C. COMSTOCK.

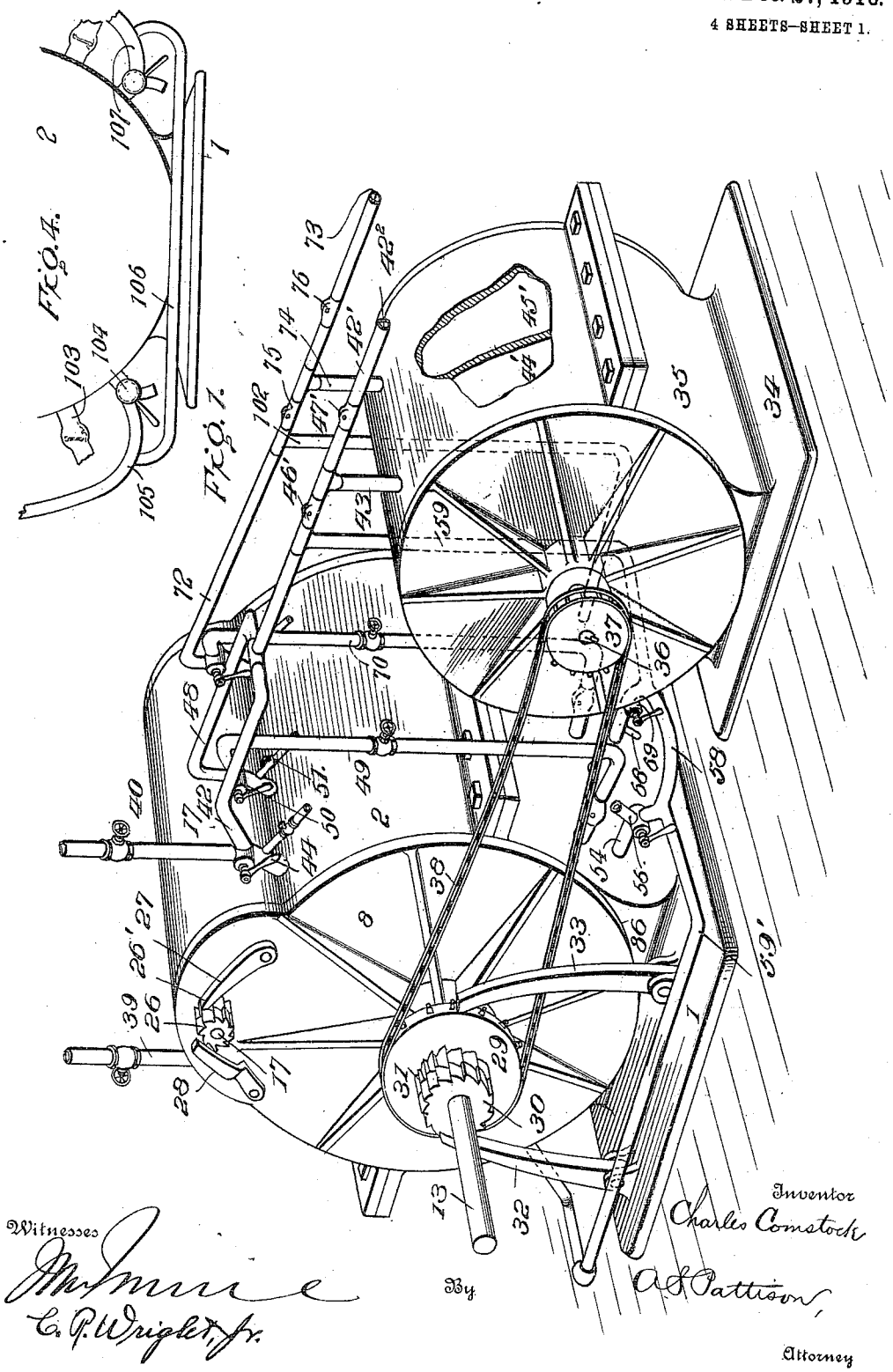
VACUUM STEAM ENGINE.

APPLICATION FILED JAN. 2, 1907. RENEWED MAY 16, 1910.

979,435.

Patented Dec. 27, 1910.

4 SHEETS—SHEET 1.



Witnesses

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4 SHEETS—SHEET 2.

FIG. 2

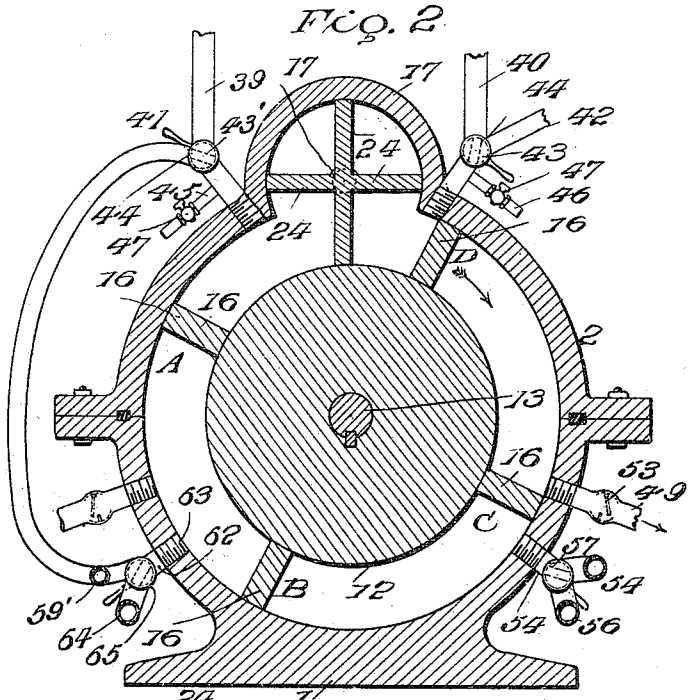
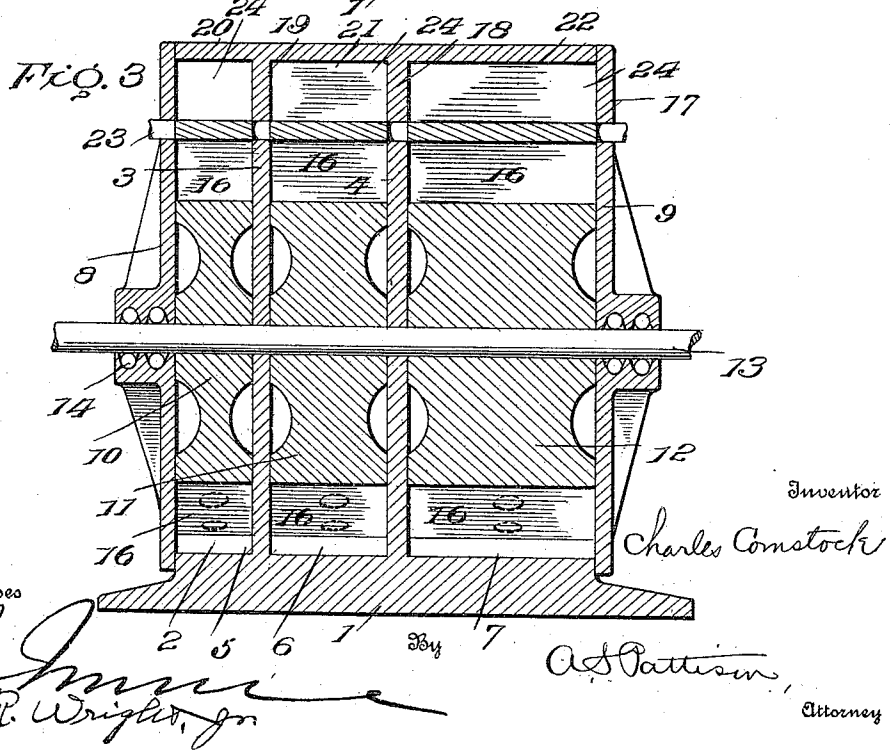


FIG. 3



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4 SHEETS—SHEET 3.

FIG. 5

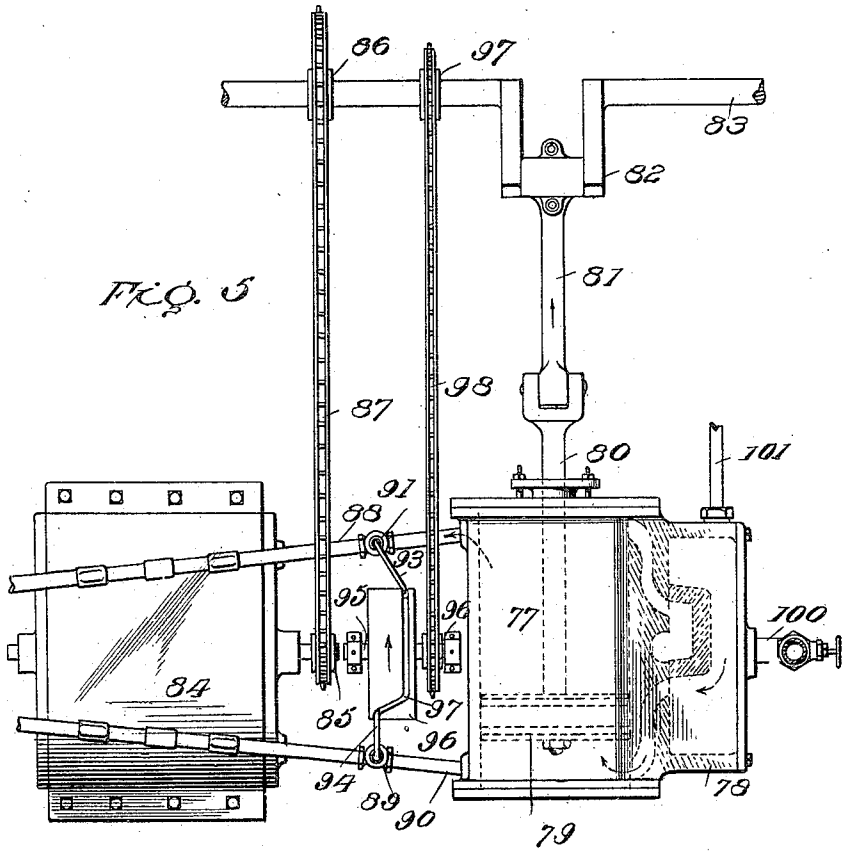
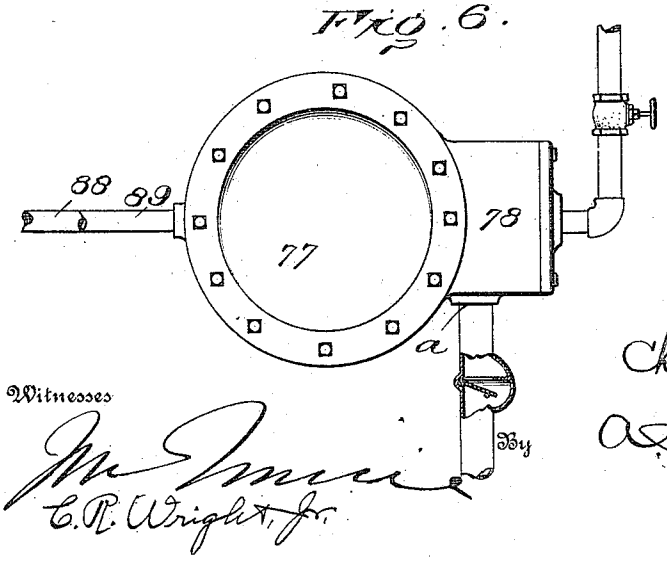


FIG. 6.



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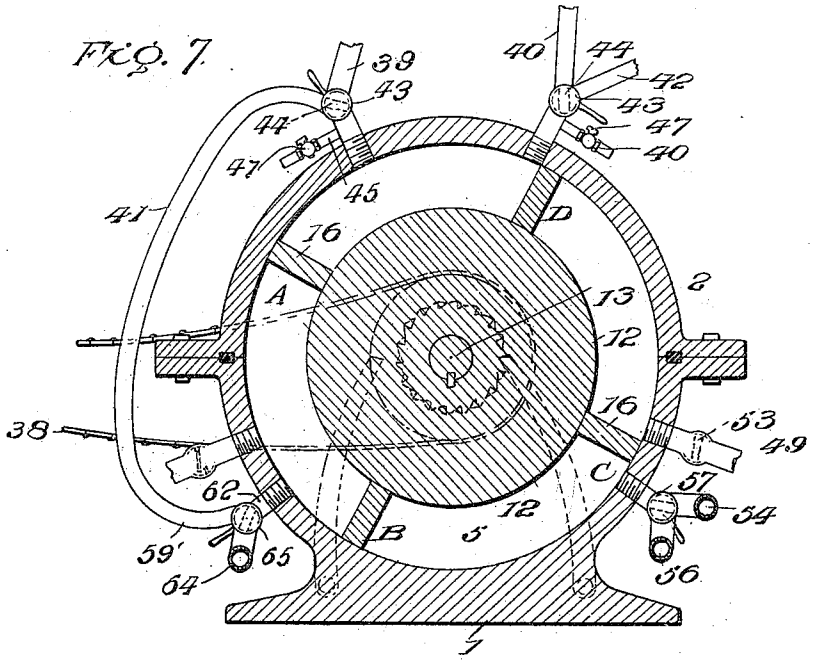
4 SHEETS—SHEET 4.

FIG. 7.



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UNITED STATES PATENT OFFICE.

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VACUUM STEAM-ENGINE.

979,435. Specification of Letters Patent. Patented Dec. 27, 1910.

Application filed January 2, 1907, Serial No. 350,383. Renewed May 16, 1910. Serial No. 561,722.

To all whom it may concern:

Be it known that I, CHARLES COMSTOCK, a citizen of the United States, residing at West Stockbridge, in the county of Berkshire and State of Massachusetts, have invented certain new and useful Improvements in Vacuum Steam-Engines, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to improvements in vacuum steam engines.

The object of my invention is to provide an engine of this character, in which a vacuum pump is in direct communication with the engine cylinder for causing a vacuum to be working on the piston or pistons simultaneously with the steam, whereby the power of the engine is greatly increased.

Another object of my invention is to so provide and arrange the engine and vacuum, that the steam supply of the engine enters a portion or chamber of the cylinder having already a complete vacuum and thus causing a kinetic inrush of steam into a vacuum and obtaining a great cyclonic explosion therein, causing a more powerful action of the steam against the piston.

Another object of my invention is to provide a simple, cheap and effective engine in which the vacuum pump is driven directly by the engine, and in which a much greater power is obtained thereby.

In the accompanying drawings, Figure 1 is a perspective view of my improved engine, showing the vacuum pump close to and coupled directly to the engine. Fig. 2, is a vertical transverse sectional view taken through the live steam chamber of the cylinder. Fig. 3, is a longitudinal vertical sectional view of the engine. Fig. 4, is a plan view of Fig. 1 showing the engine cylinder partly broken away. Fig. 5, is a top plan view of a reciprocating engine, showing a vacuum pump coupled thereto and embodying my invention. Fig. 6, is an end view of Fig. 5. Fig. 7, is a vertical sectional view of the cylinder similar to that shown in Fig. 2, the rotary abutment being omitted.

Referring now to the drawings, 1 represents an elongated broad flat base having cast therewith, or otherwise secured thereto the engine cylinder 2 which, as shown, is of an elongated form, and divided by divisions 3 and 4 into three separate cylinders. First, reading from left to right, Fig. 3 is the live steam chamber 5 which is of a narrow form, as will be hereinafter more fully described. The next chamber of cylinder 6 is of a width considerably larger than the live steam cylinder, as it is to receive the exhaust steam from the live steam cylinder. The third and last cylinder 7 is considerably larger than the cylinder or about equal in area to the cylinders 5 and 6, this being necessary as it receives the exhaust from the cylinder 6, and this steam having been twice expanded requires a much larger area. The ends of the cylinder 2 are closed by removable cylinder heads 8 and 9 which are bolted or otherwise removably fastened thereon.

Within the three cylinders or chambers 5, 6 and 7 are three pistons 10, 11 and 12 which are made of a size to snugly fit the divisions or partitions and cylinder heads, and a packing is either carried by the pistons or by the divisions and cylinder heads, so as to form a tight joint therewith to prevent the steam from leaking inwardly toward the shaft. The said pistons are all carried by a shaft 13 which is mounted in roller bearings 14 carried by the cylinder heads 8 and 9, and said shaft extends through the divisions of the cylinder. The pistons are keyed upon the shaft 13 in any well known manner, and said pistons are of a solid form 15 smaller in diameter than the bore of the cylinder, as shown. Said solid portions are provided at equal distances apart with four radially extending piston heads 16 which extend out and engage the inner periphery of the cylinder. While I have shown and described four piston heads, it will be understood that any desired number of heads may be used. The outer ends and sides of the piston heads are preferably provided with a packing to form a tight joint with the inner periphery of the cylinder to prevent the leakage of the steam and vacuum therearound.

Extending the entire length of the cylinder at its upper end is a semi-circular housing 17 which is cast with the cylinder and has its lower end in communication with the cylinder, and the cylinder heads 8 and 9 close the outer ends of said housing. The partitions or divisions 3 and 4 extend upward, as indicated at 18 and 19 within the housing, and form the three abutment chambers 20, 21 and 22 which, as shown in Fig. 3 are of a length to correspond with the piston in communication therewith. Extending longitudinally through the housing 17 is a shaft 23 which is journaled in the cylinder heads, and

the divisions. The said shaft extends outwardly at each end beyond the cylinder heads, and carried by said shaft within the chambers 20, 21 and 22 are the abutments 24 which correspond to the chambers. Said abutments are each formed of four blades 25 which extend radially from the shaft. The said abutments are of a length to snugly fit the inner periphery of the housing, and the outer periphery of the solid portion of the piston, and forms an abutment against which the steam abuts for giving the proper resistance in one direction to the steam, while the steam in the opposite direction engages one of the piston heads. The shaft 23 at both ends extends beyond the cylinder heads 8 and 9 and has rigidly secured thereto at each end the ratchet wheels 25 and 26, which have their teeth disposed in opposite directions. Carried by the outer face of the cylinder heads 8 and 9 adjacent the ratchet teeth are two pawls 27 and 28 which are pivoted at such a point that either pawl may be thrown in engagement with its respective ratchet, and thus the abutment shaft may be positively held against rotation in either direction according to the direction the engine is rotating. The pawl 27 engages the inner ratchet wheel 25 while the pawl 28 engages or is adapted to engage the outer ratchet wheel. The piston heads 10 during the rotation thereof engage the abutments and cause the same to turn and allow the piston head to pass the same, and the next blade of the abutment assumes a vertical position and forms the abutment while the steam is working upon the head which has just passed the abutment. When the pawl 27 is in engagement with the ratchet 26′, as shown in Fig. 1, the piston 15 is rotating in the direction indicated by the arrow in Fig. 2, and the abutment is rotating in the opposite direction, as also indicated by arrow in said figure. The pawl 27 holds the abutment against rotation in the opposite direction, as indicated, caused by the pressure of the steam thereon, and thus forms a permanent part of the cylinder, and serves as an abutment against which the steam exerts its driving force.

The shaft 13 on the outside of the cylinder heads 8 and 9 is provided with a sprocket wheel 29 which is rigidly keyed upon the shaft as will be hereinafter more fully described. The said shaft on the outside of the sprocket wheel is provided with ratchet wheels 30 and 31 which are keyed upon the shaft and have their teeth disposed in opposite directions. Pivotally carried by the base on each side of a point directly below the shaft, are pawls 32 and 33 which are so positioned that they will engage respectively the ratchets 30 and 31 and thus when the piston is rotating in the direction indicated by arrow, Figs. 1 and 2, the pawl 32 is engaging the ratchet 30 and the piston is held against rotation in the opposite direction, so that it will be always rotated in the same direction until the pawls are changed, and the steam admitted from the opposite side, as will be hereinafter more fully described. Located close to the said cylinder is a pump base 34 upon which is mounted a pump cylinder 35, which, as shown, is of a rotary type, although I do not care to limit myself to a rotary pump, as other forms of pumps may be used provided they are close to and connected directly to the engine cylinder. The shaft 36 of the pump is in a line with the sprocket 29, which is considerably larger than the sprocket wheel 37 of the pump shaft, and passing over the sprocket wheel is a chain 38, and by means of which the pump shaft is rotated very rapidly and creates a vacuum as will be hereinafter fully described.

The cylinder 2 on opposite sides of the abutment housing 17 is provided with steam supply pipes 39 and 40 which communicate therewith, and through which the live steam passes to the cylinder 6 of the engine. The said pipes 39 and 40 have connected thereto the vacuum pipes 41 and 42, and at the juncture of the pipes 40 and 42, and the pipes 39 and 41 are cocks 43 and 43′ which have a passage 44 therethrough which is adapted to communicate with either the steam or vacuum when the cylinder may be supplied with either. The said passage is so located that the same can be turned across the pipe so that both the vacuum and the steam can be cut off. Between the point of juncture of the steam and vacuum pipes and the cylinder there are pipes 45 and 46 which are provided with cocks 47 for the purpose hereinafter fully described. Two steam inlet and vacuum ports are provided one on each side of the abutments so that the engine may be reversed, all of which will be hereinafter more fully described. The vacuum pipe 42 leads horizontally outwardly, as shown at 42′, and across the upper end of the pump 35, and has an open end 42^2 which is open to the atmosphere for discharging the steam, water, etc., drawn from the cylinder. Connected to said pipe is a pipe 42′ which is connected to the pump 35. The said pump is divided into two compartments of equal size and are numbered 44′ and 45′. On each side of the pipe 43 the pipe 42′ is provided with check valves 46′ and 47′, both of which swing outward toward the open end 42 of the pipe. The pipe 42′ has a branch pipe 48 leading to the second cylinder as shown. Connected to said pipe 48 is the exhaust pipe 49 of the first cylinder, and at the juncture of said pipes 48 and 49 is a two-way cock 50 constructed and arranged in precisely the same manner as the cocks 43 and 43′, whereby either steam or vacuum

may be communicated with the cylinder. An air inlet pipe 51 is connected thereto adjacent the cylinder, and provided with cock 52 for closing or opening the same.

The exhaust pipe 49 of the cylinder is connected to the cylinder a distance from the steam supply equal to the distance between the piston heads, so that as one piston head is passing the steam and the steam is being admitted, the piston head in advance thereof has just commenced to pass the exhaust, whereby the chamber between the two piston heads is being exhausted. The said exhaust pipe is provided with an outwardly swinging valve 53 which allows of the free escape of the exhaust steam. Adjacent said pipe 49 is a vacuum pipe 54 which, when the piston head has passed it, the vacuum commences to work upon the piston heads, and the flap valve 53 is automatically closed, and a pulling action is taking effect upon the opposite side of the head to that being acted upon by the steam. Connected to said vacuum is an air intake pipe 56 and a two-way valve 57 controls the pipes 54 and 56, so that a vacuum is working or the engine is taking air, as will be hereinafter more fully described. The pipe 54 leads outwardly at 58 and upwardly at 59, and connected to the pipe 42′ leading and connected to the vacuum pump.

The pipe 58 has connected thereto a pipe 59 which leads around the side of the cylinder, and extends upward at 41, and is connected to the steam supply pipe 39. At the connection of the vacuum pipes 41 and 39 is the two-way cock 43′, heretofore described, whereby either steam or vacuum is admitted according to the direction it is desired to run the engine.

Connected to the pipe between the cock 43′ and cylinder is an air intake pipe 43′ which is provided with a cock 47 by means of which the pipe is opened or closed, all of which will be hereinafter more fully described in the operation of the engine.

Leading from the pipe 59 is a pipe 62 which is connected to the cylinder 5 at 63, and connected to said pipe 62 is an air intake pipe 64, and at the juncture of the pipes 64 and 63 is a two-way cock 65 being the same as the two-way cocks heretofore described for opening either the vacuum or the air pipes, or for closing the same.

The pipe 58 has connected thereto a vacuum pipe 66 which connects to the cylinder 6 at 67, and is provided with an air intake pipe 68, and a two-way valve or cock 69, the same as heretofore described. Connected to said cylinder 6 is an exhaust pipe 70 which is provided with an automatic closing valve operating the same as the valve 53, and said exhaust leads upwardly at 71 and is connected to the third cylinder 7 and forms the steam supply therefor. Connected to the said pipe 71 is a vacuum pipe 72 and at the juncture of said pipe 72 is a two-way cock as heretofore described. The vacuum pipe 72 leads over the top of the pump cylinder 35 and has an open end 73. Connected to said pipe 72 is a down-pipe 74 which has its lower end connected to the pump cylinder. The pipe 72 on each side of the pipe 74 is provided with outwardly-opening valves 75 and 76 which operate the same as the valve in the pipe 42′.

The pipe and arrangement of the exhausts and vacuum bring the same on the opposite side of the cylinder for reversing the engine.

From the drawings, it will be seen that the two cylinders 5 and 6 are connected to the left hand half of the pump cylinder, while the cylinder 7 is connected to the right hand half, this being necessary as the areas of the two cylinders 5 and 6 are approximately that of the cylinder 7, and this is necessary in order to get the same amount of vacuum in each and all of the cylinders.

From the foregoing description it will be seen that when the engine is running in the direction indicated by arrow in Fig. 2, the valve 43 is opened so that steam is entering on the right of the abutment, and the steam is working against the piston head D. The ratchets on the abutment and engine shaft are set as shown in Fig. 1, so that the piston and the abutment cannot rotate in any other direction than that indicated by arrow in Fig. 2. The space between the piston heads D and C is exhausting and the second cylinder is taking steam at the same time as cylinder 5. The valve 43 is so set that vacuum is working on A as soon as it has passed the said air port 53, and therefore having a pulling action upon the piston A. The valve 65 is so set that the space between the pistons C and D is taking air and the same being a vacuum space, the air rushes inwardly and forces the piston head D around. The valve 43′ is set so that a vacuum is working between the piston head D and the rotary abutment, so that as the space between piston A and the abutment is opened to steam, the steam rushes into the vacuum space with kinetic power and forces the piston around with greatly increased power, the same as the air does through the valve 65.

When it is desired to reverse the engine, the pawl 32 is thrown out of engagement with the ratchet 30, and the pawl 33 is thrown in engagement with the ratchet 31. The pawls 27 and 28 are like-wise reversed, and thus the rotation of the abutment and piston is just the opposite of that shown in Fig. 2. The valve 43′ is turned so that steam is entering the space between the rotary abutment, and the piston head D. The valve is so turned that a vacuum is working between the heads D and C, the air inlet is

taking air between A and B. The valve 43 is so turned that a vacuum is working on the piston head A between it and the abutment, the operation being the same as described when running in the opposite direction. By this construction and arrangement of the piston heads and ports, it will be seen that at all times, when running in either direction, one piston head is being acted upon on one side by steam and on the opposite side by a vacuum, another piston head is being acted upon by the kinetic inrush of air and the same piston head on the opposite side is being acted upon by a vacuum, and thus preparing the chamber between the heads A and D with a vacuum for aiding in rotating the piston and also for having a vacuum into which an inrush of steam, gains a greater power than would the inrush of steam into a chamber with atmospheric pressure.

In the form shown in Fig. 4, I have shown my invention as applied to a reciprocating engine, and in which 77 represents the cylinder having the usual steam chest 78 applied thereto, and the piston 79 and piston rod 80. Connected by a link 81 to a crank 82 carried by the shaft 83. Adjacent to said cylinder is a pump 84 which shaft has a sprocket 85, and the shaft 83 carrying a sprocket 86, and passing around said sprocket is a chain 87 which is adapted to rotate the pump very rapidly, as will be seen by the proportional size of the sprocket wheels.

Connected to opposite sides of the pump are two pipes 88 and 89 which are connected to opposite ends of the cylinder 77, and said pipes intermediate the pump and cylinder are provided with cocks 90 and 91 which are provided with inwardly-extending operating levers 93 and 94. Mounted between said pipes and between the pump and the engine, is a shaft 95 carrying a cam 96 which is provided with a groove 97 which is so arranged and timed that the valve 90 is closed when the piston is in the position indicated in dotted lines, and the valve 91 is opened allowing the vacuum to work upon the piston on the opposite side from the steam, and when the piston has reached the opposite end of the cylinder the valve 90 is opened and the valve 91 is closed. The shaft 95 carries a sprocket 96 and the shaft 83 also carries a sprocket 97 over which a chain 98 passes, and whereby the cam 90 is turned with the engine. The steam chest 99 is provided with the usual steam supply 100 and exhaust 101. The exhaust pipe 101 is provided with an automatically closing flap valve 102 for closing when the vacuum is working, as shown in Fig. 5.

In the form shown in Fig. 7, I dispense with the abutment, the piston heads, the exhaust inlets, and vacuum ports, all being arranged precisely like that shown in Fig. 2. The pawl and ratchet, as shown in dotted lines, prevents the piston from rotating but in the determined direction, and the steam rushing into vacuum with kinetic force causes an explosion which will rotate the piston, the operation being well understood from the operation as described in respect to the form shown in Figs. 1 to 3 inclusive, like numerals indicating like parts. In this form I propose to use but a single cylinder or chamber pump. From my description of Fig. 7, also Figs. 1 to 3 inclusive, it will be understood that I might dispense with the steam supply and I have therefore shown the air intake ports. In such instances, the chain 38 can be removed and an independent engine coupled to the pump 35 for rapidly rotating the same. In such case, when the engine is running in the direction indicated by arrows, Fig. 2, the valve 43 is entirely cut off, and the cock in the air intake is opened so that the kinetic inrush of air into vacuum will rotate the piston together with the vacuum and gain great power. To reverse the engine, the valve 43′ is closed entirely and the valve in the air intake is opened, and the remaining valves set as described in respect to Fig. 2 when reversing.

Referring to Figs. 1 to 4 inclusive, the pipe 72 has connected thereto on the inside of the valve 75 a downwardly-extending pipe 102 which is connected to the cylinder 7 below the exhaust 103, the said exhaust opening into the atmosphere and having a flap valve the same as shown in the other exhausts. The pipe 102 has connected thereto an air-intake 104 and at the juncture of said pipes 104 and 102 is a two-way valve 105 like the ones heretofore described. The pipe 102 on the outside of the valve 105 has connected thereto a pipe 106 which leads around the cylinder and is connected to the pipe. The pipes being arranged in the same manner as the pipes shown in Fig. 2 in respect to the cylinder 5, and by means of which the vacuum is created at the proper places in the cylinder 7.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is:—

1. A vacuum engine comprising a cylinder, a piston therein, the cylinder having a steam inlet port located at one side of the piston, a vacuum port located at the opposite side of the piston, a vacuum pump directly connected with said vacuum port, and an exhaust port independent of said vacuum pump.

2. The combination with a steam engine comprising a cylinder having inlet and exhaust ports and a piston therein, of a vacuum pump independent of said ports and directly connected with the cylinder to form a vacuum therein at one side of the piston.

3. A vacuum engine comprising a cylin-

der having inlet and exhaust ports, a piston therein, and a pump in direct communication with the cylinder independent of said ports, for creating a vacuum within the cylinder in front and in rear of the piston.

4. The combination with a steam engine comprising a cylinder having inlet and exhaust ports and a piston therein, of a vacuum pump independent of said ports and directly connected with the cylinder and adapted to create a vacuum therein after the usual exhaust of the steam therefrom.

5. The combination with a steam engine comprising a cylinder having inlet and exhaust ports and a piston, of a vacuum pump driven by the engine and directly connected with the engine cylinder independent of said ports to create a vacuum therein at one side of the piston.

6. A vacuum engine comprising a cylinder having inlet and exhaust ports, a piston therein, a vacuum pump adjacent the cylinder, a pipe connection between said pump and cylinder independent of said ports, and means operated by the piston for operating the pump.

7. A vacuum engine comprising a cylinder having steam inlet and exhaust ports, a piston therein, a vacuum pump in communication with the cylinder independent of said ports, and means operated by the piston for operating the pump.

8. A vacuum engine comprising a cylinder having inlet and exhaust ports, a piston therein, a vacuum pump in communication with the cylinder independent of the ports, and means operated directly by the piston for operating the pump.

9. A vacuum pump comprising a cylinder having inlet and exhaust ports, a piston therein, a rotary vacuum pump in communication with the cylinder independent of said ports, and means operated directly by the piston for operating the pump.

10. A rotary vacuum engine, comprising a cylinder, a piston therein, a rotary reversible abutment operated by the piston, and a pawl for preventing the abutment from rotating in but one direction and holding it against the pressure of the steam.

11. A rotary vacuum engine, comprising a cylinder, a piston therein, a rotary reversible abutment operated by the piston, and pawls for allowing the piston to rotate in either direction, but preventing it rotating in the opposite direction caused by the pressure of the steam against the same.

12. A rotary vacuum engine, comprising a cylinder, a piston therein, a piston shaft extending through the cylinder, two ratchets carried by the shaft and having their teeth arranged in opposite directions, pawls for engaging the ratchets, whereby either pawl can be thrown in engagement with the ratchet, whereby the piston is prevented from rotating in but one direction.

13. A rotary vacuum engine, comprising a cylinder, a piston therein, a steam supply therefor, an air intake, a vacuum, and an exhaust, all coöperating automatically.

14. A rotary vacuum engine, comprising a cylinder, a piston therein, a rotary reversible abutment operated by the piston, a steam supply, an air intake, a vacuum, and exhaust, all coöperating automatically with the piston.

15. A rotary vacuum engine, comprising a cylinder, a piston therein, piston heads carried by the piston, a rotary abutment operated directly by the piston heads, said cylinder having steam, air inlet, vacuum and exhaust ports, all coöperating automatically with the piston.

16. A rotary vacuum engine, comprising a cylinder, a piston therein, piston heads carried by the piston, a rotary reversible abutment operated directly by the piston heads, said cylinder having a steam supply for the cylinder, an air intake pipe in communication with the cylinder, a vacuum pipe in communication with the cylinder, means operated directly by the engine for creating a vacuum in said pipe, an exhaust pipe in communication with the cylinder, and an outwardly swinging flap valve within said pipe and opened by the exhaust and closed by the vacuum.

17. A rotary vacuum engine, comprising a cylinder, a piston therein, piston heads carried by the piston, a rotary reversible abutment operated by the piston, said cylinder having arranged on each side a steam supply, an air intake, a vacuum and an exhaust all coöperating automatically with the piston.

18. A rotary vacuum engine, comprising a cylinder divided into compartments of different dimensions, a steam supply for the small compartment, the exhaust of said compartment forming the supply for the adjoining cylinder, a shaft extending through the several cylinders, pistons keyed upon the shaft, a sprocket wheel carried by the shaft, a rotary vacuum pump in communication with each of said compartments, a sprocket wheel carried by the shaft of said pump, and a chain passing around the two sprocket wheels whereby the pump is driven directly by the engine and a vacuum is created in each compartment.

19. A rotary vacuum engine, comprising a cylinder, a rotary piston therein, piston heads carried by the pistons, a combined steam and vacuum port on each side of the cylinder, a two-way cock controlling said port whereby the steam or vacuum may be admitted to either side of the cylinder for reversing the structure.

20. An engine comprising a cylinder having steam inlet and exhaust ports, a vacuum pump in communication with the cylinder independent of said ports to form a vacuum chamber in which the steam is admitted, and means for driving the pump directly by the engine shaft.

21. A vacuum engine, comprising a cylinder, a piston therein, a vacuum pump in communication therewith and driven directly by the engine for forming a vacuum in advance of the piston and in rear of the piston simultaneously.

22. A vacuum engine, comprising a cylinder, a piston therein, a vacuum pump in communication therewith, and driven directly by the engine for forming a vacuum in advance of the piston and in rear of the piston preparing the steam chamber with a vacuum immediately before the admission of the steam.

23. A rotary vacuum steam engine, comprising a cylinder, a rotary piston therein, piston heads carried by the piston, a vacuum pump in communication with opposite sides of the cylinder for pumping all steam condensation etc. from between the pistons directly in advance of the steam actuated piston head and also for creating a vacuum between the piston heads immediately before the admission of steam thereto.

24. A vacuum engine, comprising a cylinder, a piston therein, a vacuum pump adjacent the cylinder, a pipe in communication with the cylinder and extending over the pump and having an open end, a branch pipe communicating with the pump, and an outwardly swinging valve on each side of the branch pipe.

25. A vacuum engine, comprising a cylinder, a piston therein, a vacuum pump adjacent the cylinder, and means carried by the engine for operating the pump, a pipe in communication with the cylinder and extending over the pump and having an open end, a branch pipe connected thereto and in communication with the pump, and an outwardly swinging valve on each side of the branch pipe.

26. A vacuum engine, comprising a cylinder, a piston therein, a rotary vacuum pump adjacent the cylinder, means operated by the engine for rotating the pump, a pipe in communication with the cylinder and extending over the pump and having an open end, a branch pipe connected thereto and in communication with the pump, and an outwardly-swinging valve within said pipe on each side of the branch pipe.

27. A rotary engine, comprising a cylinder, a rotary piston therein, piston heads carried by the piston, a rotary abutment operated by the piston, a combined steam and vacuum port connected to the cylinder on each side of the abutment, means for admitting either steam or vacuum to the cylinder on either side of the abutment, an exhaust port located a distance from the steam inlet equal to the distance between the piston heads, and a vacuum port connected to the cylinder below the exhaust and a vacuum pump proper piped to the vacuum ports and driven directly by the engine.

28. A rotary vacuum engine, comprising a cylinder, a rotary piston therein, piston heads carried by the cylinder, two ratchets carried by the piston shaft on the outside of the cylinder and having their teeth disposed in opposite directions, pawls for engaging said ratchets, a rotary abutment operated by the piston heads, and having its ends extending beyond the cylinder, two ratchets carried by the shaft and having their teeth disposed in opposite directions, and pawls for engaging said ratchets, whereby the piston and abutment may be locked against rotation in either direction.

29. A rotary vacuum engine, comprising a cylinder, a rotary piston therein, piston heads carried by the piston, a rotary abutment operated by the heads, a combined steam inlet and vacuum pipe in communication with the cylinder, on each side of the abutment, a two-way valve controlling said steam and vacuum ports, whereby either steam or vacuum may be admitted to the cylinder or both cut off entirely, exhaust ports in communication with the cylinder a distance from the steam inlets equal to the distance between the piston heads, and combined air and vacuum ports below the exhausts, and two valves controlling the air and vacuum ports whereby either the air or vacuum ports may be opened or closed or both closed, and a vacuum pump connected to the several vacuum ports and driven directly by the engine.

30. A rotary vacuum engine, comprising a cylinder, a rotary piston therein, piston heads carried by the piston, a rotary abutment having legs equal in number to the piston heads, and operated by the heads, a combined steam inlet and vacuum pipe in communication with the cylinder on each side of the abutment, a two-way valve controlling said steam and vacuum ports whereby either steam or vacuum may be admitted to the cylinder or both cut off, air inlet pipes having a controlling valve in communication with combined steam and vacuum pipes intermediate the two-way valve and the cylinder, exhaust ports in communication with opposite sides of the cylinder a distance from the steam inlets equal to the distance between the piston heads, outwardly swinging valves carried by the exhaust, combined air and vacuum ports below the exhausts and two-way valves controlling said vacuum and air inlet ports, whereby either the air or vacuum ports may be opened or closed, or both

closed, and a vacuum pump connected to the several vacuum ports and driven directly by the engine the pistons, ports and valves capable of being so set that the engine can run in either direction and in either event one portion of the vacuum space between two heads is receiving steam, the space immediately in advance thereof being acted upon by the vacuum, the space ahead of this being furnished with air, and the other portion of the steam receiving chamber is being acted upon by the vacuum.

31. A rotary vacuum engine, comprising a cylinder divided into three compartments of different widths, a shaft extending through the cylinder, pistons carried by the shaft within the compartments, piston heads carried by the piston and arranged at different points on each piston, a steam supply for the first compartment, the exhaust of said compartment forming the steam supply for the second cylinder, and likewise the third cylinder supplied by the exhaust of the second, a rotary vacuum pump adjacent the cylinder, means for operating said pump driven directly by the engine, said pump divided into two equal compartments, a pipe in communication with one compartment and connected to the first and second compartments of the cylinder, and a pipe connecting the third compartment of the cylinder with the other compartment of the pump, and means for automatically controlling the vacuum.

32. A rotary vacuum engine, comprising a cylinder divided into three compartments of different widths, pistons therein, a steam supply for each compartment, an air intake for each compartment, an exhaust for each compartment, a flap valve within the exhaust and opened outwardly, a rotary pump adjacent the cylinder and divided into two equal compartments, a pipe having branch pipes communicating with the first and second compartments of the cylinder and extending over the pump, within automatic pump valves, and having an open end, a pipe leading downwardly to the pump, an automatic check valve on each side of the pipe leading to the pump, a pipe connected to the third compartment of the cylinder and extending over the second compartment of the pump, a pipe leading downwardly and communicating with the pump, an automatic check valve on each side of the pipe, and a hand-cock connected to each vacuum pipe adjacent the cylinder.

33. A vacuum engine, comprising a cylinder divided into several compartments, a shaft extending through the cylinder, a piston keyed to the shaft within each compartment, four piston heads carried by each piston and arranged at equal distances apart, the heads of each piston being arranged in line in respect to the piston of the adjoining piston, a housing extending across the cylinder and divided to correspond with the compartment of the cylinder, a shaft extending through said housing, rotary abutments carried by the shaft and timed with the piston heads of their respective compartments, each compartment having a steam supply, an air intake, an exhaust, and a vacuum communication therewith, and a pump driven directly by the engine for creating a vacuum within each compartment, an automatic means for controlling the exhaust and vacuum.

34. A rotary engine, comprising a cylinder, a piston therein, a steam inlet on one side of the cylinder, an exhaust on the same side, and a vacuum pump in direct communication with the cylinder adjacent the exhaust.

35. A rotary engine, comprising a cylinder, a piston therein, a steam inlet on one side of the cylinder, an exhaust on the same side, and a vacuum pump in direct communication with the cylinder adjacent the exhaust and driven by the engine.

36. A rotary engine, comprising a cylinder, a piston therein, a steam inlet, an exhaust, and a vacuum pump in direct communication with the cylinder independent of the steam inlet and exhaust.

37. A rotary engine, comprising a cylinder, a piston therein, a steam inlet, an exhaust, and a vacuum pump in direct communication with the cylinder independent of the steam inlet and exhaust and driven directly by the engine.

38. A rotary engine, comprising a cylinder having steam inlet and exhaust ports, a piston therein, and a pump driven directly by the engine for exhausting the air in front of the piston independent of said ports.

39. A rotary vacuum reversible engine, comprising a cylinder, a piston therein, a vacuum pump, in direct communication with the cylinder, a reversible circular abutment having legs timed with the piston and ratchets for locking the engine shaft and abutment shaft against rotation in either direction.

40. A rotary vacuum engine, comprising a cylinder, a rotary piston therein, piston heads carried by the piston, a rotary abutment having legs equal in number to the piston heads, and operated by the heads, two ratchet disks carried by the shaft of the rotary abutment on the outside of the cylinder and having their teeth arranged in opposite directions, a pawl engaging each ratchet disk, a combined steam inlet and vacuum pipe in communication with the cylinder on each side of the abutment, a two-way valve controlling said steam and vacuum ports whereby either steam or vacuum may be admitted to the cylinder or both cut off, air inlet pipes having a controlling valve in communication with combined

steam and vacuum pipes intermediate its two-way valve and the cylinder, exhaust ports in communication with opposite sides of the cylinder a distance from the steam inlets equal to the distance between the piston heads, outwardly-swinging valves carried by the exhaust, combined air and vacuum ports below the exhausts and two-way valves controlling said vacuum, and air inlet ports, whereby either the air or vacuum ports may be opened or closed or both closed, and a vacuum pump connected to the several vacuum ports and driven directly by the engine, the pistons, ports and valves capable of being so set that the engine can run in either direction and in either event one portion of the vacuum space between two heads is receiving steam, the space immediately in advance thereof being acted upon by the vacuum, the space ahead of this being furnished with air and the other portion of the steam receiving chamber is being acted upon by the vacuum.

41. A rotary vacuum engine, comprising a cylinder, a rotary piston therein, piston heads carried by the piston, a rotary abutment operated by the heads, two ratchet disks carried by the shaft for the rotary abutment on the outside of the cylinder and having their teeth arranged in opposite directions, a pawl engaging each ratchet disk, a combined steam inlet and vacuum pipe in communication with the cylinder on each side of the abutment, a two-way valve controlling said steam and vacuum ports, whereby either steam or vacuum may be admitted to the cylinder or both cut off entirely, exhaust ports in communication with the cylinder a distance from the steam inlets equal to the distance between the piston heads, and combined air and vacuum ports below the exhausts, and two valves controlling the air and vacuum ports whereby either the air or vacuum ports may be opened or closed, or both closed, and a vacuum pump connected to the several vacuum ports and driven directly by the engine.

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

CHARLES COMSTOCK.

Witnesses:
JOHN L. FLETCHER,
CHARLES R. WRIGHT, JR.