April 2, 1946. J. D. TEAR 2,397,819

MOTION REPRODUCING DEVICE

Filed Feb. 25, 1942 2 Sheets-Sheet 1

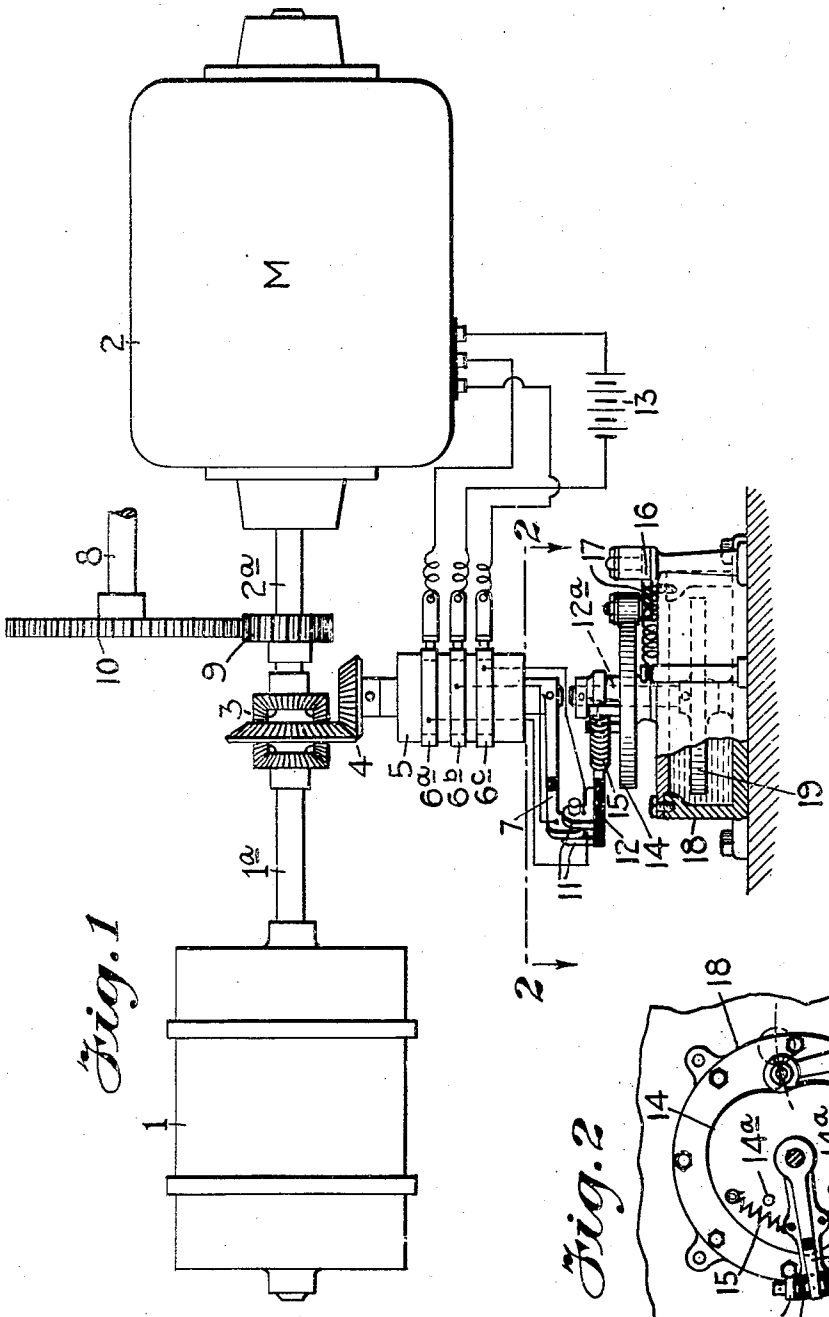


Fig. 1

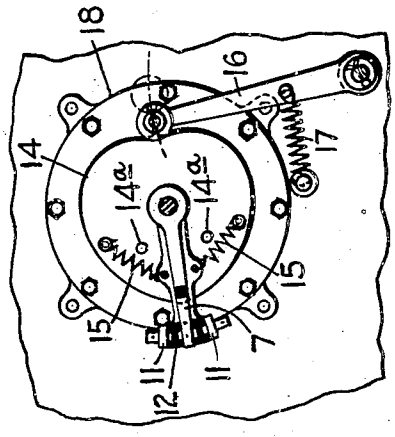


Fig. 2

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Fig. 3

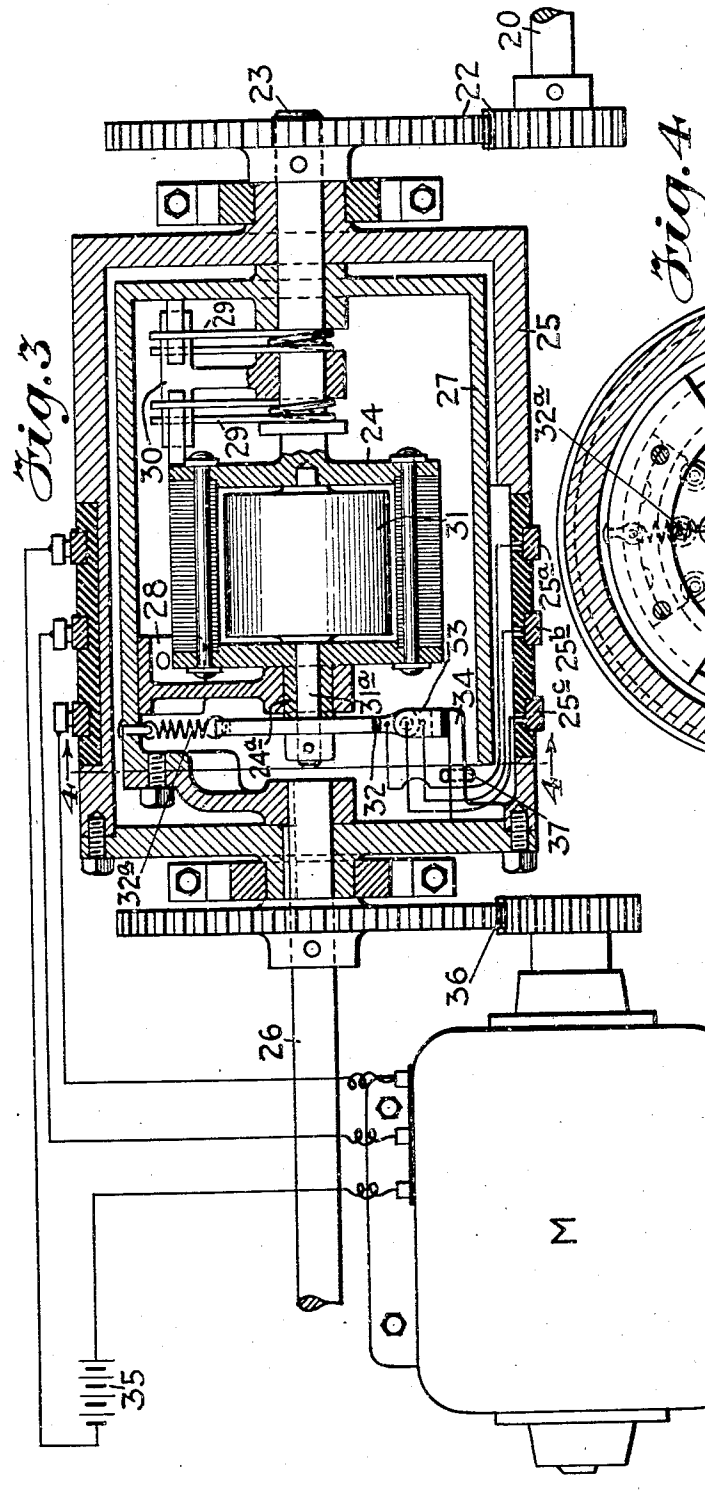
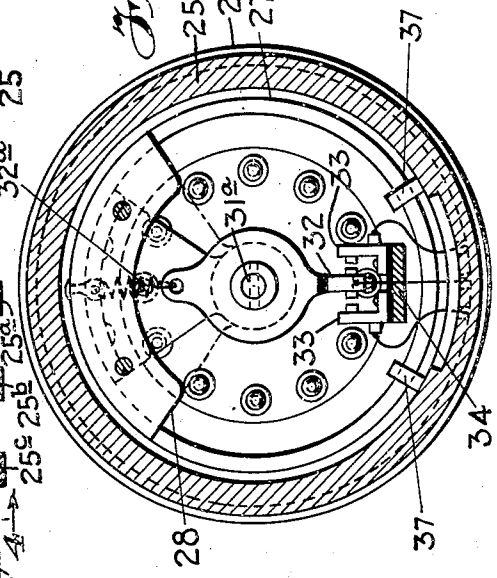


Fig. 4



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MOTION REPRODUCING DEVICE

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6 Claims. (Cl. 172—239)

This invention relates to motion reproducing mechanism where the movement of a primary member, sometimes referred to as the motion-receiving or input member, is reproduced by a secondary or follower member, sometimes referred to as the driven or output member.

Problems arise in connection with such follow-up mechanism where the initial power input to effect the movement of the member to be followed is insufficient to drive the follower. A power device in the nature of an electric servo-motor or other prime mover is employed in such cases, and the contacts governing the prime mover are themselves controlled by the two members. Normally one contact of the pair is connected to be moved by the primary member and is sometimes referred to as the primary contact. The other or secondary contact is positionally independent of the primary member. The movement of the follower is fed back to the contacts in a direction to counteract the effect of the movement of the primary member, and consequently the prime mover is energized only until the movement of the primary member is reproduced by the follower. When positional agreement of the primary and secondary members is attained, the contacts are automatically opened by the action of the feed-back or response.

When the rates of input and response movements equalize the contacts are said to be satisfied, for under that condition the follower is moving at synchronous speed with the primary member and the contacts are closed just enough to produce the synchronizing speed of the prime mover.

The present invention aims to improve the action of such following mechanism so as to cause the follower member to reproduce the movement of the primary member smoothly and accurately. To this end the contact mechanism is designed to adapt itself readily to errors in positional relationship of the primary and secondary members without marked alteration in the demands upon the motor, and to tend constantly to bring about agreement in positional relationship. In other words the contacts will absorb limited errors and will gradually erase the error when the condition which produced the error ceases.

In accordance with the invention this result is obtained by so yieldingly mounting the contacts that under conditions of non-synchronous speeds the contacts interfere and the pressure of one against the other causes them to assume a different operative position at which the contacts are satisfied.

Specifically one of the contacts is mounted to yield against the force of a centering spring, and at initiation or acceleration of primary movement, until the motor and follower and hence the feed-back can catch up, the tendency of the primary contact to overrun the secondary contact is absorbed in the yielding of the yieldable contact, with the consequence that the contacts are out of center position when they are satisfied, that is, when the members are at synchronous speed and the feed-back equals the input.

The force of the centering spring is effective to restore the contacts to their central or biased position. The demand upon the motor therefore requires it not only to maintain synchronism with the input, once synchronism has been attained, but also to erase the positional error of the follower member. The characteristics of the biasing member are such that the tendency to erase the error is substantially proportional to the quantitative value of the error. To limit the accumulation of speed of the motor and minimize the tendency to overrun and to effect a smoothness in motor response, the return movement of the displaced contact is retarded so that the response contact tends to leave the returning contact and deenergize the motor. In this way the follower member is brought smoothly up into synchronism and phase with the primary member.

In the form of mechanism used for purpose of illustration, the servo-motor is an electric motor of the split field type, there being a pair of contacts for each field, so that the motor will cause the follower to reproduce the motion of the primary member in either direction.

The illustrated embodiments of the invention will now be described, after which the invention will be pointed out in claims.

Fig. 1 is an elevation, partly in section and partly diagrammatic, of an apparatus embodying the invention;

Fig. 2 is a transverse sectional plan of the same on line 2—2 of Fig. 1;

Fig. 3 is a longitudinal sectional elevation of a modified embodiment of the invention;

Fig. 4 is a transverse sectional elevation on the line 4—4 of Fig. 3.

The construction of Figs. 1 and 2 is of the type in which the response or feed-back operates on the primary contact to counteract the movement of the contact produced by the input, with the result that the motor runs until the input is matched, and at synchronous speeds the contact is stationary. As shown a receiver motor 1 of a synchro transmission system is the primary mem-

ber and the electric servo-motor 2 is the secondary member. A differential 3 compares the speed of these two members, the shaft 1a of the receiver 1 driving one side of the differential, and the shaft 2a of the servo-motor driving the other side of the differential, while the center of the differential is connected by bevel gears 4 to drive a vertical drum 5 provided with slip rings 6a, 6b and 6c and having on its lower end a radial contact member 7 constituting the primary contact. The motor shaft 2a drives an output shaft 8 through spur gears 9 and 10.

The primary contact has its outer end insulated and has double contacts coacting with a double secondary contact member 11 on the outer end of an arm 12 pivoted below and in axial line with arm 7. The primary contact is electrically connected to slip ring 6b, and secondary contacts 11 are respectively connected to slip rings 6a and 6c. Brushes engage the slip rings and the central brush is connected to the center terminal of the motor through a source of energy 13, while the other two brushes are connected with the other two motor terminals.

A heart cam 14 is mounted loosely on the shaft 12a of the secondary contact arm 12 and centering springs 15 connect opposite sides of the arm 12 to lugs on the top of the heart cam and bias the arm and hence the secondary contacts 11 to a central position which is the position at which the primary and secondary members 1a and 2a are in positional agreement. Studs 14a on the heart cam limit the angular movement of the arm 12 relative to the cam, and a roller on the end of pivoted arm 16 is urged by spring 17 into coacting relation to the heart cam in the usual way, whereby the heart cam may yield when the movement of the arm 12 exceeds the limits of the studs 14a and will be returned to its center position when the arm returns within the limits of the studs.

Suitable friction means are provided to retard the return of the secondary contacts from displaced position. In the construction shown this is in the form of a viscous drag. Oil is provided in a container 18 which as shown is secured to a base and which provides trunnion bearings in its top and bottom walls for the shaft 12a of the secondary contact arm. A check device in the form of a paddle member 19 is secured on the shaft within the oil and exerts a retarding force opposing angular movement of the shaft.

From the above description it is evident that the secondary contact member will yield angularly under the force of the primary contact member when the follower is out of phase with the primary member and to the extent that it is out of phase. Thus the mechanism is permitted to adjust itself to the error and permit the follower to come smoothly into synchronous speed, while the centering springs 15 exert a biasing force substantially proportional to the error to return the contacts to center position where there is positional agreement of the members, the motor responding to this additional demand until the error is erased. The retarding mechanism checks the speed of the return since the primary contact through the response or feed-back tends to get ahead of the retarded secondary contact and thus gradually absorb the momentum of the follower mechanism and bring it up into agreement with little or no tendency to overrun. Thus the follower action is made smooth and at the same time accurate.

In the construction of Figs. 3 and 4 the invention is adapted to a follow-up mechanism in which the response or feed-back instead of acting upon the primary contact member to take out the movement of the input, moves the secondary contact so as to break the contact when the members are in positional agreement. In this case the error is represented by an angular displacement of the primary contact against the force of a centering spring, and drag means are provided to check the speed of return of the displaced contact.

The input is represented by shaft 20 and the servo-motor is numbered 21. The input shaft through reducing gears 22 drives shaft 23 of rotor 24 which carries the primary contacts and is rotatively mounted in the housing 25 that carries the secondary contacts and is connected to be turned by the servo-motor to break the contacts when the response is complete. The housing 25 has end hubs that are journaled in fixed bearings, as indicated, and the one hub provides a bearing for the shaft 23 while the other hub is keyed to the output shaft 26.

Within the housing 25 and axially surrounding the rotor 24 is an intermediate rotor 27 which bears at its opposite ends on the shafts 23 and 26. A sector bracket 28 on the inside of the rotor 27 provides a bearing for a hub 24a on the end of the rotor 24 opposite its connection with the shaft 23. Centering springs 29 in the form of coil springs on the shaft 23 rotatively join the rotors 24 and 27 through an intermediate member 30 that bears freely on the shaft 23 between the springs 29 and has lateral arms in abutting relation to alined arms on the two rotors, the ends of the springs straddling the respective pairs of abutting arms.

The rotor 24 is provided with an electrical winding of the squirred cage type and axially bearing within it is a permanent magnet 31 in the form of a drum which has an extended shaft 31a bearing in the hub 24a and having secured on its outer end the primary contact member 32. One end of this contact member is connected to the intermediate rotor 27 by a centering spring 32a, and the opposite end is insulated and is provided with the double primary contacts.

The outer rotor housing 25 carries the secondary contacts 33 through bracket 34. Slip rings 25a, 25b and 25c on the housing 25 are connected, respectively, with the double primary contact and with the individual secondary contacts. Slip ring 25a is connected through a source of current 35 to the center terminal of the motor 21, and the other two slip rings are connected to the reverse terminals of the motor.

The output shaft 26 is connected to the motor by gearing 36 and is keyed to the outer rotative housing 25, whereby rotation of the motor is transmitted to housing 25.

The rotor 24 and magnet 31 constitute a magnetic drag or coupling between the rotor 24 and the contact member 32. The intermediate rotor 27 through its yielding drive is rotated with the rotor 24 and the primary contact member 32 therefore follows the rotor 24 due to the centering spring 32a and the magnetic drive effect upon the magnet 31. As the follower gets out of phase relation the primary contact presses against the cooperative secondary contact and the magnet 31 is restrained from following the rotors 24 and 27. The spring 32a is thereby extended since its connection to the rotor 27 gets out of radial line with the member 32, and a centralizing force is thereby exerted on the

primary contact member substantially proportional to the error. As soon as the motor gets up to synchronous speed the contacts are satisfied and tendency of the motor further to increase its speed to erase the error is kept within check by the magnetic drag which the rotor 24 imposes upon the magnet 31.

Stops 37 limit the relative movement of housing 25 and rotor 27, and in case of further disagreement between the input and output members, rotor 24 has to move relative to rotor 27 which is permitted by the yieldable drive afforded by the spring couplings 29 and the intermediate transmitting member 30. In other words this yieldable drive serves the same purpose as the heart cam of the previous construction.

It is obvious that changes may be made in the constructions shown in the drawings and above particularly described within the principle and scope of the invention as defined in the following claims.

I claim:

1. Motion reproducing mechanism comprising a movably mounted motion receiving member, a movably mounted driven member, a reversible power means for moving the driven member, means for controlling the direction of movement of the power means comprising two cooperative control elements mounted for limited relative movement, means responsive to relative movement between the members for effecting the limited relative movement of the control elements, yieldable mounting means for one of the elements including means biasing the element toward a position to effect positional agreement between the members, said yieldable mounting means being effective to permit joint movement of the elements and relative movement between the members when the relative movement between the members is in excess of that corresponding to the limited relative movement of the control elements, and means effective in proportion to the rate of return movement of the yieldably mounted element to retard the return movement of the element to its biased position.

2. Motion reproducing mechanism comprising in combination with a primary member and a follower member, a reversible power means for moving the follower member, means for energizing the power means including a primary control element, a primary contact fixedly mounted on the primary control element, a secondary control element and a pair of secondary contacts mounted on the secondary control element in fixed relation relative to each other and to the secondary control element, means for moving the primary element by movement of the primary member to cause the primary contact to engage one or the other of the pair of secondary contacts in accordance with the direction of movement of the primary member and thereby to effect corresponding direction of movement of the power means, means for yieldably mounting one of the control elements including means biasing the element to a position to effect positional agreement between the members, the engagement of the primary and secondary contacts being effective to cause a displacement of the yieldable control element by an amount representative of the error in position of the members, and means effective in proportion to the rate of return movement of the yieldably mounted element to retard the return movement of the element to its biased position.

3. Motion reproducing mechanism comprising in combination with a primary member and a follower member, a reversible power means for actuating the follower member, means for energizing the power means including a primary contact and a pair of secondary contacts, said secondary contacts being mounted in fixed relation to each other, means for moving the primary contact by movement of the primary member to engage one of the pair of secondary contacts, means actuated by the power means to disengage the contacts, one of the contact structures being yieldable under the pressure of its cooperative contact to allow the contacts to adjust themselves to the relative positions of the members and thereby absorb errors in the positional relation of the members, means biasing the yieldable contact in the direction to remove error, the force of said biasing means being proportional to the error, and means for retarding the return movement of the yieldable contact in proportion to its rate of return to its biased position.

4. Motion reproducing mechanism including an input member, an output member, power means for actuating the output member, and means for controlling the power means, said controlling means comprising a differential having input elements operably connected to the input and output members and an output element representative of the positional relation of the members, cooperative primary and secondary contacts for controlling the energization of the power means, means for actuating one of the contacts by the output element of the differential, means yieldably mounting the other of said contacts to permit movement under the force of its cooperative contact when there is an error in the positional relation of the members, whereby the yieldably mounted contact is displaced an amount proportional to said error, means resiliently biasing the yieldable contact toward the position where positional agreement of the members is effected, and means for retarding the return movement of the yieldable contact in proportion to its rate of return to its biased position.

5. Motion reproducing mechanism comprising in combination with an input member and a following member, a reversible power means for actuating the following member, means for energizing the power means including a primary contact and a pair of secondary contacts for selectively controlling the direction of rotation of the power means, said secondary contacts being fixedly mounted with respect to each other, means for engaging the primary contact and one of the secondary contacts in accordance with the direction of movement of the input member, yieldable means biasing the secondary contacts to open contact relation to the primary contact when the members are in positional agreement, the engaged contacts coacting to effect a displacement of the secondary contacts by an amount proportional to the error in positional relation of the members, and means for retarding the return of the secondary contacts to their biased position in proportion to their rate of return.

6. Motion reproducing mechanism comprising in combination with an input member and a following member, a reversible power means for actuating the following member, means for energizing the power means including a primary contact and a pair of secondary contacts for selectively controlling the direction of rotation of the power means, said secondary contacts being fixedly mounted with respect to each other,

means for engaging the primary contact and one of the secondary contacts in accordance with the direction of relative movement of the input member, yieldable means biasing the primary contact to open contact relation with the secondary contacts when the members are in positional agreement, the engaged contacts coacting to effect a displacement of the primary contact from its biased position by an amount proportional to the error in positional relation of the members, and means for retarding the return of the primary contact to its biased position in proportion to its rate of return.

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