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CONTROL MECHANISM

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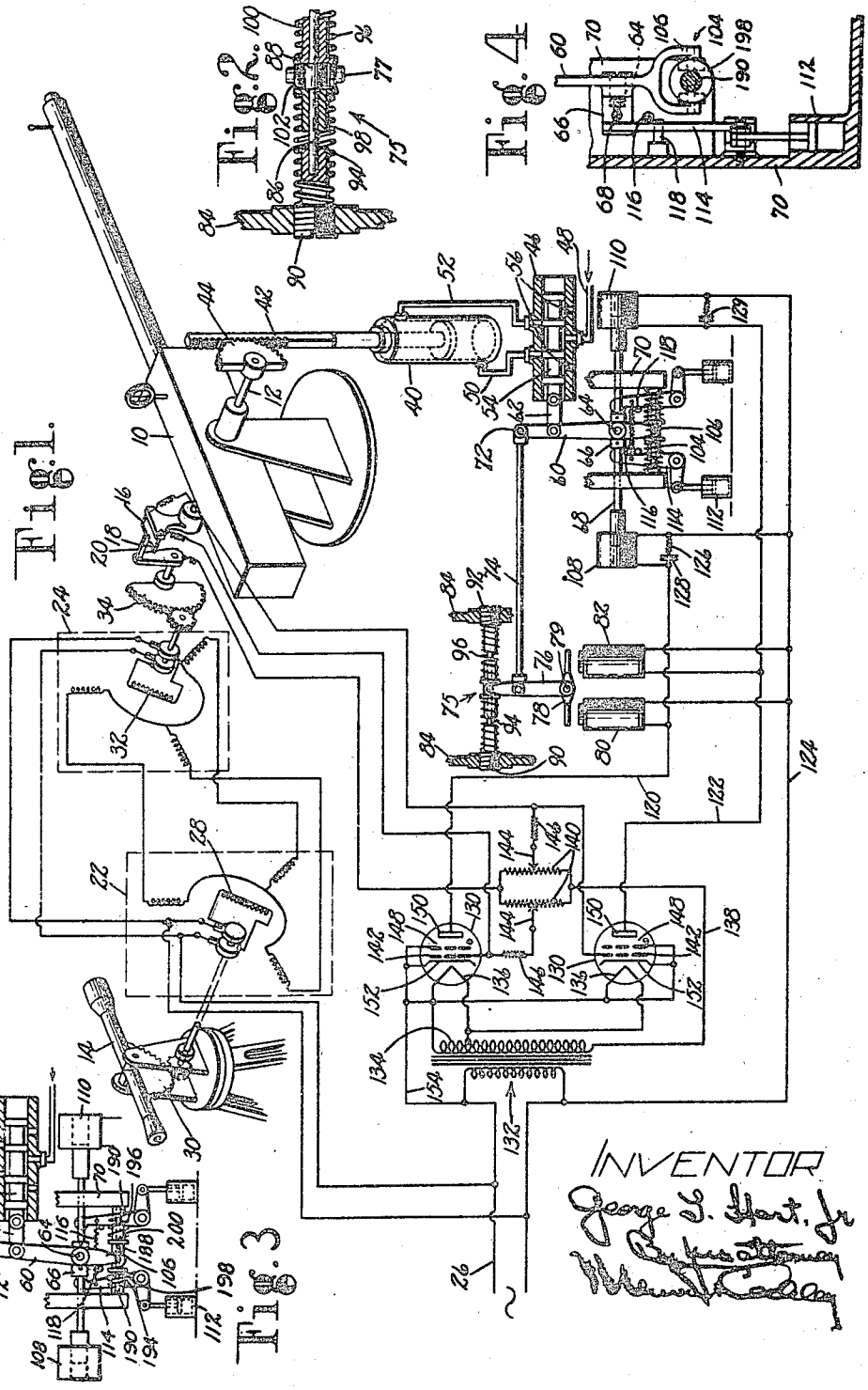


Fig. 1.



Fig. 2.



Fig. 4



Fig. 3

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## CONTROL MECHANISM

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This invention relates to control mechanisms, and more particularly to mechanisms for controlling the operation of a motor to determine the direction and extent of movement of a movable contrivance or member. An object of the present invention is to provide an improved control mechanism of the above-mentioned type by means of which a smoother operation of the motor is effected with resultant greater ease and accuracy of control. It will be understood, however, that the invention in its various novel and useful aspects is not limited to use in control mechanisms of the particular type illustrated.

For the purpose in view, and in accordance with one feature of the invention, there is provided a pulsating device for controlling the operation of a motor whereby a series of automatically repeated pressure impulses are imparted to the motor as the usual control member, with which control mechanisms of the above-mentioned type are provided, is moved to start the motor in operation. Not only is the operation of the motor thus rendered smoother, but a more sensitive control of its operation and of the extent of movement of the work piece is provided, since any tendency for friction between the parts to delay the action of the motor in response to movements of the control member is avoided.

In the illustrated arrangement, an electromagnetic device, to which a pulsating current is supplied, operates a valve of a fluid-pressure system to draw it away from the original neutral, or closed, position and as rapidly to return it to that original position. When this is done at a high frequency, a series of small impulses are imparted to the motor, thereby advantageously starting the motor gradually and at the same time providing a system in which the impulses can be rapidly withdrawn so that there shall be no overrunning of the motor.

In accordance with still another feature of the invention, there is provided an arrangement in which a vibratory force is imparted to a control device so that it is rapidly vibrated, or dithered, and in which this vibratory force is superimposed on a steady force imparted to the control in the same direction, for example, as the pulsating force. This may advantageously be accomplished, as herein illustrated, by also including in the control system a solenoid-operated-valve mechanism which is restrained, or delayed, as by means of a dashpot.

These and other features of the invention will best be understood from a consideration of the following specification taken in connection with the accompanying drawing, in which

Fig. 1 is a diagram illustrating the control system of the present invention applied to the training of a gun;

Fig. 2 is an enlarged detail, in horizontal section, showing a spring centering device for returning a vibrating armature to its neutral position;

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Fig. 3 is a diagram of the solenoid-operated parts in Fig. 1 in the positions assumed after the valve-operating lever has been pulled to one side; and

Fig. 4 is a side elevation of these parts, taken from the left in Fig. 1, and with portions in section.

The control system is herein illustrated as cyclically operated and utilized for training a gun in elevation by means of signals received from a remote-control device, such as a telescope or sight.

A manual movement of the telescope is followed by a corresponding movement of the gun, thus completing one cycle. It will be understood, however, that this is only one application of the system which can be utilized wherever it is desired to move a member, such as a gun, a definite amount under the control of an operator who may be near or far away. A gun 10 is herein shown as capable of tilting with a horizontal axle 12 to change its elevation in response to signals from a similarly tiltable telescope or sight 14. Carried on the axle 12, for tilting movement with the gun, is a pair of contacts 16, 18 associated with which is an intermediate contact 20 operator-controlled by connection to the sight 14 as by means of a Selsyn generator or transmitter 22 and a receiver 24 shown as connected to a source of alternating-current power such as the mains 26. To this end, the rotor 28 of the transmitter 22 is gear-connected to a segment 30 on the sight 14, while the rotor 32 of the receiver 24 is geared to a segment 34 carrying the intermediate contact 20.

Tilting movement to elevate or depress the gun is imparted to the axle 12 and hence to the gun by means of a fluid-pressure motor 40 the piston of which is connected to a rack 42 meshing with a segment 44 upon said axle. The hydraulic motor 40 is controlled by a piston-type slide valve unit 46. This is normally in a neutral, or closed, position, as shown in Fig. 1, in which pressure fluid supplied through the pipe 48 cannot be delivered to either of the pipes 50, 52 leading to opposite sides of the piston of the motor 40. When a slight movement in one direction or the other is imparted to the valve piston 54 of the unit 46, pressure fluid is admitted to one end of the motor and is exhausted through one of the ports 56 from the other end of the motor.

Movements of the valve are effected by impulses transmitted to the valve piston 54 by means of a lever 60 connected to said valve piston by a link 62. This lever is supported and fulcrumed at 64 on a fulcrum block 66 carried by a rod 68 slidably guided in fixed supports 70. At

its other end, the lever 60 is fulcrumed at 72 to a rigid rod 74 which is connected to a lever 76 of an armature 78 adapted to be tilted about a fixed axis 79 in one direction or the other by electromagnets 80, 82. The dual means provided by these magnets are effective to cause recurrent movements of the control valve each in a different direction away from its neutral closed position, thereby intermittently to open the valve slightly. After each such movement, the valve is urged toward its neutral position by a spring centering device 75 for returning this armature lever 76 to its mid position. This device is supported between fixed members 84 and comprises, as shown specifically in Fig. 2, a rod 86 having an enlarged block-like abutment 88. This rod is supported in the fixed members 84 by screws 90, 92 having reduced portions surrounded by coil springs 94, 96, respectively, which bear at their inner ends upon headed sleeves 98, 100, the springs 94, 96 acting to hold the headed sleeves against opposite sides of the enlarged abutment 88. The armature lever 76 has a forked upper end the arms 77 of which bear disk-like rolls 102 each having a diameter which is equal to the distance between the ends of the abutment 88. The result of this arrangement is that exact balancing of the springs is unnecessary and the displacement of the armature lever 76 in either direction is opposed by one of the return springs 94, 96, but only one. A similar centering device 104 carried by the supports 70 acts upon the lower end 106 of the lever 60. This centering device 104 includes a central abutment 188 on a rod which is carried by holders 190 on the supports 70. Pressed against this abutment by springs 194 and 196 are headed sleeves 198 and 200, these numerals being digits made up from those in Fig. 2 by adding 100 and referring to corresponding parts. Displacement of the rod 68 which carries the fulcrum 64 is effected by solenoids 108, 110 having cores attached respectively to the opposite ends of the rod 68. The action of either one of these solenoids is opposed and rendered gradual by a one-way dashpot, such as that shown at 112, which is connected to a bell-crank lever 114 one arm of which at its upper end bears against an end of the fulcrum block 66. A similar dashpot and bell crank are provided to bear upon the opposite end of the block 66 and the bell cranks are urged thereagainst by means of a strong central spring 116 which draws each bell crank against the block 66 and also against a stop pin such as that at 118.

Provision is made for delivering a pulsating current through leads 120 or 122 and a return wire 124 to one of the electromagnets 80, 82 and to one of the solenoids 108, 110. A resistance 126 and a condenser 128 in series are bridged across the solenoid 108, and a similar arrangement is provided at 129 for the solenoid 110. This serves to smooth out the pulsations of current and to cause a steady pull upon one of the solenoids.

Any suitable arrangement for providing a pulsating current may be interposed between the contacts 16, 18, 20 and the electromagnetic valve-operating device. Illustrated herein are electronic devices 130 the anodes 150 of which are connected to the leads 120 and 122, respectively. Power is supplied to these tubes, which may be gas-filled Thyratron tubes, such as the type designated by the numeral "884," from the mains 26 through an auto-transformer 132. Bridged across a portion 134 of the secondary of this transformer are the heaters 136 of the tubes,



while the other portion of the secondary is connected through a circuit 138 to potentiometers 140 arranged in a parallel circuit the other end of which is connected to the intermediate operator-controlled contact 20 associated with the gun. The other contacts 16, 18 on the gun are connected to the grids 142 of the respective tubes to which the arm 144 of a corresponding potentiometer is also connected through a suitable resistance 146. The tubes are shown as provided with shield grids 148 between the grids and the anodes 150, and these shield grids along with the cathodes 152 are connected through a lead 154 to the low-voltage end of the auto-transformer 132. The adjustment of the potentiometers is such that a negative bias is provided for the grids 142. As soon, however, as the operator-controlled contact 20 touches one or the other of the contacts 16, 18, a portion of the corresponding potentiometer will be bridged through the corresponding resistance 146, thereby radically changing the grid bias and bringing the tube to a condition where it will be conductive and will supply a pulsating current to the electromagnetic devices which control the valve.

In the operation of the device during a single cycle of the control system, movement of the sight 14 will impart a movement in a similar direction and amount to the intermediate contact 20 which will, at the end of the previous operation of the mechanism, have been brought to a point between the spaced contacts 16, 18. This tilting of the sight will therefore close the circuit, through the contact 18 for example, thus changing the grid bias on the upper tube 130 and delivering a pulsating current in one direction to the electromagnet 80 and to the corresponding solenoid 108. As noted above, however, the current delivered to the solenoid will be smoothed out before it reaches it. Inasmuch as the action of the solenoid is resisted by the dashpot 112, the valve piston 54 will first be vibrated rapidly by oscillations of the lever 60 having a range lying in one direction away from an initial or neutral position. These vibrations about the fulcrum 64 are effected by means of one magnet such as that at 80. A series of rapid pulsations will be imparted to the valve to open it a small fraction of the width of an associated part in one direction and as rapidly to close it, thus delivering a series of impulses all in the same direction to one side of the hydraulic motor 40. A gradual and smooth starting of the motor is thus accomplished. It will be understood that, as the sight is moved, the gun will be moved in the same direction as the sight and to a proportional extent. As the movement of the sight is stopped, the contacts 18 and 20 will be separated as a result of the movement of the gun to the position determined by the sight. The pulsations will then cease and the valve will be immediately returned to its neutral position by the centering device 75 associated with the armature lever 76. In addition, a steady force in the same direction as that imparted by the magnet 80 will be imparted to the valve through the solenoid 108 acting on the fulcrum 64, and this action will be resisted by the bell crank 114 attached to the dashpot 112 and by the spring 116 between the two bell cranks. This force will act through the lever 60 to open the valve in the same direction as the pulsations imparted by the electromagnet 80 with which it is concurrent, and it will hasten the response of the hydraulic motor 40 since the forces are additive. Just as soon, however, as the

circuit is broken between the contacts 18 and 20, the solenoid-controlled fulcrum 64 will return to its midposition. This will be effected first by the centering device 104, and this action will then be followed up by the return of the bell crank 114. This bears against one side of the fulcrum block 66. The centering device 104 will be used chiefly for insuring an immediate return of the fulcrum 64 in case there is a delayed action of the bell crank 114 due to imperfect relief of the dashpot.

The action of the pulsating current delivered to one of the magnets 80 or 82 is to set up a series of vibrations having their locus or range in one direction from the central position, that is to say, so that the lever 76 will move either to the left of its central position and back again or to the right of its central position and back again. The frequency of these pulsations is comparatively large, and the degree of movement imparted to the piston 54 of the valve is only a small fraction of the width of a cooperating port in the valve. In practice, a movement of five to ten thousandths of an inch is found satisfactory. Following each pull of the electromagnet, a centering device 75 serves to bring the lever 76 back to its mid-position. There is, therefore, a consequent gradual movement of the motor piston in one direction. At the same time that these periodic impulses are delivered to the motor, one of the solenoids 108, 110 becomes energized and delivers a steady pull to the fulcrum point 64 upon the lever 60 and tends to drag the valve piston to a fully-opened position. Whether or not it reaches a fully-opened position depends upon the length of time that the contacts 18 and 20, for example, remain closed and upon the setting of the dashpot 112 which delays this movement. As soon as the contacts are opened, both the vibratory force and the steady pull applied to the valve piston are reduced to zero, and the piston is returned to its neutral position, as shown in the drawing, by the action of the centering devices 75 and 104. This return movement is immediate and does not wait for the dashpot-controlled bell crank 114 to be pulled back to contact with a pin 118 by the spring 116.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In a cyclically operated control system, a movable member, a motor for moving the member, a device for connecting the motor to a source of power, an operator-controlled means constructed and arranged to determine the direction and extent of movement of the member by control of said connecting device, and means for rapidly vibrating said connecting device many times during each cycle, said latter means being set in operation by movement of the operator-controlled means.

2. In a cyclically operated control system, a hydraulic motor, a valve controlling said motor and having a neutral closed position, means for normally holding said valve in its neutral position, and means for periodically vibrating the valve through only a range both limits of which lie at one side of its neutral position during a cycle of the control system to produce a gradual movement in the sense indicated by the position of the range with respect to the neutral position.

3. In a fluid-pressure system, a motor, a control valve for said motor, electromagnetic means for recurrently moving said control valve in one direction away from a neutral closed position intermittently to open the valve to send a series of impulses to the motor, and resilient means urging said control valve toward its neutral position after each movement.



4. In a fluid-pressure system, a motor, a control valve for said motor, a pivoted armature connected to said valve, an electromagnet for turning said armature to open the valve, and operator-controlled means for delivering a pulsating current to said electromagnet.

5. In a fluid-pressure system, a motor, a reversing valve for said motor, a pivoted armature connected to said valve and spring-biased to hold said valve in its neutral closed position, electromagnets operating said armature arranged respectively to open said valve in opposite directions, and means for delivering a pulsating current to one of said electromagnets, thereby to cause a smooth, gradual movement of the motor in the desired corresponding direction.

6. In a fluid-pressure system, a motor, a control valve for said motor having coacting valve members, resilient centering means for one valve member, means for imparting to the one valve member a series of rapidly repeated impulses in one direction away from its initial position tending to open said valve and then to release it, and means also connected to said valve member for imparting a steady force in the same direction as the series of impulses.

7. In a fluid-pressure system, a motor, a control valve for said motor having coacting valve members, spring-biased electromagnetically-operated means for delivering a series of pulls intermittently to one of said members to open said valve slightly, and a delayed valve-operating device arranged to impart a steady opening pull to the same valve member.

8. In a fluid-pressure system, a motor, a control valve for said motor, a lever connected to said valve to move it, means for imparting a pulsating movement to said lever to open the valve intermittently, and additional means for imparting a steady pull to said lever to open the valve a progressively greater amount.

9. In a fluid-pressure system, a motor, a slide valve controlling said motor, a lever connected to said slide valve, means for vibrating said lever to open the valve intermittently, and means for moving the fulcrum of said lever to fully open the valve.

10. In a fluid-pressure system, a motor, a slide valve for controlling said motor, a plurality of electromagnets each connected to said valve to move it in the same direction, means for supplying a pulsating current to said magnets, and means for smoothing out the current delivered to one of the magnets.

11. In a fluid-pressure system, a motor, a slide-valve mechanism controlling said motor, an electric solenoid mechanism connected to said slide valve, a spring mechanism tending to return said valve to closed position, a one-way dashpot mechanism loosely contacting the solenoid mechanism to delay the action of said solenoid, and a spring for restoring the dashpot mechanism when the solenoid becomes ineffective.

12. In a fluid-pressure system, a motor, a reversing control valve for said motor, a lever connected to said control valve, displaceable fulcrums at the opposite ends of said lever, springs returning said fulcrums to a predetermined position, means for imparting a vibratory force to said lever to move one end of it to open the valve

intermittently, and means for applying a progressive force to another portion of the lever to carry the valve further in the same direction.

13. In a fluid-pressure system, a motor, a reversing control valve for said motor, a spring-biased armature connected to said control valve to move it open in either direction and arranged to return it to its neutral position, and dual means alternatively energized to impart a rapidly pulsating pull in either of two directions to said valve to operate the motor in a direction corresponding to the direction of the range of movement imparted by the armature.

GEORGE T. HART, JR.

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