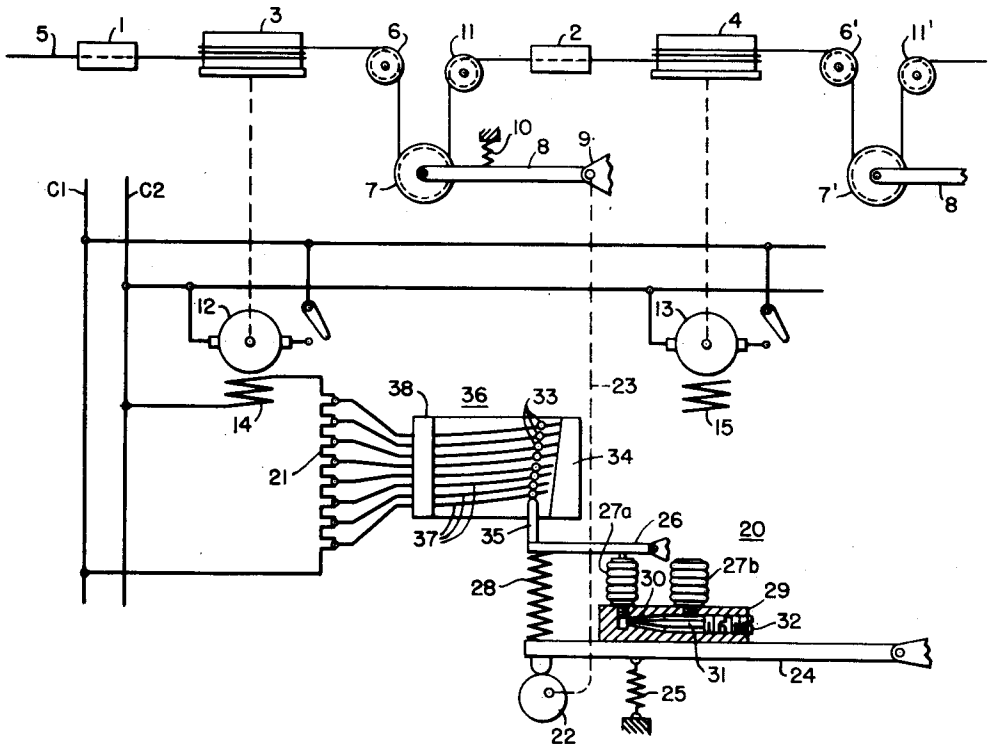
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REGULATING APPARATUS

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WITNESSES:

Robert C. Baird

E. F. Oberheim

INVENTOR

William O. Osbon.

BY

Paul E. Friedemann

ATTORNEY

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REGULATING APPARATUS

William O. Osbon, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates generally to regulating devices and more in particular to an electrical system for regulating a quantity to be controlled.

One object of this invention is to provide a regulating system which is stable in operation.

More specifically, it is an object of this invention to provide a regulating system which anticipates variations in a quantity to be controlled affording rapid correction of the said quantity and which is highly damped to minimize overshoot and undershoot in regulation.

A specific object of this invention is to provide a wire drawing mill regulator in which the velocity of motion as well as the displacement of a wire tensioning device about which the wire is entrained is utilized to regulate the wire drawing motor.

An ancillary object of this invention is to provide a motion transmitting device including a system of two levers in which the levers are so connected that one is moved as a function of the velocity of motion of the other.

Additionally, it is an object of this invention to provide a motion transmitting device of the class described in which one lever is moved both as a function of the velocity of the motion and as a function of the displacement of the other lever.

The foregoing statements are merely illustrative of the various aims and objects of this invention. Other objects and advantages will become apparent upon a study of the following specification when considered in conjunction with the accompanying drawing, in which the single figure illustrates an electrical regulating system embodying the principles of this invention.

Referring to the drawing:

The figure is a schematic view showing the relationship of the motion transmitting device in connection with a wire mill regulator.

The application of this invention is illustrated in connection with a wire mill regulator. In wire mills it is usually necessary to draw a wire through many dies in succession to sufficiently reduce its diameter. In the drawing, the wire drawing dies are respectively designated 1 and 2. Although only two dies have been illustrated, it will be appreciated that more dies may be employed depending upon the diameter of the wire which is being drawn and the final diameter of the wire which is desired. Capstans 3 and 4 are utilized to draw the wire through the respective dies 1 and 2. As illustrated, the wire 5 is fed through the die 1 and on the trailing side

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of die 1 is wound about the capstan 3. Upon leaving the capstan the wire 5 is passed over a pulley 6, after which it is entrained about a pulley 7 mounted upon an arm 8 which is pivotally mounted at its extremity opposite the mounting of the pulley 7. This pivotal mounting is designated 9. The arm 8 is biased in a direction opposing the force acting thereon due to the tension of the wire 5. This biasing is accomplished by means of a compression spring 10. The assembly of the pulley 7 and pivotal arm 8 is usually referred to as a "dancer." From the pulley 7, the wire passes over a pulley 11 and thereafter enters the die 2 through which it is drawn by the capstan 4 in a manner similar to that previously described, after which it is entrained about the pulley system 6', 7' and 11' comprising the dancer assembly of the succeeding drawing stage of the apparatus.

The capstans 3 and 4 are respectively driven by the motors 12 and 13 respectively having shunt field windings 14 and 15, the excitation of each of which is controlled to vary the speed of the associated motor. The motors are preferably connected to a D. C. generator not shown or other suitable supply of direct current illustrated by the conductors C1 and C2.

In practice, it has been customary to utilize the motion of the dancer arm 8 to control the excitation of the shunt field winding of the corresponding motor. This was accomplished by means of a rheostat connected in series with the shunt field winding of the motor, the rheostat being actuated by motion of the dancer arm 8 to control the amount of series resistance in the motor field circuit. Such an arrangement, however, has been found unsatisfactory due to the time delays of the system and the fact that a relatively large position error of the dancer arm 8 was required before an appreciable change in capstan speed could be realized. The system stability was thus quite poor and as a consequence sustained oscillations or hunting occurred making it difficult to thread the wire through the wire drawing machinery without breakage, or if the wire threading process had been successfully completed to operate over any period of time without wire breakage.

This invention utilizes the motion of the dancer arm 8 as in the above described case to control the excitation of the shunt field for the capstan motor, but instead of utilizing the position of the dancer arm as the sole indication of the correction which is required, the velocity of the motion of the dancer arm 8 is employed in addition

to control the amount of series resistance in the shunt field circuit for the motor. Inasmuch as the motor regulating systems for each of the capstan motors are the same, this system is illustrated in connection with only one of the motors.

In practicing this invention a leverage system 20 is utilized to control the resistor 21 which is connected in series with the field winding 14 of the motor 12. This leverage system is actuated by a cam 22 which as shown by the broken line 23, is connected to the dancer arm 8 at its pivot to be angularly driven in dependence of angular motion of the dancer arm. The cam 22 bears against a lever 24 which is spring biased by means of a tension spring 25 into continuous engagement with the cam. A lever 26 which is shorter in length than the lever 24 and approximately parallel to it is connected with the lever 24 by means of a flexible bellows 27a and a spring 28. These levers are pivoted for movement in a common plane and their free extremities, when the levers occupy their normal relative position, terminate on a common line substantially perpendicular to the levers.

The bellows 27a forms part of a hydraulic dashpot system including a second bellows 27b which forms a variable volume reservoir of hydraulic fluid. The bellows are connected to a block 29 having a tapered opening or passage 30 therein which communicates with each of the bellows 27a and 27b. The tapered passage 30 opens in one extremity of the block 29 and this extremity is threaded to receive a needle valve 31 which threads into the threaded opening and projects into the tapered passage 30 to determine the cross-sectional area of this passage. The needle valve 31 threads into the threaded extremity of the passage a sufficient distance that a cap screw 32 may be utilized to close the threaded end of the tapered passage once the needle valve has been adjusted. Thus it will be appreciated that a restricted passage for viscous flow of fluid between the bellows 27a and 27b is provided and that the effect of the bellows 27a in transmitting a force from the lever 24 to the lever 26 is dependent upon the velocity of motion of the lever 24. Thus a velocity sense is imparted to the system.

The cam 22 on the dancer arm shaft 23 is designed so that the displacement of the lower lever 24 is proportional to the displacement of the dancer arm 8. The force transmitted by the bellows 27a from the lower lever 24 to the upper lever 26 is proportional to the velocity of motion of the lower lever or to the rate of change of position of the dancer arm. Thus, when the lower lever is moved rapidly, the force transmitted by bellows 27a is high and the displacement of the upper lever 26, as determined by the velocity, the relative ratios of levers 24 and 26, and the stiffness of spring 28, is high. For the lever ratios shown, the displacement of the free extremity of the lever 26 for rapid motions is approximately of the order of three times the cam displacement. The spring 28 is disposed between the free extremities of the levers 26 and 24, which terminate in a common line substantially perpendicular to the two levers, so that in the normal position of these levers the spring is under neither tension nor compression. The two ends of the spring are attached firmly to the extremities of the two levers respectively. Thus, when the lower lever 24 is moved very slowly, the viscous force due to the flow of fluid between the bellows is negligible, and the motion of the free extremity of the upper lever 26 bears substantially a 1:1 ratio with that of the lower lever, this motion being transmitted substantially entirely by the spring 28. The effective stiffness of the bellows system is made small compared to that of the spring to improve this 1:1 proportionality during slow motions.

The motion of the free extremity of lever 26 is utilized to control the resistance of resistor 21. This is accomplished by means of a contact device 36 comprising a plurality of flexible conducting strips 37 which at one extremity are secured in spaced relation in an insulating block 38. The free extremities of the strips 37 are provided with a plurality of contacts 33 disposed in side by side relation and the extremities of these strips beyond the contacts 33 normally bear against the sloping surface of a block 34 which spaces the contacts. A prod 35 which is connected to the free extremity of the lever 26 engages the lowermost contact and is sufficiently long so that in the normal operating position of the lever 26 it closes the first few contacts of the contacting device. The conductor strips 37 are connected along spaced taps of the resistor 21. As the contacts 33 are progressively closed by motion of the prod 35, the tapped sections of the resistor 21 are progressively shunted to decrease the overall resistance of resistor 21. Motion of prod 35 in the reverse direction progressively opens the contacts 33 to increase the effective resistance of the resistor 21.

In operation, should there be a difference between the speed of the wire 5 as it is drawn from the die 1 and the speed thereof as it enters the die 2, the dancer arm 8 moves. By virtue of the velocity responsive effect of the bellows assembly, the contact device 36 receives a relatively large initial deflection at the instant the dancer arm 8 starts to move. This produces a corrective change in motor field current even before the dancer arm has accumulated a displacement sufficient in itself to produce the required correction. The series resistance variation in the circuit of the shunt field winding 14 thus anticipates the displacement of the dancer arm affording a large initial correcting stimulus for the system at the instant a velocity appears. This anticipatory action tends to counteract the delaying effect of the inductances of the generator field circuit and the generator-motor armature circuit and of the inertia of the motor and its connected load. As the dancer arm 8 approaches the correct position, its velocity, and consequently the effect of the dashpot, decreases and the free extremities of the two levers return to their normal position relative to each other. Thus the resistance of the resistor 21 is changed in a direction to meet the requirements of the new steady-state condition which is maintained until further deflection of the dancer arm obtains.

The foregoing disclosure and the showing made in the drawing are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense.

I claim as my invention:

1. Regulating apparatus for regulating a quantity to be controlled comprising, in combination, a pair of pivotally mounted levers, means responsive to said quantity for moving one of said levers, motion transmitting means connecting said levers together at points spaced from the pivot axes thereof in which the ratio of the ratio of moment arms of the other of said levers to the ratio of moment arms of said one lever is greater

than unity, said motion transmitting means comprising a hydraulic system having an orifice therein in which the force transmitted from said one lever to said other lever is a function of the rate of fluid transfer across said orifice, and means responsive to movement of said other lever for controlling said quantity.

2. Apparatus for regulating a quantity comprising, in combination, a pair of pivotally mounted levers, a flexible bellows connecting said levers at points spaced from the pivot axes thereof, a second flexible bellows, means forming an orifice connecting said bellows, said bellows being filled with a suitable fluid medium, spring means connecting said levers, said spring being undeflected when said levers occupy a predetermined position, which position corresponds to a predetermined value of said quantity; means responsive to said quantity for moving one of said levers, and means responsive to movement of the other of said levers for controlling said quantity.

3. Apparatus as set forth in claim 2, in which said spring means connects the free extremities of said levers.

4. Apparatus for regulating a quantity comprising, in combination, a pair of pivotally mounted levers, a flexible bellows connecting one of said levers to the other of said levers at points removed from the pivot axes thereof, said points being located so that the ratio of the ratio of the moment arms of the other of said levers to the ratio of the moment arms of said one lever is greater than unity, a second flexible bellows, means including an orifice connecting said bellows, said bellows being filled with a suitable fluid, a spring connecting said levers for biasing said levers to a predetermined angular relationship, means responsive to said quantity for moving said one lever, and means responsive to movement of said other lever for controlling said quantity.

5. Apparatus for regulating a quantity comprising, in combination, a pair of pivotally mounted levers, a flexible bellows connecting one of said levers to the other of said levers at points

removed from the pivot axes thereof, said points being located so that the ratio of the ratio of the moment arms of the other of said levers to the ratio of the moment arms of said one lever is greater than unity, a second flexible bellows, means including an orifice connecting said bellows, said bellows being filled with a suitable fluid, a spring connecting said levers for biasing said levers to a predetermined angular relationship, the stiffness of said spring being higher than the stiffness of said bellows, means responsive to said quantity for moving said one lever, and means responsive to movement of said other lever for controlling said quantity.

6. Motion transmitting apparatus comprising, in combination, a pair of pivotally mounted levers, a flexible bellows connecting one of said levers to the other of said levers at points removed from the pivot axes thereof, said points being located so that the ratio of the ratio of the moment arms of the other of said levers to the ratio of the moment arms of said one lever is greater than unity, a second flexible bellows, means including an orifice connecting said bellows, said bellows being filled with a suitable fluid medium, a spring connecting said levers for biasing said levers to a predetermined angular relationship, angular movement of one of said levers effecting angular movement of the other of said levers.

WILLIAM O. OSBON.

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