(No Model.) 2 Sheets—Sheet 1.

W. COOPER.

PNEUMATIC HYDRAULIC LOCOMOTIVE.

No. 504,668. Patented Sept. 5, 1893.

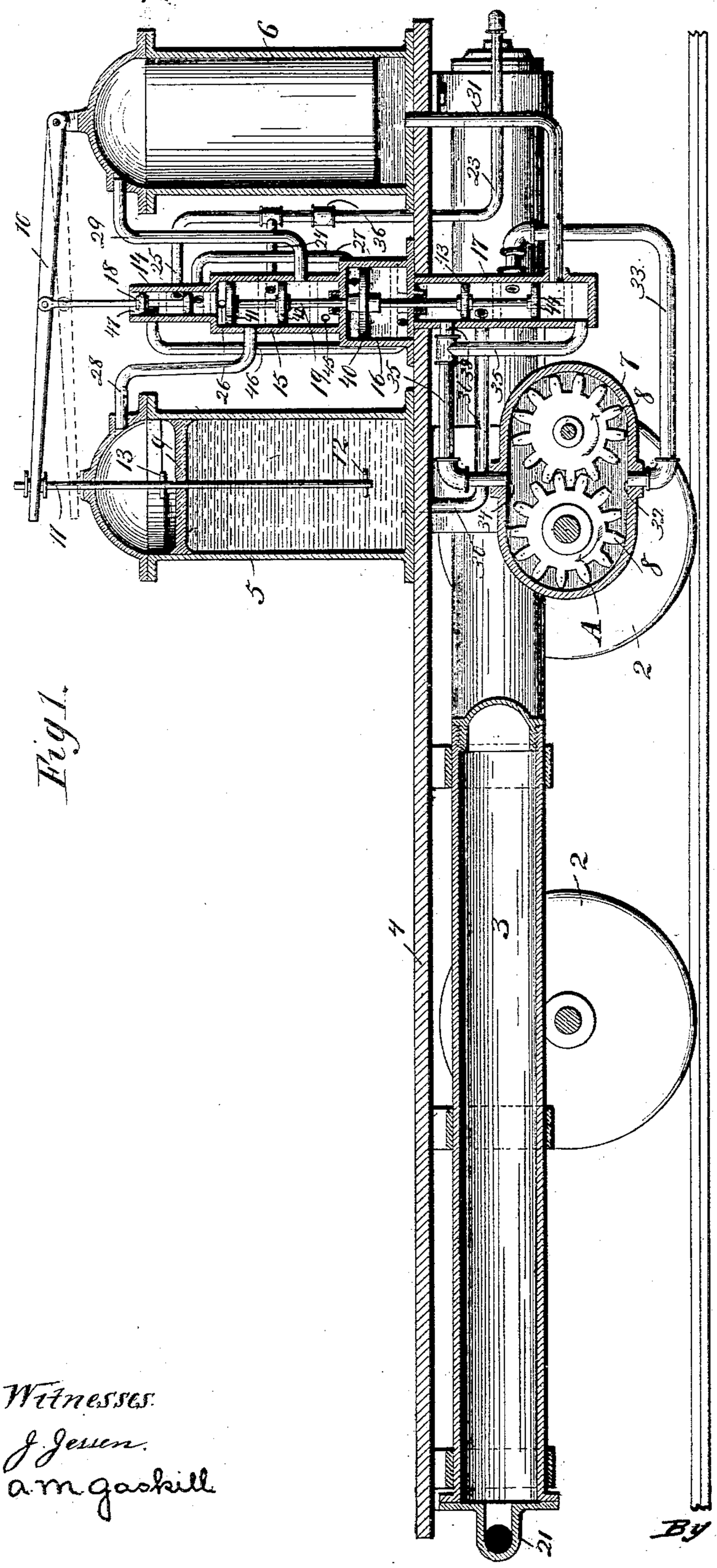

Fig 1.

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(No Model.) 2 Sheets—Sheet 2.

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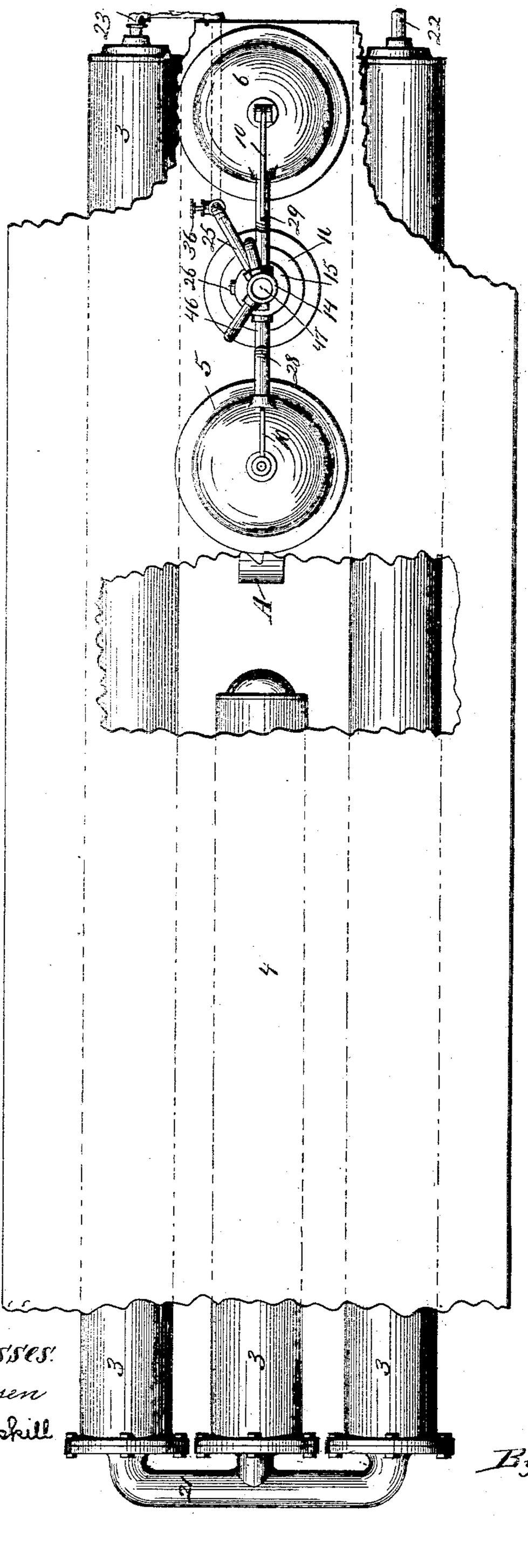
Fig. 2.



Witnesses:
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Inventor:
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UNITED STATES PATENT OFFICE.

WILLIAM COOPER, OF MINNEAPOLIS, MINNESOTA.

PNEUMATIC HYDRAULIC LOCOMOTIVE.

SPECIFICATION forming part of Letters Patent No. 504,668, dated September 5, 1893.

Application filed November 6, 1889. Renewed February 9, 1893. Serial No. 461,687. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM COOPER, of Minneapolis, in the county of Hennepin and State of Minnesota, have invented a certain new and Improved Pneumatic Hydraulic Locomotive, of which the following is a specification.

My invention relates to improvements in locomotives, and consists in the application of hydraulic engines to purposes of propulsion force being given to the propelling liquid by the application of compressed air or gas generated under pressure. I do this by combining certain reservoirs containing liquid and certain other reservoirs containing the compressed air with a suitable mechanism for controlling and conveying the compressed air from said air reservoirs into said liquid reservoirs, and a suitable mechanism for controlling and conveying the liquid from said liquid reservoirs to the motor thereby imparting motion to the same. The pneumatic reservoirs are charged with a sufficient supply of air or other gas under pressure to operate the motor for a considerable time before being recharged.

My device further consists in the construction and combination hereinafter described and particularly pointed out in the claims.

In the accompanying drawings forming a part of this specification I show a special construction, designed by me for the application of my invention to the propulsion of street cars, but it is obvious that the invention may be applied to various uses, and that such special construction may be modified in a number of ways without departing from the spirit of my invention, and hence I do not desire to be confined to the exact construction shown and described.

As shown in the drawings, Figure 1 is a vertical longitudinal section of my improved motor as applied to a street car, and Fig. 2 is a plan view of the same part of the floor being broken away to show the arrangement of the pneumatic reservoirs.

In the drawings, 2 represents the car wheel, 3 the pneumatic reservoir comprising three independent cylinders arranged parallel with each other under the floor 4 of the car being connected together by means of the pipe 21 so as to form a common reservoir.

Arranged upon the floor of the car are the liquid reservoirs 5 and 6, preferably vertical cylinders adapted to hold the liquid employed in driving the motor and provided with suitable connecting pipes for conveying the same through the motor, the liquid being conveyed and reconveyed to and fro through the motor from one reservoir to the other, the liquid thus being used over and over again without waste.

Arranged underneath the car body, in suitable connection with the carrying wheels of the car, is the motor A.

While any form of positively acting liquid or hydraulic motor preferred may be used, I prefer to use the form herein shown, in which 7 represents a suitable case for the motor, in which are arranged the toothed or spur wheels 8 one being preferably secured to the driving axle, and the other journaled in said case and engaging with the first whereby as the liquid pressure is applied to the spurs or teeth the motor is operated in the ordinary manner, and the car thereby propelled.

By positively acting motor, I wish to be understood as meaning a motor which is driven positively by the pressure of the liquid passing through it, a given quantity of said liquid passing through said motor, no matter whether the load under which it is running be great or small. This class of positively acting motors is used in distinction from another style of motors which are driven by the weight or impact of the fluid, and which will only run under light loads, their construction being such that under any considerable load the fluid will pass through the motor without causing the same to revolve.

While any suitable fluid may be used to propel the motor, I prefer to use the mineral oil which serves as a lubricator with the parts in which it comes in contact, and will not congeal when used at a low temperature. The pneumatic reservoir is so connected with the liquid reservoir that the compressed air, as released from it, is conveyed first into one reservoir thereby forcing the liquid out of the reservoir through the motor and into the other reservoir, and then as the liquid is exhausted from the first reservoir, the air connection is automatically shifted to the other reservoir whereby the liquid is forced, by the pressure of the air, from it through the motor

and back to the first reservoir, so that the pneumatic pressure is continuously applied to the liquid forcing it to and fro through the motor until the supply of compressed air is exhausted or cut off. It will be seen that the liquid extends in the form of a liquid column or piston from one reservoir through the motor to the other reservoir, and therefore that the pressure exerted upon the liquid by the admission of the air to the liquid reservoir is transmitted through this liquid column or piston directly to the motor, and therefore that by increasing or decreasing this pressure the power upon the motor is instantly increased or decreased in a corresponding ratio. It will also be seen that by stopping the movement of this liquid column or piston the motor will be instantly stopped. This is an especial advantage in a locomotive, as by this means the locomotive may be stopped, started or reversed at will. The liquid column forms a perfect means for controlling the motor, and the speed of the locomotive, so that in going down grade where the weight of the locomotive accelerates the speed the liquid column may be used to retard the speed, and I am thus enabled to dispense with any other governing device.

In order that the flow of the liquid through the motor may be continuous in one direction for the most efficient operation of the motor, the connections between the fluid reservoirs and the motor are automatically shifted simultaneously with the shifting of the air connections with the reservoir, so that the reservoir which is receiving the pneumatic pressure is always connected with the inlet port of the motor, and the other reservoir with the outlet port of the motor.

Arranged in the reservoir 5 is the piston 9 adapted to rest upon the top of the inclosed liquid and to move upward and downward in the reservoir with the rise and fall of the liquid.

Pivoted to the top of the reservoir 6 is the lever 10 provided with the rod 11 at its opposite end which extends through the top of the reservoir 5 nearly to the bottom of the reservoir, and is adapted to be reciprocated through the piston 9 and the wall of the reservoir. Arranged upon this rod are the stops 12 and 13 on either side of the piston 9 and respectively near the top and bottom of the reservoir. The piston 9 thus in its movement up and down in the reservoir with the varying height of the liquid strikes the stops 12 and 13 as it approaches the upper and lower limits of its movement, thus serving to raise and lower the rod 11 and to operate the lever 10.

Arranged, preferably in a vertical position between the reservoirs 5 and 6, partly above and partly below the floor of the car, are the series of cylindrical chambers or cylinders 14, 15, 16 and 17, the cylinder 14 being an open head cylinder and communicating with the cylinder 15, but the cylinders 15, 16 and 17 being independent and non-communicating excepting through the connections hereinafter described.

Arranged in the cylinder 14, with its stem connected to the lever 10, is the double piston valve 18 which is thus reciprocated in the cylinder by the movement of the lever as before described.

Arranged in the cylinders 15, 16 and 17, and adapted to be reciprocated in a suitable packing in the walls between the same, is the spindle or shaft 19 fitted with a double piston valve 41 and 42 arranged in the cylinder 15, the single piston valve 40 arranged in the cylinder 16, and the double piston valves 43 and 44 arranged in the cylinder 17.

The air cylinders of the reservoir 3 are connected together, as above described, by means of the pipe 21, and are fitted with the inlet pipe 22 by means of which air may be forced in to charge the reservoir, and with the outlet pipe 23 for conveying the compressed air to the operative parts of the motor. The pipe 23 is provided with the branch pipe 24 communicating with the cylinder 15 at or about its center and with the branch pipe 25 communicating with the cylinder 14 at or near its center. Leading from the upper part of the cylinder 14 to the lower part of the cylinder 16 is the pipe 46 and from the lower part of the cylinder 14 to the upper part of the cylinder 16 is the pipe 27. The upper and lower members of the double valve 18 as reciprocated in the cylinder 14 pass respectively the openings into the pipes 46 and 27 whereby when the valve is raised to its limit the pipe 46 is put into communication with the pipe 25 whereby the air entering the cylinder from the pipe 25 is conveyed to the cylinder 16 beneath the valve 40 and when the valve 18 is at its lower limit the pipe 46 is put in communication with the outer air through the open head 47 and the lower member of the valve having passed below the opening of the pipe 27 this pipe is brought in connection through the cylinder with the pipe 25 and serves to convey the air from it into the cylinder 16 above the valve 40. Leading from the upper part of the cylinder 15 into the upper part of the reservoir 5 is the pipe 28 and leading from the lower part of the cylinder 15 to the top of the reservoir 6 is a pipe 29. The function of the valves 41 and 42 as reciprocated in the cylinder 15 is the same as that of the valves in the cylinder 14 the valve 41 in its movement passing the opening into the pipe 28 and the valve 42 in its movement passing the opening of the pipe 29 so that when the valves are in their proper position as shown by the full lines in the drawings the pipe 24 communicates through the cylinder with the pipe 28 and the pipe 29 is in communication through the cylinder with the exhaust port 45. When the valves are in their lower position as indicated by dotted lines in the drawings, the pipe 29 is brought in connection through the cylinder with the pipe

24 and the pipe 28 with the exhaust port 26. A pipe 30 opening into the reservoir 5 preferably through its bottom connects it with the upper part of the cylinder 17 and the pipe 31 connected similarly with the reservoir 6 connects it with the lower part of the cylinder 17. The pipe 33 entering the cylinder 17 between the openings of the pipes 30 and 31 connects the cylinder with the inlet port 32 of the motor while the pipe 35 opening into the bottom of the cylinder 17 and having also branch 38 opening into the top of the cylinder connects the cylinder with the outlet port 34 of the cylinder. The piston valves 43 and 44 as reciprocated in the cylinder 17 automatically reverse the connections of the reservoirs with the pipes 33 and 35. When the valves are at the upper limit of their movement, as shown by the full lines in the drawings, the flow of the liquid is from the reservoir 5, through the pipe 30, the cylinder 17, the pipe 33 to the motor, and from the motor through the pipe 35, the cylinder and the pipe 31 to the reservoir 6. When the positions of the valves are at their lower limits, as indicated by the dotted lines the flow is from the reservoir 6 to the pipe 31, the cylinder, and the pipe 33 to the motor, and from the motor through the pipe 35 its branch 38, the cylinder, and the pipe 30 to the reservoir 5.

A suitable reducing valve 36 may be arranged in the air pipe 23 to control the flow of the air or to cut it off entirely.

In arranging the device for use a sufficient quantity of oil is placed in the reservoirs to approximately fill one reservoir and all the connections between the reservoirs, so that when one reservoir is empty the other will be full. The pneumatic reservoir is then charged through the pipe 22 or by the generation of gas therein by any suitable chemical means, and the motor set in operation by opening the valve 36. If, for example, the reservoir 5 is filled with the oil so that the piston has raised stem or rod 11 the valves 18 will be in the position indicated by the full lines. The flow of the air through the pipe 25 into the cylinder 14 and thence through the pipe 46 into the bottom of the cylinder 16 will serve by the pressure of the air upon the valve 40 to raise it to its higher position, indicated by the full lines, the air above the valve being forced out of the pipe 27 into the bottom of the cylinder 14, and thence to the outer air through the exhaust port 26. With the movement of the piston 40, the stem 19 is moved upward also carrying the valves in the cylinder 15 and 17 to their upper positions as shown by the full lines, the air above the valve 41 exhausting through the port 26. The flow of air from the pneumatic reservoir is then established through the pipe 24 into the cylinder 15, and thence through the pipe 28 into the reservoir 5, whereby its piston 9 is forced downward forcing the oil out through the pipe 30 into the cylinder 17, and thence by the pipe 33 through the inlet port 32 of the motor. The pressure of the oil upon the teeth of the wheels 8 laterally being in excess of the pressure upward because of the greater surface exposed, the wheels are caused to rotate oppositely in the direction indicated by the arrow, thus turning the driving axle and the wheels 2 and propelling the cars. The oil being carried up between the teeth of the wheels, within the case, is forced outward through the outlet port 34 whence it is conveyed by the pipe 35 into the bottom of the cylinder 17, and thence by the pipe 31 into the reservoir 6, the air confined in the reservoir 6 being forced out by the inflow of the oil through the pipe 29 into the cylinder 15 and exhausting through the port 45. As the piston descends into the reservoir 5 it strikes the stop 12, which moving the rod 11 and the lever 10 downward, thereby shifts the position of the piston valves 18 to their lower limit indicated by the dotted lines. The air entering the cylinder 14 by the pipe 25 is then conveyed by the pipe 27 into the cylinder 16 above the valve 40 forcing the valve downward to the position indicated by the dotted lines, and with it the spindle 19 and the connecting valves all of which assume their lower positions as above described. The air confined beneath the valve 40 escapes through the pipe 46 into the cylinder 14 and through the exhaust vent 47. The air entering the cylinder 15 through the pipe 24 is thus diverted into the pipe 29 and the reservoir 6 exerting its pressure upon the liquid therein contained and forcing it outward through the pipe 31, thence it flows into the cylinder 17 above the valve 44, and is carried by the pipe 33 to the inlet port of the motor, whence it flows through the outlet port and the pipe 35 through its branch 38 into the top of the cylinder 17, and thence through the pipe 30 into the reservoir 5. The air contained in the reservoir 5 is forced outward through the pipe 28 into the cylinder 15 exhausting through the vent 26. When the piston 9 has risen so as to strike the stop 13, the standard is raised thereby shifting, as before described, the valves 18 to their first described position, when the reversing action of the apparatus takes place as above described, and the flow of the liquid is again reversed. Thus, as will be seen, so long as the air flows through the pipe 23 from the pneumatic reservoir, the oil is carried by continuous flow through the motor, the directions of the air and liquid currents being automatically reversed as above described.

Suitable means, other than those described, may be employed to regulate or stop the movement of the motor independent of the action of the valves, and modifications may be made in the construction of the apparatus so long as the pneumatic pressure is applied to the propelling liquid to force it through the motor, without departing from the principle of my invention. It is also evident, as above indicated, that the air or gas pressure may be supplied or produced in any number

of well known ways. The gas thus produced under pressure, or atmospheric air stored under pressure, may be fed into the tanks or reservoirs on the cars at a central station where a large plant has been constructed, or the pressure might be generated in the reservoirs attached to the cars by the bringing together of certain chemicals in combinations well known for this purpose.

It should also be understood that an important feature of my invention consists in the use of the piston, 9, or its equivalent, fitting practically air tight in the tank or reservoir, 5, and furnishing a partition between the liquid below and the gas above, as well as operating the valve motion. By this construction, two beneficial results are obtained, first, a positive valve motion is secured which is practically a necessary feature, inasmuch as the valves are frequently operated under an air pressure of six hundred pounds to the square inch, and present a considerable resistance to be overcome by the valve actuating apparatus. When such valve actuating apparatus consists of an air-tight piston as above set out, it is driven with a power immensely in excess of any resistance which the valve will present, and a quick and positive valve action is assured: whereas if the attempt is made to operate the valve by simple floats, said floats will be submerged or lifted clear of the liquid whenever a slight sticking of the valve occurs, and the operation of the whole apparatus will be interfered with. The second beneficial result is that the piston serving as a partition, tends in a measure to prevent the congealing of the oil by the cold generated by the expansion of the compressed air above it, and, also, prevents entirely the commotion of the oil, which would otherwise occur, when the full air pressure is turned onto the tank, said commotion resulting in an unequal action of the motor, and tending to waste the oil by vaporizing the same, and by forcing it up into the air passages from which it would be expelled by the exhaust on the next reversal of action of the apparatus.

I claim—

1. The combination in a locomotive provided with a suitable driving axle, of a hydraulic motor connected with said axle, a pneumatic reservoir carried by said locomotive, liquid reservoirs adapted to be alternately connected with said pneumatic reservoir, and valve controlled mechanism by means of which said liquid reservoirs are alternately connected with the inlet and outlet ports of said motor, and a column of liquid extending from one of said liquid reservoirs through said motor to the other liquid reservoir, whereby the air passing from the pneumatic reservoir to the liquid reservoirs forces the column of liquid to and fro from one reservoir to the other through said motor driving said motor continuously in the same direction in its passage.

2. The combination with a pneumatic reservoir, of liquid reservoirs adapted to be alternately connected with said pneumatic reservoir, a motor connected with said reservoirs with a liquid column or piston extending from one of said reservoirs to the other through said motor, and valve mechanism whereby said liquid reservoirs are alternately connected with the inlet and outlet ports of said motor.

3. The combination with a pneumatic reservoir, of liquid reservoirs adapted to be alternately connected with said pneumatic reservoir, a suitable motor and valve controlled mechanism by means of which said liquid reservoirs are alternately connected with the inlet and outlet ports of said motor, with a column of liquid extending from one of said liquid reservoirs through said motor to the other liquid reservoir, whereby the air passing from the pneumatic reservoir to the liquid reservoirs forces the column of liquid to and fro from one reservoir to the other through said motor, driving said motor continuously in the same direction in its passage.

4. The combination in a locomotive provided with a suitable driving axle, of a hydraulic motor connected with said axle, liquid holding reservoirs connected with said motor and carried by said locomotive, a pneumatic reservoir carried by said locomotive and connected with said liquid reservoirs and suitable valve connections whereby the air from the pneumatic reservoir is admitted first to one and then the other of said liquid reservoirs, and the liquid is thereby forced to and fro from one reservoir to the other passing in the same direction through said motor, for the purpose specified.

5. The combination in a locomotive provided with a suitable driving axle, of a hydraulic motor connected with said axle, liquid holding reservoirs connected with said motor and carried by said locomotive with a column of liquid extending from one of said liquid reservoirs to the other through said motor, and a pneumatic reservoir also carried by said locomotive and connected with said liquid reservoirs, for the purpose specified.

6. The combination with the positively acting hydraulic motor which has inlet and outlet ports, of a combined gas and liquid tank, connections extending from the lower portion of said tank, to both the inlet and outlet ports of said motor, the pneumatic reservoir, connections extending from said pneumatic reservoir to the upper portion of the combined gas and liquid tank, a piston fitting tightly in the tank, and valve mechanism operated thereby for controlling and shifting the above mentioned connections simultaneously so that when the lower portion of the tank is connected with the inlet port of the motor the upper portion of the tank is connected with the pneumatic reservoir, and when the lower portion of the tank is connected with the out-

let port of the motor, the upper portion of said tank is connected with the exhaust, substantially as described.

7. The combination of the motor, the pneumatic reservoir, the liquid reservoirs adapted to alternately discharge the propelling liquid therefrom into said motor and to receive the said liquid as discharged from said motor, automatic reversing mechanism actuated by the rise and fall of the liquid in said reservoirs for shifting connection between said pneumatic reservoir and said liquid reservoir, and automatic reversing mechanism actuated by the pressure of the air from said pneumatic reservoirs for shifting the connections between said liquid reservoirs and said motor, substantially as described.

8. The combination of the pneumatic reservoir 3, the liquid reservoirs 5 and 6, the pipes connecting said pneumatic reservoir with said liquid reservoirs, a valve mechanism adapted to alternately open and close communication between said pneumatic reservoir and each of said, liquid reservoirs, the piston 9 carried by the liquid in one of said liquid reservoirs, adapted by means of suitable connecting mechanism to actuate said valve mechanism, the motor A, having the inlet port 32 and the outlet port 34 and the automatically reversible connections between said ports and said liquid reservoirs, substantially as and for the purpose set forth.

9. The combination of the pneumatic reservoir, the liquid reservoir, the motor having the rotary pistons 8, 8 the inlet port 32 and the outlet port 34, the pipe 23 connecting with the pneumatic reservoir, and having branches 24 and 25, the cylinder 14 fitted with the double piston valve 18 and connected at a point between said valves with the pipe 25, upper and lower outlet pipes 46 and 27, and suitable exhaust ports, the piston actuated lever 10 connected to the stem of said piston valve and adapted to actuate the same, the cylinders 15, 16 and 17 fitted with a common valve spindle 19, double piston valves secured to said piston and arranged in said cylinder 15, and said cylinder 17, and a single piston upon said spindle arranged in said cylinder 16, said pipes 46 and 27 entering said cylinder 16 respectively at the bottom and top of the same by means of which compressed air is conveyed into said cylinder to actuate said piston, and said other valves connected to said common stem, pipes 28 and 29 connecting said cylinder 15 with the liquid reservoir respectively above and below the connection between said cylinder and said branch pipe 24 whereby as said piston valves are operated said pipes 28 and 29 are alternately brought in communication with the pipe 24, pipes 33 and 35 respectively connecting ports 32 and 34 with the cylinder 17, and pipes 30 and 31 respectively connecting said cylinder with the liquid reservoir in such manner that said double piston valve in its operation alternately connects said pipes 33 and 35 to each of the pipes 30 and 31, substantially as and for the purpose set forth.

10. The combination of a positively acting hydraulic motor, two combined gas and liquid tanks, a pipe connecting the lower portion of one tank with one side of said motor, and a second pipe connecting the lower portion of the other tank with the other side of said motor, whereby the liquid contained in one tank may be driven through the motor into the other tank, in a continuous column, together with an inlet for compressed gas in said tanks, valves controlling the flow of gas in said inlets and the flow of liquid in said pipes, connecting apparatus whereby said valves are operated simultaneously, a tightly fitting piston in one of said tanks which is driven in one direction by the liquid acting upon one side thereof and in the other direction by the gas acting upon the other side thereof, and a suitable connecting mechanism extending from said piston to the valve operating apparatus, substantially as described.

11. The combination of a combined gas and liquid tank, a tightly fitting piston in said tank, which forms a movable partition between the gas and the liquid, inlet and outlet passage ways for gas at one end of the tank, inlet and outlet passage ways for the liquid at the other end of the tank, valves which control the flow of gas and liquid in said passage ways, apparatus which simultaneously operates said valves, and connections from the above mentioned piston to said valve actuating apparatus, substantially as described.

In testimony whereof I have hereunto set my hand this 19th day of September, 1889.

WILLIAM COOPER.

In presence of—
A. M. GASKILL,
BESSIE BOOTH.