position, in combination, instrumentalities including a radio transmitter at the control point adapted to radiate waves of a predetermined radio frequency modified depending upon the desired load movement, a motor at the remote point for moving the load, instrumentalities including a radio receiver at the remote point adapted to pick up the radiated waves and move the load motor in accordance with the said wave modification at the control point, instrumentalities including a movable control device operatively connected with the load motor and also including a radio transmitter at the remote point adapted to radiate waves of a radio frequency different from that radiated by the said transmitter at the control point as modified by the movable device in dependence on the said load movement, and instrumentalities including a control motor operatively connected with the first instrumentalities and also including a radio receiver at the control point adapted to pick up the waves radiated by the transmitter at the remote point to control the control motor for coordinating the first instrumentalities at the control point with the load at the remote point in accordance with the said wave modification at the remote point.

10. In a remote control system controlled from a control point to move a load at a remote point to any desired end position, in combination, instrumentalities including a radio transmitter at the control point adapted to radiate waves having selected characteristics modified depending upon the desired load movement, a motor at the remote point for moving the load, instrumentalities including a radio receiver at the remote point adapted to pick up the radiated waves and move the load motor in accordance with the said wave

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modification at the control point, instrumentalities including a movable control device operatively connected with the load motor and also including a radio transmitter at the remote point adapted to radiate waves having characteristics different from that radiated by the said transmitter at the control point as modified by the movable device in dependence on the said load movement, and instrumentalities including a control motor operatively connected with the first instrumentalities and also including a radio receiver at the control point adapted to pick up the waves radiated by the transmitter at the remote point to control the control motor for coordinating the first instrumentalities at the control point with the load at the remote point

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in accordance with the said wave modification at the remote point.

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