

Dec. 28, 1948.

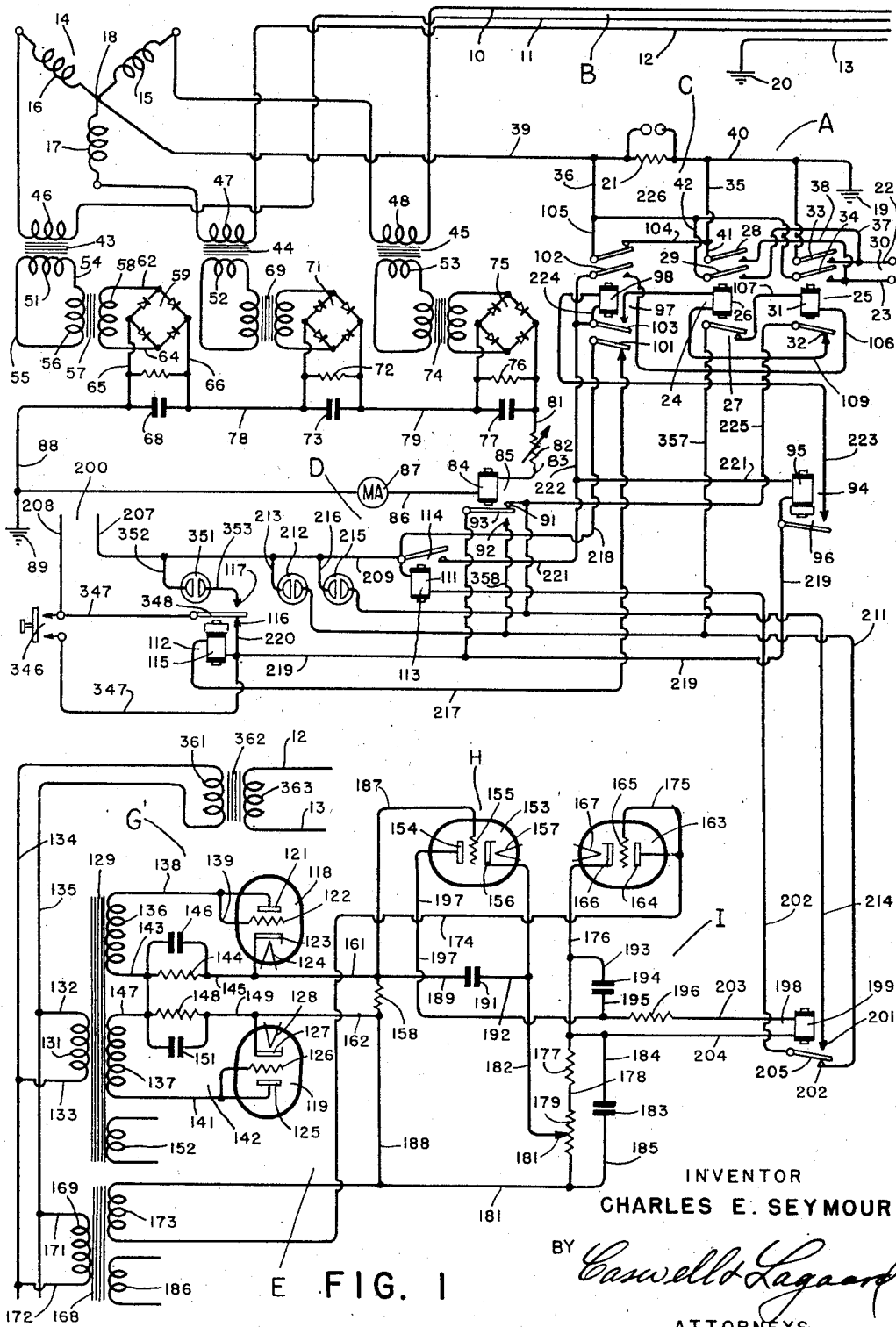
C. E. SEYMOUR

2,457,607

REMOTE CONTROL SYSTEM

Filed Nov. 8, 1946

2 Sheets-Sheet 1



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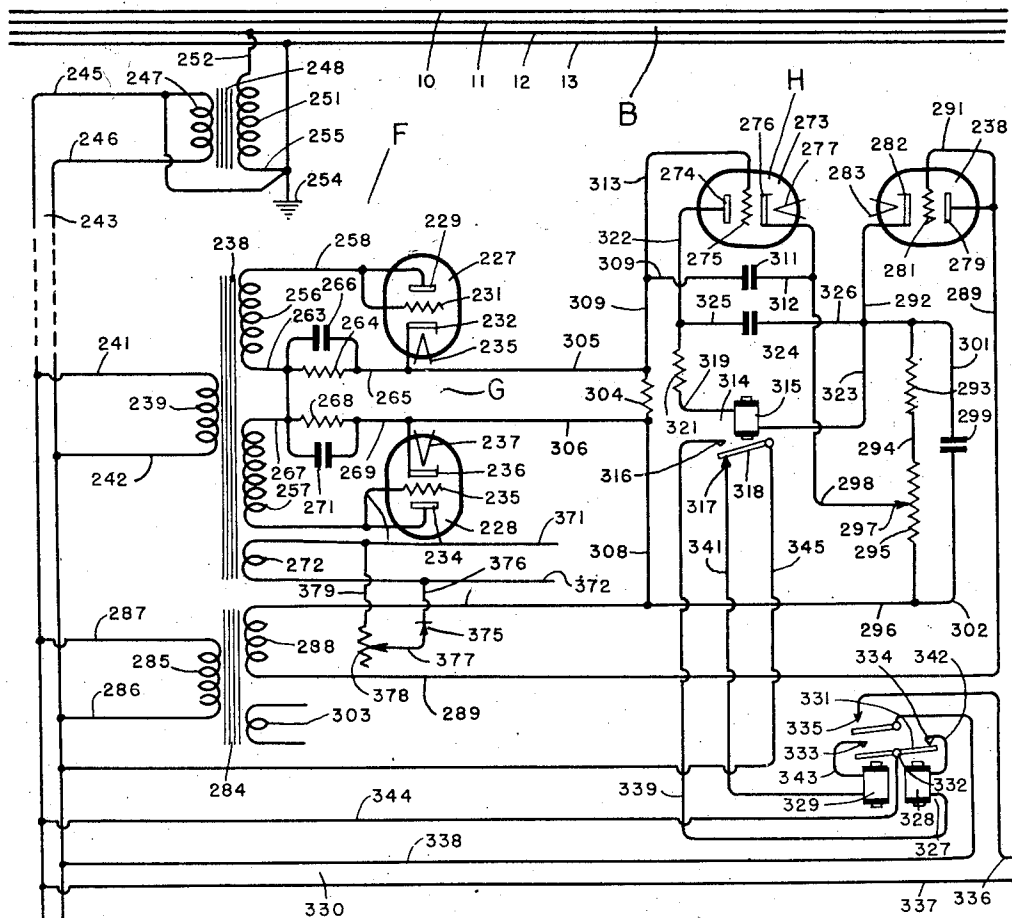
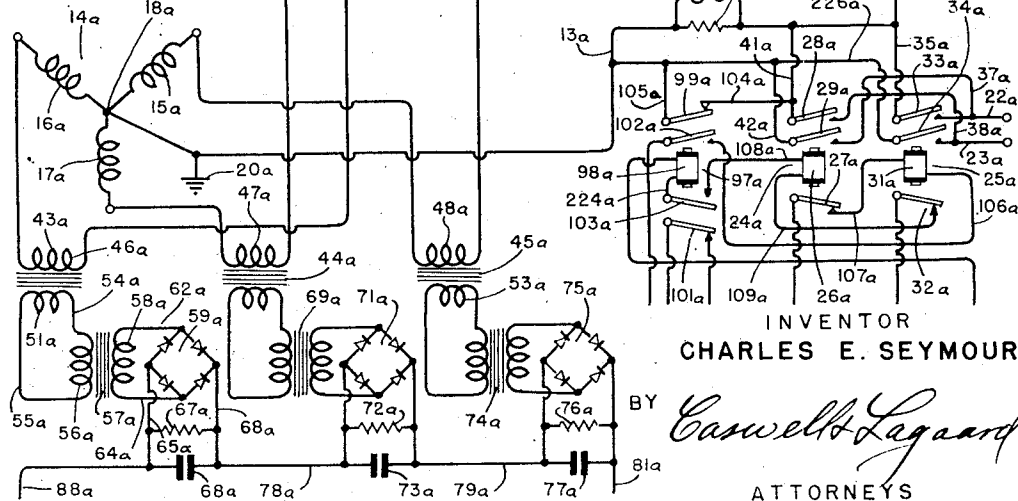


FIG. 3

FIG. 2



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2,457,607

REMOTE CONTROL SYSTEM

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Application November 8, 1946, Serial No. 708,536

15 Claims. (Cl. 171—97)

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My invention relates to remote control systems and has for an object to provide a control system which may be connected to an alternating current line and operated without interfering with the normal use of the line to cause some remotely disposed apparatus to operate and to terminate the operation thereof.

Another object of the invention resides in providing a remote control system utilizing a transmitter and one or more receivers and in which the transmitter operates to shift the axis of the voltage of the line.

A still further object of the invention resides in providing a system adapted to be connected to a Y type polyphase line and particularly to the neutral thereof.

An object of the invention resides in connecting a resistance to the line and in applying a direct current voltage across said resistance.

Another object of the invention resides in providing means for reversing the polarity of the voltage across said resistance.

A still further object of the invention resides in providing a remote control system in which the controlled circuit is operated upon variation of the load on the line.

A feature of the invention resides in providing a system in which increase in the load on the line above a predetermined value provides a certain polarity of the direct current voltage across said resistance and decrease in the load on the line below said value causes reversal of the polarity of said voltage across the resistance.

Another object of the invention resides in constructing the remote control device with a receiver having two circuits energized by opposed voltages procured from the line and normally balancing one another but adapted to become unbalanced upon shift of the axis of the voltage of the line.

A still further object of the invention resides in employing a load device energized by both of said voltages, and in further providing means responsive to the voltage across said load device for controlling the controlled circuit.

Another object of the invention resides in providing thermionic tubes in said circuits.

Other objects of the invention reside in the novel combination and arrangement of parts and in the details of construction hereinafter illustrated and/or described.

In the drawings:

Fig. 1 is a wiring diagram of the transmitter of a remote control system embodying my invention.

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Fig. 2 is a wiring diagram of a modification of a portion of the same.

Fig. 3 is a wiring diagram of the receiver of the system.

My improved remote control system comprises a transmitter which I have indicated in its entirety by the reference character A and which is connected to an alternating current power transmission line B at one locality in said line. This transmitter includes a voltage modifier C which serves to modify the voltage of the line B in a manner such as not to interfere with the normal operation of the line. Said transmitter includes an actuating device D which renders the voltage modifier C inoperative. This actuating device in the form of the invention illustrated, is operated by the load on the line and serves, when the load reaches a certain maximum, to cause the voltage modifier to modify the line voltage in one manner and when the load on the line reaches a predetermined minimum, to cause the modifier to modify the line voltage in another manner. The transmitter of my invention further includes a checking device E which serves to insure that the modified voltage has been effectively utilized and which renders the voltage modifier inoperative after a predetermined period of time. At a remote locality in the transmission line is located a receiver F which includes a detector G responsive to the modification of the voltage produced by the voltage modifier C. This detector energizes an amplifier H which, in turn, operates the control device J and controls the circuit adapted to be controlled by the invention. These various parts of the invention will now be described in detail.

My invention is preferably applied to a polyphase power transmission line. The line B illustrated in the drawings, is a Y type of transmission line having three conductors 10, 11 and 12 connected to the various phases of a three phase source of power and a neutral 13. The source of energy for the line B has been diagrammatically designated in the drawings by the numeral 14, and may consist of a generator or transformer having windings 15, 16 and 17 connected in Y. Conductor 10 is connected to winding 15, conductor 11 is connected to winding 16 and conductor 12 is connected to winding 17. The neutral 13 follows along the conductors 10, 11 and 12 and is grounded as indicated at 20 at the power station and at other localities along the line, not shown in the drawings.

Power for operating the various relays of the transmitter A is procured from a line 200 having

conductors 207 and 208. This line may be connected to any suitable source of current capable of operating the various relays. Said line may be either supplied from a direct current source or an alternating current source as found suitable.

The voltage modifier C includes a resistance 21 which is connected by means of a conductor 39 to the neutral point 18 of the source of power 14 and by means of a conductor 40 to the ground 19. Across this resistance is impressed a direct current voltage which modifies the line voltage of the line B by shifting the axis of said line voltage a slight amount. The direction of the shift of the axis of the line voltage is controlled by changing the polarity of the source of direct current impressed across the resistance 21. The voltage modifier receives voltage from any suitable source of direct current by means of a line 30 having conductors 22 and 23 which are connected to said source. In actual practice, a rectifier energized from the line B may be employed or a storage battery charged by a charger energized from a source of alternating current may be utilized. The current from the said source is controlled by two polarity relays 24 and 25 which are energized as will be presently more fully described. The relay 24 comprises a winding 26, a normally closed switch 27 and two normally open switches 28 and 29. The relay 25 includes a winding 31, a normally closed switch 32 and two normally open switches 33 and 34. The two conductors 22 and 23 are connected to one side of each of the switches 33 and 34. The other sides of these switches are connected by means of conductors 35 and 36 to the resistance 21 at the ends of the same. Conductors 37 and 38 are also connected to the conductors 22 and 23 and are further connected to one side of each of the switches 28 and 29. The other sides of these switches are connected by means of conductors 41 and 42 to the conductors 35 and 36 previously referred to. It will, however, be noted that the connections between the conductors 22 and 23 and the resistance 21 are reversed through the two relays 24 and 25 so that when one relay operates, the direct current potential applied across the resistance 21 has one polarity and when the other relay is operated, has the opposite polarity.

Operating in conjunction with the relays 24 and 25 is a shorting relay 97. This relay has a winding 98, two normally closed switches 99 and 101 and two normally open switches 102 and 103. The switch 99 is connected by means of conductors 104 and 105 to the conductors 35 and 36 which are connected to the ends of the resistance 21. It will readily be comprehended that when the relay 97 is de-energized, that the resistance 21 is shorted out and the neutral point 18 of the source of power 14 is directly connected to ground. The switch 102 has its fixed contact connected by means of a conductor 106 to the winding 31 of relay 25. The other side of this winding is connected by means of a conductor 107 to the fixed contact of the switch 27 of relay 24. The winding 26 of relay 24 is connected by means of a conductor 108 with the fixed contact of the switch 103 of relay 97, while the other side of said winding is connected by means of a conductor 109 with the fixed contact of the switch 32.

The actuating device D includes a circuit which is operated by the load on the line B. For this purpose, three current transformers 43, 44 and 45 are employed having primaries 46, 47 and 48 and secondaries 51, 52 and 53. The primaries 46, 47 and 48 are connected in the conductors 11, 12

and 10 respectively. The secondary 51 of the transformer 43 is connected by means of conductors 54 and 55 to the primary 56 of a transformer 57. This transformer is used to convert the current passing through the transformer 43 into voltage suitable for operating a relay. The secondary 58 of this transformer is connected by means of conductors 63 and 64 to a full-wave rectifier 59 which, in turn, applies the rectified voltage through conductors 65 and 66 to a resistance 67 and a condenser 68 connected in parallel. In a similar manner, the secondary 52 of transformer 44 is connected to a transformer 69 which, in turn, feeds a rectifier 71. This rectifier, in turn, impresses direct current voltage across a resistance 72 and a condenser 73 connected in parallel. In like manner, transformer 45 feeds a transformer 74, which, in turn, feeds a full-wave rectifier 75. This rectifier, similar to the rectifiers 59 and 71 applies direct current voltage across a resistance 76 and a condenser 77 connected in parallel. The pairs of impedance energized by the respective rectifiers 59, 71 and 75 are connected in series by means of conductors 78 and 79. The resistance 76 and the condenser 77 are connected by means of a conductor 81 to a variable resistance 82. This resistance is connected by means of a conductor 83 with the winding 84 of a load relay 85. The said winding 84 is further connected by means of a conductor 86 with a milliammeter 87. This milliammeter is connected by means of a conductor 88 with the conductor 65 previously referred to and is further grounded as indicated at 89. By means of the resistance 82, the relay 85 can be caused to cut in when a predetermined maximum load is on the line B and to drop out when a predetermined minimum load is on said line. The relay 85 includes two switches 91 and 92, the switch 92 being normally open and the switch 91 normally closed. These switches have a common switch arm 93.

The actuating device D further includes an operating relay 94 which has a winding 95 and a normally open switch 96. Operating in conjunction with this relay is a hold-in relay 111 and a lock-out relay 112. The hold-in relay 111 comprises a winding 113 and a normally open switch 114. The relay 112 has a winding 115, a normally closed switch 117 and a normally open switch 116. Relay 94 is a time controlled relay which does not close the switch 96 until after the lapse of approximately two minutes. This relay may be of the motor driven type and any such relay as is now well known in the art may be used for this purpose. The relay 112 is also a time controlled relay. This relay closes the switch 117 after a lapse of approximately thirty seconds. The relay 111 is also a time controlled relay but this relay operates to maintain the switch 114 closed for approximately five seconds after the said relay has been de-energized.

The checking device E includes a detector G', an amplifier H' and a power supply I' for the same similar to the receiver F. The detector G' includes two thermionic tubes 118 and 119. The tube 118 has a plate 121, a grid 122, a cathode 123 and a heater 124 therefor. The tube 119 includes a plate 125, a grid 126, a cathode 127 and a heater 128 therefor. The two tubes 118 and 119 are connected to a transformer 129. This transformer has a primary 131 which is connected by means of conductors 132 and 133 to a line 130 consisting of conductors 134 and 135 which is energized by the line B. The conductors 134 and 135 of line 130 are connected to the secondary 361 of a trans-

former 362. The primary 363 of this transformer is connected to the conductors 12 and 13 of line 13. The transformer 129 further includes two secondaries 136 and 137 which are connected in opposition. One end of the secondary 136 is connected by means of a conductor 138 with the plate 121 of tube 118. The grid 122 of said tube is connected to the plate 121 by means of a conductor 139. In like manner, the corresponding end of the winding 137 is connected by means of a conductor 141 with the plate 125 of tube 119. The grid 126 of this tube is connected by means of a conductor 142 with the plate 125. The other end of the secondary 136 of transformer 129 is connected by means of a conductor 143 with a resistance 144. This resistance is connected by means of a conductor 145 with the cathode 123 of tube 118. A condenser 146 shunts the resistance 144. In like manner, the other end of the secondary 137 of transformer 129 is connected by means of a conductor 147 with a resistance 148. This resistance is, in turn, connected by means of a conductor 149 with the cathode 127 of tube 119. A condenser 151 shunts the resistance 148. Power for energizing the heaters 124 and 128 is derived from a secondary 152 on the transformer 129. Inasmuch as the matter of connecting up heaters is well known in the art, the connections for the same have been omitted from the drawings to reduce the complication of the same. The detector G' further includes a resistance 158 which is connected to the cathodes 123 and 127 of tubes 118 and 119 by means of conductors 161 and 162.

For furnishing power for the amplifier H', the power supply I' is employed. This power supply includes a thermionic tube 163 which has a plate 164, a grid 165, a cathode 166 and a heater 167 for the same. Energy is delivered to the tube 163 from a transformer 168 which has a primary 169 connected to the line 130 by means of conductors 171 and 172. The transformer 168 has a secondary 173 which is connected by means of a conductor 174 to the plate 164 of tube 163. The grid 165 of this tube is connected by means of a conductor 175 with the plate 164. The cathode 166 of tube 163 is connected by means of a conductor 176 with a fixed resistance 177 which, in turn, is connected by means of a conductor 178 with a variable resistance 179. Resistance 179 is, in turn, connected by means of a conductor 180 with the other side of the secondary 173 of transformer 168. A condenser 183 is connected across both of the resistances 177 and 179 by means of conductors 184 and 185, thus shunting both of said resistances.

The amplifier H' of the checking device E includes a thermionic tube 153 which has a plate 154, a grid 155, a cathode 156 and a heater 157 for the same. The cathode 156 of said amplifier is connected by means of a conductor 182 to a movable contact 181 on the resistance 179. The grid 155 of said tube is connected by means of a conductor 187 with one end of the resistance 158. The other end of this resistance is connected by means of a conductor 188 with the conductor 180. A conductor 189 connects the conductor 187 with a condenser 191 which, in turn, is connected by means of a conductor 192 with the conductor 182. A conductor 193 connects the conductor 176 to a condenser 194. This condenser is further connected by means of a conductor 195 with one end of a resistance 196. The same end of this resistance is also connected by means of a conductor 197 with the plate 154 of tube 153.

The checking device E further includes a

checking relay 198. This relay has a winding 199, a normally open switch 201 and a normally closed switch 202. These switches have a common switch arm 205. The winding 199 is connected by means of a conductor 203 to the resistance 196. The said winding is further connected by means of a conductor 204 with the conductor 184 and the conductor 176. The switch arm 205 of relay 198 is connected by means of a conductor 206 with the one end of the winding 113 of relay 114. The other end of said winding is connected by means of a conductor 209 with the conductor 207 of the line 200. The switch 202 of relay 198 is connected by means of a conductor 211 with a signal lamp 212 which, in turn, is connected by means of a conductor 213 with the conductor 209. The switch 201 of relay 198 is connected by means of a conductor 214 with a signal lamp 215 which, in turn, is connected by means of a conductor 216 with the conductor 209.

Power for energizing the heaters 157 and 167 of the tubes 153 and 163 is derived from a secondary 186 on the transformer 168. The conductors for connecting the heaters to this secondary have been omitted from the drawings for the reasons previously brought out.

The various relays of the actuating device D are connected in the following manner: The winding 115 of lock-out relay 112 is connected by means of a conductor 217 with the switch 101. The other side of this switch is connected by means of a conductor 218 with the winding 113 of relay 111, the switch 114 and the conductor 209. The other end of the winding 115 of relay 112 is connected by means of a conductor 219 with the switch 96 of operation relay 94 and with one end of the winding 95 of said relay. Winding 115 is also connected by means of a conductor 220 with switch 116. The switches 116 and 117 have a common switch arm 348 which is connected by means of a conductor 349 with the conductor 208 of line 200. The other end of the winding 95 of said relay is connected by means of a conductor 221 with the switch 114 of hold-in relay 111. Conductor 221 has connected to it, another conductor 222 which, in turn, is connected to both of the switches 102 and 103 of relay 97. A conductor 357 connects switch 27 with switch 92. The switch 96 of operation relay 94 has connected to it, a conductor 223 which, in turn, is connected to one end of the winding 98 of relay 97. The other end of said winding is connected by means of a conductor 224 to the conductor 222 previously referred to. The switch 91 of the load relay 85 is connected by means of a conductor 225 to the switch 32 of the polarity relay 25. A conductor 226 connects the switch 34 of polarity relay 25 with the conductor 42. Switch arm 93 is connected to conductor 219 by means of a conductor 355. A conductor 356 connects switch 92 with conductor 211.

For the purpose of resetting the lock-out relay 115, a push button 346 is employed. This push button is connected by means of a conductor 347 to conductor 219 and thus to the winding 115 of said relay. The other side of said push button is directly connected to the conductor 208 of line 200. In conjunction with the lock-out relay 112, a lamp 351 is employed. This lamp is connected by means of a conductor 352 with the conductor 207 of line 200. Said lamp is further connected by means of a conductor 353 with the switch 117. When relay 112 drops out, switch 117 closes and lights the lamp 351.

The receiver F, which is shown in detail in Fig. 2, is similar to the checking device E of the transmitter A. This receiver, as previously brought out, includes detector G. This detector employs two thermionic tubes 227 and 228. The tube 227 has a plate 229, a grid 231, a cathode 232 and a heater 233 for the same. The tube 228 comprises a plate 234, a grid 235, a cathode 236 and a heater 237 for the said cathode. The two tubes 227 and 228 are energized by a transformer 238. This transformer has a primary 239 which is connected by means of conductors 241 and 242 to a line 243. The line 243 has two conductors 245 and 246. The conductors 245 and 246 are connected to a primary 247 of another transformer 248. The conductors 241 and 242 from the primary 239 of transformer 238 are connected to the conductors 245 and 246 respectively. The transformer 248 has a secondary 251 which is connected by means of a conductor 252 to the conductor 12 of line B. A ground conductor 253 is connected to the neutral 13 of the line B and is grounded as indicated at 254. The other side of the secondary 251 is connected by means of a conductor 255 with the conductor 253 and thus grounded. The transformer 238 includes two secondaries 256 and 257 which are connected in opposition. One end of the secondary 256 is connected by means of a conductor 258 to the plate 229. The grid 231 of tube 227 is also connected to the plate 229 by means of a conductor 259. In like manner, the corresponding end of the secondary 257 is connected by means of a conductor 261 to the plate 234 of tube 228. The grid 235 of this tube is connected by means of a conductor 262 with the plate 234. The other end of the secondary 256 of transformer 238 is connected by means of a conductor 263 with a resistance 264. This resistance is connected by means of a conductor 265 to the cathode 232 of tube 227. A condenser 266 shunts the resistance 264. In like manner, the other end of the secondary 257 of transformer 238 is connected by means of a conductor 267 to a resistance 268. This resistance is, in turn, connected by means of a conductor 269 with the cathode 236 of tube 228. A condenser 271 shunts the resistance 268. Power for energizing the heaters 233 and 237 is derived from conductors 371 and 372 connected to a secondary 272 on the transformer 238. Such connections being well known in the art, have not been shown in the drawings. The detector G further includes a load device 304 which, in the form of the invention shown, is illustrated as a resistance. This resistance is connected to the cathodes 232 and 236 of the tubes 227 and 228 by means of conductors 305 and 306 respectively.

The amplifier H of the receiver F consists of a thermionic tube 273 which has a plate 274, a grid 275, a cathode 276 and a heater 277 for the same.

For furnishing power for the tube 273, the power supply I is employed. This power supply includes a thermionic tube 278 which has a plate 279, a grid 281, a cathode 282 and a heater 283 for the said cathode. Energy is delivered to the tube 278 from a transformer 284 which has a primary 285 connected to the conductors 245 and 246 of line 243 by means of conductors 286 and 287. The transformer 284 has a secondary 288 which is connected by means of a conductor 289 with the plate 279 of tube 278. The grid 281 of this tube is connected by means of a conductor 291 with the plate 279. The cathode 282 of the tube 278 is

connected by means of a conductor 292 with a fixed resistance 293 which, in turn, is connected by means of a conductor 294 with a variable resistance 295. Resistance 295 is, in turn, connected by means of a conductor 296 with the other side of the secondary 288 of transformer 284. The resistance 295 has a movable contact 297 which is connected by means of a conductor 298 with the cathode 276 of tube 273. A condenser 299 is connected across both of the resistances 293 and 295 by means of conductors 301 and 302 thus shunting both of the said resistances. Power for energizing the heaters 277 and 283 of the tubes 273 and 278 is derived from a secondary 303 on the transformer 284. Again, the wiring of the heaters has been omitted from the drawings. One end of the resistance 304 is connected by means of a conductor 308 with the conductor 296. The other end of this resistance is connected by means of a conductor 309 with a condenser 311 which, in turn, is connected by means of a conductor 312 to the conductor 298. A conductor 313 connects the conductor 309 with the grid 275 of the tube 273.

The amplifier H operates the control device J. This device includes a relay 314. Relay 314 has a winding 315, a normally open switch 316 and a normally closed switch 317. These switches have a common switch arm 318. One end of the winding 315 of relay 314 is connected by means of a conductor 319 with a resistance 321. This resistance is, in turn, connected by means of a conductor 322 with the plate 274 of tube 273. The other end of the winding 315 of the relay 314 is connected by means of a conductor 323 with the conductor 301 previously referred to and which is connected to the plate 282 of tube 278. A condenser 324 is connected by means of a conductor 325 with conductor 322. This condenser is also connected by means of a conductor 326 with the conductor 292.

Since the relay 314 depends for operation on the shift of the current passing through the winding of the same above and below a predetermined normal current, it can readily be comprehended that variations in line voltage will produce a variation in the heater current and plate voltage of the various tubes and thus affect the relay current. To overcome this effect, a half wave rectifier 375 is employed which is connected by means of a conductor 376 with the conductor 372 leading from the secondary 272 of transformer 238. This rectifier is further connected by means of a conductor 377 with a variable resistance 378. Said resistance is, in turn, connected by means of a conductor 379 with the conductor 371. The resistance 378 forms a load on the secondary 272 and the rectifier 375 serves to rectify the current passing through this resistance. This unidirectional current has the effect of shifting the axis of the flux in the case of the transformer 238. The rectifier 375 is so connected that when the line voltage increases the shift in axis increases the negative bias on the grid of tube 273 which reduces the output of the same to an extent sufficient to offset the increase in filament and plate voltage to the tubes. The reverse occurs when the line voltage decreases.

Relay 314 of receiver F operates a load control relay 327 which constitutes a part of the control device J. This relay has dual windings 328 and 329 which jointly control a pivoted armature 331. The said armature swings about a fulcrum 332 and is adapted to be attracted by either

of the windings 328 or 321. Associated with this armature are two switches 333 and 334, the armature 331 forming a common contact for both of said switches. The winding 329 also has associated with it a switch 335 together with the switch 333. The load to be controlled is, connected to a line 330 comprising conductors 336, 337 and 338. Conductor 337 is directly connected to the conductor 245 of line 243, while conductor 338 is connected to the switch 335. This switch is connected to the conductor 338 which, in turn, is connected to the conductor 246 of line 243. The winding 329 of relay 327 is connected by means of a conductor 339 with the switch 316. Switch 318 is connected by means of a conductor 341 with one end of the winding 328 of relay 327. The other end of this winding is connected by means of a conductor 342 with the switch 334. Switch 333 is similarly connected by means of a conductor 343 with the other end of the winding 329. The armature 331 of the relay 327 is connected by means of a conductor 344 with the conductor 245 of line 243. Switch 318 of relay 314 is connected by means of a conductor 345 with the conductor 246 of said line.

In Fig. 2, I have shown a modification of the invention. Due to the similarity of the two forms of the invention, description of the invention will now be repeated and the corresponding parts of the system shown in Fig. 2 will be designated by the same reference characters as used in Fig. 1, and to which have been added the suffix character *a*. In the form of the invention here shown, the resistance 21*a* instead of being connected directly to ground, is connected in the neutral 13*a*, which in this form of the invention, is grounded at the locality of the source of power 14, as indicated at 20*a*.

The operation of my invention is as follows: Assume that the line feeding the load to be controlled is disconnected. All of the relays in both the transmitter and receiver would then occupy the positions shown in the drawings. Sufficient current would be flowing through the winding 84 of relay 95 of transmitter A to cause the switch arm 93 of said relay to close switch 91. An examination of Fig. 1 would indicate that circuits through the switch 91 are broken at switch 102, 103 and switch 201. The various parts of the invention would hence remain as shown. If now, the load on line B decreases sufficiently to permit of connecting the controlled load to the line, the current through the winding 84 of relay 85 drops sufficiently to drop the switch arm 93. This causes the switch 92 to become closed. The following circuits can now be traced: Commencing with the conductor 208 of line 200, the circuit can be traced through conductor 349, the switch 116, conductor 219 and conductor 355 and through switch 92. From this switch, current passes through conductors 356 and 211 through switch 202, through conductor 206, through the winding 113 of relay 111 and through conductor 209 back to the other side 207 of the line 200. This energizes relay 111 and closes switch 114. A new circuit is now established. This circuit commences at conductor 207 of line 200, passes through conductor 209, switch 114, conductor 221, the winding 95 of relay 94, through conductor 219 and through the switch 116 back to the other side 208 of the line 200. This energizes relay 94. Relay 94 is a time-controlled relay requiring approximately one to two minutes to operate. The said relay may be a motor-

driven type of relay or any other relay suitable for the purpose. The purpose of this relay is to prevent temporary line load variations of the line from cutting in the load on the line. After the lapse of the required time, relay 94 closes switch 96. This establishes a circuit from conductor 208 of line 200 through switch 116, conductor 219, switch 96, conductor 223, the winding 98 of relay 97, conductor 224, conductor 222, conductor 221, switch 114, which was previously closed, conductor 209 and conductor 207 of line 200. Energization of relay 97 closes two circuits and opens two other circuits. One of the circuits which is open includes the circuit through switch 99, conductor 104, resistance 21 and conductor 105. This removes the short from the resistance 21 and connects the said resistance between the neutral point 18 of the source of power 14 and ground. The other circuit which is open includes 207, conductor 209, 218, switch 101, conductor 217, the winding 115 of relay 112, conductor 220, switch 116 and conductor 349 to conductor 208 of line 200. Relay 112 is a time-controlled relay which does not release until the expiration of a predetermined time after its de-energization, thus maintaining switch 116 closed during this interval. This relay is for the purpose of disconnecting the remote controlled system from the line in the event of failure of operation. The manner of using this relay will be subsequently more fully described.

One of the circuits closed by the relay 97 commences with the conductor 207 of line 200, includes conductor 209, switch 114, conductors 221 and 222, switch 102, conductor 106, the winding 31 of relay 25, conductor 107, switch 27 of relay 24, conductor 357, switch 92, conductor 355, conductor 219, switch 116 and conductor 349 to conductor 208 of line 200. This energizes relay 25. Energization of this relay closes two circuits and opens one circuit. The two circuits closed connect the source of direct current from conductors 22 and 23 of line 30 across the resistance 21 so as to produce a certain polarity at said resistance. The direct current impressed across this resistance affects the line voltage by shifting the axis of the same a small amount. This shift in the axis of the line voltage is transmitted through the entire network and is present at the receiver B.

The action at the receiver F is as follows: In normal operation, the voltage from the line 243, which is stepped down from the line B through transformer 248, impressed upon the two tubes 227 and 228 opposing voltages which exactly balance one another. The potential across the resistance 304 is hence normally zero. Since the tubes 227 and 228 rectify the alternating current impressed upon the same, it will readily become apparent that if the axis of the line voltage is shifted, one of said tubes will pass a greater amount of current than the other. This will effect a drop across the resistance 304. This potential is impressed upon the amplifier H which is connected to the relay 314. The relay 314 is at all times energized by the tube 273. When the potential across resistance 304 is in a direction to decrease the grid bias on tube 273, a greater amount of current flows through the winding 315 of relay 314. This causes switch 316 to close. This completes a circuit commencing with conductor 245 of line 243 through conductor 344, through switch 334 of relay 327, through switch 334 and through conductor 341 to switch 316. Said circuit includes the con-

ductor 345 and the other side 246 of said line 243. Further energization of the winding 328 of relay 327 operates the same to open switch 334 and to close switches 333 and 335. This connects the conductors 338 and 336 together and connects the line 330 to the load. At the same time, the circuit through the winding 328 of relay 327 is opened.

At the same time that the shift in the axis of the voltage of the line B operates the receiver F, said shift in the axis, in a similar manner, operates the checking device E. The output of the transformer 129 is delivered to the two tubes 118 and 119, which impresses voltage across the resistance 158. This voltage is amplified by the tube 153 which operates the relay 198. Relay 198 is similar to relay 314 and is at all times energized. If the current flowing through this relay exceeds the normal amount, the switch 201 is closed. If the current drops below normal, switch 202 is closed. With the parts as arranged in the drawings, it was assumed that the load on line B had decreased to cause actuation of the relay 314 in a manner to close the switch 316. This would likewise cause switch 201 to be closed. At the same time, switch 202 would be opened. Switch 202 controls energization of the holding relay 111. This relay, in turn, controls energization of the operation relay 94. Opening of the switch 202 would drop out relay 111 and likewise, drop out relay 94. Relay 111 is a timed relay and does not drop out until after a predetermined period following its de-energization. This is for the purpose of giving all of the receivers on the line ample opportunity to function. The de-energization of relays 94 and 111 opens switches 96 and 114 which control the energization of the relay 97. At the same time, opening of the switch 114 de-energizes relays 24 and 25 and the said relays drop out. Immediately, the short through switch 99 is reestablished and the neutral point 18 of the source of power 14 is directly connected to ground. The various relays and other parts of the system now assume the same positions as indicated on the drawings except that the switch 92 of relay 85 remains closed and switch 91 remains open. Also, switch 201 remains closed and switch 202 remains open. At the receiver F, the parts remain as shown in the drawings except that the switch 316 remains closed and the switch 317 remains open and likewise, the switches 333 and 335 remain closed and the switch 334 remains open. The voltage on the line B is thus brought back to normal and the various lines 330 connected to the loads associated therewith. These circuits now continue to be energized until the load on the line B increases above normal.

When the load on the line B increases to such an extent that it becomes undesirable to further continue energization of the line 330, relay 85 is operated in a manner to close the switch 91. This establishes a circuit through relay 111 which again closes switch 114. Switch 114 again operates relay 94 which, after the lapse of a certain period of time, closes switch 96. Switch 96 again energizes relay 97 which removes the short across the resistance 21, thus placing the said resistance between the neutral point 18 of the power supply 14 and ground. In this case, however, relay 24 is operated instead of relay 25. The circuit for energizing relay 24 can be traced as follows: Commencing with the side 208 of line 209, the current in said circuit passes through switch 116, conductors 219 and 355, switch 91,

conductor 225, switch 32, conductor 109, the winding 26 of relay 24, conductor 168, switch 103, conductor 222, conductor 221, switch 114 and conductor 209 back to the conductor 207 of the said line. Relay 24 is so connected that the polarity of the direct current voltage from line 30 which is impressed on resistance 221 is reversed. This causes the shift of the axis of the voltage of line B to be in the opposite direction. The result is that the voltage across the resistance 304 of detector G is increased, thereby increasing the bias on the tube 273. This reduces the current supplied to the relay 314 and causes the switch 316 to open and the switch 317 to close. This causes a circuit through the winding 329 of relay 327 to be established through switch 317. The armature 331 is now attracted by the winding 329 and switches 333 and 335 opened. This de-energizes the relay 327 and also opens the circuit through line 330. The parts now remain as shown in the drawings without exception as far as the receiver is concerned. The shift in the axis of the voltage of the line B also operates the checking device E in the same manner as the receiver F. This again causes switch 201 to open and switch 202 to close. Relay 111 is again de-energized and correspondingly, relays 94, 97 and 24 are de-energized and the parts of the transmitter then occupy the positions shown in the drawings without exception.

The purpose of the switch 112 is as follows: Normal operation of the system usually takes five or six seconds. In the event that the checking device E does not function, the shift in voltage on the line B would continue. Relay 112 is a time-controlled relay which continues to operate for approximately thirty seconds after de-energization. In event of failure of the checking device E, relay 112 would, at the expiration of this period, open the switch 116 and de-energize relays 111, 94, 97 and relays 24 or 25 whichever was energized. At the same time, a circuit through switch 117 would be established which would light up the lamp 351. In order to reset the relay 112, for future operation, the push button 346 is operated which directly supplies energy to the winding 115 of said relay through the conductor 347, conductor 217, switch 101, conductor 218 and conductor 209.

The two lamps 212 and 215 are controlled by the two switches 91 and 92. One of these lamps is always energized and indicates whether or not the switch 335 is open or closed.

My invention may be put to numerous uses. In the furnishing of electric power for water heaters, it becomes highly desirable to furnish the power at times other than during peak loads. For this reason, it is necessary that the heaters be turned on and off at the required times. The instant invention makes it possible to automatically turn the heaters on and off whenever required without disturbing the normal operation of the line.

The advantages of the invention are manifest.

The control system of my invention may be applied to existing power lines without appreciable change or alteration thereof. My improved control system does not interfere with the normal operation of the line and does not cause the stopping of clocks or interfere with other devices which are ordinarily energized from the line. The receivers of the invention require but a small amount of energy and numerous such devices may be applied to the line and simultaneously operated. The device is entirely automatic and

will cut in as soon as the load on the line becomes low enough and will cut out before peak load is reached. Thus, the heaters are operated so that substantially a full tank of hot water is available at all times at each of the localities where the receivers are installed.

Changes in the specific form of my invention, as herein described, may be made within the scope of what is claimed without departing from the spirit of my invention.

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

1. In a remote control system, operable over an alternating current line, a transmitter including a resistance connected in series in one of the conductors of said line, said transmitter utilizing a direct current voltage adapted to be applied across said resistance to shift the axis of the voltage of said line and a receiver responsive to variations in the shift of the axis of an alternating current voltage and connected to said line at a locality remote from said transmitter.

2. In a remote control system, operable over a polyphase alternating current line, a transmitter including a resistance connected to said line, said transmitter utilizing a direct current voltage and including a terminal having a positive potential, actuating means responsive to the load on said line and operating when the load on the line exceeds a certain value to connect said terminal to one end of said resistance to procure a shift in the axis of the potential of said line in one direction and when the load falls below a certain value to connect said terminal to the other end of said resistance to shift the axis of the potential of said line in the opposite direction, and a receiver responsive to variations in the shift of the axis of an alternating current voltage and responding in different ways to the shift of the axis in opposite directions, said receiver being connected in said line at a locality remote from said transmitter.

3. In a remote control system, operable over an alternating current line, a transmitter utilizing a direct current voltage adapted to be applied to said line to shift the axis of the voltage of said line and a receiver responsive to variations in the shift of the axis of an alternating current voltage and connected to said line at a locality remote from said transmitter, said transmitter further including a checking device responsive to variations in the shift of the axis of an alternating current voltage and connected to said line and serving to maintain said direct current voltage applied to said line for a predetermined period after actuation of said transmitter.

4. In a remote control system, operable over an alternating current line, a transmitter utilizing a direct current voltage adapted to be applied to said line to shift the axis of the voltage of said line and a receiver responsive to variations in the shift of the axis of an alternating current voltage and connected to said line at a locality remote from said transmitter, said transmitter further including a checking device responsive to variations in the shift of the axis of an alternating current voltage and connected to said line and serving to de-energize said transmitter upon the occurrence of a shift in the axis of the line voltage sufficient to operate said receiver subsequent to a certain period following initiation of said transmitter.

5. In a remote control system, operable over an alternating current line, a transmitter includ-

ing a resistance connected to said line, means for applying a direct current voltage across said resistance to shift the axis of the voltage of said line and a load controlled device for controlling the polarity of the direct current voltage across said resistance.

6. In a remote control system, operable over an alternating current line, a transmitter including a resistance connected to said line, means for applying a direct current voltage across said resistance to shift the axis of the voltage of said line, a relay responsive to the load on said line and adapted when the load exceeds a certain value to procure a certain polarity of the direct current voltage across said resistance and when the load falls below said value to reverse the polarity of the direct current voltage across said resistance, and a receiver responsive to variations in the shift of the axis of an alternating current voltage and responding in different ways to the shift of the axis in opposite directions, said receiver being connected in said line at a locality remote from said transmitter.

7. In a remote control system, operable over an alternating current line, a transmitter for shifting the axis of the voltage of the line, a receiver comprising two circuits having opposed voltages procured from the line and normally balancing one another, but adapted to become unbalanced upon shift of the axis of the voltage of the line and control means responsive to the unbalance of the voltages in said circuits.

8. In a remote control system, operable over an alternating current line, a transmitter for shifting the axis of the voltage of the line, a receiver comprising two circuits having opposed voltages procured from the line and normally balancing one another, but adapted to become unbalanced upon shift of the axis of the voltage of the line, a load device energized by both of said circuits and control means responsive to the voltage across said load device.

9. In a remote control system, operable over an alternating current line, a transmitter for shifting the axis of the voltage of the line, a receiver comprising two circuits, each having a thermionic tube energized by the line and connected in opposition to procure opposed voltages in said circuits normally balancing one another but adapted to become unbalanced upon shift of the axis of the voltages of the line, a load device energized by both of said circuits and control means responsive to the voltage across said load device.

10. In a remote control system, operable over an alternating current line, a transmitter for shifting the axis of the voltage of the line, a receiver comprising two circuits having opposed voltages procured from the line and normally balancing one another, but adapted to become unbalanced upon shift of the axis of the voltage of the line, a load device energized by both of said circuits and control means including a thermionic tube having its grid connected to a circuit containing said load device.

11. In a remote control system, operable over an alternating current line, a transmitter for shifting the axis of the voltage of the line, a receiver comprising a transformer energized by said line and having two secondaries, two circuits connected to said secondaries, two thermionic tubes connected in said circuits, a load device energized by both of said tubes, said secondaries being connected in said circuits in a

manner to cause the outputs of said tubes to

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normally balance one another but to become unbalanced upon shift of the axis of the voltage of the line and control means responsive to the voltage across said load device.

12. In a remote control system, operable over an alternating current line having a number of main conductors and a grounded neutral associated therewith, an impedance connected in series in said neutral between the source of power supplying said line and ground, a transmitter including a source of direct current applied across said impedance and shifting the axis of the alternating current flowing in said main conductors, and a receiver connected to one of said main conductors and to said neutral and responsive to variations in the shift of the axis of the alternating current voltage in said line, said receiver being connected to said line at a locality remote from said transmitter.

13. In a remote control system, operable over an alternating current line, a transmitter including an impedance connected in series in one of the conductors of said line, said transmitter utilizing a direct current voltage adapted to be applied across said impedance to shift the axis of the voltage of said line and a receiver responsive to variations in the shift of the axis of alternating current voltage and connected to said line at a locality remote from said transmitter.

14. In a remote control system, operable over an alternating current line, a transmitter for

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shifting the axis of the voltage of the line, a receiver comprising two circuits, each having an amplifier energized by the line and connected in opposition to procure opposed voltages in said circuits normally balancing one another, but adapted to become unbalanced upon shift of the axis of the voltages of the line, a load device energized by both of said circuits and control means responsive to the voltage across said load device.

15. In a remote control system, operable over an alternating current line, a transmitter for shifting the axis of the voltage of the line, a receiver comprising two circuits having opposed voltages procured from the line and normally balancing one another, but adapted to become unbalanced upon shift of the axis of the voltage of the line, a load device energized by both of said circuits and control means including an amplifier connected to a circuit containing said load device.

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