

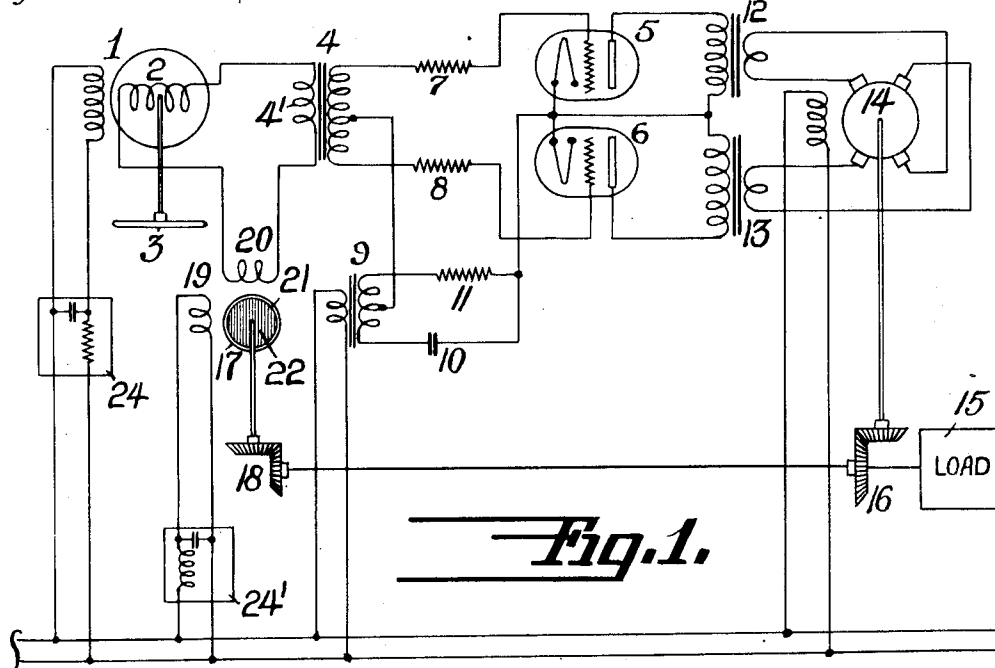
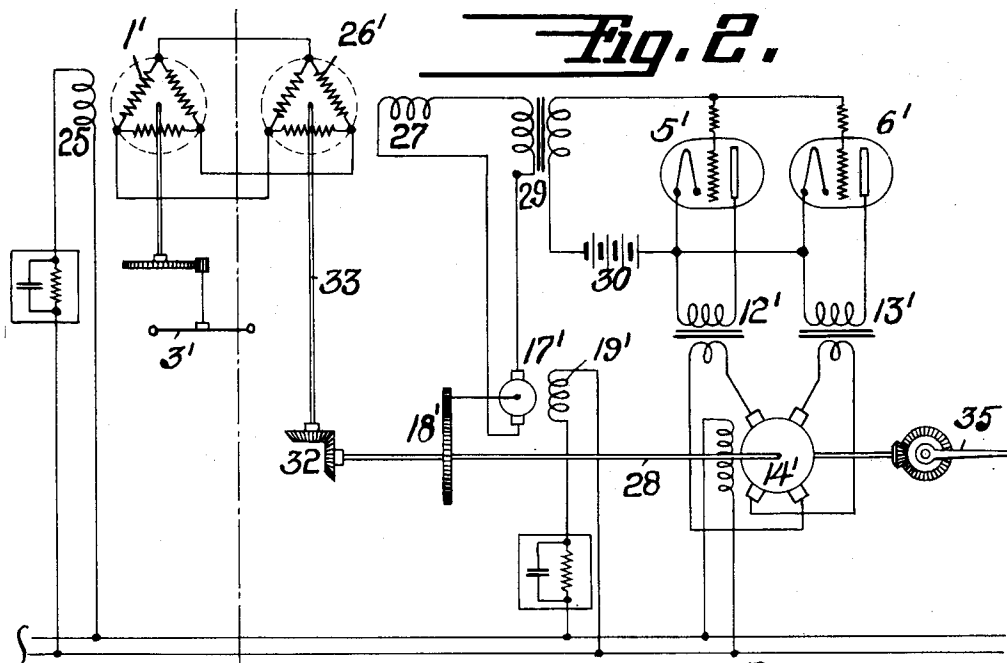
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NONHUNTING OR DEAD BEAT REMOTE CONTROL

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NONHUNTING OR DEAD BEAT REMOTE
CONTROL

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This invention relates to improvements in the remote control of movable objects and more especially to means for controlling electric motors of considerable power and driving loads of considerable inertia from a low power controller. In most systems of this type, there is a marked tendency to hunt or overshoot the position of rest so that the system becomes oscillatory and unstable. According to my invention, I combine the signal voltage from the controller with a voltage generated as a function of the direction and speed of rotation of the motor with the result that for every position of the controller or relative position of the controller and controlled objects there is a definite motor speed so that if the controller approaches or reaches its zero position while the motor, due to the inertia of the armature or load, is still rotating at good speed there is impressed a counter E. M. F. on the motor amounting to a reversal of the torque producing current thus bringing the motor quickly to rest by the time the controller has reached the zero position.

Referring to the drawing,

Fig. 1 is a wiring diagram showing how my invention may be applied to the control of the speed and direction of a power motor from a distance. Such a system might be adapted for use for multiple unit electric train control or for the control of the speed of the driving motors of sound picture projectors, etc.

Fig. 2 is a similar wiring diagram showing my invention as applied to a system for reproducing the position of a controlling object by a receiving object, such as between the pilot house and rudder of a ship or between a telescope or sound locator and a searchlight or as a follow-up system.

In both figures the source of power is shown as single phase alternating current, although obviously my invention is not limited thereto. The controller 1 in Fig. 1 is represented as a vario-coupled transformer in which the secondary 2 is rotatable with respect to the primary by means of a controller handle 3 so that the voltages induced therein may be varied from zero when the coils are at right angles to a maximum in one phase relationship or polarity or in the other, dependent on whether the controller is rotated clockwise or anti-clockwise. The signals from the controller may be supplied to a transformer 4 by means of which opposite phases are applied to the grids of a pair of electron tubes 5 and 6 through suitable resistances 7 and 8 in such a manner that the phases on the grids

of the two tubes are oppositely shifted in accordance with the magnitude and direction of the signal. For this purpose I have shown a system of dynamic phase shift described and claimed in the prior patent of Francis L. Moseley, No. 2,088,659, dated August 3, 1937, for Phase shift control of electron tubes, in which a bias voltage is added to the signal voltage to produce a phase shift on the grid. For this purpose a phase shift net work employing a transformer 9, having a center tap leading to a center tap on the transformer 4, is employed, the primary being excited directly from the supply and a bias voltage being produced by any suitable means, such as a condenser 10 and a resistance 11 connected in circuit to the cathodes of the tubes. The heater winding of all tubes is omitted for sake of clearness. The output of the two tubes is led through suitable transformers 12 and 13 which control the speed and direction of the power motor 14. A very simple form of power motor adapted for use in this circuit is a reversible repulsion motor, the field of which is continuously excited from the supply and the two pair of brushes respectively short circuited through the secondaries of the transformers 12 and 13. In such a circuit the tubes act as variable resistances shunted across the brushes as explained more fully in the copending application of said Francis L. Moseley, now Patent #2,008,364, dated July 16, 1935, for Remote control of heavy objects. The motor armature is shown as coupled to a load 15 through gearing 16.

While the system so far described would turn the motor on and off with a limited speed control, it has no accurate speed control and would overshoot the position of rest, and if employed in a follow-up system would continually hunt, and it is to the securing of accurate speed control and the preventing of hunting that this invention is mainly directed. For this purpose I couple to the motor 14, or what amounts to the same thing, to the load 15, a generator 17 through suitable gearing 18. Said generator is so designed as to produce an alternating current electromotive force normally in opposition to or 180° out of phase with the signal supplied from the controller 2 in Fig. 1 or 27 in Fig. 2, which electromotive force varies in direction and magnitude with the direction and speed of the motor or load. To accomplish this special function in the best manner requires a special type of generator which I have shown in Fig. 1 and term a "field distorting generator" or "dynamic transformer".

It is shown as having two fields 19 and 20, the former excited from the line and the latter placed at right angles thereto. The rotor may comprise merely a thin copper cylinder 21 on an iron core 22. When the armature is stationary, no voltage is induced in the field 20 but as the armature is rotated the lines of force from the field 19 are distorted to pass through a coil 20, the amount of the distortion varying from zero at zero speed and approaching 90° at high speeds. The induced voltages in coil 20 may be coupled directly in circuit between signal 2 and the primary 4' of transformer 4 so as to superimpose this voltage on the signal voltage with the result that the signal actually impressed on the transformer 4 is the resultant of the external signal and the voltage generated as a function of the direction and speed of the motor. It will be understood that the proper phase relationship is maintained in the system by means of suitable phase correctors 24 and 24'. With my system, therefore, the motor 14 will have a definite speed for each position of the controller since, as the controller is moved from point to point, the strength of the signal will rise until the speed of the motor is such as to impress a counter signal which will hold the resultant signal to the fixed value.

A very important application of my invention is in the positional control of heavy objects from a distance, such as searchlights, guns or ships' rudders. In Fig. 2 the sending device is shown as a pilot wheel 3' of a ship, to which is coupled a suitable inductive device 1' which is of a type often used for transmitting angular motion and is shown as comprising a field 25 excited from a single phase supply and an armature having a multi-tapped winding connected to a similar winding 26' on a similar inductive device driven by the receiver or the motor 14' turning the same. It will readily be seen, therefore, that no electro-motive force will be produced in a field 27 of the receiving device as long as the armatures 1' and 26' are in the same angular position, but that an alternating E. M. F. will be produced in the field 27 of a magnitude and direction or polarity, dependent on the relative turning of the sending and receiving instruments in one direction or the other. The signal produced in 27, therefore, is quite similar to the signal produced in the winding 2 in Fig. 1. Said signal is also preferably combined with a counter signal generated by the rotation of the motor as in Fig. 1.

The generator 17', in this case, is shown as driven by step-up gearing 18' from the shaft 28 of the power motor 14'. Said shaft is also shown as driving the armature 26' through gearing 32 and shaft 33. In this instance the generator is shown as an ordinary commutator type, single phase generator in which the field 19' is excited from the supply. The armature, therefore, will generate an A. C. voltage of the same frequency as the supply and which varies in magnitude and polarity with the direction and speed of the motor. Said armature is shown as coupled between the signal supplied by the coil 27 and the input transformer 29.

A somewhat different form of tube control is also shown in this figure. In this instance the grid circuits of the two tubes 5' and 6' are connected in parallel to the transformer 29, while the plates of said tubes are connected in opposition or push-pull fashion to transformers 12' and 13'. In addition, a source of direct current

30 may be inserted to bias the tubes to prevent starting until the grid swings to a predetermined potential. In this system the tubes are either full on or entirely off, giving a sensitive control which would be unstable without my hunt preventing and speed control generator previously described but which is remarkably dead beat and accurate when my invention is applied thereto.

By my invention the rudder or other controlled object may be accurately and quickly positioned in accordance with the movements of the controller without overshooting. Suppose, for instance, that the pilot desires to turn sharply. He rotates the pilot wheel quickly to swing the rudder 35 through the desired angle. This results in a large signal being sent to the tubes resulting in a quick pick-up of the motor. As the motor speeds up, however, a point will be reached where the voltage generated by the generator 17 will prevent further increase in speed. As the rudder approaches the desired position, the armature 26' of the receiver is turned with the rudder and motor 14' so that the signal voltage becomes weaker and weaker until it becomes zero. At the same time the counter voltage supplied by the generator 17' will be maintained as long as the motor speed persists so that if the inertia of the motor armature or rudder gives it a greater speed than the normal speed for any given relative position of the pilot wheel and rudder, a counter E. M. F. will be applied to quickly slow down the motor to the proper speed and bring it to rest by the time the rudder has reached the desired position.

In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

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

1. Means for reproducing position at a distance comprising an A. C. power motor, an A. C. power source therefor, a signal sending device also powered from said source, an A. C. generator driven by said motor, the output of which is normally in phase opposition to the signal of said sending device, means including electron discharge tubes for controlling the speed and direction of said motor in accordance with signal voltages impressed on said tubes, said signal voltages comprising the resultant of the external signal from said device, and a voltage generated by said generator as a function of the direction and speed of rotation of said motor.

2. In a remote positional control for heavy objects the combination with a reversible motor and alternating current source, of sending and receiving inductive devices for supplying voltages varying in direction and magnitude in accordance with the relative position of the sending and receiving devices, the latter being positioned by said motor and the motor being governed by the output of said devices, an additional generator driven by said motor, and means for impressing

the output thereof on the input circuit to the motor.

3. Means for rotating an object to maintain it in positional agreement with a remote controlling object, comprising an A. C. electric power motor for rotating the driven object, a weak alternating current signal means, the output of which is dependent in amount and phase on the relative position of said objects, electron tube means controlled by said A. C. signal to cause actuation of said motor to drive the driven object, and electric means responsive to the speed and direction of said motor for generating an A. C. electromotive force counter to that supplied by said signal to said tube means and also supplied to the latter for preventing overrunning of said motor.

4. Means for reproducing position comprising, in combination with a controlling and a driven object, means for producing an A. C. signal which varies in magnitude and direction with the amount and direction of variation in position between said objects, an A. C. generator driven by said driven object and producing an A. C. signal of like frequency with said other signal and which varies in magnitude and direction with the speed and direction of rotation of the driven object, an electron tube circuit governed by said combined signals, and a motor controlled by the output of said circuit for driving the driven object.

5. Means for reproducing position comprising in combination with a controlling object and a driven object, a field winding and a poly-circuit armature winding relatively rotated by said controlling object in a predetermined angular relation therewith, a source of alternating current supply connected to said field winding, a second poly-circuit armature winding electrically connected to said first armature winding so as to produce an alternating magnetic field moving with said controlling object, a motor for driving said driven object, a coil in said field, one of said coil and second windings being driven by said motor, means responsive to the electromotive force induced in said coil for controlling said motor so as to cause the motor to drive the driven object into positional agreement with the controlling object, and an alternating current generator driven by said motor, the electromotive force generated by which is proportional to its velocity, said electromotive force being superimposed on the electromotive force supplied by said coil to control said motor, whereby overrunning is prevented.

6. Means for reproducing position comprising, in combination with a controlling and a driven object and an A. C. source, means for producing an A. C. signal which varies in magnitude and direction with the amount and direction of variation in position between said objects, a rotor having an outer ring of non-magnetic but electrically conductive material and an inner iron core supporting said ring and rotated by said driven

object, two field windings adjacent said rotor arranged in quadrature, one of said windings being excited from said A. C. source, and a motor for driving said driven element controlled by the combined output of said signal and said second winding on said rotor.

7. In a remote positional control for rotatable objects, the combination with an A. C. sending device, an A. C. reversible motor for turning said object with said device, an alternating current source, means for governing the speed and direction of said motor including an electron tube also powered from said source, said sending device furnishing a controlling signal of variable magnitude and direction governed by the relative positions of said device and object for governing the speed and direction of said motor, a rotor having a cylindrical member of non-magnetic electrical conducting material mounted on an iron core rotated by said motor, a field winding supplied from said A. C. source and positioned so that its field is intersected by said member, and a second field winding arranged in quadrature to said first field winding and electrically connected to oppose the input signal to said tube.

8. In a remote positional control for rotatable objects, the combination with a sending device, a reversible motor for turning said object with said device, an alternating current source for energizing said sending device and for supplying said motor, means for governing the speed and direction of said motor including an electron tube also powered from said source, said sending device serving to supply a controlling signal of variable magnitude and direction governed by the relative positions of said device and object for governing the speed and direction of said motor, a rotor having a hollow cylindrical member of non-magnetic electrical conducting material provided with an iron core and rotated from said motor, a field winding supplied from said source and arranged so that its field extends transversely through said cylindrical member, and a winding arranged at right angles to said field winding and connected to oppose the input signal to said tube.

9. In a remote positional control, the combination with an alternating current source, a sending device of limited power energized by said source, a remote controlled device requiring power motor actuation, a reversible power motor for turning said controlled device, means including an electron tube supplied from said sending device with a controlling signal of varying magnitude and direction for governing the speed and direction of said motor in accordance with the magnitude and direction of variance between the sending and controlled devices, a small alternating current generator driven by said motor having its field excited from said source, and means for impressing the output thereof in opposition to the input signal to said tube.

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