(No Model.)

6 Sheets—Sheet 1.

R. SMITH.

RECIPROCATING PROPELLER.

No. 264,903.

Patented Sept. 26, 1882.

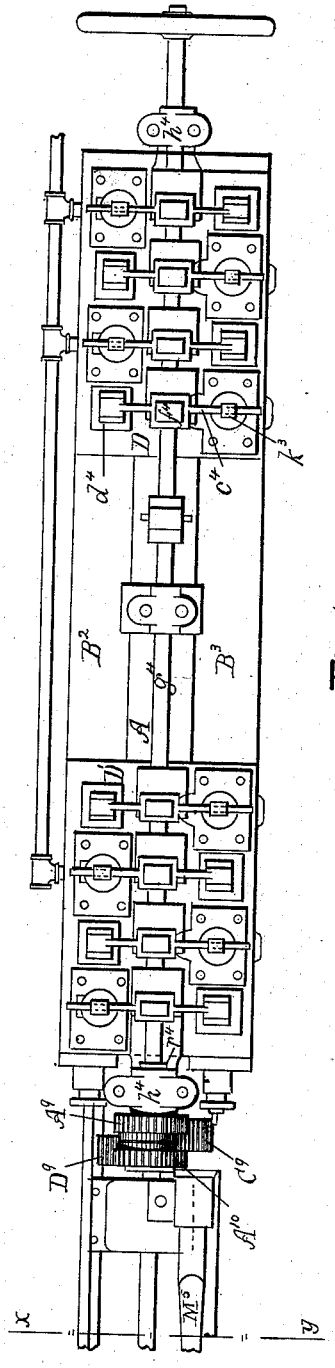

Fig. 1 in two parts.

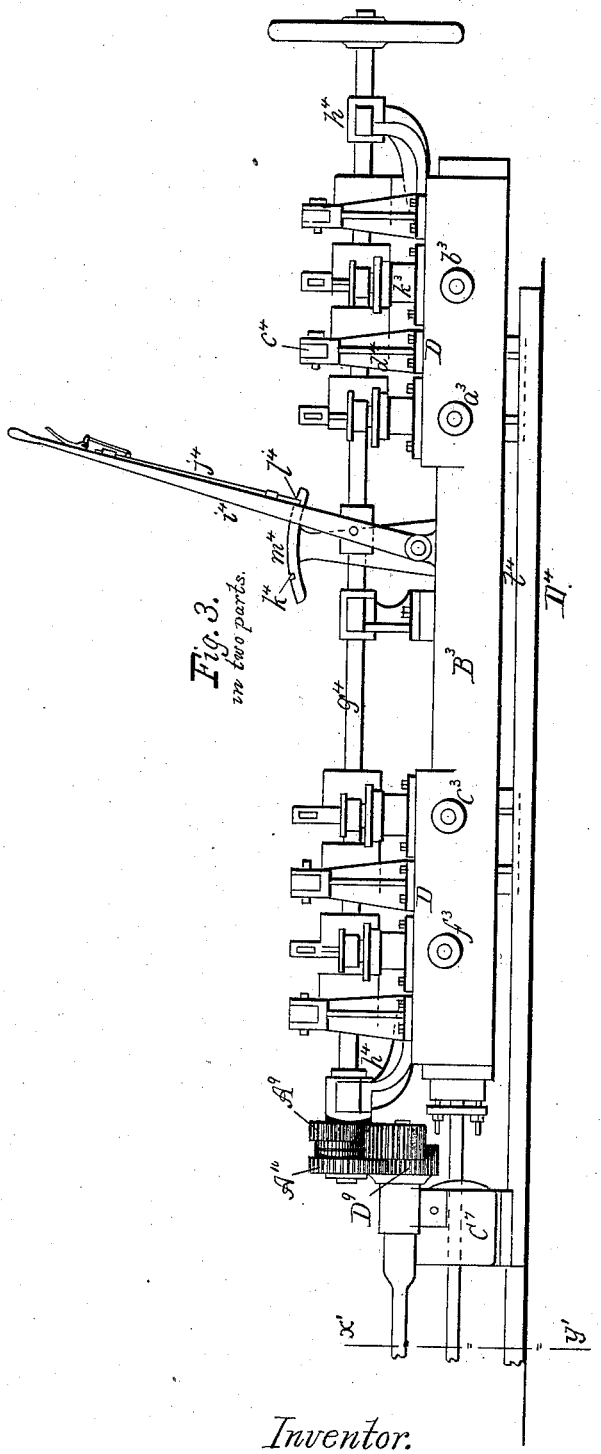

Fig. 3. in two parts.

Witnesses
H. C. Lodge.
F. D. Simpson.

Inventor.
Richard Smith.
F. Curtis, Atty.

N. PETERS. Photo-Lithographer, Washington, D. C.

(No Model.)

6 Sheets—Sheet 2.

R. SMITH.

RECIPROCATING PROPELLER.

No. 264,903. Patented Sept. 26, 1882.

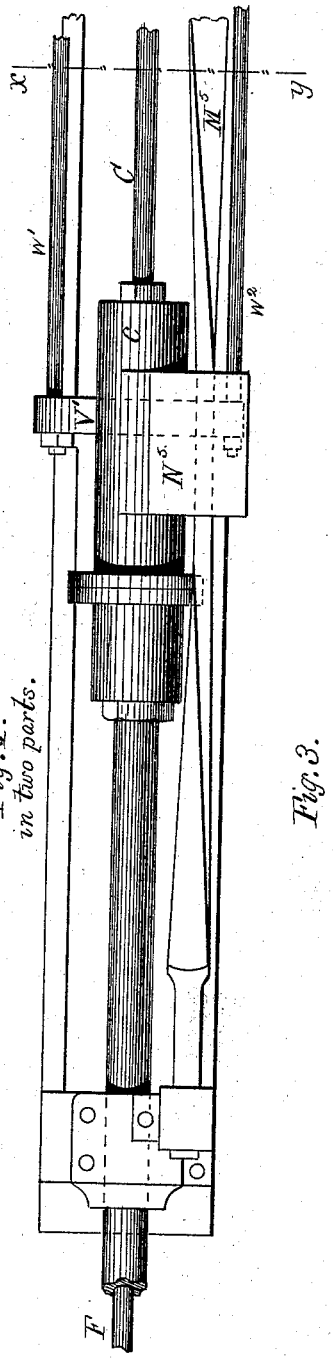

Fig. 1.
in two parts.

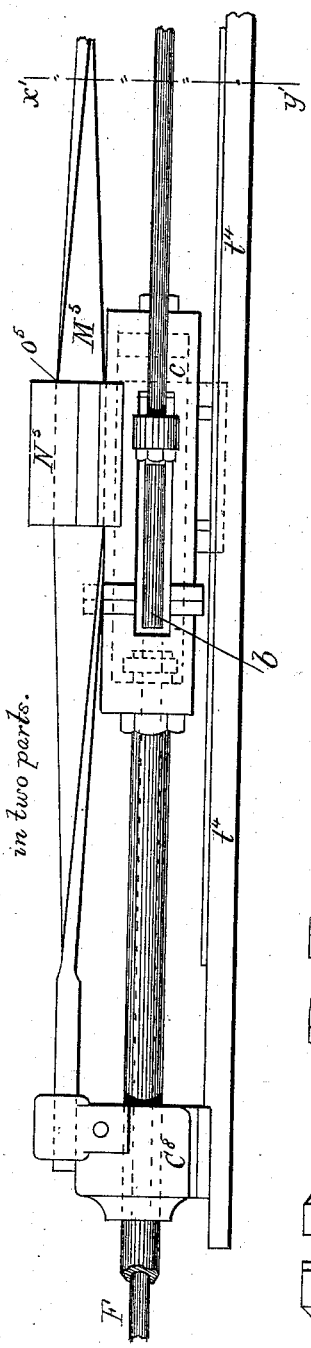

Fig. 3.
in two parts.

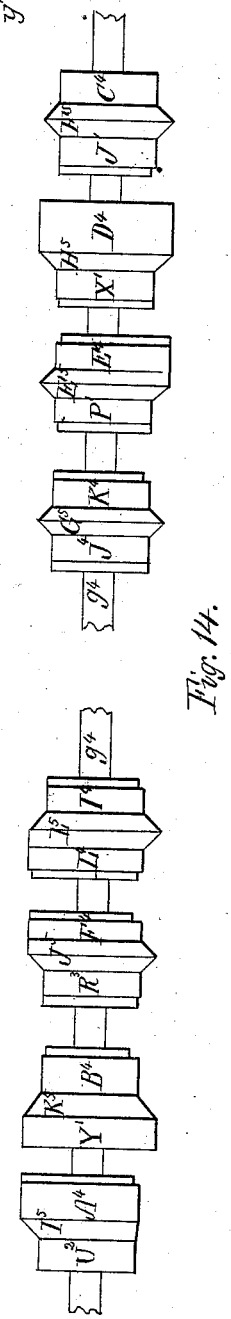

Fig. 14.

Witnesses.
H. E. Lodge.
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N. PETERS. Photo-Lithographer, Washington, D. C.

(No Model.)

6 Sheets—Sheet 3.

R. SMITH.

RECIPROCATING PROPELLER.

No. 264,903. Patented Sept. 26, 1882.

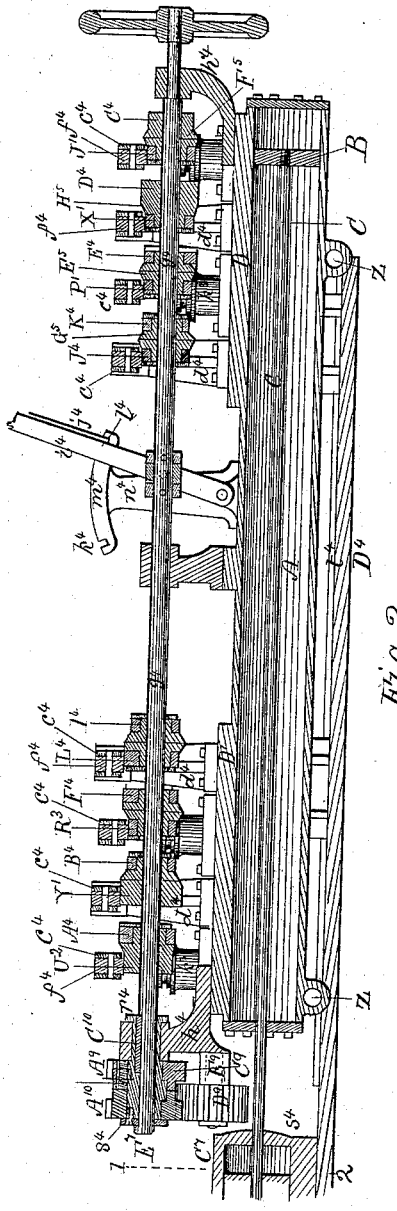


Fig. 2.
In two parts.

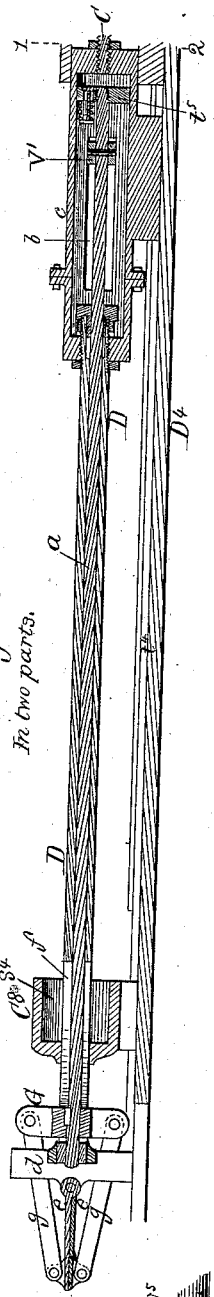


Fig. 13.

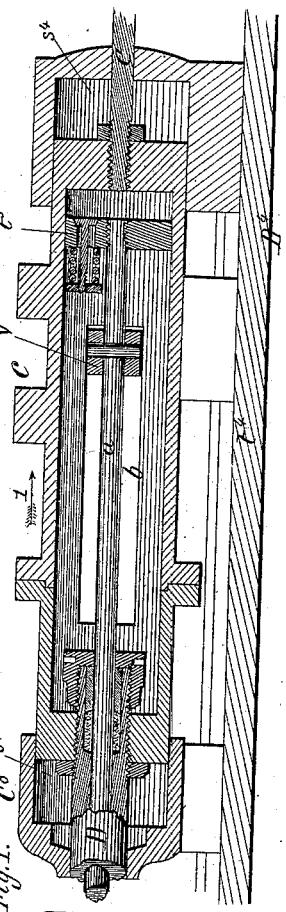


Fig. 18.
On line c.d. of Fig. 1.

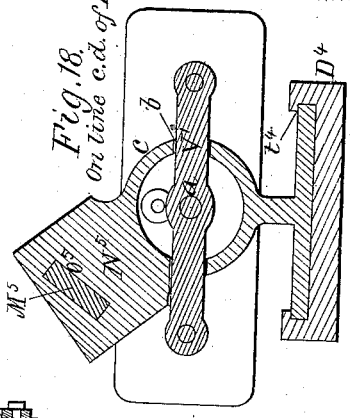


Fig. 14.

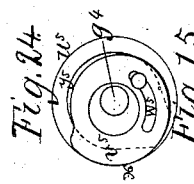


Fig. 15.

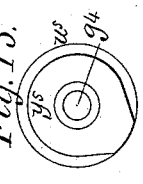
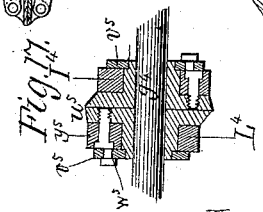


Fig. 17.



Witnesses.
H. E. Lodge
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J. Curtis. Atty.

N. PETERS. Photo-Lithographer. Washington, D. C.

(No Model.)

6 Sheets—Sheet 4.

R. SMITH.

RECIPROCATING PROPELLER.

No. 264,903. Patented Sept. 26, 1882.

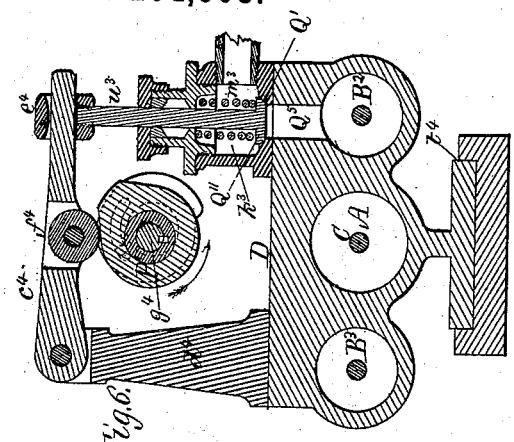

Fig. 6.

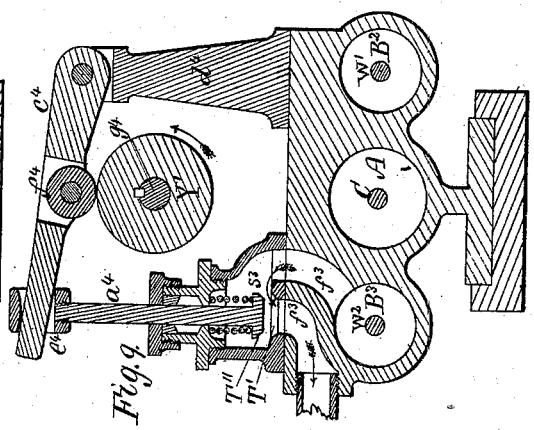

Fig. 9.

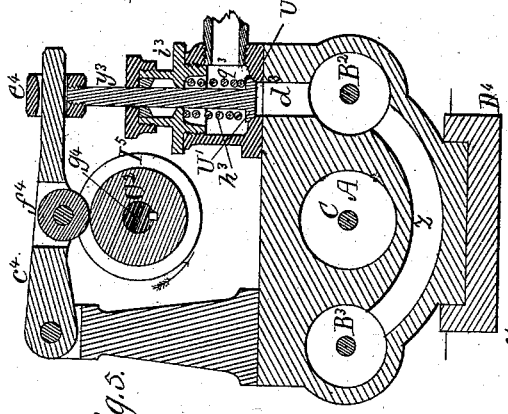

Fig. 5.

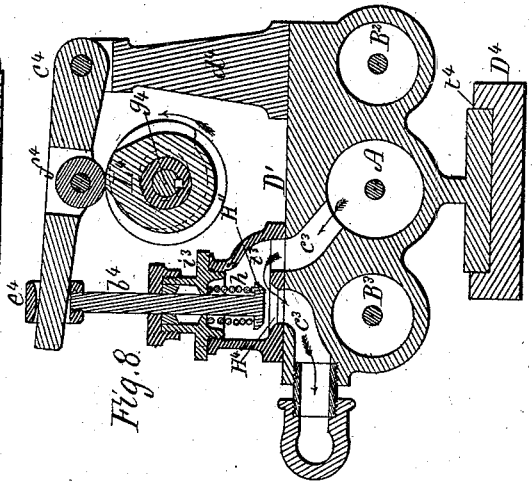

Fig. 8.

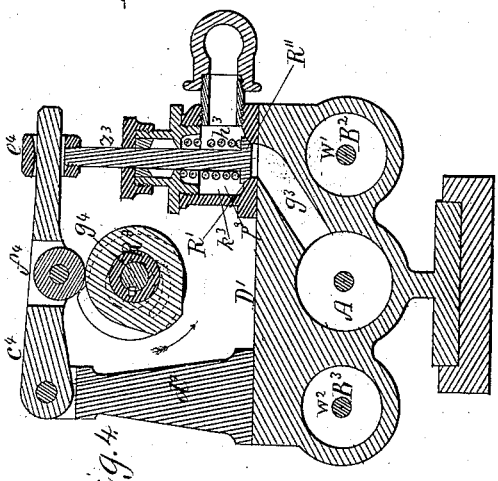

Fig. 4.

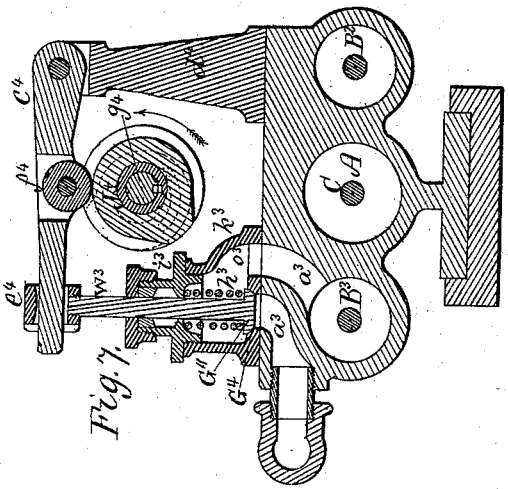

Fig. 7.

Witnesses.

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(No Model.)

6 Sheets—Sheet 5.

R. SMITH.

RECIPROCATING PROPELLER.

No. 264,903. Patented Sept. 26, 1882.

Fig. 12.

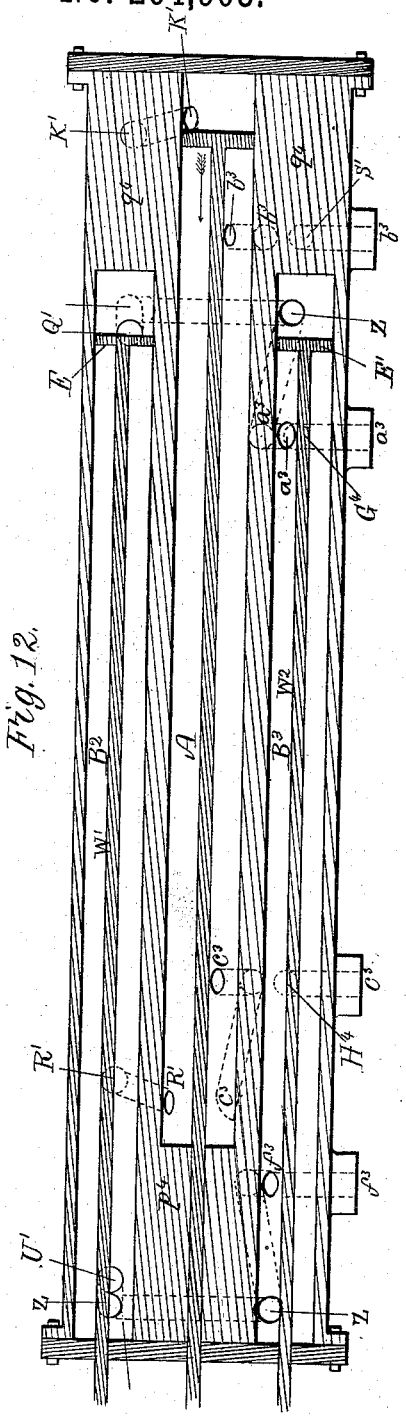


Fig. 16.

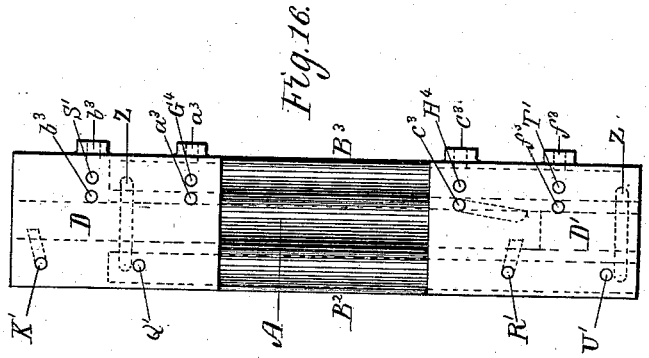


Fig. 11.

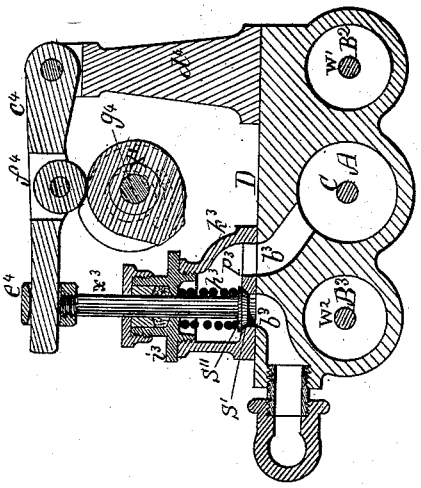
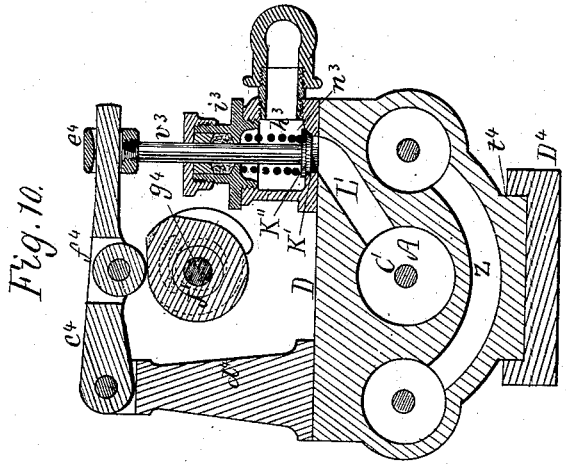


Fig. 10.



Witnesses.
H. E. Lodge
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N. PETERS. Photo-Lithographer. Washington, D. C.

(No Model.)

6 Sheets—Sheet 6.

R. SMITH.

RECIPROCATING PROPELLER.

No. 264,903.

Patented Sept. 26, 1882.

Fig. 21. on line c.d. of Fig. 20.

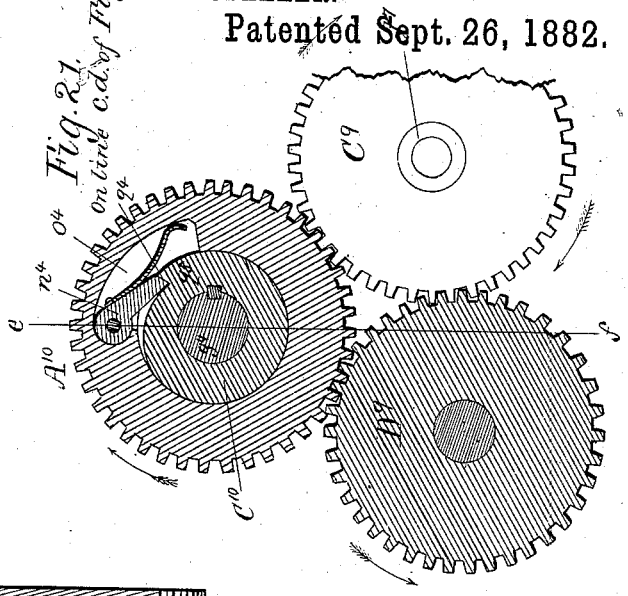


Fig. 20. on line e.f. of Fig. 21.

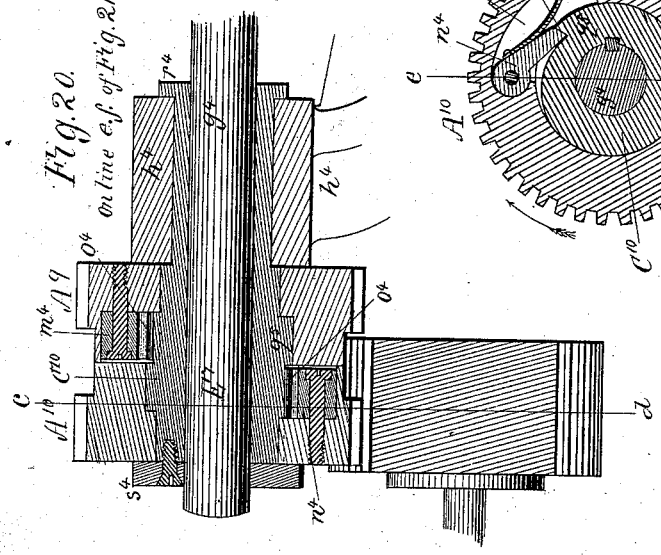


Fig. 22.

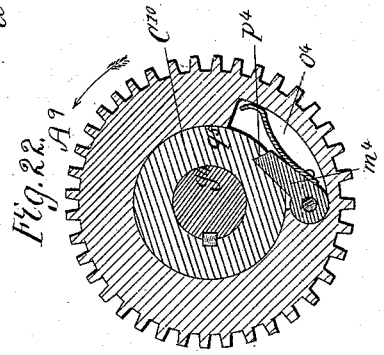


Fig. 19.

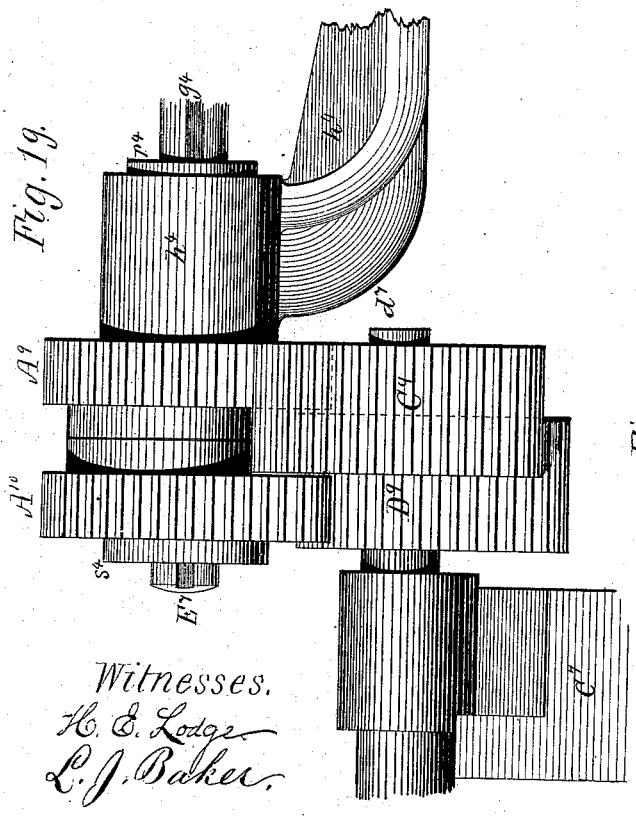
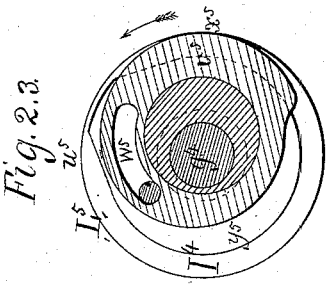


Fig. 23.



Witnesses.
H. E. Lodge.
L. J. Baker.

Inventor.
Richard Smith.
F. Curtis. Atty.

N. PETERS. Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

RICHARD SMITH, OF SHERBROOKE, QUEBEC, CANADA.

RECIPROCATING PROPELLER.

SPECIFICATION forming part of Letters Patent No. 264,903, dated September 26, 1882.

Application filed January 9, 1882. (No model.)

To all whom it may concern:

Be it known that I, RICHARD SMITH, a citizen of the Dominion of Canada, residing at Sherbrooke, in the county of Sherbrooke, Province of Quebec, Canada, have invented certain new and useful Improvements in Reciprocating Propellers; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the acompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

This invention is to be considered in the light of an improvement upon a class of propellers shown and described in Letters Patent of the United States issued to myself on the 7th day of June, 1881, in which one or more folding blades or vanes, expanding when driven in one direction, create resistance upon or to the water to propel the vessel, and folding on the return or retreat stroke to offer no resistance to the progress of the vessel, are hinged at their bases or pintles to the outer end of the propeller-shaft, which in turn is secured to the outer end of the piston-rod of a steam-cylinder, the edges of the blades or vanes being pivoted by suitable connecting-links to the end of the piston-rod of a second steam-cylinder independent of but co operating with the first.

In the pratical working of the propeller as above patented I have encountered several serious obstacles, which my present improvements are intended to correct. First, the action of the blades as they close upon the water in folding as the propeller completes its active stroke in driving the vessel forward tends to neutralize the legitimate functions of the propeller by exerting a resistance to the water in the wrong direction, thereby inducing a retarding motion or backward draft upon the vessel; second, the shocks or thrust upon the vessel and machinery from the "pounding" of the propeller—that is, the sudden resistance to the water on the starting of the propeller in its active stroke to drive the vessel ahead as its blades expand and bring up against their bearings. I obviate the objection first named by cutting off steam from the primary or main cylinder before the piston of the auxiliary cylinder reaches the end of its stroke, and admitting steam to the said side cylinder coincident with the completion of the stroke of the main piston and as the traverse of the propeller bodily ceases, by which means the blades are fully closed as the outgoing stroke terminates and offer no resistance to the water on the return-stroke. Therefore the final act of closing the blades becomes a means of aiding rather than retarding the propulsion of the vessel, as the tendency is to crowd the water rearward from before the blades, in lieu of drawing it forward into them, when the propeller is under rapid headway in its return-stroke. I obviate the second-named objection by first admitting live steam to the primary cylinder at the beginning of the active stroke (when propelling the vessel ahead) and advancing the cross-head to which the blades are pivoted until such blades are nearly open, and then admitting live steam to the side cylinder or cylinders, and exerting the full power of the combined cylinders to advance the propeller bodily and permit the resistance of the water to complete the unfolding of the blade or blades with an easy motion and allow the cross-head to gradually overtake the blades, thereby avoiding the shocks and thrusts incident to the sudden full opening of the blades against the cross-head.

My improvements further relate to means for converting the reciprocating rectilinear movements of the piston-rods into continuous rotary motion in one direction of the cam-shaft which operates the various valves of the engine, the same being a clutch-feed mechanism consisting of a horizontal rock-shaft composed of a spiral bar arranged in longitudinal alignment with the auxiliary cylinder (which is disposed to one side of the main cylinder) and rocked on its axis in alternately opposite directions to the extent of one-half a revolution in each direction by the traverses in right lines of a cross-head which surrounds the spiral bar or shaft and unites the propeller-shaft and main piston-rod, these intermittent semi-rotary movements of the rock-shaft being converted into continuous rotary movements of the cam-shaft by a series of gears and dogs, as hereinafter explained.

My improvements further relate to means for absorbing or greatly relieving the shocks

and thrusts to the vessel and machinery, which would otherwise naturally result from suddenly arresting the momentum and changing the direction of stroke of the propeller in the absence of a crank-motion, this feature in my improvements being accomplished by the employment of "dash-pots" between each end of the cross-head which connects the propeller-shaft and main piston-rod and the standards or bearings which support respectively the outer end of the frame and inner portion of the latter.

My improvements further relate to the peculiar or novel construction of the cylinders and their ports and valves, whereby steam is first admitted to the primary cylinder at the beginning of the active stroke of its piston in propelling the vessel ahead until the propeller-blades are nearly open, and then admitted to the side cylinders, whereby the latter operate with the first or main cylinder in advancing the propeller bodily and allowing the resistance of the water to gradually close its vanes, as before premised, and also whereby admission of steam to the main cylinder is cut off and its piston (during the active stroke of the latter in driving the vessel forward) brought to a stop before the propeller-blades begin to close, the auxiliary pistons advancing to close the blades, while the main piston remains idle.

My improvements further consist in a single cam-shaft rotating continuously in one direction and carrying a series of cams, and operating with the series of valves and valve-levers to actuate the entire series alternately when advancing or backing the vessel, the shaft being shugged endwise to one or the other of its extremes of position, according to the necessity for opening or closing the valves, to effect the advance or the backing of the vessel, as the case may be.

My improvements further consist in the novel construction of the cams for actuating the valve-levers, in which each cam is a plate independent of the hub which carries it, and is secured to the end of the hub in an adjustable manner, a sectoral plate, also secured adjustably to the hub, being employed, in order that the valves which govern the admission of live steam to the cylinders may be adapted to cut off such steam at any point in the traverse of a given piston, it being borne in mind by the reader that the live-steam ports are always live-steam ports, while the exhaust-ports are at all times exhaust-ports, and the two are not used alternately in common, as in ordinary steam-engines.

Minor details of my improvements will appear during the following description of the various parts of the apparatus.

The drawings accompanying this specification represent, in Figure 1, a plan, in Fig. 2 a vertical section, in Fig. 3 a side elevation, and in Figs. 4, 5, 6, 7, 8, 9, 10, and 11 cross-sections, of an engine and propeller containing my invention; and Fig. 12 is a horizontal section of the three cylinders of a steam-engine and propeller containing my improvements or invention. Fig. 13 in said drawings represents a vertical longitudinal section through one of the cross-heads of the propeller-shaft. Fig. 14 is a side view of the cam-shaft and its cams. Fig. 15 is a face view of one of the cams. Fig. 16 is a plan of the cylinders, showing the various valve-passages in dotted lines. Fig. 17 is a section of one of the cams. Fig. 18 is a vertical cross-section of the cross-head of the propeller-shaft. Fig. 19 is a side elevation. Figs. 20 and 21 are sections of the train of reversing-gears, to be explained. Fig. 22 is a section of one of said gears. Fig. 23 is a section of one of the cams and cut-offs. Fig. 24 is a side view of one of the cut-offs.

Reference being had to the above-named drawings, it will be seen that A represents a horizontal steam-cylinder, which constitutes the primary or main cylinder of the engine, and is provided with a piston, B, and piston rod C in the usual manner. No general steam-chest is employed in this engine, as in ordinary steam-engines; but the body of metal of which the cylinders are cast is reduced to a flat surface or table upon the top at each end, as shown at D or D′, and each valve is contained in a chamber in an independent boss erected upon the table.

B^2 B^3 in the drawings represent two lesser or auxiliary steam-cylinders, arranged parallel with and upon opposite sides of the main or center cylinder, A, the combined area or capacity of these auxiliary cylinders being preferably somewhat in excess of that of the said main cylinder, in order to obtain a preponderance of power over the latter for purposes hereinafter explained. The cylinders B^2 B^3 are virtually one, as they have free intercommunication by passages Z Z. (See Figs. 5, 10, and 12 of the drawings.) The pistons of the side cylinders are shown at E E′, respectively, and the rods of such pistons at W′ W^2. The piston-rod C of the main piston B plays within a guide or standard, C^7, erected upon the bed-plate D^7 of the engine, immediately in rear of the three cylinders, the outer end of this rod C being secured to the inner end of a horizontal tubular cylinder or cross-head, *c*, which is supported at bottom upon and slides to and fro of ways or guides t^4 upon the base-plate before named. The two auxiliary piston-rods W′ W^2 are connected at their outer ends to opposite ends of a horizontal bar or yoke, V′, which intercepts the cross-head *c* of the main rod C at right angles to the latter by passing through longitudinal slots *b b* in opposite walls of said head *c*, the length of these slots *b*, as in my patented propeller above alluded to, being such as to permit of the requisite play of the auxiliary piston-rods in opening or closing the vanes of the propeller.

From the yoke V′ the construction of the propeller itself is in this instance substantially the same as that shown in my patent alluded to; but to properly explain the operation of my present invention it will be essential to describe briefly the construction of the propeller, which is as follows:

To the outer end of the piston-rod C of the main or center cylinder, A, I secure, by the intermediate slotted head or hub, *c*, the inner end of a tubular shaft, D, which I term the "propeller-shaft," as it drives the expanded propeller rearward to forge the vessel ahead; and to the outer or rear end of the said shaft D, and at right angles to the axis, I secure a vertical cross head or bar, *d*, which is guided at top and bottom by and plays between parallel horizontal ways or guides, which constitute the upper and lower boundaries of a rectangular oblong opening in the dead-wood of the vessel, the outer or rear end of the shaft D being journaled in a standard, C^8, erected upon the bedplate D^4 of the engine, in manner similar to the standard C^7, before named.

To the center of the cross-head *d*, I pivot the adjacent inner edges or pintles of twin flat, thin blades or wings *e e*, which, combined, constitute the body of the folding propeller, these blades being preferably oblong rectangles in outline, and being of a length and width according to the nature and capacity of the vessel they are to drive.

In some modified forms of my propeller I employ but one piston and cylinder to open and close the blades and drive the propeller; but as shown in the present instance the piston-rod of the center cylinder and the propeller-shaft D are in axial alignment. Hence, in order that the side cylinders and their pistons may function to aid in operating the propeller, it becomes necessary to divert the rods of the said cylinders from the axes of the latter in order to operate upon the propeller through the tubular shaft D; and to this end I employ the transverse yoke or bar V′, before mentioned as connecting the outer ends of the two piston-rods W′ W^2. The yoke V′ is connected at its center to the inner end of a rod or shaft, *a*, contained within the propeller-shaft D, such yoke playing within the slot *b* of the cross-head *c* and operating to open and close the blades of the propeller through the medium of the shaft *a*.

To the outer end of the rod or shaft *a*, I secure at its center a vertical bar, G, and I create in opposite walls of the shaft D slots or openings *f f*, which together form a common passage to receive the head G and permit of play of such head by and with the said rod *a* and to and fro of the shaft D. To each extremity of the head or bar G, I pivot one end of one of twin links, *g g*, the opposite or inner ends of these links being pivoted respectively to the outer edges of the blades *e e* of the propeller.

Returning to the construction of the cylinders and their adjuncts, it will be seen that the inner table, D, has upon each side two ports, those upon one side being represented by Q′ and K′ and on the other by G^4 and S′, these ports being placed alternating or obliquely with respect to each other, in order that their respective operating-levers shall not interfere. The valves of the ports are ordinary drop check-valves, the valve of the port Q′ being shown by the letter Q″, of the port K′ by the letter K″, of the port G^4 by the letter G″, and of the port S′ by the letter S″. The ports K′ Q′ are always live-steam or inlet ports, while the ports G^4 S′ are always exhaust-ports. The ports K′ K′ communicate with the adjacent or inner end of the center cylinder, A, by a passage, L′. The port Q′ connects with the adjacent or inner end of the side cylinder B^2 by a vertical passage, Q^5, directly beneath it. The exhaust-port G^4 makes exit from the adjacent or inner end of the opposite side cylinder, B^3, by a direct passage, a^3, while the exhaust-port S′ makes exit from the adjacent or inner end of the center or main cylinder, A, by a passage, b^3, and is always full open while the vessel is backing. Upon the opposite or outer table, D′, the above arrangement of ports and valves is duplicated—that is, U′ and R′ represent live-steam or inlet ports upon one side of such chest, which are always inlet-ports, and T′ H^4 exhaust-ports upon the opposite side, which are always exhaust-ports. The valve of the port U′ is shown at U″, of the port R′ at R″, of the port T′ at T″, and of the port H^4 at H″. The port U′ communicates with the adjacent or outer end of the side cylinder B^2 by a vertical passage, d^3, directly beneath it. The port R′ communicates with the adjacent or outer end of the main or center cylinder, A, by a passage, g^3. The port T′ makes exit from the adjacent or outer end of the side cylinder B^3 by a passage, f^3, and the port H^4 makes exit from the adjacent or outer end of the center cylinder, A, by a passage, e^3. Each valve of the entire series is lowered (when permitted to do so by the recession of its actuating-cam) by a coiled spring, h^3, which encircles its stem and exerts its stress between the top of the valve and the under side of the cap-plate i^3, which constitutes a guide to the upper part of the stem of each valve and serves to close the top or mouth of a hollow boss, k^3, erected upon the table D or D′, the interior of this boss constituting an individual valve-chamber, and the various valve-chambers thus provided communicating respectively with the inlet and exhaust ports of the engine, as hereinafter explained.

In order to a clear understanding of the complex arrangement of the valves and adjuncts in this engine, I have shown the valve-chamber of the valve K″ at n^3 and its stem at v^3, of the valve Q″ at m^3 and its stem at w^3, of the valve G″ at o^3 and its stem at w^3, of the valve S″ at p^3 and its stem at x^3, of the valve U″ at q^3 and its stem at y^3, of the valve R″ at k^3 and its stem at z^3, of the valve T″ at s^3 and its stem at a^4, and of the valve H″ at t^3 and its stem at b^4. It is to be understood that these individual valve-chambers are to be supplied with steam from a common supply-pipe, as shown in Figs. 1, 4, and 6 of the drawings. As before stated, each valve is lowered and closed by the function of a spring, and to raise and open the various valves I proceed as follows: With each valve I employ a horizontal lever,

c^4, arranged transversely of the table D or D′ and pivoted at its base to the top of a post, d^4, erected upon said table to one side of the latter, these levers being arranged necessarily alternately in opposite directions, and the nose of each extending through an eye or guide, e^4, formed upon or secured to the top of each valve-stem. The center of each lever c^4 carries an anti-friction bowl, f^4, to bear upon the periphery of the cam below it. The various cams for operating the levers c^4 are of equal capacity, but differentially disposed, and are secured to a common horizontal shaft, g^4, located longitudinally and centrally over the main cylinder A, and mounted in bearings or brackets h^4, secured to the outer ends of said cylinder, continuous rotary motion in one direction being imparted to this shaft by means hereinafter explained, and it being journaled in its bearings in such manner as to be susceptible of short endwise movements or "shug."

To shug the shaft g^4, I employ an upright reversing-lever or shipper, (shown at i^4 in the drawings,) which is pivoted at its lower end to the top of the main cylinder A, and carries upon one side a sliding bolt, j^4, for locking it in position, the lower end of which bolt operates with two notches, k^4 l^4, created in the upper edge of a sectoral plate, m^4, secured to or forming the upper part of a vertical post, n^4, erected also upon the top of the cylinder A and alongside the lever i^4, a suitable hand-latch, o^4, being pivoted to the upper end or handle of the lever i^4, to control the movements of the bolt, after the manner of reversing-levers of locomotive-engines.

The series of cams for operating the valve-levers and valves when the vessel is to be propelled ahead are as follows: the cam for operating the valve G″ at J^4 and for operating the valve S″ at X′. The inlet-valve U is compelled to remain closed by its spring during the entire time the vessel is being propelled ahead, and to accomplish this I employ, in place of an active cam, a concentric circular disk or head, U^2, which I term a "dummy," since its action upon the valve-lever does not fluctuate, the diameter of this dummy being equal to or preferably slightly less than the smaller diameter of a cam, in order to have no effect in lifting a valve-lever. The cam for operating the valve R″ is shown at R^3. The valve T″ is compelled to remain full open against the stress of its spring during the time the vessel is driven ahead, and to effect this I employ, in place of an active cam, a concentric circular disk or dummy, Y′, the diameter of which is equal to or preferably slightly greater than the largest diameter or swell of a cam. The cam for operating the valve H″ is shown at L^4.

The cams that come into use when the shaft is shugged, preparatory to backing the vessel, are as follows, (see Figs. 2 and 14:) The cam for operating the valve Q″ is shown at E^4 as formed upon or secured to the opposite end of the hub E^5, which is common to it and the cam P′. The valve K″ is compelled to remain closed during the entire time of backing the vessel, and for this purpose no cam is employed to act upon its lever, but in place of the cam a dummy or concentric circular head or disk, C^4, is formed upon the opposite end of the hub F^5, which contains the cam J′, which dummy C^4, as its diameter is less than the smallest diameter of a cam, has no effect to raise the valve. The valve G″ is operated by a cam, K^4, secured to or formed upon the end of the hub G^5, which carries the cam J^4. The valve S″ is compelled to remain open during the time the vessel is being backed by the employment of a second dummy or concentric circular disk or head, D^4, formed upon or secured to the opposite end of the hub H^4, which contains the cam X′, the diameter of this dummy D^4 being equal to or somewhat greater than the largest diameter of a cam. The valve U″ is operated by the cam A^4, secured to or formed upon the hub I^5, which carries the dummy U^2, before explained. The valve R is operated by the cam F^4, secured to the opposite end of the hub J^5, which carries the cam R^3. The valve T″ is operated by the cam B^4, secured to the opposite or inner end of the hub K^5, which carries the large dummy Y′; and the valve H″ is operated by the cam I^4, formed upon or secured to the opposite or inner end of the hub L^5, which carries the cam L^4.

When the vessel is to be driven ahead the shaft g^4 and the cams carried by it stand in the relative positions shown in Figs 2, 4, 5, 6, 7, 8, 9, 10, and 11 of the drawings—that is, in their extreme inward positions—in which case the cams J′, X′, P′, J^4, L^4, and R^4 and the dummies Y′ U^2 are brought into action. When the vessel is to be backed the lever or shipper i^4 is to be reversed and the cam-shaft and its cams brought to their extreme outer positions, in which case the cams E^4, K^4, I^4, F^4, B^4, and A^4 and the dummies C^4 D^4 are brought into use.

The center cylinder and the side cylinders are of equal length, but are not arranged in the same plane longitudinally—that is, the center cylinder stands in advance of the side cylinders a distance equal to that necessary for either the center or side pistons to travel in order to open or close the vanes of the propeller, for the reason, as before stated, that the pistons of the side cylinders continue to advance in the act of closing the blades as the propeller completes its outgoing stroke (when the vessel is driven forward) after the piston of the center cylinder has completed its traverse, whereas in the act of backing the vessel the center piston continues on as the propeller completes its inward traverse to close the vanes after the pistons of the side cylinders have completed their strokes. I prefer, for convenience of construction and neatness and compactness in appearance, that the three cylinders shall outwardly present an appearance of equal length, and to this end I close up the outer or rear end of the main cylinder and the inner or front ends of the side cylinders, as shown at p^4 and q^4, respectively, (see Fig. 12;)

but these spaces between the outward boundary of the center cylinder and the inner boundaries of the side cylinders are of greater length than is necessary to permit of the continued movements of the piston named, in order to allow a cushion of live steam to be introduced between each piston as it completes its stroke and the respective head of its cylinder. My object in employing this cushion of steam is to aid in absorbing or lessening the strain and thrusts upon the engine incident to the arrest and reversal of the strokes of the pistons in the absence of a crank-motion.

To convert or transform the reciprocating movements of the pistons into continuous rotary motion in one direction of the cam-shaft g^4, I proceed as follows:

M^5 in the drawings denotes a narrow flat bar or shaft of uniform thickness and width and of a length fully equal to the extreme length of the stroke of the pistons, this bar, which is in effect a rock-shaft, being journaled at each end in the bearings or standards C^7 C^8, before alluded to, and being parallel with the three piston-rods and to one side of the center rod, C, this bar or shaft M^5 being given a twist of one-half a turn in its effective length.

Upon the top of the cross head *c*, I erect a block or head, N^5, which has a longitudinal horizontal passage, O^5, to receive securely the bar M^5; and it is obvious that, as the block N^5 follows the movements of the cross-head *c* during the reciprocations of the latter, it will impart alternating intermittent torsive or rocking motions to the bar M^5 upon its journals to the extent in each direction of a half-turn, or one hundred and eighty degrees of a circle. Moreover, to the inner end or journal, D^7, of the spiral rock-shaft M^5, I secure a spur-gear, C^9, and I inclose the adjacent end or journal E^7 of the cam-shaft g^4 in a sleeve or tubular shaft, C^{10}, which is secured to such shaft, and I mount loosely upon the outer end of this sleeve C^{10} two spur-gears, A^9 A^{10}, each of which operates upon or takes hold of the sleeve at times by a spring-impelled dog, m^4, or n^4 (see Figs. 20, 21, and 22,) pivoted at one end to the gear and contained in a pocket in the end of such gear, as shown at o^4, the nose of each dog taking into or operating with one of two notches, p^4 and q^4, in the periphery of the sleeve or a swell or hub, q^5, of said sleeve, these dogs taking hold of and acting upon the sleeves in the same direction through the gears carrying them advance intermittently in opposite directions. The dogs m^4 n^4 and the notches p^4 q^4 are arranged diametrically opposite each other, and each gear A^9 and A^{10} advances intermittently a half-revolution with each half-turn of the rock-shaft; and to effect these alternating semi-rotations in opposite directions of the said gears A^9 A^{10}, I proceed as follows: The teeth of the driver C^9 extend preferably, though not necessarily, entirely across its face. The gear A^9 engages and is driven by the said gear C^9; and in order that the inner adjacent ends of the gears A^9 A^{10} may stand closely together, I remove the teeth from the outer half of the gear A^9, and as it is essential that the gear A^{10} shall not engage the gear C^9, I also remove the teeth from the inner half of the said gear A^{10}, and I dispose the outer half of the latter to one side of the said gear C^9. Furthermore, the gear C^9 engages and drives an intermediate spur-gear, D^9, which is pivoted to a bearing, E^9, in rear of the said driver C^9, and this intermediate D^9 in turn engages and drives the gear A^{10}. The sleeve C^{10} has a flange or shoulder, r^4, upon its inner end, to bear against the adjacent end of the bearing or bracket h^4 of the center cylinder, while the outer gear, A^{10}, is prevented from slipping off the sleeve C^{10} by a screw passing through a washer, s^4, overlapping its outer end and screwing into the end of the said sleeve. The gear A^9 is retained in place by the bearing h^4 upon one side and the end of the swell q^5 of the sleeve C^{10} upon the other. With each traverse of the cross-head *c* inward, as shown by its arrow 1, (see Fig. 13,) the reader being supposed to face the outer ends of the propeller, the rock-shaft M^5 is rocked to the extent of one-half turn to the left, which necessarily rotates the gear C^9 to the left an equal distance, or half-turn, and this semi-rotation of the gear C^9 rotates the gear A^9 to the right also a half-turn. As the gear A^9 thus describes a semi-rotation its dog m^4 takes hold upon the sleeve C^{10} and rotates the latter also a half-turn to the right, and this imparts a semi-rotation in the same direction to the cam-shaft. As the gear A^9 advances and rotates the cam-shaft, as last stated, the gear A^{10}, by reason of the intermediate D^9, is driven a half-turn in the opposite direction, or to the left, and its dog slips over the periphery of the sleeve C^{10} without effect upon the latter—that is to say, the gear A^{10} and its dog retreat in readiness to act in their turn upon the sleeve to advance the cam-shaft a half-revolution upon the return or outgoing traverse of the cross-head *c*. As the cross-head *c* returns—that is, executes its outgoing stroke—the gear A^9 is idle, and the gear A^{10} is active; in other words, the rock-shaft is rocked or rotated a half-turn to the right, the gear C^9 a half-turn in the same direction, and the gear A^{10}, by means of the intermediate D^9, is rotated a half-turn to the right, and its dog n^4 takes hold upon the sleeve C^{10} and advances the latter and the cam-shaft a half-turn to the right, or in the same direction as driven by the gear A^9 at first, the said gear A^9 during the active advance of the gear A^{10}, as last stated, returning or retreating to the left, in readiness to again take hold of the sleeve upon the ingoing of the cross-head. The alternating semi-rotations of the gears A^9 A^{10} and their dogs thus become continuous, and the cam-shaft is rotated continuously in one direction so long as the cross-head *c* reciprocates. The cross-head *c*, spiral rock-shaft M^5, gears C^9, A^9, A^{10}, and D^9, and dogs m^4 n^4 constitute, in effect, a simple and effective

double-treadle motion, whereby the reciprocations of the pistons of the engine are converted into continuous rotations of the cam-shaft.

To absorb or relieve to some extent the shocks and thrusts consequent upon the arrest of the momentum and the reversal of the stroke of the pistons, in the absence of a crank-motion, I employ "dash-pots" of ordinary construction, which I provide in the present instance by creating a pocket, s^4, in each standard C^7 C^8 and adapting the ends of the cross-head *c* to enter and fill these pockets with an air-tight joint. The dash-pots operate as with such devices in general. As the end of the cross-head completes its traverse in one or the other direction and enters the pocket the air in the latter is compressed with greater or less power, according to the distance the cross-head penetrates, and offers a resistance to the cross-head, thereby cushioning the cross-head and absorbing to a great extent the shock and concussion which would otherwise ensue upon its arrest and reversal. For similar reasons, I add a dash-pot to the interior of the cross-head *c* by adding to the inner end of the shaft *a* a plunger, t^5, adapted to closely fill the outer end of the said cross-head. This dash-pot aids to absorb or relieve the thrust consequent upon the resistance of the water to the propeller, as the propeller executes its outgoing traverse and its blades unfold.

The operation of this engine and propeller is as follows, premising the description by the statement that the pistons and the valves and their operative cams are in the relative positions shown in the drawings, with the exception of valve K″, which is shown as closed, but is to be open, and the intention being to propel the vessel ahead: Both the main piston and auxiliary pistons are at their extreme positions at the inner or front ends of their respective cylinders, as shown in Fig. 2 of the drawings. The inlet-valve K″ is to be open by the shortest side or diameter of its cam J′ being uppermost and permitting the spring of said valve to hold it closed upon its seat. The valve Q″ is closed, and soon to open, as the shortest of its cams, P′, is uppermost. Valve S″ is closed as the shortest diameter of its cam X′ is uppermost, the valve U″ being permanently closed while the vessel is driving ahead by its dummy u^2. The exhaust-valve T″ is held permanently open while driving ahead by its dummy Y′. The valve R″ is closed by the smallest side of its cam R^3 coming uppermost. The exhaust-valve H″ is open by the superior side of its cam L^4, and, finally, the exhaust-valve G^4 is closed by the smallest side of its cam J^4. The propeller is closed and necessarily stands at its extreme inner position. Steam, being let on, enters the inner end of the main cylinder A through the passage L′ and starts the piston B of this cylinder outward, or in the direction of its arrow 1, at same time putting the cam-shaft in rotation until the blades of the propeller are nearly open, at which point the said piston B arrives opposite the pistons E E′ of the side cylinders, B^2 B^3, (though this exact relation of these is not important,) and the cam P′ presents its longest diameter uppermost and opens the inlet-valve Q″, and live steam is admitted to the adjacent or inner ends of the side cylinders through the passage Q^5, and the three pistons traverse their respective cylinders in company until the end of the outward traverse of the center piston is about reached, when the inlet-valve K″ closes by the smallest side of its cam J′ and the inlet-valve R″ is opened by the superior side of its cam R^3, and live steam is admitted to the outer end of the center cylinder, A, in advance of its piston B to cushion the latter. The valve K″ remains closed until the pistons E E′ complete their strokes and the blades of the propeller are fully closed, (owing to the momentum of the propeller and its adjuncts and the superior area of the two side pistons which together operate to overcome the pressure of live steam upon the center piston admitted through the port R′, just opened,) it being understood that during this outward traverse of the propeller the completion of the opening of its blades has been effected gradually and quietly by the resistance of the water, without shock or strain to the vessel or machinery, and by the dash-pot in the cross-head *c;* and it being also understood that while the pistons are executing these traverses in company the center cylinder is exhausting from the port H^4 by way of its passage g^3, and the side cylinders from the port T′ by way of the passage f^3 from the cylinder B^3.

Simultaneous with the completion of the traverses of the side pistons last explained and the opening of the valve R″ the exhaust-valve S″ of the center cylinder opens (by the longest side of its cam X′ acting upon and raising the lever of such valve S″) in readiness to permit of exit of exhaust-steam from this end of said center cylinder by way of the passage b^3. The valve Q″ closes by the lesser side of its cam P′ simultaneously with the opening of the exhaust-valve S″ and the inlet-valve E″, while with the closing of the valve Q″ the exhaust-valve G^4 opens by the superior side of its cam J^4 acting upon its lever. The propeller now stands at its outward extreme with its blades closed. The propeller now returns in its folded state as follows: The main piston B moves inward by steam admitted to the outer end of the center cylinder by the port R″, opened as last explained, (the valve U″, as stated, remaining permanently closed and the tendency to a vacuum in the side cylinders being relieved by the exhaust-port T′ of the cylinder B^3, which, as stated, is also permanently open, while the vessel is being propelled ahead,) and completes its stroke, carrying with it in the same direction, by means of the yoke V′, the side pistons and their rods, such pistons being passive for the reason that the valve U″ is closed, as stated, for the purpose of preventing premature opening of the propeller and the tendency to a vacuum in the side cylinders being relieved by the open ex-

haust-port T′ of the cylinder B^3. As the three pistons complete their strokes in company, the center cylinder exhausts by way of its passage b^3 and port S′, and we are brought to our starting-point. Now, to back the vessel, supposing the ports, valves, and cams to be in the positions first assumed, and as shown in Fig. 12 of the drawings, the engineer seizes the reversing lever or shipper i^4 and reverses its position and shugs the cam-shaft g^4, thereby throwing the cams J′, X′, P′, J^4, I^4, and R^3, and dummies Y′ and U^2 out of action, and bringing into action the opposite cams, E^4, K^4, I^4, F^4, B^4, and A^4, and dummies C^4 and D^4, the dummies Y′ and U^2 being replaced by the cams A^4 B^4 and the cams J′ X′ by the dummies C^4 D^4, while the cams R^3 P′ are replaced by the cams E^4 F^4, and the cam J^4 by the cam K^4, and the cam L^4 by the cam I^4. In this change of cams the valves stand in the following positions: The valve K″ is closed by its dummy C^4, and remains closed while the vessel is backed. The valve Q″ is closed as before. The valve S″ is held full open, and remains open while backing by the dummy D^4. The valve U″ is closed by the smaller side of its cam A^4 being uppermost. The valve G″ is closed by the lesser side of its cam K^4 coming uppermost. The exhaust-valve T″ opens by the longest side of its cam B^4 being uppermost. The valve H″ opens by the superior side of its cam I^4 being uppermost. The live-valve R″ is closed by the shortest side of its cam F^4 being uppermost. The steam being let on or already on, the inlet-valve Q″ opens by the largest side of its cam E^4 coming uppermost, and steam is admitted to the inner ends of the side cylinders by the port Q′ and passage Q^5, (it being remembered that these two cylinders are in free communication,) and impels the pistons E E′ outward, carrying with them by means of the yoke V′ the center piston, B, which is at this time idle, owing to the fact that its valve K″, as before stated, is closed by its dummy C^4, and remains thus closed while the vessel is backing to prevent premature opening of the blade of the propeller, the tendency to a vacuum in the cylinder A being relieved by the exhaust-port S′, which, as before stated, remains open by its dummy D^4 during the time the vessel is backing. The pistons B and E E′ travel together, as stated, until they reach the extreme of their outward traverse, the side cylinders meanwhile exhausting from the cylinder B^3 through its passage f^3 and port T′, when the inlet-valve Q″ closes by the recession of its cam E^4 and cuts off steam to the side cylinders, while simultaneous therewith the valve U″ opens by the superior side of its cam A^4 to admit steam to the side cylinders through the port U′ and passage d^3. The exhaust-port G^4 also opens by the superior side of its cam K^4, and the exhaust-valve T″ closes by the receding of its cam B^4, and the side pistons begin and continue their return or inward active stroke for a short distance until the propeller-blades are full open, when the yoke V′ takes d of the cross-head c and the inlet R″ is opened by the superior side of its cam F^4, and the exhaust-valve H″ closes by the receding of its cam I^4, and the three pistons move inward in concert, carrying with them the open propeller, until the side pistons reach the extremes of their strokes in this direction, (the side cylinders meanwhile exhausting from the cylinder B^3 through their common passage, a^3, and port G^4,) when the inlet-valve U″ closes by the receding of its cam A^4 and steam is cut off from this end of the side cylinders, and simultaneous therewith the exhaust-valve T″ opens by the ascent of the longest side of its cam B^4 and the valve Q″ opens by the ascent of the superior side of its cam E^4, and steam is admitted to the inner ends of the side cylinders.

Each cam of the series is of like form and construction, and is constituted as follows, (see Figs. 15, 16, 17, and 23:) A circular hub, w^5, is employed, which is secured to the shaft g^4 by a set-screw or otherwise, in order that it may be changed in position axially upon such shaft, if necessary; and the said hub is preferably formed in halves, in order that the position of one cam may be changed upon the hub with respect to the cam upon the opposite end. One of the cams, as an illustration, is shown at y^5 in the drawings as a flat plate having a circular concentric opening to inclose a shoulder upon the hub, and is to be secured to the hub by a set-screw or otherwise. Moreover, with each cam I employ a cut off, which is a thin, flat plate, v^5, inclosing an eccentric shoulder upon the end of the hub, and adjustable upon such shoulder with respect to the cam, a set-screw passing through a slot, w^5, in such cut-off, and screwing into the end of the hub, serving to hold the cut-off rigidly to the hub when its position upon the latter is determined. The cut-off v^5 is segmental in form, and its longest diameter or portion x^5, which is immediately in rear of the swell of the cam, serves to hold open a valve the requisite length of time. By changing the position of the cut-off with respect to the cam the admission of steam to the cylinders is cut off at any desired point in the strokes of the pistons.

By the employment of two auxiliary cylinders and pistons operating upon each side the main cylinder and connecting the rods of said cylinders by a yoke secured to the shaft which operates the edges of the propeller-blades, as stated, I am enabled to exert the power of the auxiliary piston equally upon opposite sides of the propeller-shaft, thereby obviating one objection found in my patented propeller before named—that is, the one-sided or unequal direction of the effort of the engine when transmitting power through the medium of such side cylinders to open the propeller-blades at the beginning of the active stroke when backing the vessel, when but one side or auxiliary cylinder is employed. It is for this reason I employ two auxiliary cylinders, situated upon opposite sides of the main cylinder; but these two cylinders are in effect one, as they

have free intercommunication, and one of them could be omitted and the whole apparatus would be operative, the only change necessary being to group all the ports in one cylinder. The employment of two auxiliary cylinders carries the entire device to a point of extreme perfection; but since one alone may be employed without invalidating the operation of the propeller I do not restrict myself to the arbitrary use of two. So, also, with regard to the blades of the propeller, I have described a pair; but it is evident that one alone may be employed without calling in the skill of an experienced mechanic to make the change. In fact, in practice I shall probably use but one blade and employ a pair of propellers reciprocating alternately.

Owing to the absence of the dead-point of a crank-motion or other indirect connection between the cylinders and propeller, the pressure of steam upon the latter is in my system constant and uniform. Hence when the momentum of the vessel is augmented during the active stroke of the propeller the momentum or speed of the latter increases in proportion with that of the vessel, and therefore exerts a uniform power during its entire stroke.

By bringing the combined power of the three cylinders into action to drive the propeller in its active stroke and but a portion of them on the return or idle stroke, I economize steam and avoid much of the shock resulting from the overcoming of the inertia in reversing the stroke of the propeller.

An obvious modification of the details of my mechanism, involving no invention, would be to connect the piston-rod of the main cylinder with the edges of the vanes and the rods of the side cylinders with the bases or hinge of such vanes.

I claim—

1. In combination with a folding propeller blade or blades, a cylinder-piston and piston-rod operating on the hinge of the blade or blades, an auxiliary cylinder-piston and piston-rod, or more than one, acting on the outer part of the blade or blades, and valves and mechanism whereby the motion of the piston-rod attached to the hinge of the blade or blades is caused to stop before that of the rod or rods attached to the outer part of each blade, in order that the blade or blades may be fully closed before the return-stroke begins.

2. In combination with a folding propeller blade or blades, a cylinder-piston and piston-rod operating on the hinge of the blade or blades, an auxiliary cylinder-piston and piston-rod, or more than one, acting on the outer part of each blade, and valves and mechanism whereby the rod attached to the hinge is first caused to advance to partly open the propeller blade or blades, and then both the rods or all the rods are caused to advance together, in order that the opening of said blade or blades may be effected gently by the pressure of the water and the shock of sudden forcible opening avoided, substantially as set forth.

3. The combination, with a propeller composed of one or more folding vanes, operated by a main and one or more auxiliary steam-cylinders, pistons, and valves to expand on the active stroke and close on the return, and the various ports and valves of said cylinders, of two sets of cams and passive hubs for controlling the positions of the valves, these cams and hubs being carried by a common rotary shaft susceptible of end shug, and one set of cams and hubs being brought into use when the vessel is driven ahead and the other when the vessel is backed.

4. In propellers for navigable vessels, composed of one or more folding vanes adapted to expand on the active stroke and close on the return, and operated in these movements by two steam-cylinders and pistons, the rod of one of which is connected with the outer edge of the vane and the other with the hinge of such vane, substantially as explained, and the arrangement of the various ports and valves of the conjoint cylinders, substantially as specified and shown, whereby live steam is admitted to the inner ends of the auxiliary cylinders in front of their pistons to cushion the latter as they reverse their motion.

5. In propellers for navigable vessels, composed of one or more folding blades expanding on the active stroke and folding on the return, and operated in these movements by main and auxiliary steam-cylinders, pistons, and rods, the combination, with the various valves and ports of the cylinders, and operating such valves, of two series of cams secured to a single shaft which has provisions for end shug, one set of such cams actuating the valves to drive the vessel ahead and the other to back the vessel, and both actuated by a suitable hand-lever which controls the endwise adjustment or shug of the shaft.

6. In reciprocating propellers for navigable vessels, main and auxiliary cylinders, (one main and one or two auxiliary,) and pistons and rods, in combination with the propeller-blades hinged at their inner edges, the piston-rod of the main cylinder being connected with the hinge of the blades and the rods of the auxiliary pistons being secured to opposite ends of a yoke which intersects the main piston-rod and is connected with the rod which actuates the outer edges of the blades.

7. The combination, with a propeller composed of one or more folding blades or vanes adapted to expand on the active stroke and fold on the return, of two steam-cylinders with their pistons and rods, and arranged upon opposite sides of the first, the piston-rod of one cylinder being connected in direct line with the propeller-shaft and the other with the shaft which actuates the vanes by an intermediate or bar, which intercepts the piston-rod of the first in such manner that the combined power of the two auxiliary pistons is exerted equally upon opposite sides of the latter-named shaft.

8. In combination with a folding propeller

blade or blades, a main steam-cylinder, two auxiliary steam-cylinders, and the pistons and piston-rods of these three cylinders, the two auxiliary cylinders operating together, and all the rods being connected to the vanes.

9. The combination, with a reciprocating propeller for navigable vessels, composed of a pair of folding blades adapted to expand on the active stroke and fold on the return, of a main central cylinder and a pair of auxiliary intercommunicating cylinders disposed upon opposite sides of it, the combined capacity of the two auxiliary cylinders exceeding that of the main cylinder, for purposes stated.

10. In propellers for navigable vessels, composed of one or more folding blades adapted to expand on the active stroke and close on the return, and operated by two or more steam-cylinders, with their respective pistons and rods, as stated, the combination, with the various valves and ports of said cylinders, of circular hubs for operating upon a portion of said valves and active cams operating upon others of said valves.

11. In combination with the vane or vanes of a propeller, and as a means of converting the rectilinear reciprocating movements of the piston-rods into continuous rotary motion of the cam-shaft, the spiral rock-shaft playing within and rocked by the cross-head of one piston-rod, and connected with the cam-shaft by two alternately-operating gears carrying spring-impelled pallets or dogs to take hold of and advance such shaft.

12. In combination with propeller-blades and cylinders, pistons, and piston-rods operating said blades, as stated, a shaft and set of cams for operating the valves and ports of said cylinders, each cam being adjustably attached to a hub secured to the said shaft, substantially as set forth.

13. In combination with the propeller-blades and the cylinders, pistons, and piston-rods whereby they are operated, a set of cylinder-valves, valve-rods, operating-levers, and a shaft carrying cams which actuate said levers, substantially as set forth.

14. In combination with a pair of folding propeller blades or vanes, three cylinders, with their pistons, piston-rods, and valves, and mechanism whereby the motion of the piston-rod attached to the hinge of the blades is caused to stop before the rods attached to the outer edges of the blades, in order that the blades may be fully closed before the return-stroke begins.

In testimony whereof I affix my signature in presence of two witnesses.

RICHARD SMITH.

Witnesses:
H. E. LODGE,
F. CURTIS.