

HENRY WATERMAN.
Improvement in Propulsion of Vessels.
No. 119,255. Patented Sep. 26, 1871.

Figure 2.

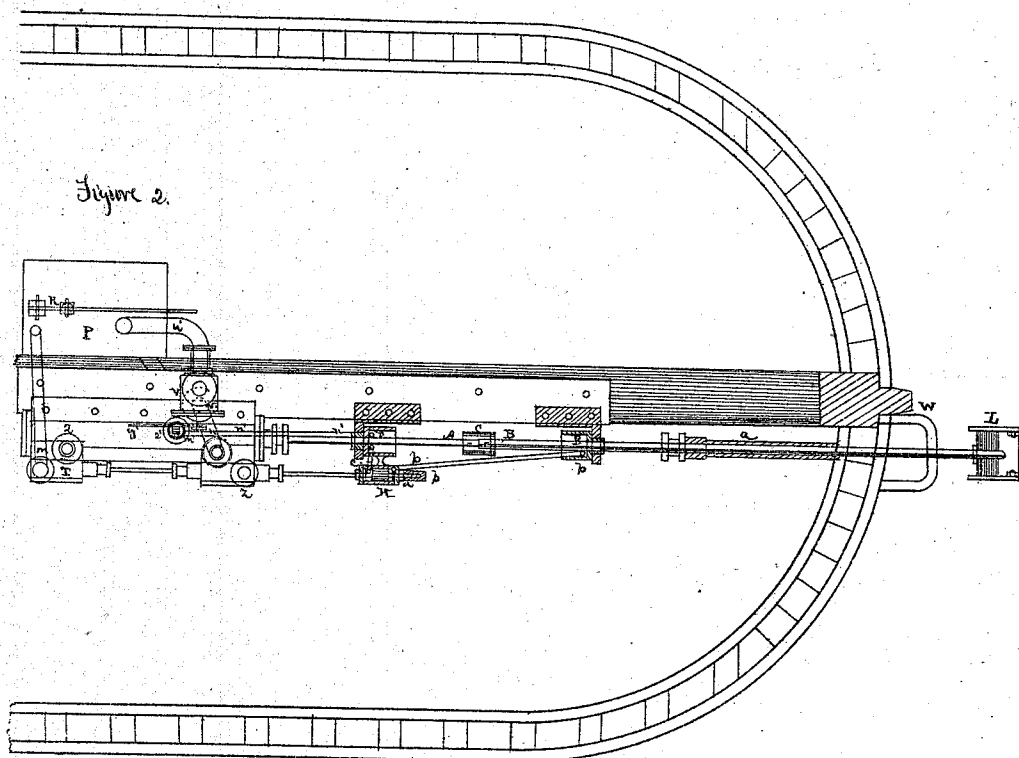
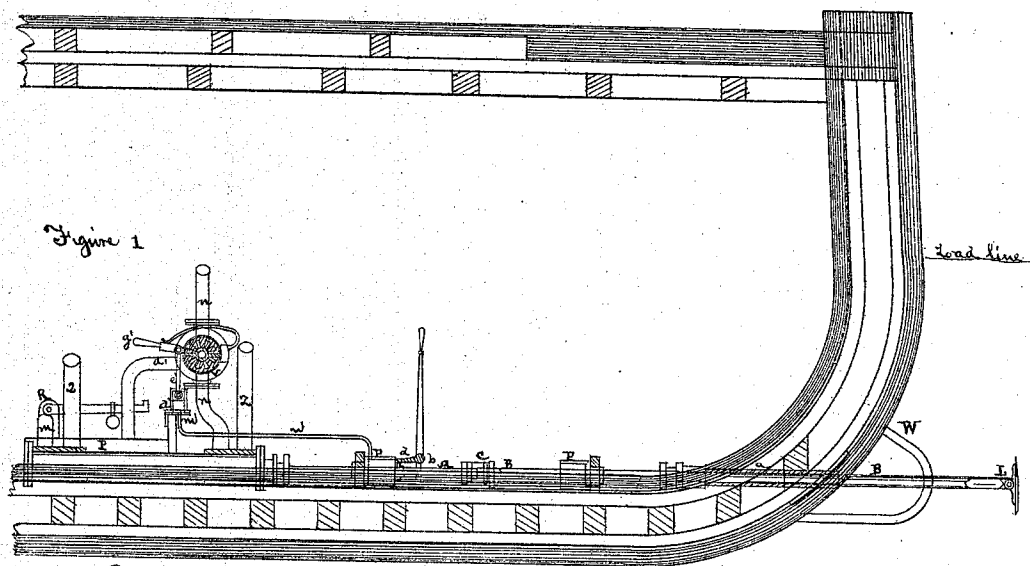


Figure 1



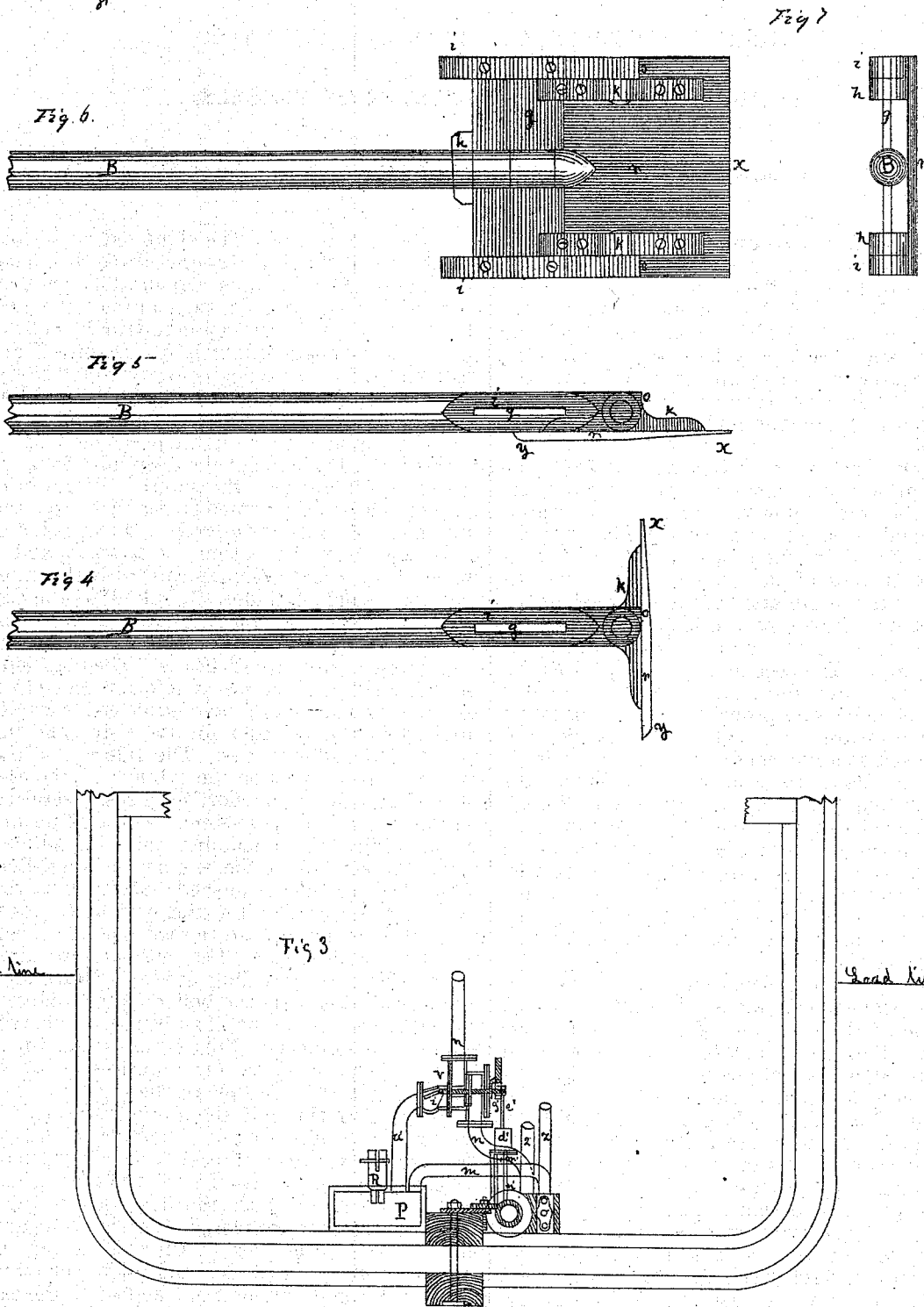
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HENRY WATERMAN. Improvement in Propulsion of Vessels.

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UNITED STATES PATENT OFFICE.

HENRY WATERMAN, OF BROOKLYN, NEW YORK.

IMPROVEMENT IN PROPULSION OF VESSELS.

Specification forming part of Letters Patent No. 119,255, dated September 26, 1871.

To all whom it may concern:

Be it known that I, HENRY WATERMAN, of the city of Brooklyn, in the county of Kings, in the State of New York, have invented certain Improvements in Propelling Steamboats; and I do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same, reference being had to the accompanying drawing making part of this specification.

The first part of my invention relates to the combination of a steam-engine with a plane surface, submerged below the surface of the water, for propelling steamboats, by coupling the piston-rod directly to the propeller-rod, and arresting the strokes of the piston and moving the valves at the termination of the strokes by compressed air; the object of this part of my invention being to save weight of machinery and space in the boat. The second part of my invention relates to the combination of a steam-engine with a chamber and propeller, and using steam of less pressure for the alternate strokes; and when used as a non-condensing engine, using a portion of the steam twice in the cylinder; the object of this part of my invention being to regulate the velocity and save fuel. The third part of my invention relates to the combination of the parts forming the propeller and its location in the boat; the object of this part of my invention being to utilize the resistance of a plane surface moving in the water as a means of propelling steamboats.

Figure 1 is a side elevation of the bow end of a steamboat embodying my invention. Fig. 2 is a plan of the same, and Fig. 3 is a transverse section. Fig. 4 is an enlarged side elevation of the plane in a vertical position. Fig. 5 is an enlarged side elevation of the plane in a horizontal position. Fig. 6 is an enlarged plan of the plane, and Fig. 7 is a transverse section. Fig. 8 is an enlarged transverse section of the plane rod.

The engine has excessively large steam and exhaust-ports, to permit a high velocity of piston, and has the ordinary slide-valves working in separate valve-chests at each end of the cylinder, without having communication with each other. I bolt it to the keelson of the boat as low down in the hold as is practicable, to secure as much depth of immersion to the plane surface as circumstances will allow. The piston-rod A (Figs 1 and 2) is coupled to the plane-rod B by

the sleeve-coupling C. The plane-rod passes out of the bow of the boat through a tube, *a*, having a stuffing-box on its inner end, in which packing is stuffed to prevent leakage around the rod. The tube is firmly fastened in the timbers of the boat, and is made water-tight. D and F are open-end cylinders or cups firmly bolted to the bed-plate of the engine centrally to the axial line of the cylinder. The piston-rod passes through D, and the plane-rod (I call the propeller a plane) through F. Each end of the coupling C is made the same diameter as the internal diameter of the cups, F being as much larger than D as the difference of areas of the rods. On one side of each cup, near the bottom, is a pipe, *b* and *c*, which lead to and communicate with the inner ends of a small cylinder, H, bolted to the cup D. The piston of this cylinder is fastened on the slide-valve stem of the engine, and the valve-stem passes through both heads. The inner side of each head has a rubber cushion attached to it to prevent hammering, and sufficient length is allowed in the cylinder for its piston and the travel of the slide-valves. The fulcrum of the starting-bar *d* is cast on the cylinder H, the end of the bar fitting into a mortised piece, *f*, screwed on the end of the valve-stem. For a better understanding of the remaining parts I shall now name the strokes of the engine and propeller. When the propeller is pushed outward from the bow of the boat I call it the outboard stroke, when it is pulled inward toward the bow I call it the inboard stroke. The outboard stroke is the alternate or retarding stroke. Steam-pipe *z* communicates with the boiler. Steam-pipe *m* communicates with the chamber P. Exhaust-pipe Q communicates directly with the atmosphere. Exhaust-pipe *n* communicates nearly all the time with the atmosphere, the steam to reach there passing through the three-way cock V; but, for a brief period of time, during the exhaustion of the steam of each inboard stroke, it communicates with chamber P, and is then not in communication with the atmosphere. The three-way cock is divided into three compartments. The lower part of the exhaust-pipe *n*, connected to the cylinder and cock, communicates with compartment No. 1 and with the exhaust-port of the inboard-stroke end of the cylinder of the engine. A continuation of the same exhaust-pipe is connected to the cock and communicates with compartment No. 2, and its up-

per end discharges into the atmosphere. (The pipe is cut in two and separated far enough apart to receive the cock.) The pipe *a'* connects to and communicates with the chamber *P* and compartment No. 3 of the cock by a branch-nozzle cast on it; and in the mouth of this nozzle is placed the hanging-valve *i'*. The cock has a small open-end cylinder, *d'*, attached to it, in which a piston works whose rod *e'* is pivoted to the lever or arm *g'*. A small pipe, *n'*, leading from near the bottom of the cup *D*, connects to the bottom of the open-end cylinder *d'* at *m'*. The arm *g'* is keyed on the movable plug or spindle of the cock, which in the drawing is represented as a disk perforated with radial openings or ports, one-half of which ports correspond with radial ports in the division-wall between the compartments Nos. 1 and 2, thereby opening communication between these compartments when the arm *g'* is not raised by the piston of the open-end cylinder *d'*. The spring resting upon the arm *g'* retains it in this position until it is overcome by the force acting upon the piston of the open-end cylinder. The other half of the radial ports in the disk correspond with radial ports in the division-wall between the compartments Nos. 1 and 3, thereby opening communication between them, when the arm *g'* is raised by the piston of the open cylinder. When the arm is raised by the piston and communication is opened between the last-mentioned compartments, the partial revolution of the disk closes the ports through the division-wall of compartments 1 and 2, and vice versa when the force acting upon the piston ceases; the spring then carries down the arm and closes the ports between the compartments Nos. 1 and 3, and opens them between Nos. 1 and 2. The disk is moved only sufficiently far each way to open and close the ports. The cock *V* may be made in any of the various forms of three-way cocks. Its use is to open and close communication with the exhaust-port of the inboard-stroke end of the cylinder and the chamber, or of the same port and the atmosphere, and of both. The use of the valve *i* is to retain the steam in the chamber while the cock is changing; for, while the disk is passing the ports in the division-walls of the compartments of the cock all the ports are open and communication is made between the chamber and the atmosphere, thereby allowing the steam in the chamber to escape. *R* is an ordinary safety-valve, of sufficient size to discharge the surplus steam, if any, delivered to the chamber. The use of the chamber is to form a receptacle to receive a portion of the exhaust-steam from the side of the piston upon which the steam acts to make the inboard stroke. From the chamber it is used on the other side of the piston to make the outboard stroke.

The use of the cushion-cups *D* and *F*, and coupling *C* entering them, (it then acting as a plunger-piston,) is to arrest the strokes of the main piston and move the slide-valves by the compressed air therein confined at the termination of the strokes; also, to use the compressed air in the cup *D* to open the three-way cock. On

the outer end of the rod *B* is attached the plane *L*, the rod being slotted for *g*, Figs. 4, 5, and 6, to pass through it. *g* is recessed on one edge to fit the diameter of the rod, and, after it is passed through the slot to the recess, it is locked fast and held in position by the key *h*. Male hinge-pieces *i i* are slotted to fit in each end of *g*, and are held in position by screws. The female hinge pieces *k k* are screwed or riveted to the face of the plate *r*, and it swings freely on the hinges one-quarter of a revolution, it being stopped in one direction by the plane-rod and in the other direction by the ends of the male hinge pieces at *o*. The line through the axis of the hinges intersecting the face of the plate is one-quarter of an inch nearer to the side *x* of the plate than to the side *y*, for the purpose of assisting in its quick change of position from the horizontal to the vertical, and vice versa, at the commencement of each stroke of the engine-piston, and to give a small preponderance of surface to the lower side of the plate when the plane is making the inboard stroke. The plate is made heavier from the center to the side *y* to cause the force of gravity to assist in the quick change of position, and the axial line of the hinges is placed the distance of one-half the diameter of the rod from the face of the plate for the same purpose. The plane-rod has a longitudinal groove, Fig. 8, commencing at the coupling end and running nearly the whole length, and feathers to fit it are inserted in the tube *a* at the bottom of the stuffing-box, in the gland of the stuffing-box, and in the bottom of cup *F*, to prevent the rod from turning on its axis. Fender-bars *W* are securely fastened to the bow of the boat, around the plane, and when it is stopped and drawn into the end of the inboard stroke it is secure from injury by collisions. In consequence of the diminished plane surface acting against the water when the outboard stroke is made the difference of pressure on the piston for the outboard and inboard strokes is as one to six, the outboard stroke requiring the less pressure. I am enabled thereby to exhaust a portion of the steam in the cylinder from the side of the piston which has performed the work of the inboard stroke into the chamber which has five-sixths less pressure, and use it from there in the same cylinder on the other side of the piston for the outboard stroke. A suitable boiler and steam force-pump being provided and attached to the engine the machinery is completed.

Steam being raised, it is admitted to the engine to warm up the cylinder and chamber, and a few strokes are slowly made, by working the slide-valves by hand with the starting-bar, to discharge the condensed steam out of the cylinder through cocks in the ordinary way; and to fill the chambers with steam the three-way cock is then held open to the chamber by blocking up the arm *g'* until sufficient pressure is attained to make the outboard stroke of the required velocity. All being now ready, a full head of steam is admitted and an inboard stroke of quick velocity is made, which is arrested at its terminating point by the air-cushion formed in

the cup D by the coupling C entering it, the coupling now acting, also, as a plunger-piston, to compress the air in the cup. The change of the slide-valve for the next stroke is made by the compressed air in the cup acting on the piston in cylinder H, through the communicating-pipe *c*, the compressed air in the cup D also acting on the piston in the small open-end cylinder attached to the cock V, through the small communicating-pipe *n'*, thereby opening communication between the exhaust-port of the inboard stroke and the chamber, and closing it between the same port and the atmosphere, as soon as the air pressure moves the piston. The air pressure in cup D will be sufficient to move the piston of the cylinder attached to the cock when the coupling C shall have passed into the cup about half way. When it has passed in to near the bottom of the cup the air pressure will be sufficient to move the slide-valves, which, when started, will be almost instantaneously moved the distance of their travel by the elastic fluid, and the exhaust steam of the inboard stroke will rush through the exhaust-port and three-way cock to the chamber until the steam pressure is equalized in the cylinder and chamber. The hanging-valve *v'* then closes and retains it. As soon as the outboard stroke has commenced and made sufficient distance to reduce the air-pressure in the cup D and the spring resting upon the arm *g'* is relieved, the elastic force contained in the spring carries the arm downward and closes the communication between the chamber and the exhaust-port and opens it between the atmosphere and the same port, and the remaining steam in the cylinder used for the inboard stroke passes out to the atmosphere through the cock and upper part of pipe *n*, while the outboard stroke is continued by the steam in the chamber. When the outboard stroke is nearly completed the coupling enters cup F and the air compressed in it arrests the stroke and changes the slide-valves by its pressure on the valve-piston communicated through the pipe *b* to the cylinder H, and the next inboard stroke is made from steam direct from the boiler. These inboard and outboard strokes are thus continued as long as steam is supplied to the engine. The momentum of the moving parts composing the piston and its rod, the coupling, and the plane rod and plane, will be more than sufficient to furnish the force required to compress the air in the cups for the purposes hereinbefore stated, even if the steam did not so do. The safety-valve R is weighted to retain only as much of the steam in the chamber and of the pressure required as will make the outboard strokes at the same velocity as is made by the inboard strokes, or to make them at less velocity, thereby regulating the speed of the engine. The surplus is discharged in the atmosphere through the valve. The economy resulting by using the steam twice in the cylinder (in the same cylinder) of the non-condensing engine than if steam was used direct from the boiler for both strokes in the usual way, is forty per centum less fuel, notwithstanding the steam used by the inboard strokes is exhausted against the pressure in the chamber. The very

large percentage saved is—in consequence of the low pressure required on the piston to make the outward strokes, causing the back pressure against these strokes, or against the piston during these strokes, (including the pressure of the atmosphere,)—to be about twice as much as the steam pressure above the pressure of the atmosphere is to do the work; and in consequence of this the amount of steam required for these strokes would be, if used direct from the boiler, two-fifths as much as is required for the inboard strokes, notwithstanding the piston-pressure, excluding the pressure of the atmosphere, is only one-sixth as much. The pressure of the atmosphere is a resistance that must be overcome before any useful effect can be produced by the steam. In the non-condensing engine it amounts to a large percentage of the work to be done, and the lower the steam is used on the piston the greater the loss.

Instead of using a separate chamber as a receptacle to receive the exhaust-steam of the inboard strokes I propose sometimes to enlarge the valve-chest T, Fig. 2, and use it instead of the chamber. The chamber or valve-chest should be of sufficient capacity to contain about five times the cubic contents of the cylinder. If the vacuum or condensing-engine is used with the plane propeller all the parts hereinbefore described are to be used for the same purposes, the only additions required being the condenser and air-pump driven by a separate engine; and both exhaust-pipes are to be connected to the condenser; but I prefer to use the non-condensing engine. The plane, having rapid motion given to it by the engine, acts upon the water as a means of resistance to pull along the boat at each stroke made in the direction of the stern. These are inboard strokes; those made in the opposite direction are retarding or outboard strokes. When the inboard strokes are made the face of the plane plate is perpendicular to the axis of the plane rod, Fig. 4, and presents a surface of about fifteen square inches for each horsepower required to move the boat, nearly all of which is at right angles with the rod for action against the water, the amount of resistance depending upon the velocity with which it moves. If it is moved thirty-two feet per second of time the resistance would be more than a thousand pounds for each square foot of surface. The perpendicular position of the plane plate is maintained during the stroke, first, by the distance of the axial line of the hinges from the face of the plate; second, by the preponderance of surface in action below the axial line of the rod; and, third, by the ends of the male hinge-pieces in contact with the face above the axial line of the rod. When the inboard stroke is completed, the lower half of the plate having nearly double the weight of the upper half, the force of gravity acts to bring the center of gravity of the mass swinging on the hinges to the perpendicular with the axis, thus commencing the change of position, completed by a few inches of movement of the outboard stroke, in consequence of the preponderance of surface below the axial line, the

distance of the axis of the hinges from the face, and the motion of the body through the water. The surface now acting against the water, Fig. 5, during the outboard stroke only equals eight percentum of that of the inboard stroke, for, although more than eight percentum of actual surface is presented, the form of it is not flat like plane surface, but is elliptical or hemispherical, and, in accordance with the laws of the motion of bodies through fluids, the resistances of these surfaces is less than half the resistance of plane surface. The resistances of the hemispherical surface, however, is about doubled, in consequence of moving against the virtual current of the water caused by the advance movement of the boat. The actual resistance, therefore, of this surface is sixteen percentum. On the completion of the outboard stroke the same circumstances have effect to change the face of the plate to the perpendicular position for the inboard stroke that do to change it to the horizontal position for the outboard stroke; and these changes are made as long as the strokes are continued. I work the plane from the bow of the boat because, first, the work done by the rod on the inboard stroke is in the direction of the cohesive strength of the metal composing it, lengthwise or by tension. It can, therefore, be much smaller in diameter than if the work was done by compression, as would be the case if the plane were worked from the stern, for then the diameter must be increased to prevent deflection or bending; second, being enabled to use a rod of smaller diameter, the weight will be considerably less, which will permit of greater velocity with the same power; and, third, more strokes can be made in the same time in consequence of less inertia and momentum, which, whatever they may be, must be overcome at the commencement and termination of the strokes.

This mode of propulsion being better adapted to freight-carrying boats, such as ocean steamers, canal-boats, and towing-boats than to ferry or passenger-boats making frequent landings, in consequence of the disadvantages under which backing them will arise, that probably it will not be used for them. Should it be found desirable, however, I propose to put in such boats another engine and propeller, the engine to be placed by the side of the other in reversed order, on the opposite side of the keelson, at an angle of about three degrees with it. The plane rod will run through a tube lying on the floor of the boat and pass out under the quarter near the stern. It will be enlarged at suitable points along it to receive rollers to carry the rod and reduce the friction of its movement in the tube.

The axis of the hinges or pivots may be placed in a vertical position, and the plane surface may be in one or more pieces and open and close for

the respective strokes solely by the motion of the body through the water combined with the distance of the axis of the hinges from the faces; or the axis of the hinges or pivots may lie in the horizontal position, and the plane surface may be in several pieces and open and close in a similar manner as shutter-blinds, the changes of position being caused by the distance of the axis of the hinges or pivots from the face, the force of gravity, and the motion of the body through the water combined; but I prefer to use the plane surface in one piece and place the axis of hinges horizontally.

The engine should be of as long a stroke as the circumstances in each case of application will permit.

I am aware that a chamber, or chambers and valve-chests, to receive the exhaust-steam from one cylinder to be used in another, or more cylinders for propelling more than one piston, have been used; I therefore disclaim them for such purpose. I am aware that plane surfaces have been applied for the propulsion of boats; I therefore disclaim them.

I claim as my invention—

1. The combination of the piston and plane rods with the coupling C and cups D and F, for arresting the strokes of the piston by compressed air, substantially as and for the purpose hereinbefore set forth.

2. The combination of the cylinder and piston and chamber with cock V and valve *v'*, located to receive and discharge the exhaust-steam from one side of the piston, substantially as and for the purpose hereinbefore set forth.

3. The combination of the pipes *b* and *c* with cylinder H and the pipe *n'* with cylinder *d'* for the purpose of moving the engine-valves and cock V by compressed air, substantially as and for the purpose hereinbefore set forth.

4. The combination of the valve R with the chamber for regulating the speed of the engine, substantially as and for the purpose hereinbefore set forth.

5. The combination of the rods A and B with a fixed support in the bow of the boat, for the purpose of using them of their minimum weight, substantially as and for the purpose hereinbefore set forth.

6. The combination of the plane-plate pivots nearer the side *x* than the side *y* with the shoulder on the ends of the male hinge-pieces *i i*, and the distance of the axis of the pivots from the face of the plate, substantially as and for the purpose hereinbefore set forth.

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