April 29, 1930. H. ROWNTREE 1,756,307

PNEUMATIC MOTOR

Filed Aug. 16, 1924 2 Sheets-Sheet 1

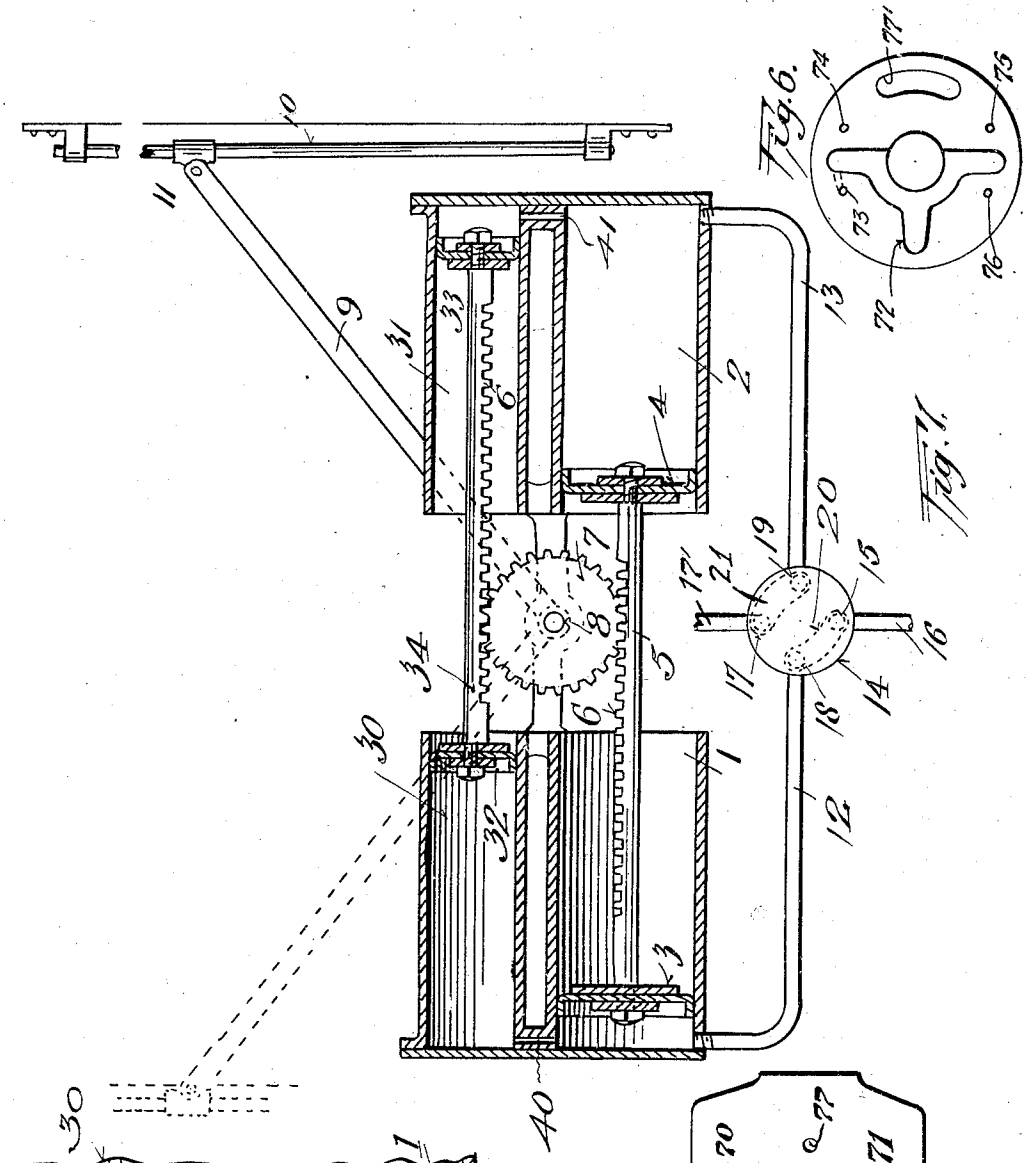


Fig. 1.

Fig. 6.

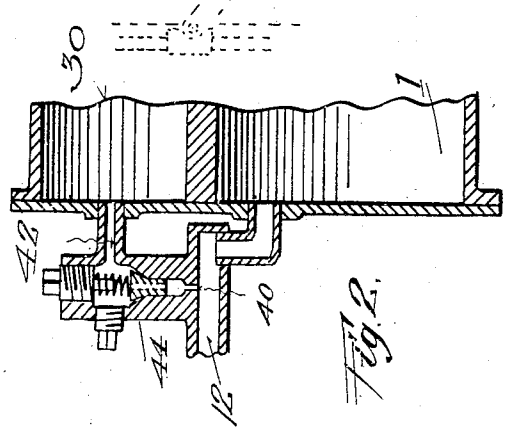


Fig. 2.

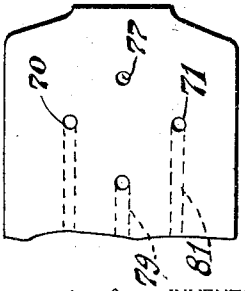


Fig. 7.

INVENTOR

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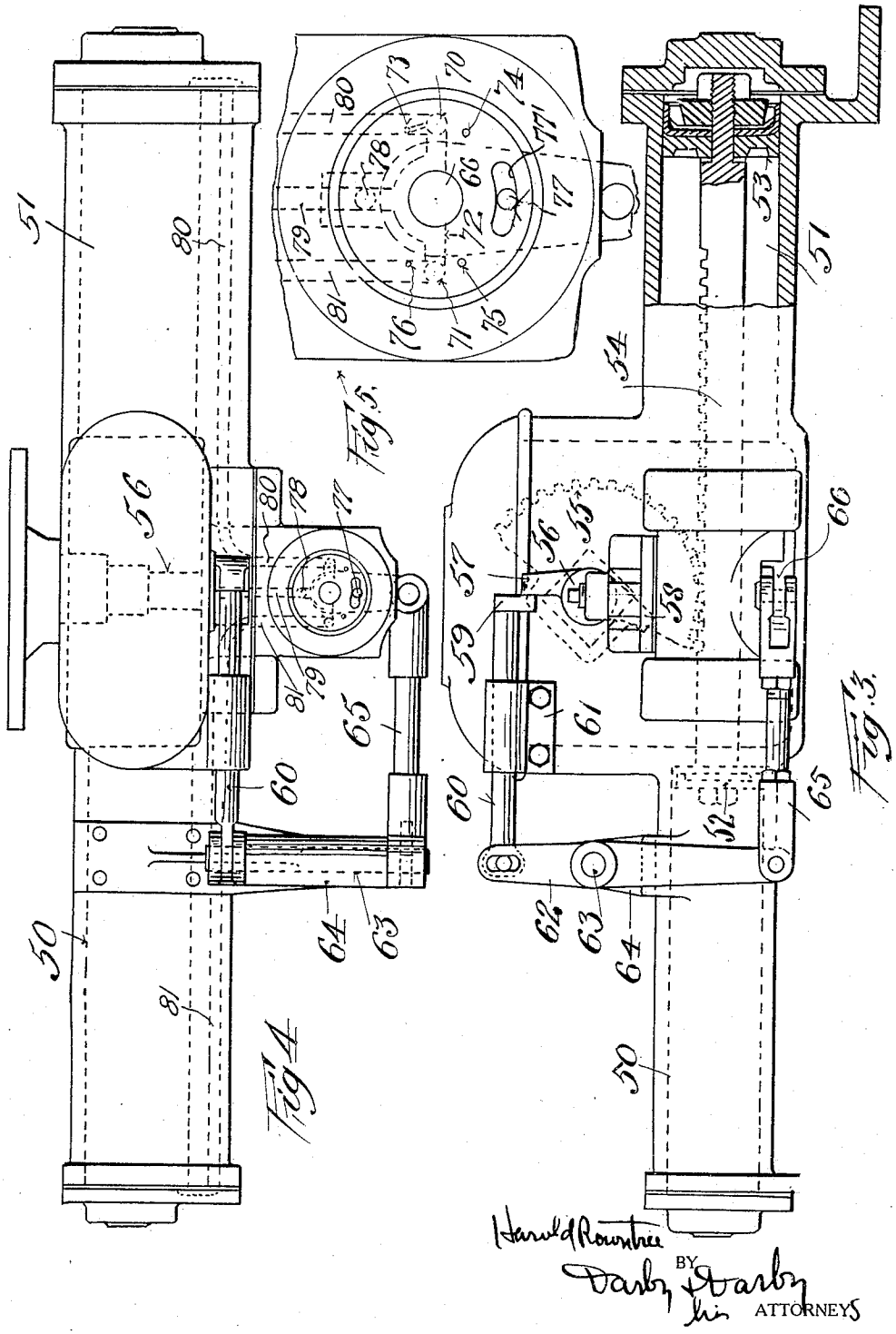
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PNEUMATIC MOTOR

Filed Aug. 16, 1924 2 Sheets-Sheet 2



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Patented Apr. 29, 1930

1,756,307

UNITED STATES PATENT OFFICE

HAROLD ROWNTREE, OF SCARSDALE, NEW YORK, ASSIGNOR TO NATIONAL PNEUMATIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF WEST VIRGINIA

PNEUMATIC MOTOR

Application filed August 16, 1924. Serial No. 732,362.

This invention relates to pneumatic motors, and particularly, though not exclusively, to pneumatic motors such as are employed for opening and closing doors, gates, or other types of closures on subway, surface and elevated cars, trains or the like.

The object of the invention is to provide a pneumatic motor construction which is simple in structure, efficient in operation and economical of manufacture, installation and maintenance.

A further object of the invention is to provide a motor of the foregoing character wherein quick initial operation is secured and wherein, in addition thereto proper cushioning of the motor, and hence the door or other closure it operates, is secured as the motor approaches the limit of its working stroke.

A further object of the invention is to provide a motor structure wherein in the event the door, in closing, encounters an obstruction, the pressure is incapable of building up to cause a slam on the withdrawal of the said obstruction. In other words, I provide a motor structure which has all the advantages and none of the disadvantages of both pneumatic and hydraulic operation in its action.

Further objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location and relative arrangements of parts, all as will be more fully hereinafter set forth, as shown in the accompanying drawings and finally pointed out in the appended claims.

Referring to the drawings:

Fig. 1 is a view in side elevation, in partial vertical section, showing a pneumatic motor embodying my invention.

Fig. 2 is a similar view showing a modified construction of a port connection between the ends of adjacent cylinders.

Fig. 3 is a similar view of a modified construction of motor embodying my invention.

Fig. 4 is a top plan view of the same.

Fig. 5 is an enlarged fragmentary plan view of the valve employed in connection with the type of motor illustrated in Figs. 3 and 4.

Fig. 6 is a plan view of the valve head from the bottom.

Fig. 7 is a plan view of the valve block showing the valve seat.

The same part is designated by the same reference character wherever it occurs throughout the several views.

Referring to Fig. 1, I employ a motor consisting of two cylinders 1 and 2 open at their adjacent ends and closed at their remote ends. In these cylinders operate pistons 3 and 4, which pistons are joined together for simultaneous operation by means of a piston rod 5 provided with gear teeth 6 thereon which mesh with the gear teeth of wheel 7 mounted on shaft 8, to which shaft is secured the door arm 9 which is connected at its opposite end to the door rod 10 of door 11, whereby upon rotation of the wheel 7 the arm 9 is rocked in one direction or the other to open or close the door. The closed end of cylinder 1 in back of piston 3 is provided with a fluid pressure supply pipe 12 and the closed end of cylinder 2 is provided with a similar supply pipe 13. These supply pipes are controlled by means of a valve 14. Valve 14 comprises a valve seat having port 15 communicating with an exhaust connection 16, a port 17 connected to a source of fluid pressure supply 17', a port 18 in communication with pipe 12, and a port 19 in communication with pipe 13. The valve has communicating ducts or recesses 20 and 21 adapted in one position of the valve, i. e., as illustrated, to establish communication between ports 17 and 19 and ports 18 and 15, and in the other position to establish communication between ports 17 and 18 and ports 15 and 19. The foregoing in essence constitutes the usual structure of non-differential pneumatic door motor and control thereof.

In accordance with my invention, however, I associate with the usual structure thus far described auxiliary cylinders 30 and 31 having pistons 32 and 33 operating therein, respectively. The cylinders 30 and 31 are of substantially the same construction as cylinders 1 and 2 and differ therefrom mainly in the difference in size, the cylinders 30 and 31 being smaller in diameter than the cylinders

1 and 2. The pistons 32 and 33 are connected together by a common rod 34, likewise provided with teeth 6 meshing with the teeth on the gear wheel 7, so that the pistons 32 and 33 move simultaneously with the pistons 3 and 4 but in a direction opposite thereto. The auxiliary motor structure thus described may be associated with the main motor structure comprising the cylinders 1 and 2 in any one of a number of ways. In the form shown—but to which I do not desire to be limited or restricted, however—I form the cylinders in a single casting with a common cylinder head for the closed ends thereof. Cylinder 30 is in communication with cylinder 1 at the closed end thereof by means of a restricted passage 40, and likewise cylinder 31 is in communication with cylinder 2 by passage 41.

The operation of the motor assembly thus formed is as follows: With the door motor, with its parts as shown and the valve in the position shown with respect to its seat, it will be seen that there is fluid pressure admitted in cylinders 2 and 31 behind the respective pistons 4 and 33, the door in this position being open and being held open because of the differential action of the cylinders 2 and 31, the cylinder 2 and piston 4 being larger in diameter than cylinder 31 and piston 33, and therefore the pressure on piston 4 being greater, overcomes the pressure on piston 33, tending to move the pistons in opposite directions. Let us now suppose that it is desired to close the door and the control valve 14 is moved to its closing position to establish communication between ports 18 and 17 and ports 19 and 15. The valve having large ports, the cylinder 2 is almost instantly emptied of pressure and the cylinder 1 almost instantly filled with pressure. On account of the smallness of the ports 40 and 41 the pressure in cylinder 31 exhausts more slowly than the pressure exhaust from the cylinder 2 and, similarly, the pressure in cylinder 30 builds up more slowly than the pressure in cylinder 1. This means, therefore, that at the instant of reversing the valve there is full pressure in cylinder 1 behind piston 3, tending to close the door; no pressure in cylinder 2, tending to obstruct the motion of the door; a little pressure momentarily remaining in cylinder 31 behind the piston 33, tending to help the door to start rapidly; but little pressure in cylinder 30, tending to resist the closing of the door. The motor, and hence the door, will thereupon start very promptly and quickly. At a certain stage in the progress of the door, however, this stage depending upon the relative size of the small ports 40 and 41 in relation to the size of the cylinders 31 and 30, the action of the cylinders 31 and 30 will change from an action which is assisting the motion of the door to one that is resisting the motion of the door, this change occurring as soon as the pressure in cylinder 31 is exhausted and as soon as the pressure in cylinder 30 has been built up. From that time on the motor will act as an ordinary differential engine, having what I have hereinbefore termed a hydraulic motion in place of a pneumatic motion. This steadies the motion of the door down to the requisite speed and gives it an easy closing movement. If, while the door is closing, the operator should desire to re-open it and should shift the valve 14 back into the position shown in the drawings, then the pressure in cylinder 1 would be almost instantly exhausted and cylinder 2 would be almost instantly refilled with pressure, but the pressure would only be exhausted slowly from cylinder 30 and the pressure would only flow slowly into cylinder 31, and therefore the action of the cylinders 30 and 31 would be to assist piston 4 in opening the door quickly so that the door would respond very promptly to the shifting of the valve and then would check down to its slower speed as soon as the cylinders 30 and 31 have begun to obstruct the door instead of assisting it.

Should the door be held by hand or by an obstruction without the valve being reversed while the door is closing, then, while it is being so held, the pressure in cylinders 1 and 30 will become uniform, if the pressure had not already become uniform prior thereto, so that when the obstruction is removed the door will start again with its steady hydraulic motion because it is having the full resistance of the cylinder 30 from the moment it starts up again.

From the foregoing it will be readily seen that I have devised a type of door motor or engine comprising a pair of primary cylinders and a pair of secondary cylinders, the primary cylinders being arranged so that the pressure in them follows instantly the action of the controlling valve, while the pressure in the secondary cylinders follows more slowly or lags behind the action of the controlling valve. The result is that for a short period of time, after the controlling valve is reversed, both the primary and secondary cylinders are tending to move the door in the same direction so that it will move rapidly, but as soon as the secondary cylinders have fallen into step they will then begin to oppose the action of the primary cylinders and a slower, steady motion of the door will result. It is obvious that by suitably arranging or regulating the size of the small ports 40 and 41 any desired point of cushion during the motion of the door may be achieved.

I wish it to be understood that my invention is not confined to any particular style or construction of engine or motor, as the principles may be applied to many types of motors.

It will be noted, in Fig. 1, that the ports 40 and 41 which connect the primary and

secondary cylinders perform a double function, namely, first, determining the length of time that elapses before the secondary cylinder acquires its full pressure and, secondly, the rate of discharge of this full pressure from the secondary cylinder. It is sometimes desirable to have these two separate functions independently controlled, and in such cases I use a form of connection as illustrated in Fig. 2. In this arrangement, the pipe line 12 leading to cylinder 1 has a small hole 40 leading to the under side of valve 44 which has a small hole through the approximate center thereof, and from the upper side of the valve 44 there is an opening 42 into the secondary cylinder 30. In this arrangement, when pressure is supplied through pipe line 12 to the cylinder 1 the rapidity with which the secondary cylinder will fill up will depend upon the size of the small hole 40 but will not be affected by the size of the small hole through the valve 44, but the rate at which the pressure in the secondary cylinder can be driven out depends upon the size of the small hole through the valve 44. In other words, valve 44 may be lifted from its seat by the pressure supplied through the port 40, whereby the size of the port 40 alone will control the rapidity with which fluid pressure is supplied to the cylinder 30. When the pressure in cylinder 30 is exhausted, however, this pressure forces the valve 44 on its seat, allowing the only egress of pressure through the hole extending through the valve 44. In this way a more perfect control of the prompt start and final cushion can be effected and the two functions of the valve may be independently adjusted.

To accomplish the purposes of my invention, it is not necessary to employ two sets of cylinders, or, in other words, two separate engines with different sized cylinders, as the invention may be readily adapted to a single engine or motor of the differential type. In this case the single differential engine is substantially identical with the ordinary, standard, differential engine, except that in connection therewith I employ a valve centering device mechanically operated by the rotation of the gear shaft.

Referring to Figs. 3 and 4, wherein this form of construction is illustrated, a standard differential motor comprising the cylinder of small diameter 50 and cylinder of large diameter 51, having their respective pistons 52 and 53 connected together by the rack rod 54, meshing with gear segment 55, mounted on the door shaft 56, is shown. On the end of the gear shaft are fastened two small arms 57 and 58 so located that one arm or the other at the extreme end of travel of the engine strikes against a lug 59 carried on a horizontal rod 60, which rod is slidably supported in a bracket 61 mounted on the casing of the motor and slidably moves this rod in one direction or the other just as the engine is reaching the limit of its motion. This rod is connected by a pin and slot connection with one end of an arm 62 pivotally supported by a pin 63 carried by a boss 64 formed integrally with or connected to the motor casing. The other end of the arm 62 is connected to a lever 65 which, in turn, is connected to the valve stem 66, of the usual standard construction. Therefore, just as the engine completes its final movement in one direction the valve is given a slight rocking movement, sufficient to move it to a dead center.

I will now describe the valve ports and arrangements employed in connection with this modified construction, with particular reference to Figs. 5, 6 and 7. In this arrangement port 70 is connected to the cylinder 51 of larger diameter through the passage 80, and port 71 to the end of the smaller cylinder 50 through the passage 81. When the valve is in its central position, which position it is always in after the door has completed its motion in either direction, both ports 70 and 71 are connected through a groove 72 under the valve seat, with the center of the valve around the stem, and thence to exhaust through the port 78 and passage 79. At 73 I provide a small hole drilled part way up into the valve from the bottom and then opening into the exhaust recess 72. The other three holes 74, 75, 77′ and 76 are drilled clear through the valve. Fluid pressure from a supply source is fed into the valve body over the valve head through the port 77. With the valve in the position shown, the fluid pressure is confined above the valve head.

In operation, let us suppose that the door is fully closed, the valve being in central or centered position and both cylinders are open to exhaust, as shown in Fig. 5. The valve is now moved clock-wise from the position shown in Fig. 5, thereby bringing the valve port 73 over the port 70 and valve port 75 over the port 71. This puts the full operating pressure, through port 75, which may be approximately one-eighth of an inch in diameter, into the small cylinder and leaves the large cylinder open to exhaust through the very small port 73. As there is no back pressure beyond the atmospheric pressure, the door starts open with a quick movement but as the pressure builds up in the larger cylinder, due to the smallness of its exhaust opening, greater and greater fluid resistance is offered until the door is cushioned down to a slow movement before it completes its opening movement, and as it reaches its fully opened position the valve is moved to center position and both ends are again exhausted.

If the valve is now moved into closing position, i. e. counter-clockwise, port 74 is now brought over the port 70 and the very small port 76 is brought over port 71. This

will put full pressure in the larger cylinder and full pressure will also begin to leak slowly into the smaller cylinder. There will, therefore, at first, be no appreciable resistance to the prompt speedy operation of the door in closing, but as the pressure in the smaller cylinder is not only built up by the motion of the piston but is also built up by the pressure leaking in through port 76, and both these results are not offset in any degree by any air leaking out through any exhaust, shortly the pressure in the smaller cylinder reaches the full operating pressure and in fact will probably exceed it due to the momentum of the door and the larger size of the other cylinder. The motion of the door therefore will be slowed down by the resistance in the smaller cylinder, but as the difference in the size of the two cylinders continues to tend to cause the piston to complete its motion, the pressure in the smaller cylinder is forced out through the small hole 76, and the door completes its motion without slamming, and as soon as the motion is completed the valve is again centered.

Again, in this instance, if during the closing motion of the door the door is held by an obstruction, the pressure in the smaller cylinder cannot be reduced below the operating pressure and if it is below the operating pressure at the moment of obstruction it will build up to the operating pressure through the pressure influx of pressure through the small port 76. The door therefore cannot start away after it has been obstructed and the obstruction has again been removed, with greater power than it had at the moment that it was obstructed, and it may start away with considerably less power.

Therefore, with the single differential type of motor, so far as the closing movement is concerned, I obtain exactly the same result as is obtained with the double differential, and with the opening movement of the motor it is not necessary to take into consideration the possibility of or make provision for the door being obstructed.

Many further modifications and changes in details will readily occur to those skilled in the art without departing from the spirit and scope of my invention, as defined in the claims.

Therefore, what I claim as new and useful, and of my own invention, and desire to secure by Letters Patent, is:

1. In a door-operating motor, the combination of a larger operating cylinder, a smaller opposing cylinder, said cylinders having pistons therein, and means for maintaining the pressure in the opposing cylinder substantially less than the operating pressure at the moment of initiation of the door movement of the motor, and for causing the pressure in the opposing cylinder to gradually build up to and be maintained at a pressure at least equal to the operating pressure during the closing movement of the motor.

2. In a door operating motor, the combination of pressure cylinders, pistons therein, means for supplying pressure to one of said cylinders and simultaneously opening the other to exhaust, and means for yieldingly opposing the action of the motor at the actuating end thereof to effect cushioning of the motor, said means being in communication with said cylinder supplied with fluid pressure.

3. In a door operating motor, the combination of pressure cylinders, pistons therein, means for supplying pressure to one of said cylinders and simultaneously opening the other to exhaust, and fluid pressure means for yieldingly opposing the action of the motor at the actuating end thereof to effect cushioning of the motor, said means being in communication with said cylinder supplied with fluid pressure.

4. In a door operating motor, the combination of pressure cylinders having passages opening into the end of each, pistons in said cylinders, means for supplying pressure to one of said cylinders and simultaneously opening the other to exhaust through said passages, and means in connection with the cylinder supplied with pressure through its passage and operated by said pistons for yieldingly opposing the action of the motor at the actuating end thereof to effect cushioning of the motor, said opposing means being effective only at or near the end of the stroke of the motor.

5. In a door operating motor, the combination of pressure cylinders having passages opening into the end of each, pistons in said cylinders, means for supplying pressure to one of said cylinders and simultaneously opening the other to exhaust and fluid pressure means in communication with said cylinder supplied with pressure and operated by said pistons for yieldingly opposing the action of the motor at the actuating end thereof to effect cushioning of the motor, said opposing means being effective only at or near the end of the stroke of the motor by reason of the movement of the pistons.

6. In a double differential door operating motor, the combination of a pair of cylinders having pressure and exhaust connections, connected pistons therein, a member actuated by the movement thereof, a pair of secondary cylinders, connected pistons therein of different areas than said first pistons also operatively associated with said member whereby each pair of pistons simultaneously move in opposite directions, and a fluid pressure connection between adjacent cylinders, said secondary pistons and cylinders acting to cushion the movement of the other pistons.

7. In a double differential door operating

motor, the combination of a pair of cylinders having pressure and exhaust connections, connected pistons therein, a member actuated by the movement thereof, a pair of secondary cylinders, connected pistons therein of different areas than said first pistons also operatively associated with said member whereby each pair of pistons simultaneously move in opposite directions, and a fluid pressure connection between adjacent cylinders, said secondary pistons and cylinders acting to cushion the movement of the other pistons.

8. In a door operating motor, the combination of a pair of cylinders, connected pistons therein, a member actuated by the movement thereof, a pair of secondary cylinders of a diameter smaller than that of said first mentioned cylinders, connected pistons therein also operatively associated with said member whereby each pair of pistons simultaneously move in opposite directions, and a restricted fluid pressure connection between adjacent cylinders, said secondary pistons and cylinders providing cushioning means for the set of pistons and cylinders.

9. In a double differential door operating motor, the combination of a pair of cylinders, with pistons operatively connected together, a member actuated by the movement thereof, a pair of secondary cylinders of a diameter smaller than that of said first mentioned cylinders, with pistons also operatively connected together and operatively associated with said member whereby one pair of pistons moves whenever the other pair of pistons is moved, and a restricted fluid pressure connection to each of said smaller cylinders, said smaller pistons and cylinders providing cushioning means for the other set of pistons and cylinders.

10. In a door operating motor, the combination of a pair of cylinders, with pistons operatively connected together, a member actuated by the movement thereof, a pair of secondary cylinders of a diameter smaller than that of said first mentioned cylinders, with pistons also operatively connected together and operatively associated with said member whereby one pair of pistons moves whenever the other pair is moved, and fluid pressure connections between each of said larger and each of said smaller cylinders respectively, said secondary pistons and cylinders acting to cushion the movement of the other pistons.

11. In a door operating motor, the combination of a cylinder of larger diameter and a cylinder of smaller diameter with pistons operatively connected together, a valve for controlling the supply of fluid pressure to and the exhaust thereof from said cylinders, means for supplying full pressure to the larger of said cylinders, and restricted pressure to the smaller of said cylinders, and means whereby both of said cylinders are open to exhaust prior to the supply of pressure to them.

In testimony whereof I have hereunto set my hand on this 15th day of August A. D., 1924.

HAROLD ROWNTREE.