L. A. LANG.

POWER SHIFT MECHANISM.

APPLICATION FILED MAY 17, 1917.

**1,328,437.**

Patented Jan. 20, 1920.

3 SHEETS—SHEET 1.

Fig. 1.

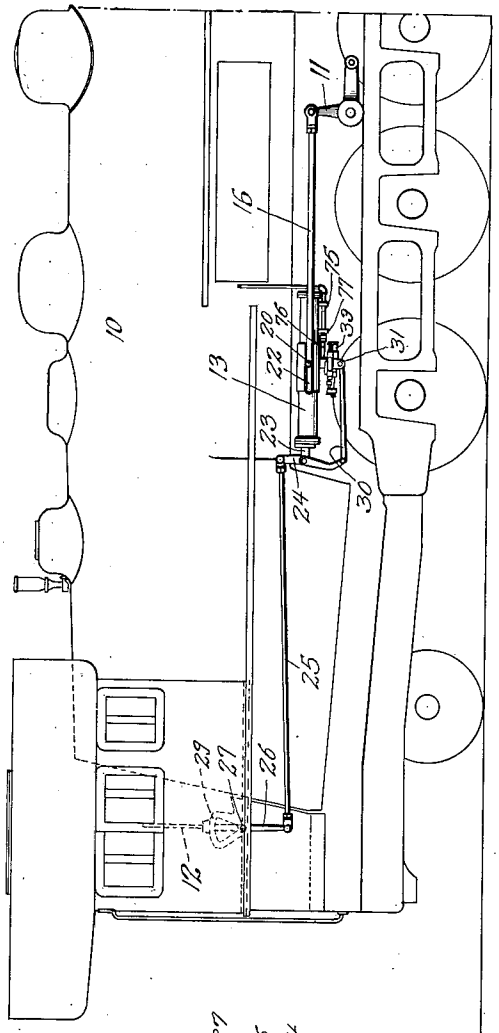
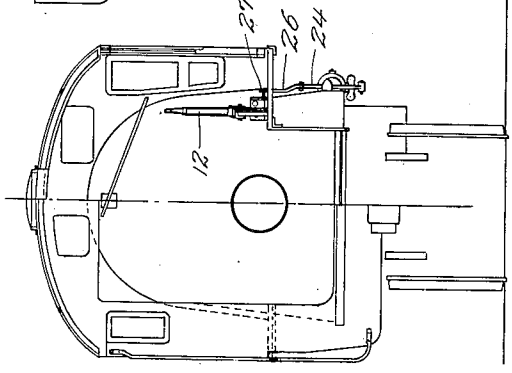



Fig. 2.




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3 SHEETS—SHEET 2.

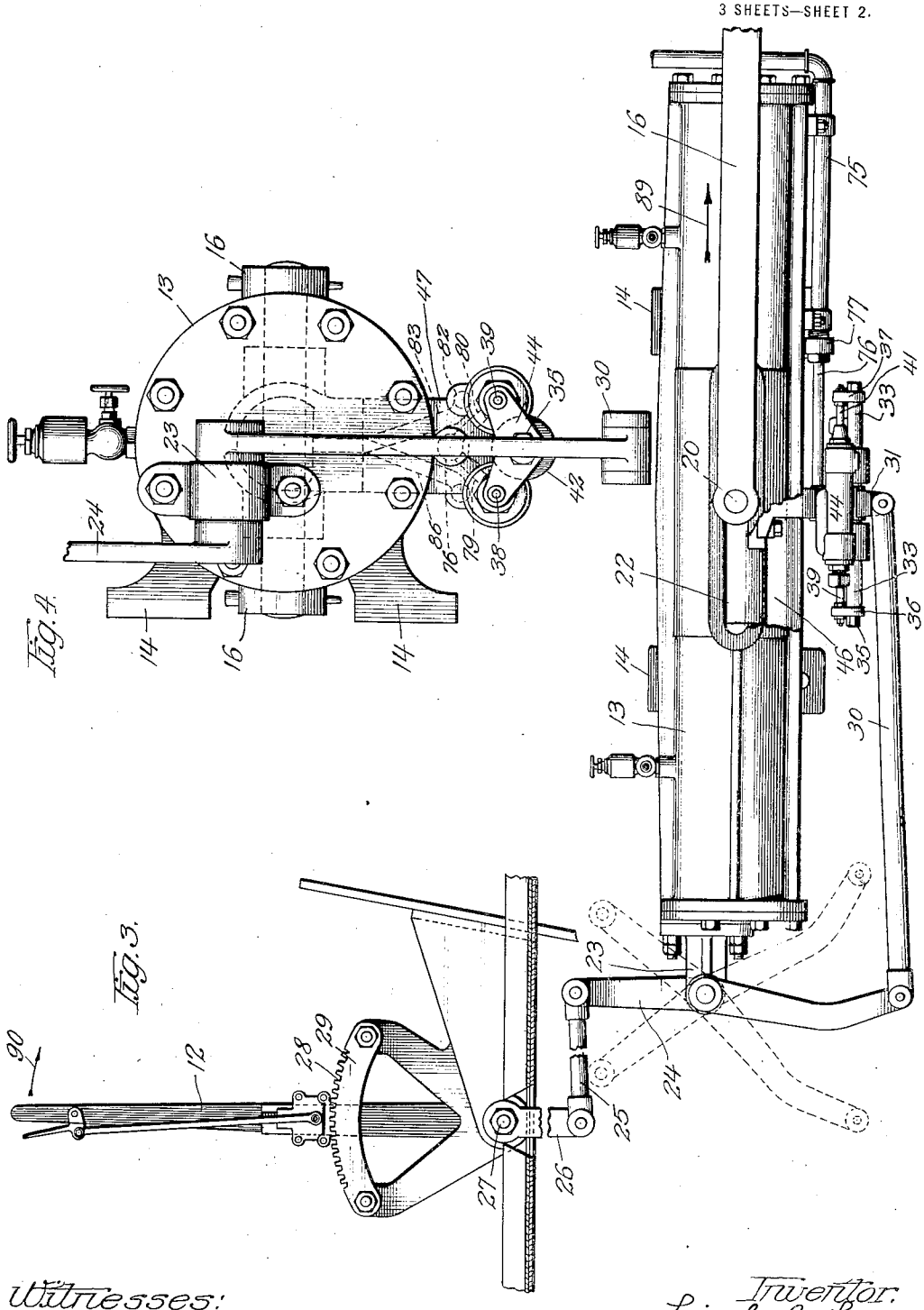



Fig. 4.

Fig. 3.

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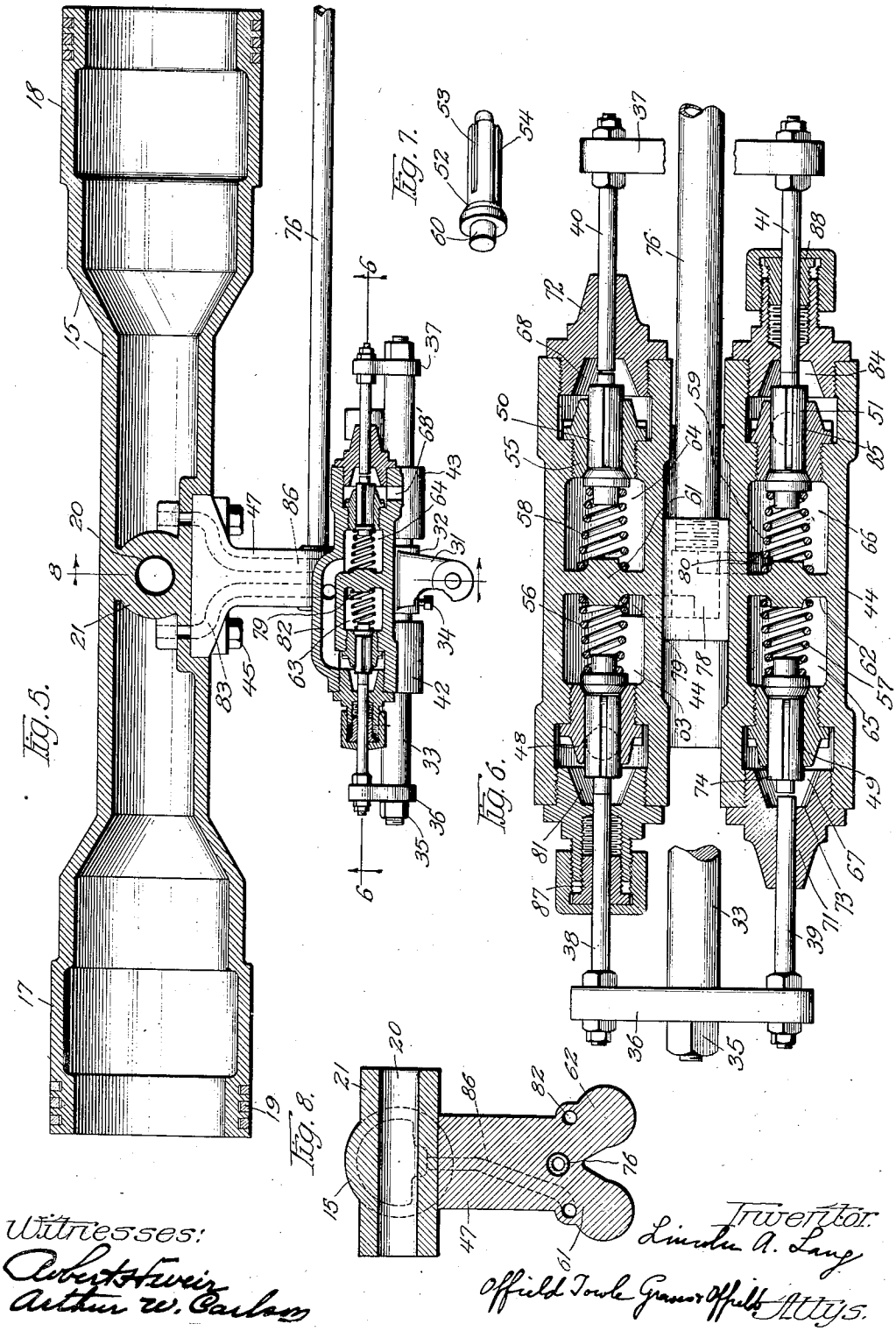
POWER SHIFT MECHANISM.

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**1,328,437.**

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3 SHEETS—SHEET 3.



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# UNITED STATES PATENT OFFICE.

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## POWER SHIFT MECHANISM.

1,328,437. Specification of Letters Patent. **Patented Jan. 20, 1920.**

Application filed May 17, 1917. Serial No. 169,217.

*To all whom it may concern:*

Be it known that I, LINCOLN A. LANG, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Power Shift Mechanism, of which the following is a specification.

My invention relates to power shift mechanism, and, while it is capable of being applied to many different uses, is particularly well adapted for use in connection with that general class of apparatus known as servo motor follow-up mechanisms; that is to say, power-operated mechanism, the extent of movement of which is determined by the position of a manually adjustable controlling device.

Among the salient objects of the invention are to provide power-shift mechanism of the class described, so organized that the number of parts needed to perform the various functions of the construction is reduced to a minimum; to provide a construction so arranged that it will occupy a minimum space; to provide a construction which embodies as far as possible a straight line movement of the controlling connection and of the main actuating member; to provide a fluid-operated construction embodying a valve arrangement such that improper adjustment of the valve or the packings therefor does not impair the effectiveness of the device; to provide a fluid-operated arrangement of the class described organized so as to facilitate admission and expulsion of the actuating fluid; to provide a fool-proof arrangement of the character described which may be operated and maintained by relatively unskilled labor; to provide an arrangement of the class described which shall be extremely simple, neat, and economical in construction; to provide an arrangement of the class described which shall be extremely sensitive and quick to respond to changes of adjustment or unbalanced conditions, while at the same time being extremely stable and not subject to hunting or other improper movement; to provide a construction in which the movement of the controlled member may be communicated to the manually actuating member; to provide a device capable of being operated in case of power failure; and, in general, to provide an improved construction of the character referred to.

In the drawings which accompany this application, I have illustrated, as a specific embodiment of my invention, a locomotive, the reversing gear for which is actuated by apparatus embodying said invention. In said drawings—

Figure 1 is a side elevation of a locomotive showing the power shift mechanism in its general location and arrangement as applied to the locomotive;

Fig. 2 is an end elevation looking forward into the cab of the locomotive shown in Fig. 1;

Fig. 3 is a side elevation of the principal part of the device with its operating connections;

Fig. 4 is an end elevation of the cylinder and valve-actuating mechanism therefor, looking from the left of Fig. 3;

Fig. 5 is a vertical longitudinal section taken through the duplex piston, with its associated valve apparatus;

Fig. 6 is a section taken on the line 6—6 of Fig. 5;

Fig. 7 is a perspective view of one of the exhaust valves; and Fig. 8 is a section taken on the line 8—8 of Fig. 5.

Referring to the drawings, 10 represents as a whole an ordinary steam locomotive having the usual boiler, cab, frame, and driving gear operated by cylinders not shown in the drawings. The reversing gear for the said cylinders is actuated by means of a bell crank 11, between which and the hand-lever 12 is interposed my improved power-shift mechanism. 13 represents the cylinder of the device, which is suitably secured to the boiler of the locomotive by means of feet or lugs 14 (see Fig. 4), the piston 15 of the said cylinder being connected to the bell crank 11 by means of a pair of suitable rods or links 16. As shown best in Fig. 5, the piston 15 is of considerable length, the ends 17 and 18 thereof being enlarged to fit the cylinder and equipped with a series of piston rings, as at 19, which maintain the ends of the piston in fluid-tight engagement with the interior walls of the cylinder. The extreme length of the cylinder and the spacing between the ends 17 and 18

of the piston effectually prevent cramping of the piston in the cylinder, due to cross stresses which may be applied to the piston.

In order to facilitate connection of the links 16 with the piston, the latter has centrally journaled therein a horizontal transverse shaft or pin 20 which is journaled in a boss-like partition 21 which separates the two hollow ends of the piston. The rear ends of the links 16 are pinned upon the ends of the said shaft 20, which ends project through a pair of slots 22 cut in the sides of the cylinder 13. It is understood that the length of the slots 22 is somewhat greater than the total stroke of the piston in its cylinder.

On the rear end of the cylinder I prefer to bolt a small bracket 23 which forms a fulcrum for the pivotally mounted lever 24. The upper end of the said lever 24 is pivotally connected by means of a link, 25 with the lower end 26 of the hand-lever 12, the latter being pivoted on a shaft or pin 27 suitably supported in the cab of the locomotive. The hand-lever 12, which may be moved into any desired position, is locked in place by a suitable spring-pressed dog which coöperates in the usual manner with notches 28 formed in the arc of a fixed quadrant 29. It will be manifest that movement of the hand-lever 12 will move the lower end of the lever 24 in an obvious manner, the said lower end of the lever 24 being connected to the control mechanism now to be described.

It will be observed that the lower end of the lever 24 is pivotally connected by means of a link 30 with a block 31 (see also Fig. 5), said block having an axially horizontal boss 32 fixedly secured to a horizontal shaft 33 by means of suitable set screws 34. On the ends of the shaft 33 are bolted, by means of nuts 35, a pair of tappet plates 36 and 37, said tappet plates 36 and 37 having adjustably secured therein two pairs of horizontal tappet rods 38, 39, 40, and 41. The rod 33 is arranged to slide in alined holes in a pair of bosses at the lower end of the valve casting designated as a whole 44. Said valve housing 44 is carried principally beneath the cylinder 13, as shown in Fig. 3, and is centrally bolted to the middle stem of the piston 15 by means of suitable studs or screws 45. The lower wall of the cylinder 13 is centrally slotted, as shown at 46, in order to admit the stem or connecting piece 47 of the valve housing which, as previously stated, is bolted to the central stem of the piston.

As shown best in Fig. 6, the valve-actuating tappets 38, 39, 40, and 41 operate a set of four valves of puppet type, viz., an intake valve 48 for the left hand end of the cylinder, an exhaust valve 49 for the right hand end of the cylinder, an exhaust valve 50 for the left hand end of the cylinder, and an intake valve 51 for the right hand end of the cylinder. As shown in Fig. 7, each of said valves 48, 49, 50, and 51, comprises the usual mushroom head 52, a cylindrical stem or body portion 53, the latter having a series of grooves 54 milled therein, each of the series of grooves commencing at a different distance from the mushroom head 52 so that when the valve is actuated it will to a certain extent throttle the flow of fluid, by reason of the fact that the various grooves of the series will one by one become gradually effective to pass fluid through the valve, it being understood that the main body or stem part 53 of the valve is a fairly good fit in the bored housing 55.

The valves 48, 49, 50, and 51 are normally held in engagement with their seats by reason of a series of coil springs 56, 57, 58, and 59, the outer ends of which fit around short projections 60 on the ends of the valves, the other ends of the springs being positioned around circular bosses 61 and 62 which divide the valve pockets 63 and 64, and 65 and 66. In view of the fact that the valves 49 and 50 are exhaust valves only, the spaces 67 and 68 being in free communication with the atmosphere through exhaust apertures, shown at 68′ in Fig. 5, it is unnecessary to provide packed glands for the tappet rods 39 and 40, which slide freely in the solid plugs 71 and 72. By referring to Fig. 6, it will also be seen that there is an opening or space 73 between the ends of the tappets 39 and 40 and the small steel plugs or studs 74 inserted in the ends of the valves 49 and 50. Such spaces are provided to permit some latitude of movement of the valve-actuating tappets without opening the exhaust valves, the amount of this latitude being determined by the nature of the work to be accomplished.

Pressure fluid, preferably compressed air, is supplied to the cylinder through a pipe 75 bolted to, and with its axis parallel to the axis of, the cylinder 13, so as to permit free sliding movement of the sliding supply tube 76, air-tight slidable engagement between said inner pipe 76 and outer pipe 75 being established by means of a suitable gland or stuffing box 77 on the end of the stationary pipe 75. The rear end of the sliding supply tube 76 is screwed into the step 47 of the valve housing and communicates with the central pocket, indicated in dotted lines at 78 in Fig. 6, said pocket 78 communicating by means of transverse passages 79 and 80 with the pockets 63 and 66 associated with the intake valves 48 and 51. The space 81 is connected to the space 64 by means of a longitudinal offset conduit 82, said conduit 82 also communicating with the left hand end of the hollow piston 15 by means of an inclined port or conduit 83

in the stem 47 of the valve housing. Similarly, the spaces 84 and 65 are connected by a similar longitudinal offset conduit, the end of which is shown at 85, said conduit 85 being connected by another inclined conduit 86 with the other or right hand end of the hollow piston 15. In view of the fact that the spaces 81 and 84 are in free communication with the cylinder ends, and consequently under pressure, the tappet rods 38 and 41 are surrounded by suitable packed glands 87 and 88.

Describing the operation of the apparatus, it will be understood, in view of the prior description, that when the main control stem 33 is moved longitudinally relative to the valve housing 44, a pair of valves at one of the ends of the valve housing will be opened by the corresponding pair of tappets, whereas the other pair of valves at the other end of the valve housing will remain closed, due to the coil springs and the pressure forcing said valves tightly against their seats. Under ordinary circumstances, the two ends of the cylinder 13 and the spaces contained within the hollow ends of the piston 15 will be filled with compressed air at substantially the same pressure, the piston being thus held in balanced relation. If, however, it be desired to change the position of the reversing gear by moving the link 16 in the direction of the arrow 89 (see Fig. 3), the link 30 will be moved in the same direction by shifting the hand lever 12 in the direction of the arrow 90. As soon as the hand lever 12 is moved in such direction, the link 30 will be thrust forward, and, by reason of the connecting block 31, the main control rod 33 will move forward, actuating the tappets 38 and 39 to open the inlet valve 48 and the exhaust valve 49. As has been previously described, the exhaust valve 49 is connected with the right hand end of the cylinder through the space 65, longitudinal conduit 85, and inclined conduit 86. Consequently, when said valve 49 opens, the pressure in the right hand end of the cylinder will be relieved permitting the unreduced pressure in the left hand end of the cylinder to move the piston forwardly. At the same time, by reason of the fact that the intake valve 48 has also been opened, compressed air will pass through the supply tube 76, into space 78, to transverse conduit 80, through the transverse conduit 79, into the space 63, through the valve 48, into the space 81, and thence through the longitudinal offset conduit 82 and conduit 83 into the left hand end of the cylinder. The piston moving forward will of course carry forward the reversing link 16 in an obvious manner.

The extent of movement of the link 16 will be determined by the movement of the hand-lever 12, for the reason that the relative position of the control rod 33 and the valve casting 47 is previously determined by the relative movement of the hand-lever 12 and the said link 16, the said parts being respectively mechanically connected to the control rod 33 and the said valve housing 44. The relative movement of the last named parts is thus differentially controlled by the movement of the hand-lever and the reversing link. Thus, if the hand-lever 12 has been moved a sufficient distance to push the control rod 33 forwardly four inches, the piston 15 will also move forward a distance of four inches until the movement of the valve housing 44 has moved the parts into the same relative position as is shown in Fig. 5. It will be understood that there is sufficient play between the ends of the control block 32 and the bosses 42 and 43 to permit a proper amount of opening of the various valves, due to the relative movement of the tappets in the valve housing. If the hand-lever 12 be jerked over too quickly for the piston to respond instantly, the block 32 will of course strike one of the bosses 42 and 43 and open the corresponding valves to the maximum extent, which valves, however, will be at once closed as soon as the piston 15 has responded and moved the valve casting into the normal position, as shown in Fig. 5.

When the handle is locked, any tendency toward improper movement of the piston, due to unbalanced forces exerted by the links 16, are automatically prevented by reason of the fact that the control shaft 33 is positively positioned by the hand-lever, and any slight movement of the piston in either direction will automatically open such valves as will immediately exhaust fluid from the proper end of the cylinder to cause the piston to at once move back into its normal position. Such tendency toward improper movement is of course also to a certain extent arrested by reason of the fact that the end of the cylinder from which the piston is moved is at that time sealed, such movement thus causing the pressure to drop below normal, the other end being opened up to full pressure. The device in this respect is particularly sensitive and responds instantly to resist the tendency of the piston to move, due to unbalanced exterior forces applied thereto. The fact that the valve arrangement is of the puppet type causes the valves to open and respond instantly to any improper movement of the piston, and similarly to any proper movement of the hand-lever.

By reason of the fact that the piston and the member to be moved, move in the same straight line as the control rod 33, which is actuated by the manual control lever, I am enabled to construct a valve mechanism which is particularly compact in design and convenient to manufacture, while at the

same time, all parts of the device are readily accessible for purposes of repair or renewal. It will be observed that improper adjustment of the glands around the tappet stems will have no effect in destroying the effectiveness of the arrangement, for the reason that the springs controlling the valves are incased within the valve housing and operate directly upon the valves to close the same, and do not have to overcome the packing friction as in the ordinary type of puppet valve with the outwardly projecting valve stem. The only effect of excessive tightening of one of the gland packings is to cause an excess of the gland friction, necessitating the use of slightly more power applied to the hand-lever 12 in order to shift the valve.

In devices of the general character described, it is frequently advantageous to be able to operate the reversing link or other controlled member by hand in case of a partial or total failure of the power supply. In my improved apparatus, this emergency manual control is readily effected by reason of the fact that if the piston does not at once respond to the opening of the valves by the movement of the hand-lever, delay in the movement of such piston will cause the block 31 to strike one of the bosses in which the rod 33 slides, and thus the piston and parts controlled thereby may be moved by exerting direct pressure thereon through the hand-lever 12 and linkage connecting the same with the block 31. Ordinarily of course the power responds quickly enough to the movement of the hand-lever to prevent said block 31 from engaging with the said bosses.

In the event that it is desired to replace the use of compressed air with steam, for instance in ship-steering apparatus, it is of course undesirable to discharge the exhaust steam from the apparatus directly into the atmosphere, or room in which the apparatus is installed. In such case, it is a simple matter to connect the exhaust apertures to a common closed conduit communicating with a telescopic pipe arranged parallel with and similar to the arrangement used for conducting the pressure fluid to the apparatus.

In developing my invention I encountered seemingly insurmountable difficulties in the way of using an expansive element, such as air or steam, in a shift mechanism of the class described. The principal difficulty encountered was that due to the failure of the piston to come to rest or to position itself in conformity with the position of the differentially controlled valve-moving mechanism positioned by the handle. In certain cases and under certain conditions, the piston would over-run its true position, as determined by the setting of the handle, and cause the differentially controlled valves to open in a direction to move the piston back in reverse direction, upon which the piston would again over-run in the other direction and possibly oscillate or "hunt" in its cylinder indefinitely, or, at any rate, for a considerable period. Such tendency to hunt is particularly prevalent in the case of apparatus designed for manipulating locomotive reverse gears, for the reason that in certain positions of the locomotive cylinder valve linkage, heavy, and in some cases extremely sudden, stresses are imposed upon the link which actuates the link of the reversing gear. Obviously, the tendency of the piston to hunt in its cylinder would be much increased by the said stresses, particularly if the same were of a vibratory character and of a vibration frequency corresponding to the vibratory movement of the control piston hunting in its cylinder. This and other difficulties are overcome in my improved apparatus.

In the first place, as shown, I employ an exceedingly long piston, chambered out at each end in order to provide extremely large clearance spaces compared with the net piston displacement, thus making the cushioning effect due to the movement of the piston in the cylinder, aside from the valve control, substantially uniform for all positions of the piston in the cylinder; whereas, if the piston be made with comparatively small clearance spaces, the difference in the cushioning action of the cylinder between positions at the end or the center of its stroke is quite marked, necessitating different adjustments of the various parts to overcome the hunting tendency.

In the second place, I adjust the inlet tappets in such a way as to provide no clearance between the tappets and the inlet valves controlled thereby when the tappet control shaft 33 is in its normal position. Under normal conditions, such arrangement maintains substantially full pressure in each end of the cylinder at all times, the slightest movement of the piston or control shaft serving to open substantially one or other of the air inlet valves.

In the third place, I provide considerable clearance, as shown at 73, between the exhaust valves and their actuating tappets. Such clearance prevents the exhaust valves from opening upon slight movements of the piston and permits the latter to respond, to a limited extent, to external stresses imposed thereon, without affecting the condition of the valve-operating mechanism. Such clearance, however, is not made sufficient to impair the sensitiveness of the device when response to a movement of the differentially actuated valve mechanism is desired.

In the fourth place, it will be noted that in my apparatus the ratio between the relative movement of the piston and the man-

ually-controlled parts is always constant relative to its effect upon the valve-controlling apparatus. That is to say, a ¼-inch movement of the piston will always result in a definite amount of movement of the valve mechanism, of course assuming that the hand control is stationary; and also, a ¼-inch movement of the hand control will always result in a certain definite movement of the valve mechanism, assuming the piston to be stationary, which ratios and conditions are constant throughout all positions of the piston. In addition thereto, the piston and the hand-lever control are so arranged that movement of the valve mechanism, or a certain movement of either of them, is identical with that due to a similar movement of the other part. This is extremely important in insuring identical operation of the valve mechanism in all parts of the piston stroke,—something which is not obtained by the use of floating lever differentials.

In the fifth place, the valves, being of the puppet type, are free from leakage and operate instantly and positively, although the valve openings are initially restricted as described.

The mechanism possesses, among other advantages, one, particularly, which is not possessed by similar devices which have heretofore been brought to my attention, viz., the movement of the power-controlled parts is communicated mechanically to the handle by reason of the fact that the parts may be so adjusted that a fairly considerable force is necessary to cause relative movement of the control shaft 33 and the housing. This is possible by reason of the inherent friction in the movement of the various parts, including the friction of the tappet rods in the glands and the resistance due both to the valve-closing springs and the fact that the valves open against pressure, particularly the exhaust valves. Thus, if the device be used for steering a ship and the steering wheel be connected to the block 31, through suitable chains and gearing (reversible), the rudder being suitably connected to the piston, pressure applied to the rudder through the waves, currents, or by reason of the fact that the ship's course is being changed, will be faithfully communicated to the steering wheel, assuming of course that the friction of the steering wheel connections is less than the resistance of the valve-moving mechanism. This feature of my invention is of almost inestimable value in ship steering, as it enables the quartermaster or pilot to "feel" the rudder, a feature, so far as I am aware, not possessed by any other power steering mechanism which has hitherto been brought to my attention.

The invention is capable of being embodied in a large number of different forms for various different purposes to suit individual plans. Hence, the invention is not intended to be limited by the specific details of the described construction, but must be interpreted in a broad sense while referring to the appended claims.

I claim—

1. In a device of the class described, the combination of a pilot member, a cylinder, a piston for said cylinder, a source of motive fluid for moving said piston, valve mechanism for controlling said motive fluid, spring means normally tending to prevent movement of said valve mechanism, and a controlling connection between said pilot member and said valve mechanism, the arrangement being such that resistance preventing actuation of the valve mechanism is sufficient to cause movement of the pilot member without operating said valve mechanism when the piston is moved by external forces.

2. In a servo-motor follow-up device, the combination of a handle, a member controlled thereby, a pair of spaced apart cylinder ends, piston means therefor connected together and constituting with said cylinder ends in effect a double-acting cylinder provided with a piston, a valve housing carried by, movable with, and forming an integral part of, said piston means and interposed between said cylinder ends, valve mechanism carried by said housing for admitting and discharging fluid to and from the said cylinder ends to move said piston whereby said controlled member is operated, and a control member for said valve mechanism mechanically connected to said handle and positively movable thereby in a direction in line with the direction of movement of said housing, the arrangement being such that movement either of the piston or of the handle will cause operation of said valve mechanism.

3. In a servo-motor follow-up device, the combination of a pair of spaced apart coaxially alined cylinder ends, an elongated piston member common to both of said cylinder ends and constituting with said cylinder ends in effect a double-acting cylinder equipped with a piston, a laterally projecting valve housing carried by, movable with, and forming an integral part of, said piston means and interposed between said cylinder ends, valve mechanism carried by said housing for admitting and discharging fluid to and from said cylinder ends to move said piston whereby said power movable member is operated, and a control member for said valve mechanism mechanically connected to said handle and positively movable thereby in a direction in line with the direction of movement of said housing, the arrangement

being such that movement either of the piston or of the handle will cause operation of said valve mechanism.

4. In a servo motor follow-up device, the combination of a controlling member, a cylinder, a piston for said cylinder, said cylinder and piston being suitably proportioned to provide a large clearance space at the limit of the piston stroke, a housing mechanically connected to said piston and provided with valve means for admitting and discharging fluid to and from the cylinder to move said piston, and a control member for said valve means movable in a direction parallel with the movement of said valve means and actuated by the controlling member.

5. In a device of the class described, the combination of a cylinder having an apertured side wall, a piston in said cylinder, valve mechanism traveling with said piston, a pilot member for actuating said valve mechanism, and a member projecting through said apertured wall for connecting the load with the piston.

6. In a device of the class described, the combination of a power cylinder having an apertured side wall, an elongated piston in said cylinder having an intermediate portion exposed through said aperture, valve mechanism secured to the exposed part of said piston controlling fluid for moving the piston in opposite directions, and a pilot member for operating said valve mechanism and movable in a direction substantially parallel with the cylinder axis.

7. In a device of the class described, the combination of a power cylinder having an apertured side wall, an elongated piston in said cylinder having an intermediate portion exposed through said aperture, valve mechanism secured to the exposed part of said piston controlling fluid for moving the piston in opposite directions, a pilot member for operating said valve mechanism and movable in a direction substantially parallel with the cylinder axis, and a member also projecting through said apertured wall for connecting the load with the piston.

8. In a servo-motor device, the combination of a pair of opposed cylinder ends having an intermediate opening, a double-ended piston associated therewith, a valve housing fixed upon and movable with an intermediate part of said piston and having a part extending through said intermediate opening, valve mechanism in said housing controlling motive fluid for operating said piston, and a pilot member for actuating said valve mechanism and movable in a direction substantially parallel with the piston axis.

9. In a device of the class described, the combination of an elongated piston, a cylinder having its side wall cut away to expose an intermediate portion of said piston, an externally arranged valve housing secured to said exposed piston part and freely exposed to the atmosphere, a source of motive fluid for moving said piston, valve mechanism on said housing for controlling said fluid, and a pilot member movable in a direction substantially parallel to the cylinder axis for actuating said valve mechanism.

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