March 11, 1930. J. PFRETZSCHNER 1,749,842

ELECTROMAGNETIC CONTROLLING APPARATUS

Filed May 8, 1928

Fig. 1.

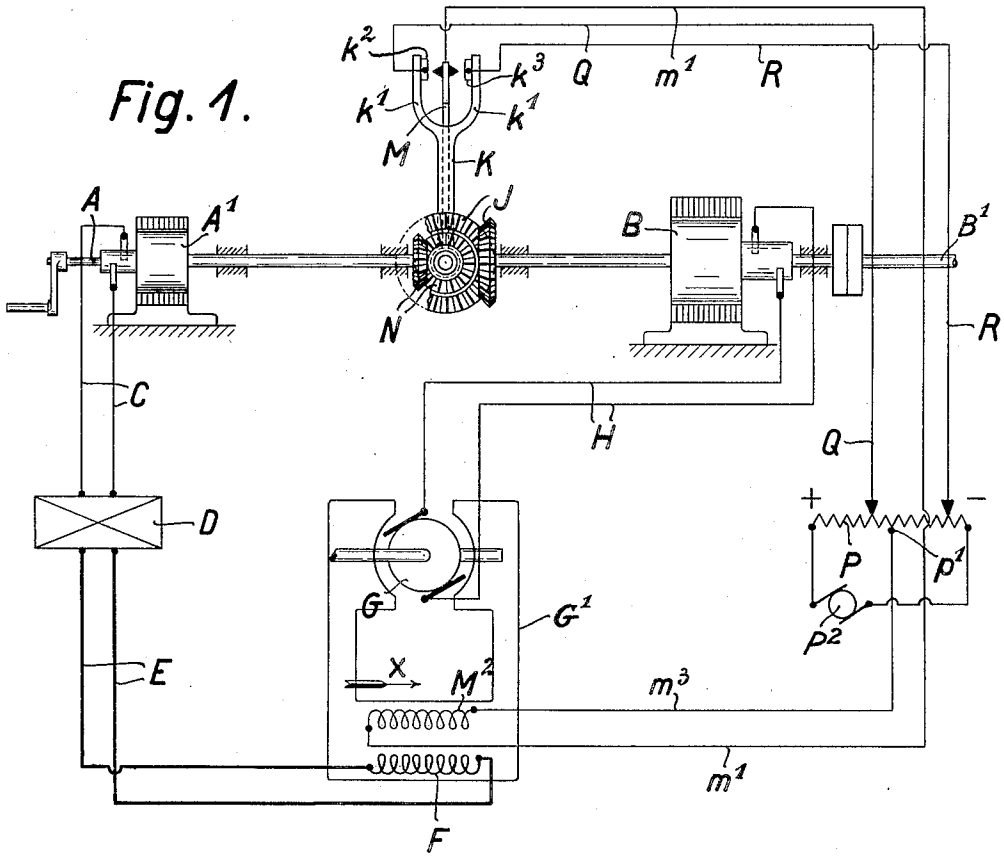
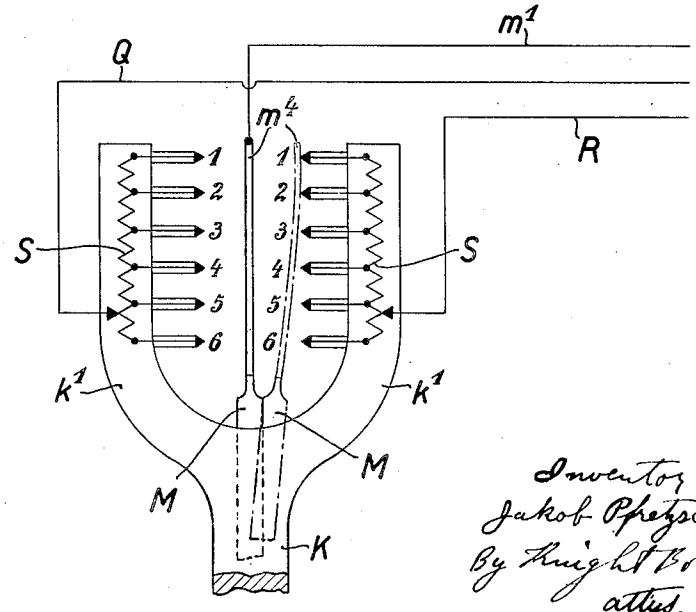


Fig. 2.



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ELECTROMAGNETIC CONTROLLING APPARATUS

Application filed May 8, 1928, Serial No. 276,187, and in Germany January 12, 1927.

This invention relates to electro-magnetic controlling apparatus comprising a device for transforming a controlling motion produced with a low expenditure of power, into a motion of a controlled member, produced in accordance with an analogous law by a power engine. Controlling apparatus of this type may be employed with hoisting machines, hauling machines and the like, in order to obtain an adjustment of the load that corresponds as exactly as possible to the adjustment of the controlling member.

Controlling apparatus of this type have already been proposed, in which a regulating device is provided for the power engine, which by a main regulation holds the speed of the power engine in a most uniform possible proportion to the speed of the low power controlling member, and which by an additional regulation affected through the intermediary of a switch re-establishes the prescribed proportions of the two paths travelled by the controlling and controlled members when a deviation from such proportion takes place. The subject matter of this invention pertains to a controlling apparatus of this type which is distinguished by great simplicity and great exactness of the transmission of the motion. The apparatus comprises an electro-magnetic regulating device fitted with an exciting winding that produces an induction proportional to the speed of the controlling member, and a source of current, which, when switched-in, produces an additional induction acting in the sense which re-establishes the prescribed proportion of the paths of the controlling and controlled members.

An embodiment of the controlling apparatus forming the subject matter of the invention is illustrated diagrammatically, by way of example, in the accompanying drawing, the power engine driving the controlled member being an electric motor.

In this drawing:

Figure 1 shows the whole arrangement of the apparatus, while

Figure 2 shows a modification of a detail of the embodiment illustrated in Figure 1.

A denotes a crank shaft, to which a controlling motion may be imparted manually with low expenditure of power, B denotes the armature of the electric motor, which constitutes the power engine intended to drive the controlled member B′ and to impart to this member a motion that corresponds, as exactly as possible, to the motion of the crank shaft A. The armature A^1 of a small continuous current generator is mounted on shaft A. The generator is connected by wires C to a current strengthener D which, in its turn, is connected by wires E to the main field winding F of a Leonard generator having a magnetic frame G′ designed for low saturation. The armature G of the Leonard generator is connected by wires H to the armature B of the motor intended to drive the controlled member and excited separately in a manner not shown. Through the intermediary of a bevel wheel gearing J, the shaft of armature B is positively connected to a fork-shaped switching arm K. The fork arms k^1 of the switching arm K are provided on their inner sides with contact pieces k^2 and k^3, respectively. Another switching arm M is arranged co-axially with arm K. Arm M is adapted to rock independent of arm K and is positively connected through a bevel wheel gearing N to the crank shaft A, the free end of arm M projects into the space between the two fork arms k^1. The connections are so made, that the two switching arms K and M rock in the same direction and at the same angular speed, if the angular speed of crank shaft A, or the controlling member, and the angular speed of armature B, or the controlled member B′, are exactly in the prescribed proportion, so that no relative motion occurs between the arms, and the arm M remains in its middle position shown in Figure 1 relative to arm K. If, however, a deviation from the prescribed proportion exists between the angular speeds of crank shaft A and armature B, a relative motion occurs between the arms K and M, in which the arm M approaches the contact piece k^2 when the armature B is leading, and approaches to contact piece k^3 when the armature B is lagging. The free end of the switching arm M projecting into the space

between the fork arms k^1, which is made of a conductive material, is connected by a wire m^1 to an auxiliary winding M^2 mounted on the stator of the Leonard generator. The other end of the auxiliary winding is connected, through a wire m^3, with the middle section of a non-inductive regulating resistance P connected to the circuit of a source of continuous current p^2. On one side of the contact point p^1 of the wire m^3 the regulating resistance P is connected through a wire Q to the contact piece k^2, and on the other side the resistance P is connected through a wire R to the contact piece k^3, which is insulated from piece k^2. With the polarity of the circuit, having the regulating resistance P, as shown in Fig. 1, a current is generated, when the switching arm M has come into contact with contact piece k^2, which flows through the auxiliary winding M^2 in the direction of arrow x, and upon the arm M touching the contact piece k^3, a current passes in inverse direction through the winding M^2. The arrangement is such, that the current in the first case, when the armature B or the controlled member is leading, effects a weakening, and in the second case, when the armature B is lagging, effects a strengthening of the magnetic field of the Leonard generator P, G.

Upon the crank shaft A being turned, an electromotive force is generated in the armature A^1 of the generator, driven by the crank shaft, which is proportional to the angular speed of the crank shaft. This electromotive force generates in the wires C a current whose strength with great approximation is likewise proportional to the angular speed of the crank shaft. The same holds true with the increased strength of the current in the wires E and in the main field winding F of the Leonard generator. As the stator of this generator is dimensioned for low saturation, the strength of the magnetic field or the induction generated in the stator is, when the influence of the auxiliary winding M^2 is neglected, with great approximation proportional to the strength of current in the main field winding F and thus also to the angular speed of the crank shaft A. The same holds good for the electromotive force of the generator and thus also of the counter-electromotive force of the motor armature B, which is proportional to the angular speed of armature B or of the controlled member. Therefore the angular speed of the controlled member is with great approximation proportional to the angular speed of the crank shaft that executes the controlling motion. The controlling apparatus A A^1, C, D, E, F, G, H, B thus constitutes in itself a so-called speed controlling apparatus. This apparatus of course suffers from slight inaccuracies, e. g. those due to the phase displacement, caused by self-induction, of the electric currents. These inaccuracies are now eliminated according to this invention in a very satisfying manner by the action of the auxiliary winding M^2 which is automatically switched in or out by the arms K and M. As long as the angular speeds of the crank shaft A and motor armature B are exactly in the prescribed proportion, the switching arm M, which is positively connected to the crank shaft, turns with the same angular speed as the arm K, which is positively connected to the motor armature B. No relative motion exists in this case between the two switching arms, arm M thus is at rest relative to arm K and assumes an angular position, in which it is not in contact with either of contact pieces k^2 and k^3, and therefore the auxiliary winding M^2 is switched out. When, however, the motor armature is leading, a relative motion arises between the switching arms K and M, and arm M comes into contact with the contact piece k^2 of arm K. The circuit P, Q, k^2, M, m^1, M^2, m^3 is thereby closed and an exciting current arises which passes through the auxiliary winding M^2 in the direction of arrow x and produces an additional induction. The exciting current in this case weakens the field of the generator F, G, so that the rotation of the motor armature B is retarded correspondingly. When the motor armature B is lagging, the switching arm M comes into contact with the contact piece k^3 of arm K, and an exciting current arises, that passes through the auxiliary winding M^2 opposite to the direction of arrow x and induces an additional field, which now strengthens the field of the generator F, G and correspondingly accelerates the rotation of the motor armature B. In both cases the auxiliary winding M^2 is connected in parallel to a portion of the non-inductive resistance P, so that the time constant of the exciting current is decreased and, consequently, a rapid excitation of the winding M^2 is obtained.

The described controlling mechanism comprising the switching arms M and K and the appurtenant gears N and J, which becomes effective upon the occurrence of a determined difference between the angles of rotation or angular paths of the controlling and controlled members and may therefore be denoted as a path controlling mechanism. This mechanism can be so designed, without difficulty by suitably determining the gear ratios, that it normally acts with only slight differences in the angular paths, whereby a very exact uniformity of motion between the controlled member with the controlling member can be obtained.

Figure 2 illustrates a modification of the portion, formed by the arms K and M, of the described path controlling mechanism, whereby both an increased rapid excitation of the auxiliary winding M^2 and an increase,

automatically adapting itself to the amount of the differences in speed, of the regulating action of the auxiliary winding is obtained. To this end a non-inductive graduated resistance S is connected to each of the fork arms k^1. Each of these resistances is fitted with six contact pieces denoted by 1 to 6 from the free end of the respective arm toward its fulcrum. The wire Q is connected to one of the resistances S, which corresponds to the former contact piece k^2, near the end nearest the fulcrum; while the wire R is similarly connected to the other resistance S which corresponds to the former contact piece k^3. The portion of the switching arm M connected to wire m^1, which projects into the space between the arms k^1, is designed as a flat spring m^4, which comes into contact successively with the contact pieces 1 to 6 when moved relative to arm K, in accordance with the angular amount of this movement, as shown in Figure 2 in dot and dash lines with one of the resistances S.

When, upon the motor armature B leading or lagging, the spring piece m^4 of arm M has come into contact with the contact piece 1 of one of the two resistances S, nearly the whole non-inductive resistance S is inserted before the auxiliary winding M^2 of the Leonard generator, whereby the rapid excitation, obtained even by the arrangement of Figure 1, of the auxiliary winding M^2 is increased. The greater the difference is, to be compensated for by the path controlling mechanism J, K, M, N, between the speeds of the motor armature B and the crank shaft A, the greater is the angle the arm M tends to turn relatively to arm K, and the greater is the elastic bending of the spring piece m^4, whereby, as can be seen from Figure 2, the contact pieces 1, 2, 3 . . . are short-circuited successively. The resistance S is thus switched out more and more, so that the strength of the current in the auxiliary winding M^2 is increased correspondingly thereby increasing the regulating action of the latter.

What I claim and desire to secure by Letters Patent, is:—

1. A controlling system having a controlling member adapted to perform a motion with low expense of power, a controlled member, a motor for imparting a motion to said controlled member bearing a constant relation to the motion of said controlling member, means for regulating said motor to run with a speed proportional to the speed of said controlling member, said speed regulating means comprising a magnetic frame, an exciting winding carried by said magnetic frame, means for feeding said winding with a current proportional to the speed of said controlling member, and an armature coordinated with said magnetic frame and controlling the energy supply to said motor, and additional regulating means comprising a switch, a source of voltage and a circuit associated with said exciting winding and including said switch and said source of voltage for generating an additional induction in said magnetic frame, said switch being adapted to disconnect said source of voltage when the distances traversed by said controlled and controlling members are proportionally in accordance and to connect said source of voltage upon a deviation of said distances.

2. A controlling system having a controlling member adapted to perform a motion with low expense of power, a controlled member, a motor for imparting a motion to said controlled member analogous to the motion of said controlling member, means for regulating said motor to run with a speed proportional to the speed of said controlling member, said speed regulating means comprising a magnetic frame, a main exciting winding carried by said magnetic frame and means for feeding said winding with a current proportional to the speed of said controlling member, and an armature coordinated with said magnetic frame and controlling the energy supply of said motor, and additional regulating means comprising a circuit associated with said main exciting winding and including a switch, a source of voltage and an auxiliary exciting winding for generating an additional induction in said magnetic frame, said switch being adapted to disconnect said source of voltage when the distances traversed by said controlled and controlling members are in proportional accordance and to connect said source of voltage upon a deviation of said distances.

3. A controlling system according to claim 2 in which said auxiliary exciting winding and said main exciting winding are arranged on the same magnetic frame.

4. A controlling system having a controlling member adapted to perform a motion with low expense of power, a controlled member, a Leonard drive comprising a generator having a magnetic frame and an electric motor supplied by said generator for imparting a motion to said controlled member analogous to the motion of said controlling member, speed regulating means comprising an exciting winding on said magnetic frame and means for feeding said winding with a current proportional to the speed of said controlling member, and additional regulating means comprising a switch, a source of voltage and a circuit associated with said exciting winding and including said switch and said source of voltage for generating an additional induction in said magnetic frame, said switch being adapted to disconnect said source of voltage when the distances traversed by said controlled and controlling members are in proportional accordance and to

connect said source of voltage upon a deviation of said distances.

5. A controlling system having a controlling member adapted to perform a motion with low expense of power, a controlled member, a Leonard drive comprising a generator having a magnetic frame and an electric motor connected to said generator for imparting a motion to said controlled member analogous to the motion of said controlling member, speed regulating means comprising a main exciting winding carried by said magnetic frame and means for feeding said winding by a current proportional to the speed of said controlling member, and additional regulating means comprising a switch, a source of voltage, an auxiliary exciting winding also arranged on the magnetic frame of said Leonard generator and a circuit associated with said main exciting winding and including said switch, said source of current and said auxiliary exciting winding for generating an additional induction in said magnetic frame, said switch being adapted to disconnect said source of voltage when the distances traversed by said controlled and controlling members are in proportional accordance and to connect said source of voltage upon a deviation of said distances.

6. A controlling system according to claim 1 in which said circuit associated with said exciting winding comprises a device for rapid excitation in either position of said switch.

7. A controlling system according to claim 2 in which said circuit associated with said main exciting winding comprises a non-inductive regulating resistance connected to said source of voltage, one end of said auxiliary exciting winding being connected to said resistance at a mid-point, and means including said switch for connecting the other end of said auxiliary winding to said resistance at either side of said mid-point.

8. In a controlling system according to claim 2 in which the switch arranged in said circuit associated with said main exciting winding consists of two contact members relatively adjustable upon a deviation of the related distances traversed by said controlling and controlled members, a non-inductive regulating resistance connected to said source of voltage, means connecting one end of said auxiliary exciting winding to said resistance at a mid-point, means connecting the other end of said auxiliary exciting winding to one of said contact members, means for connecting the other contact member to said resistance at either side of said mid-point, and a second non-inductive regulating resistance arranged at one of said contact members having a plurality of contact pieces, one of said contact members engaging the contact pieces arranged at the other successively as the deviation of the related distances of said controlling and controlled members increases.

9. In a device of the class described, a controlling member, a controlled member, an electric motor for driving said controlled member, an electric generator adapted to be driven by said controlling member, a dynamo electric machine comprising a field winding connected to said generator and an armature winding connected to said motor, a circuit comprising a source of current, an auxiliary exciting winding in said dynamo electric machine, and a reversing switch for coupling said auxiliary exciting winding to said source of current, and means for operating said switch in accordance with the relative speeds of said controlling member and said controlled member.

10. In a device of the class described, a controlling member, a controlled member, an electric motor for driving said controlled member, an electric generator adapted to be driven by said controlling member, a dynamo electric machine comprising a field winding connected to said generator and an armature winding connected to said motor, a circuit comprising a reversing switch adapted to act upon a deviation of said two members from their prescribed relative speeds, a source of current, a non-inductive regulating resistance, and an auxiliary exciting winding in said dynamo electric machine.

11. In a device of the class described, a controlling member, a controlled member, an electric motor for driving said controlled member, an electric generator adapted to be driven by said controlling member, a dynamo electric machine comprising a field winding connected to said generator and an armature winding connected to said motor, a circuit comprising a reversing switch adapted to act upon a deviation of said two members from their prescribed relative speeds, a source of current, a non-inductive regulating resistance, an auxiliary exciting winding in said dynamo electric machine, means connecting one end of said auxiliary exciting winding to said resistance at a mid-point, and means including said switch for connecting the other end of said exciting winding to said resistance at either side of said mid-point.

12. In a device of the class described, a controlling member, a controlled member, an electric motor for driving said controlled member, an electric generator adapted to be driven by said controlling member, a dynamo electric machine comprising a field winding connected to said generator and an armature winding connected to said motor, a circuit comprising a source of current, an auxiliary exciting winding in said dynamo electric machine, a reversing switch acting upon a deviation of said members from their prescribed relative velocities, means connecting one end of said exciting winding to an arm of said switch, a plurality of contacts on another arm of said switch, a non-inductive resistance, means connecting said contacts to said resist-

ance at spaced points, means connecting said resistance to the other end of said exciting winding, the construction of said switch being such that said first mentioned arm engages said contacts successively as the deviation of said motor and said generator from the prescribed relative distances to be traversed by them increases.

The foregoing specification signed at Cologne, Germany, this 24th day of April, 1928.

JAKOB PFRETZSCHNER.