Oct. 1, 1946. A. ARNOT 2,408,543

ELECTRICALLY OPERATED DISTANT-CONTROL DEVICE

Filed Dec. 16, 1942 2 Sheets-Sheet 1

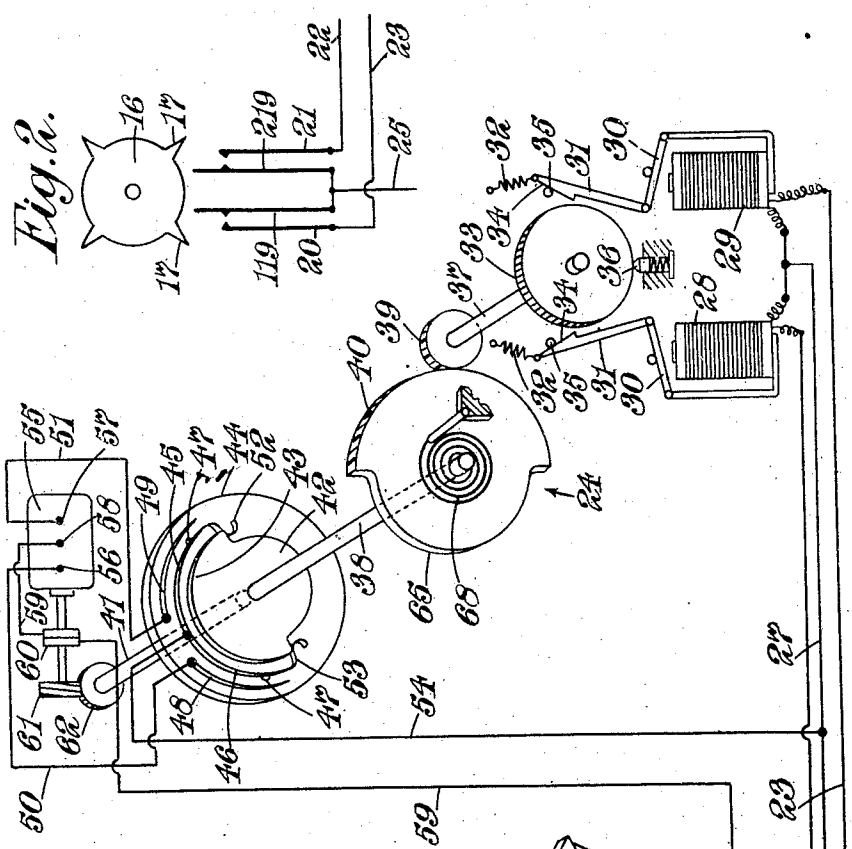


Fig. 2.

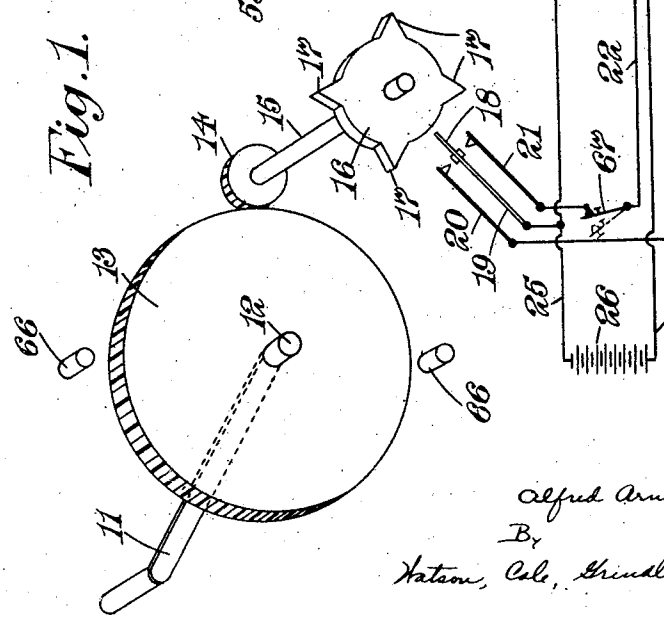


Fig. 1.

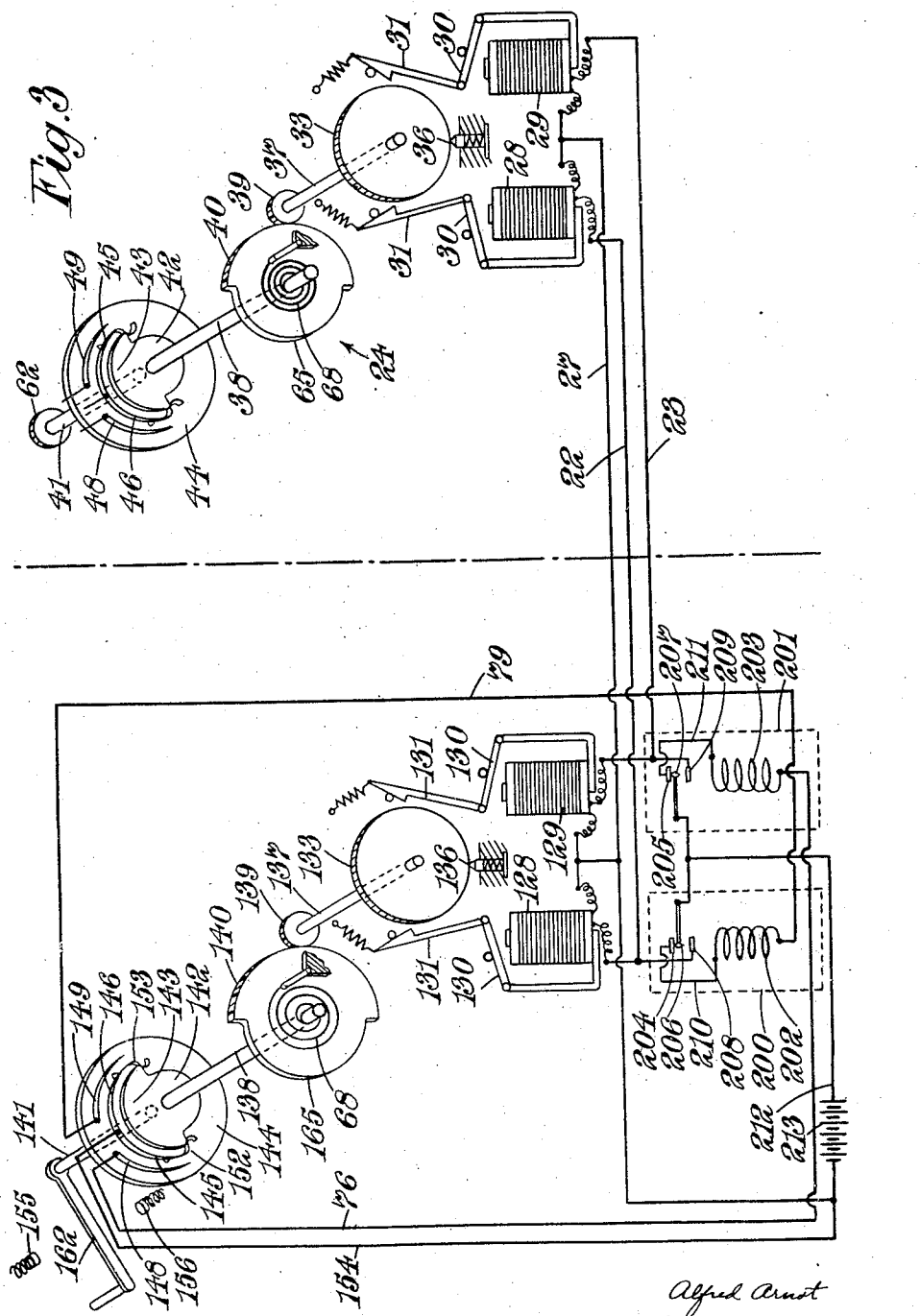
Alfred Arnot
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Fig. 3



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ELECTRICALLY OPERATED DISTANT-CONTROL DEVICE

Alfred Arnot, Warrington, England, assignor to Aeronautical & Mechanical Investments Limited, a British company

Application December 16, 1942, Serial No. 469,270
In Great Britain September 22, 1941

1 Claim. (Cl. 172—239)

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This invention comprises improvements in or relating to electrically operated distant-control devices.

It is an object of the invention to provide a device whereby a control member in one position has its movement followed by a follower member in another position, the synchronisation of the movements being effected electrically.

According to the present invention a transmitter is provided comprising a control member and two make-and-break contacts so operatively connected to the control member that one of them is closed repeatedly when the control member is moved in one direction and the other contact is closed repeatedly when the control member is moved in the other direction, the interconnection between the control member and the contacts being such that the number of operations depends upon the extent of the control member's movement, in combination with two control lines, one of which receives impulses through one of the make-and-break contacts and the other through the other contact and a receiver comprising two electromagnetic actuating mechanisms for pawl-and-ratchet movement, one connected to one control line and the other to the other line one of which serves to actuate a follower member in one direction and the other to actuate it in the opposite direction. By this means if the actuating member is moved in one direction the make-and-break contact which is repeatedly closed on this direction of movement energises one of the control lines and thereby operates one of the electromagnetic ratchet devices to move the follower member in a corresponding direction through a number of steps corresponding to the extent of the movement of the actuating member. When the actuating member is moved in the opposite direction the other control line is energised periodically and the follower member is caused to make a corresponding number of steps in the opposite direction. Thus the follower member will follow the control member with an accuracy which is only limited by the fineness of the steps of its movement.

The make-and-break contacts may be directly mechanically operated by a cam device or devices driven by the control member. Alternatively the make-and-break contacts may be actuated by a relay the circuit of which is closed by a cam or equivalent part moved by the control member and opened again when synchronism between the control member and the follower is reached by means of electromagnetically operated ratchet mechanism connected to the control lines.

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Preferably in order to facilitate the use of fine steps and of a small amount of energy in the transmission lines the part which is to be controlled is not directly mechanically operated by the pawl-and-ratchet devices but is caused to copy closely the movements imparted by the pawl-and-ratchet devices through the interposition of an electric servo mechanism as hereinafter described.

The following is a description, by way of example, of certain forms of apparatus in accordance with the invention, but it will be understood that this apparatus is described only to indicate the principle of the operation and many modifications can be made in detail without departing from the spirit of the invention.

In the accompanying drawings:

Figure 1 is a diagram of one form of distant-control apparatus in accordance with the invention,

Figure 2 is a diagram of a modification of Figure 1, and

Figure 3 is a diagram of an alternative form of apparatus.

Referring first to Figure 1, a control member 11 is provided in the form of an arm mounted on a rotatable shaft 12. The shaft carries a large gear-wheel 13 which meshes with a pinion 14 on a secondary shaft 15 which carries a multi-point cam 16. The points 17 of the cam are arranged to strike in succession upon a striker 18 which forms part of a spring contact-arm 19 disposed radially to the cam with the striker 18 lying in the path of the points 17. When the cam 16 is rotated clockwise by the control member 11, the spring contact-arm 19 is repeatedly deflected to the left of its mid position as viewed in the figure, and makes and breaks contact repeatedly with an electric contact 20 located to the left of it. When the control member 11 is moved in the other direction, the cam 16 is rotated anti-clockwise and the arm 19 is deflected repeatedly towards another contact 21 located on the other side of it from the contact 20. It will be observed that the number of times which contact is made in either direction of rotation depends upon the extent of the movement of the control member.

From the two contacts 20, 21 there extend two control lines 22, 23 to a receiving apparatus which is indicated generally in the drawings by the numeral 24. The spring contact-arm 19 is connected by a line 25 to one pole of a battery

26 and the other pole of the battery is connected to a return line 27.

The receiver 24 comprises two electromagnets 28, 29 energised by the control-lines 22, 23, respectively. Each electromagnet has a pivoted armature 30 which carries a pawl 31, and a spring 32 in each case serves to return the armatures 30 to their initial position when the magnets 28 or 29 are de-energised. The pawls 31 are located one on each side of a ratchet-wheel 33 having double-faced teeth so that one pawl will rotate the ratchet in one direction and the other in the other direction. The pawls 31 also have pallet faces 34 which, when they are drawn back by the spring 32, engage fixed pins 35 which lift them out of engagement with the ratchet-teeth. Thus, for each energization of either of the electromagnets 28, 29, one of the pawls 31 is drawn down, engages the ratchet-wheel 33 and moves it forward one tooth; when the current is interrupted the pawl returns to its initial position and the pallet engages the pin 35 and thus lifts the pawl away from the ratchet so that it does not interfere with the movement of the ratchet by the other pawl should the next impulse come in on the other transmission line.

The ratchet-wheel 33 is also engaged by a spring centering member 36 which bears on the notches between the ratchet-teeth, or on a separate series of centering recesses, and which serves to prevent the ratchet wheel from overrunning so as to move more than one tooth at each impulse. Any other means for preventing overrunning may be employed if desired, such means being well known.

The ratchet-wheel 33 is mounted on a secondary shaft 37 which is geared to a main shaft 38 by means of a pinion 39 on the secondary shaft 37 and a gear-wheel 40 on the main shaft 38. The ratio of the gear-wheel 40 to the pinion 39 multiplied by the number of ratchet teeth on the wheel 33 is equal to the ratio of gear-wheel 13 to pinion 14 multiplied by the number of points 17 of the cam 16, and thus the main shaft 38 will rotate angularly to the same extent and in the same direction as any movement applied by the control member 11 to the gear-wheel 13, assuming the connections are appropriately made. (The gear ratio in the transmitter and the receiver 24 may differ if desired in cases where the angular movement of the receiver is not required to be identical but to bear some ratio to that of the transmitter.)

The part which is to be controlled, which might be, say, the flaps on the wing of an aircraft, is provided with a control shaft 41 which constitutes a follower member and which is concentric with the main shaft 38 of the receiver. The two shafts are brought close together without being mechanically interconnected. On the main shaft 38 is a cam 42 having a bulge 43 on one side which extends around part of its circumference. Close to the cam there is mounted on the follower shaft 41 a control disc 44 carrying two insulated spring contact-arms 45, 46 which are electrically connected together and form the movable members of a two-way contact circuit. Each arm carries a contact 47 which is adapted to close against one of two spring contact-arms 48, 49 connected respectively to the two lines 50, 51 of a two-way circuit. The ends 52, 53 of the contact-arms 45, 46 are curved inwardly to engage the cam 43 on the main shaft 38 and their ends engage simultaneously the ends of the bulge on the cam in such manner that if the cam moves relatively

to the disc 44 clockwise, as viewed in the figure, it will lift the contact-arm 45 and close the circuit to the line wire 51, while if it moves anti-clockwise relatively to the disc 44, it will lift the contact arm 46 and close the line-wire 50. The contact-arms 45, 46 are energised by a line 54 which is branched from the line 27, hereinbefore referred to, connected to the battery 26.

The lines 50 and 51 are connected to the terminals 56, 57 of a reversible electric motor 55. The motor 55 has a third terminal 58 which is connected to a return-line 59 leading to the other terminal of the battery 26 from that to which the line 54 is connected. The motor is such that if the line 50 is energised, it will rotate in one direction, and if the line 51 is energised, it will rotate in the other direction. The motor is connected mechanically to the follower-shaft 41 through an electromagnetic clutch 60, a worm 61 and worm-wheel 62, the arrangement being such that if the contact-arm 45 is lifted by the main shaft 38 moving clockwise, the follower-shaft 41 will be driven clockwise until the disc 44 brings the end 52 of the contact-arm 45 past the end of the bulge 43, whereupon the circuit is broken and motion ceases, while if the main shaft 38 is driven in the opposite direction, the contact on the arm 46 will be closed, the line 50 will be energised, and the motor will rotate in the reverse direction causing the follower-shaft 41 to move anti-clockwise until it catches up with the cam 43 and the circuit is broken again.

In the result, the follower-shaft 41, which is also the control shaft for the wing-flaps or other device to be operated is made to conform to the movements of the main shaft 38, which follows the movements of the control-member 11 and thus the flap or other device to be operated is made to conform precisely to the movements of the control-member 11, without any mechanical connection existing between the parts and without the transmission from the transmitter to the receiver 24 being required to convey the energy for operating the parts; the lines 22, 23 merely act as signal lines. It will of course be understood that instead of the control-member 11 and the main shaft 38 and follower-shaft 41 being employed, equivalent parts moving in straight lines instead of angularly could be used.

In any mechanism of this kind it is desirable to provide means to ensure that in the event of loss of synchronism between the transmitter and the receiver, synchronism can be restored simply. To this end, in the mechanism described, a number of teeth are cut out of the gear-wheel 40, as shown at 65 in the position which corresponds to the extreme of the movement of the control-member 11, where the latter abuts against a stop 66. A normally-closed push-button 67 is provided in one of the transmission lines (the line 22 in the figure), so that the line can be broken by operating the push-button whenever desired. If this is done and the control-member 11 is moved, movement of the ratchet-wheel 33 will take place in a clockwise direction only, because the electromagnet 28 which would rotate it in an anti-clockwise direction is prevented from operating by the line 23 being broken. Thus one or two partial reciprocations of the control-member 11 will move the gear-wheel 40 to its extreme position when the gap 65 comes opposite the pinion 39 and the parts are no longer in gear; hence it will move no further. The control-member 11 being then moved to the corresponding extreme position against the stop 66, the push-button 67

is released. The apparatus is now in synchronism. A bias spring **68** surrounds the shaft **38** and gives the gear-wheel **40** a bias towards engaging with the pinion **39** when it is in the said extreme position, so that as soon as the control-member is moved away from this position, the shaft **38** will immediately fall into gear with the pinion **39** and will follow the movement exactly.

If the control-member **11** is liable to be moved with a rapidity too great for the pawl-and-ratchet mechanism to follow it accurately, it is possible to mount a governor on the shaft **15** so as to limit the maximum speed of movement. Moreover, a spring may be interposed between the control-member **11** and the gear-wheel **13** so that the control-member can be moved at once to the desired position and the cam will follow at a rate determined by the strength of the spring and by the governor, which rate will be arranged to be not greater than that which is permissible for the transmission of the impulse.

Inaccuracies of synchronism may arise in certain instances due to the cam **16** occasionally making sufficient movement for one of its points to press the spring contact **19** into engagement with the contact-arm **21** and the movement ceasing before the point of the cam has actually passed the striker **18**. This will lead to an impulse being sent out in one direction which will not be picked up on return movement of the cam. To guard against this, the modification illustrated in Figure 2 can be provided. In this instance, the parts are all similar to those already described, with the exception that instead of the spring-contact-arm **19**, two arms **119, 219** are provided, one to close against the contact member **20** and the other against the contact-member **21**. If the cam **16** is rotating clockwise, it must pass the member **219** before reaching the contact-member **119**, and similarly if the direction of rotation is reversed, the member **119** must be passed before **219** is reached. This will mean that no circuit is closed until the projection **17** of the cam reaches the second of the two members and, should the movement be reversed before it has passed the second of the two members, the other contact will necessarily be closed.

In the alternative form of apparatus illustrated in Figure 3 the receiver **24** is similar to that already described for the receiver **24** of Figure 1 and the corresponding parts are similarly numbered in the drawings. The electric motor drive is not shown in the figure, but would be provided as already described. The transmitter, however, differs. In fact, the mechanism of the transmitter is the same as that of the receiver **24**, but in addition two relays **200** and **201** are provided which serve to close the make and break contacts of the two control lines **22** and **23** respectively. As soon as the circuit of the relay winding **202** or **203** of the relays **200** or **201** are energised, repeated impulses are sent to the control lines **22** or **23** until the relay winding circuit is broken. To this end the relay **200** has two fixed contacts **204** and **208** and one movable contact **206** which is spring loaded to make contact with fixed contact **204** and is adapted to be magnetically drawn on to fixed contact **208** by means of the relay winding **202**. The contact **208** is connected by a line **210** to a magnet **128** having a pawl **131** for operating a ratchet wheel **133**, the parts **128** to **133** corresponding to the parts **28** to **33** of the receiver **24**, and is also connected to the transmission line **22**. Contact **204** is connected to the relay coil **202**, and contact **206** is connected by line **212** to the battery **213**. Relay **201** is similarly equipped with two fixed contacts **205** and **209**, with a movable contact **207** spring loaded towards contact **205** and magnetically drawn to contact **209**. Contact **209** is connected by line **211** to a magnet **129** having a pawl **131** for operating a ratchet wheel **133**, the parts **129** to **133** corresponding to the parts **28** to **33** of the receiver **24**, and is also connected to the transmission line **23**. Contact **205** is connected to the relay winding **203**, and contact **207** is connected by line **212** to the battery **213**.

The relay windings **202** and **203** are connected by lines **79** and **76** respectively to two spring contacts **149, 148** on a disc **144**. The contacts **148, 149** are arranged to be engaged respectively by contacts **145, 146** which form part of a two-way circuit fed by line **154** from the battery **213**. The contacts **145, 146** have end portions **152, 153** to engage a cam **142** on a main shaft **138** carrying a gear-wheel **140** meshing with a pinion **139** on a secondary shaft **137** driven by the ratchet wheel **133**; all the parts **133** to **153** correspond to the parts **33** to **53** of the receiver **24** and operate in the same way. The disc **144**, which corresponds to the disc **44** of the receiver is mounted on a shaft **141**, but instead of this being driven through a worm gear **62** by an electric motor, it is driven by an arm **162** which constitutes the control member, the movements of which are to be copied.

It will be seen that the control member when moved in one direction (clockwise in the figure) will carry the tail **152** of the contact arm **145** against the bulge **143** of the cam **142** and close the contact of the line **76**, while if the control member **162** is moved anti-clockwise, the line **79** will be energised.

If then the control member **162** is moved clockwise and the line **76** is energised, the relay winding **203** will be completed through contact **205** and the contact **207** will be drawn downwards to complete the circuit to magnet **129** and control line **23** through contact **209**. However, as soon as contact **207** leaves **205** it breaks the circuit of relay winding **203** and will only carry on to the contact **209** for a short period due to its inertia; it will then return to contact **205** under the influence of a spring and repeat the cycle until line **76** is opened through the contacts **145, 148**; in the meantime it will have sent a series of repeated impulses to the magnet **129** and the control line **23**. Similarly if the control member **162** be moved in an anti-clockwise direction line **79** is energised and the relay **200** will send a series of repeated impulses to the magnet **128** and the control line **22**.

Thus it will be seen that in the complete sequence of operation the rotation of the control member **162** closes either of the pairs of contacts **145, 148** or **146, 149**; this energises either the line **76** or **79** causing the relay **201** or **200** to vibrate; impulses are thereby sent to the magnets **129** and **29** or **128** and **28** which step round the ratchet wheels **133** and **33** until the ratchet wheel **133** which rotates the cam **142** through a gear wheel and pinion **140** and **139**, has once more opened the contact **145, 148** or **146, 149**. The relay **201** or **200** will then immediately cease vibrating, and no further impulses will be received by the magnet. The movement of the ratchet wheel **133** is copied precisely by the ratchet wheel **33** of the receiver unit, which then operates precisely as the receiver of Figure 1.

By this mechanism the control member **162** has

merely to move the shaft 141 and disc 144 and does not directly operate a cam such as the cam 16 in Figure 1. The movement of the control member can therefore be made extremely light and it can, if desired, be provided with a friction control such as to give a suitable "feel" to the movement.

In the event of synchronism being lost due to one of the pawls 31 or 131 slipping on a ratchet, synchronisation can be effected by moving the control member to either extreme position. To this end, the gear-wheel 140 is provided with a notch 165 similar to the notch 65 in Figure 3, and at the extreme position of the control member 162 are disposed two spring loaded stops 155 and 156 so arranged that the pinion 139 just enters the notch 165 of the gear-wheel 140 when the control member 162 touches either of these stops 155 or 156. The gear wheels 140 and 40 are also fitted with bias springs such that at either extreme position of travel they tend to mesh with their respective pinions 139 or 39. If then the control member 162 be pressed against either of the spring loaded stops 155 or 156 the contacts 145, 148 or 146, 149 will be closed and the relay 201 or 200 will vibrate and send impulses to the magnets 128, 28 or 129, 29.

This will rotate ratchet wheels 133 and 33 until the pinions 139 and 39 come to the cut away portions 165 and 65 of the gear-wheels 140 and 40 respectively; due to the fact that pinion 139 can then no longer rotate the gear-wheel 140, the cam 142 cannot rotate sufficiently far to open the contacts 145, 148 or 146, 149, as the control member 162 is being moved further than its normal travel by pressing against the spring loaded stops 155 or 156, and in a short space of time both receiver and transmitter elements will have taken up their corresponding extreme positions. As soon as the control member 162 is released it will be pushed by the spring loaded stops to its own limiting position, whereupon the contacts 145, 148 or 146, 149 will be opened and synchronism will have been restored.

It will be appreciated that the relays 200, 201 should be given such natural frequency of operation by appropriate design of the parts as to make them work at the optimum speed for the ratchet mechanisms, and that this speed is quite independent of the speed at which the control-member 162 is moved by the operator to a desired position. Moreover, more than one transmitter may be connected to the receiver by means of branch circuits from the control lines, and any transmitter will be able to effect movement of the receiver from any desired position in the circuit. In this case means must be provided to ensure that the control-arms 162 of the various transmitters are all moved into the same position in response to movement of any one of them. This can be effected by connecting the shafts 138 to the shafts 141 by some form of clutching device which will transmit power from the shaft 138 to the shaft 141 whenever they are out of synchronism, but will not transmit power in the opposite direction. For example, an electric clutch can

be provided between the two shafts electrically connected to the other transmitter or transmitters in such a way that movement of any one transmitter lever will energise the clutches of all the other transmitters. Again, each of the transmitters might be provided with a motor such as the motor 55, and the corresponding worm-gear 61, 32, but with means to disconnect it whenever it is desired to operate the shaft 141 by hand.

Instead of employing in the receiver or transmitter or both a ratchet-wheel with double-faced teeth and two sets of pawls, it is possible to employ two single ratchets which are connected together through a differential gear, so that one ratchet drives the mechanism in one direction and the other in the other direction; in this case a convenient form of step by step ratchet mechanism is that commonly employed for operating preselector switches in automatic telephony.

I claim:

Electrically-operated distant-control apparatus having in combination, in a transmitter, a movable control member, a follower therefor, a cam and cam-engaging member carried one by the control member and the other by the follower, the cam having a contact-operating portion which when the follower is in synchronism with the control member is in close proximity to the cam-engaging member, idle sections of the cam adjoining said contact-operating portion, two pairs of make-and-break contacts operated by the cam-engaging member so that one pair of contacts is altered when the control member moves relatively to its follower from a position of synchronism therewith in one direction and the other pair when it moves in the other direction, two ratchet-operating repeating-relays the energizing circuits of which are controlled one by one of the said pairs of contacts and the other by the other pair, line contacts repeatedly actuated by the relays when energized for making and breaking line circuits and thereby sending out repeated line signals, electromagnetically operated ratchet mechanism at the transmitter energized by said line signals and operatively connected to the follower to move it after the control member, at least one of the ratchet mechanisms comprising oppositely-handed ratchet teeth on a single shaft engaged by pawls, one pawl for moving the shaft in one direction and the other pawl for moving the shaft in the other direction and wherein the shaft is connected to the means for operating the contacts through a reduction gear so that the number of steps executed by the ratchet-operating relays in bringing the follower to its desired position is increased, said reduction gear comprising a gap for the purpose of automatically synchronizing the transmitter and receiver at the extreme of movement of the parts in one direction or the other, and, in a receiver, similar magnetically operated ratchet mechanism operated in step with that of the transmitter by the same line signals to actuate a part to be controlled.

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