(No Model.) 3 Sheets—Sheet 1.

# L. M. SHAW.

## PISTON ENGINE.

No. 442,401. Patented Dec. 9, 1890.

Fig. 1.

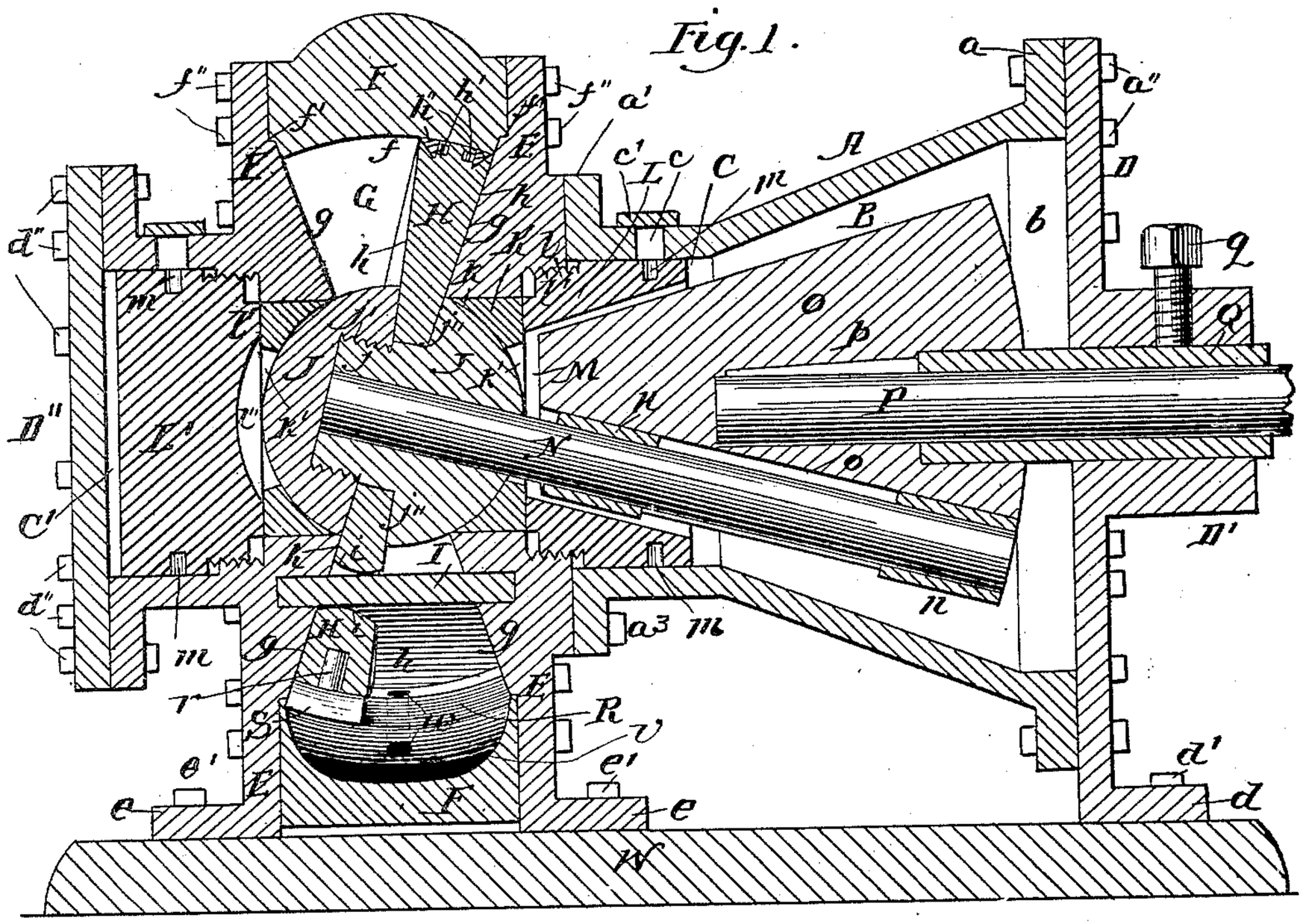
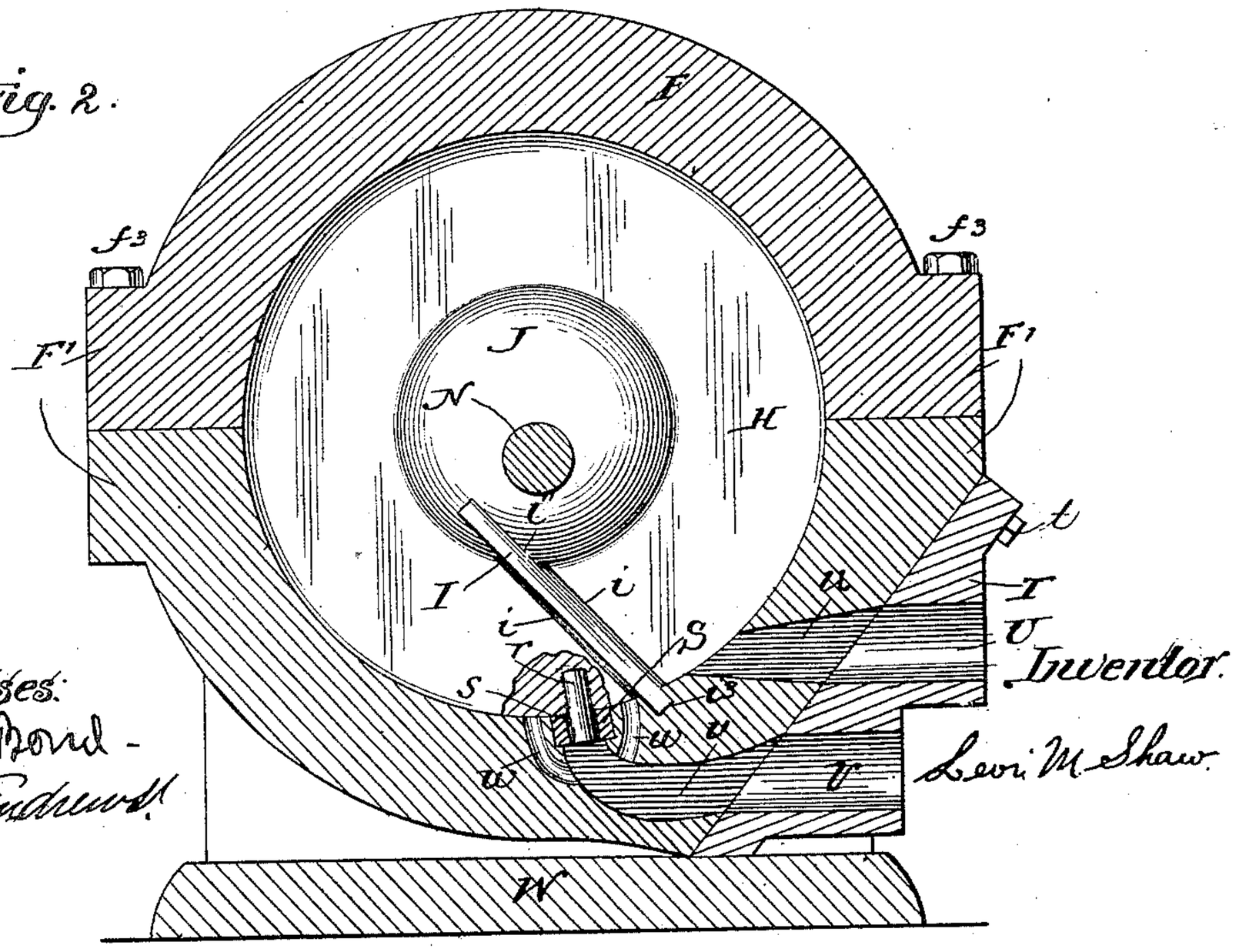


Fig. 2.



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(No Model.) 3 Sheets—Sheet 2.

# L. M. SHAW.

## PISTON ENGINE.

No. 442,401. Patented Dec. 9, 1890.

Fig. 3.

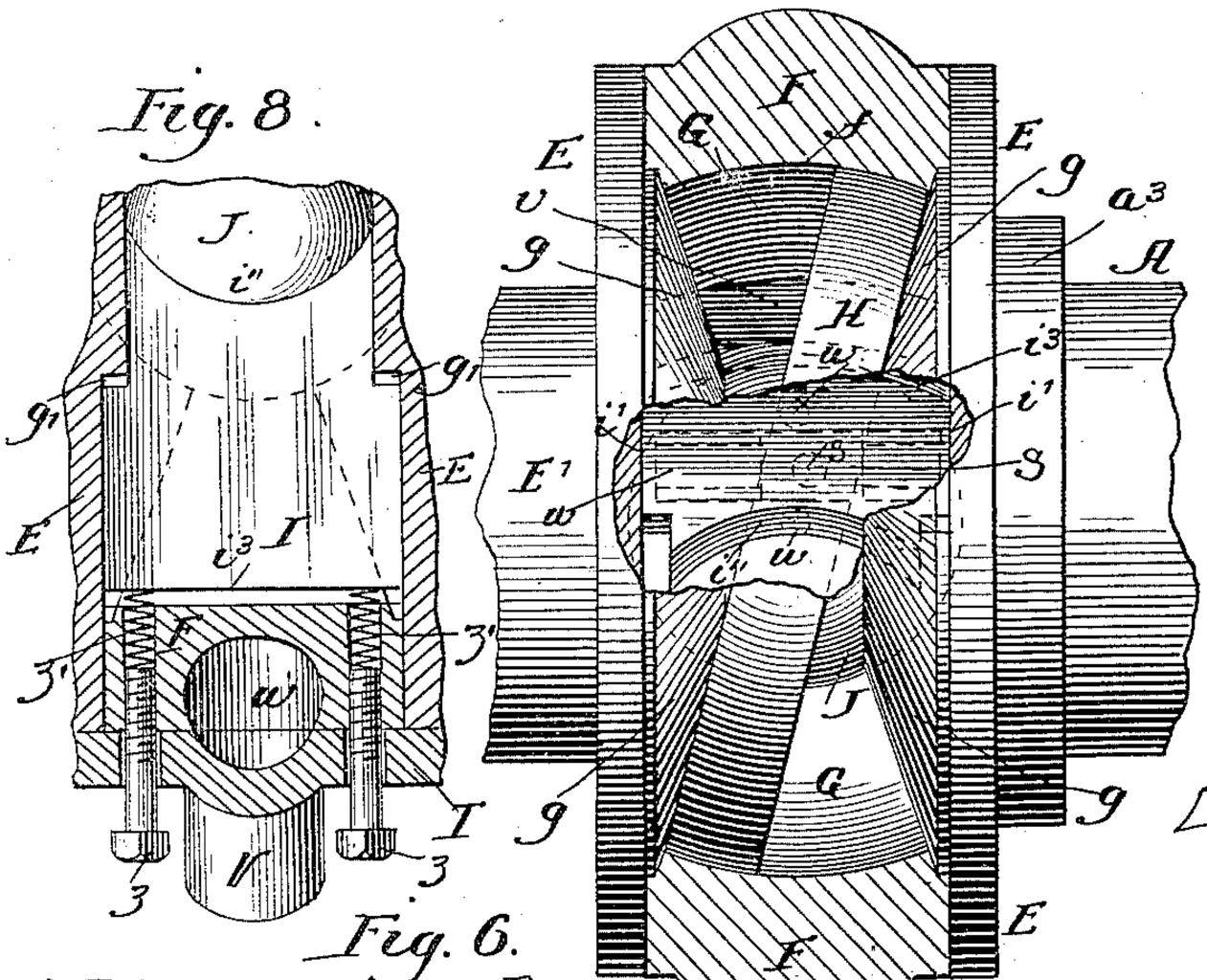



Fig. 8. Fig. 6. Fig. 7.

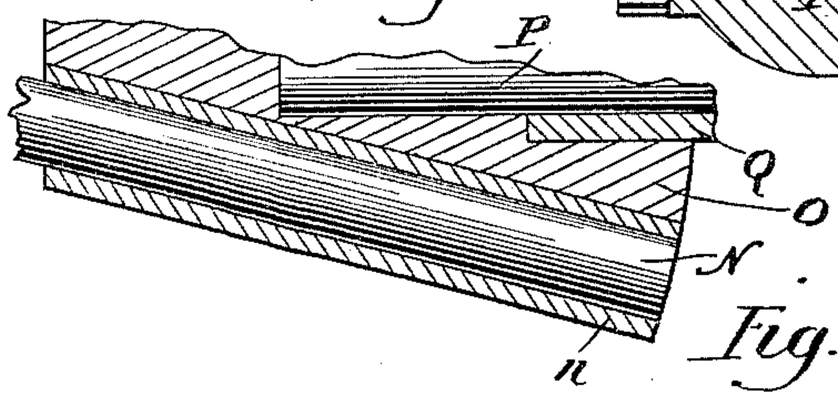



Fig. 4.

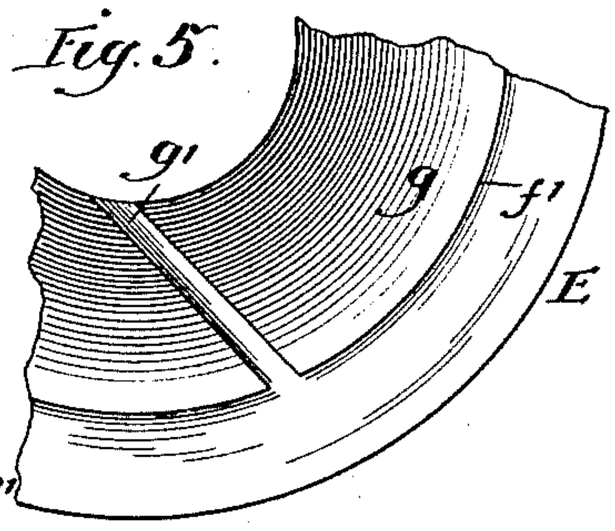
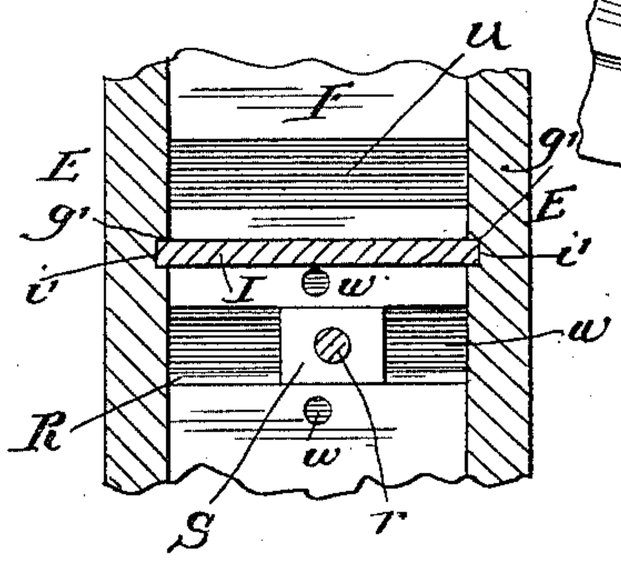



Fig. 5.

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3 Sheets—Sheet 3.

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## PISTON ENGINE.

No. 442,401. Patented Dec. 9, 1890.

*Fig. 9.*

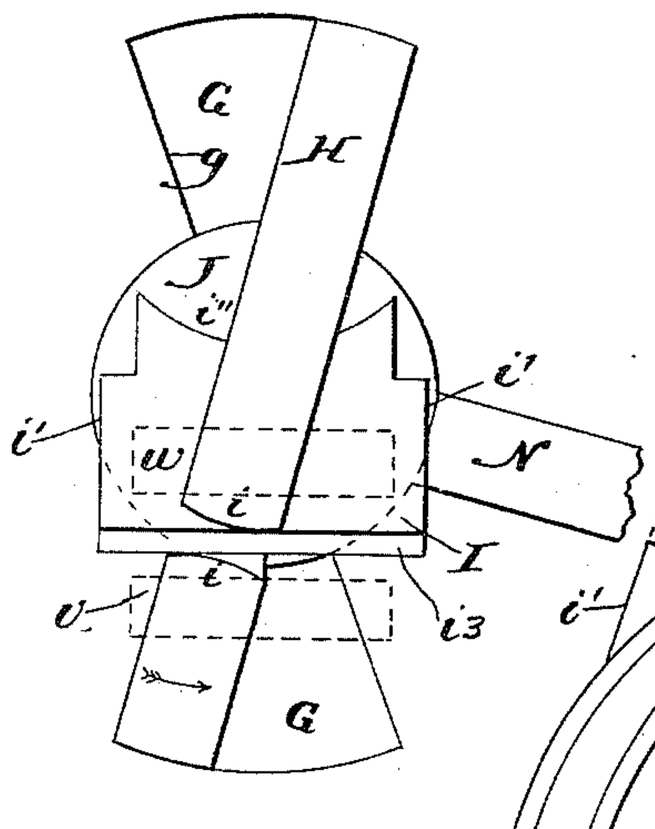



*Fig. 10.*

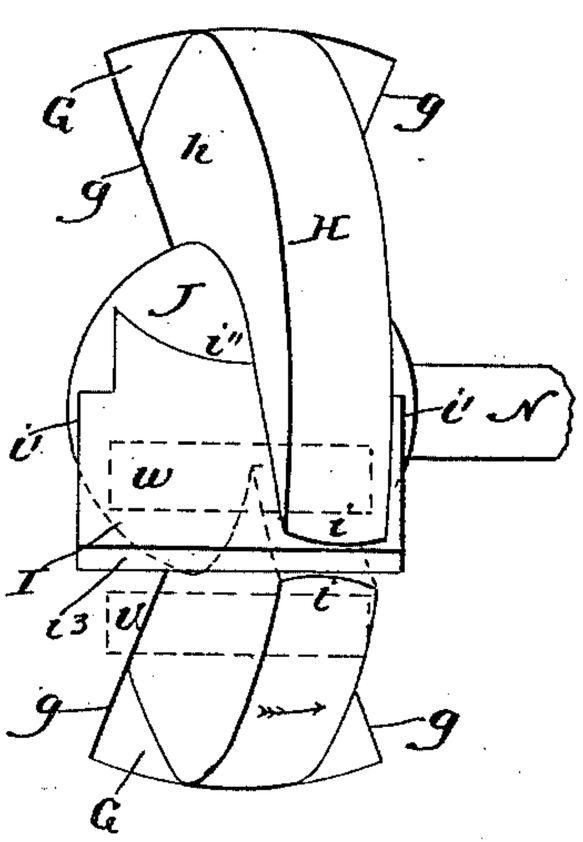



*Fig. 13.*

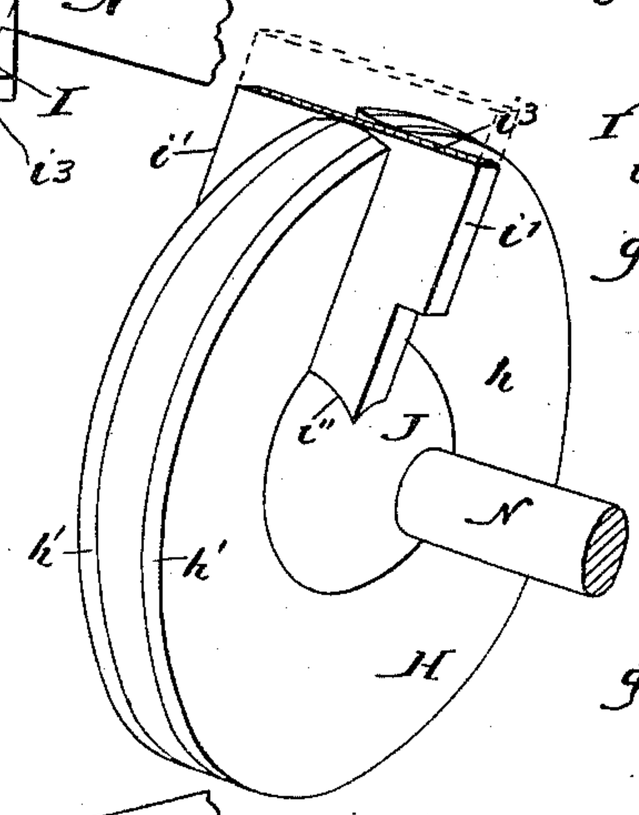



*Fig. 11.*

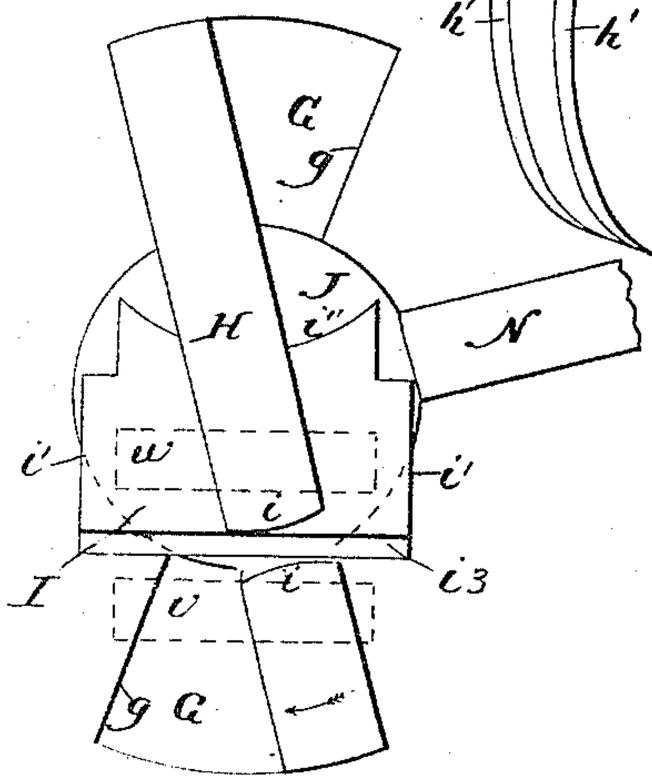
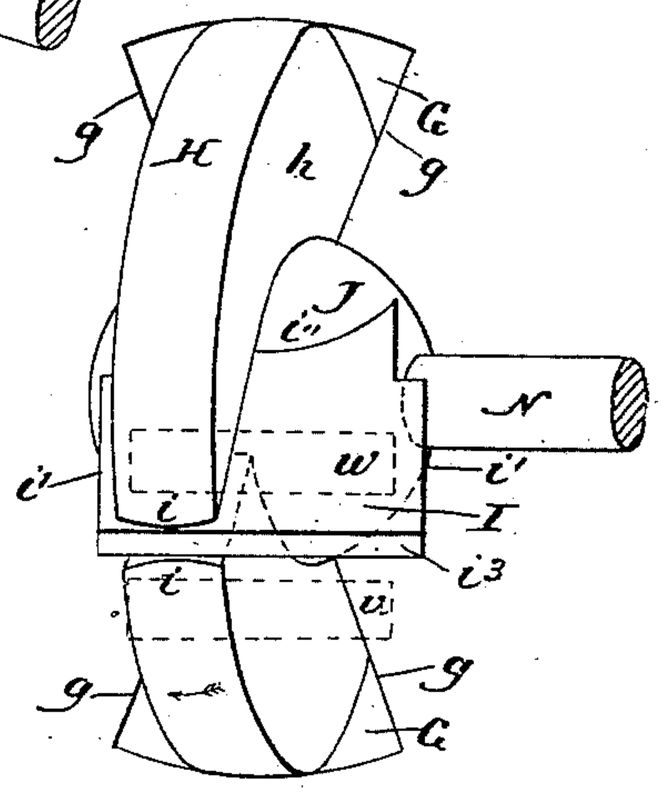



*Fig. 12.*




Witnesses:
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J. R. Underwood

Inventor:
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# UNITED STATES PATENT OFFICE.

LEVI M. SHAW, OF GYPSUM, KANSAS, ASSIGNOR TO HENRY C. STAVER, OF CHICAGO, ILLINOIS.

## PISTON ENGINE.

SPECIFICATION forming part of Letters Patent No. 442,401, dated December 9, 1890.

Application filed December 4, 1889. Serial No. 332,587. (No model.)

*To all whom it may concern:*

Be it known that I, LEVI M. SHAW, of Gypsum, in the county of Saline and State of Kansas, have invented certain new and useful Improvements in Piston Engines; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it pertains to make and use the same, reference being had to the accompanying drawings, forming a part hereof, in which—

Figure 1 is a central longitudinal section with the piston-shaft and the driven shaft in elevation. Fig. 2 is a cross-section through the center of the steam-chest with the piston and abutment in elevation. Fig. 3 is a sectional elevation of the steam-chest with the flange of the piston partly broken away to show the abutment, looking down thereon. Fig. 4 is a detail in section showing the abutment and the guide-block for the piston. Fig. 5 is a detail, being an elevation of the inner face of a part of the wall of the steam-chest, showing the groove for the abutment. Fig. 6 is a detail showing a continuous box for the piston-shaft instead of an inner and outer box. Fig. 7 is a perspective view of the abutment. Fig. 8 is a detail in section showing the abutment and its adjusting devices; Figs. 9, 10, 11 and 12, outline views showing the relative positions of the piston, the piston-shaft, and the walls of the steam-chest at different points in the circle described by the piston-shaft. Fig. 13 is a perspective view, in a diagram form, showing the abutment and piston.

This invention relates to engines in which a piston is employed having a travel in straight lines across the steam-chest and a rolling motion against the walls of the steam-chest, producing a compound reciprocating and gyrating motion, by which the end of the piston-shaft is caused to describe a circle around a line-shaft with which the piston-shaft is connected, thereby driving such line-shaft; and the objects of the invention are to give the piston an unbroken travel in its circuit around the walls of the steam-chest, thereby preserving a constant contact between the faces of the piston and the walls of the steam-chest; to improve the connection between the piston-shaft and the shaft to be driven and have the two shafts in proper alignment and the piston-shaft properly supported and guided; to furnish a support for the piston from the flange thereof by which a straight line travel of the piston across the steam-chest will be insured, and to improve generally the construction and operation of the engine as a whole; and the nature of the invention consists of the several parts and combinations of parts hereinafter described, and pointed out in the claims as new.

In the drawings, A represents the end of the case, which may be formed of a single piece or of two halves, each having a flange, by which and suitable bolts the two halves are connected together. The outer end of the case A has a flange $a$, and the inner end has a flange $a'$.

B is a cone-shaped circular chamber in the end A, which chamber at its outer end terminates in a straight wall $b$.

C is an annular chamber at the inner end of the case A, which chamber has a straight wall, and, as shown, the wall of the case A has a passage or opening $c$, closed by a cap $c'$, by which opening communication is had with the chamber C.

D is an end plate for closing the outer end of the case A, for which purpose the plate is secured to the flange $a$ by bolts $a''$, and, as shown, at one side of the plate D is a foot $d$, for the passage of the bolts $d'$ for attaching the plate to the base or support of the engine.

E are annular plates, one for each side of the steam-chest, and one of these plates E is attached to the flange $a'$ of the case A by bolts $a^3$, so as to make a steam-tight connection between the plate E and the case A, and the other plate E has an extension or wall E', forming an annular chamber C', similar to the chamber C, and the end of this chamber is closed by a plate D'', attached to a flange on the end of the wall E' by bolts $d''$. This plate D'' is solid; but the plate D has a central boss or hub D', in which is a central hole for the reception of a sleeve, as shown in Fig. 1.

F is a ring located between the plates E and secured in position between the plates by bolts $f''$, and, as shown, in order to form a firm union between the ring and the plates, each plate on its inner face has a shoulder $f'$,

and the inner face of the ring F is formed on the arc of a circle, so as to form a face or wall *f*. The ring F can be a continuous one or can be made of two half-rings, each half-ring having a flange F′, as shown in Fig. 2, by means of which and bolts $f^3$ the half-rings are joined together.

G is the steam-chest, formed between the inner face *f* of the ring F and the inner faces *g* of the plates E, and each face *g* of each plate E projects inward, as shown in Fig. 1, so that the steam-chest is wider at its periphery than at its inner edge, and the side walls of the steam-chest are of a convex shape.

H is an annular flange, the periphery of which fits and coincides with the face *f* of the ring F, and, as shown, in the periphery of the flange H are triangular-shaped packing-rings *h*″, one on each side of the center of the flange, and each packing-ring is projected and held outward by a spring *h*′, located in a recess at one side of the recess which receives the packing-ring *h*′. The flange H has on each side an inclined face *h*, the inclination of which coincides with the inclination of the walls *g*, forming on each side of the flange H a concave face coinciding with the convex face of the side walls *g* of the steam-chest, as shown in Fig. 1.

I is the abutment passing through the flange H, for which purpose the flange H has a slot or opening *i*, and this abutment cuts across the steam-chest from one side wall to the other and forms a partition separating the inlet and outlet ports for the steam, which ports are located on opposite sides of the abutment, as shown in Fig. 4. Each side wall or face *g* of the steam-chest has a groove *g*′, (shown in Fig. 5,) which groove is cut diagonally across the face or wall, and these grooves *g*′ receive the side edges *i*′ of the abutment I, by which the abutment is located at one side of the center of the flange in a diagonal plane parallel with a radial line passing through the center of the flange, which plane in its passage cuts the radial lines on the flange, except the one with which it is parallel, as shown in Fig. 2, and this abutment is inclined in its relation to the line of contact of the flange with the walls of the steam-chest for the line of contact to pass from the exhaust to the supply side of the abutment with an unbroken support in passing from the inner to the outer end of the abutment, and vice versa.

J is a ball made in two parts, one of which has a screw-threaded neck or end *j*, which enters a screw-threaded hole *j*′ in the other portion of the ball, as shown in Fig. 1, and this ball as a whole has a central annular recess *j*″, which receives the inner edge of the flange H, for which purpose the flange has a central hole for the passage of the end *j*, so that the end can be passed through such hole and the female portion of the ball be screwed to place, firmly connecting the flange H with the ball J, as shown in Fig. 1, and when connected the flange H and the ball J constitute the piston. The inner end of the abutment I fits against the face of the ball J, for which purpose this end has a circular concave face *i*″, conforming to the face of the ball, and, as shown, this inner end of the abutment is of a less width for the purpose of permitting the abutment to cut through the packing-rings for the ball without destroying the rings. The edges *i*′ of the abutment I fit snugly in the grooves *g*′ formed therefor in the inner face of each plate E, and the outer end $i^3$ of the abutment fits snugly in a groove formed therefor in the inner face of the ring F, so that when the abutment is in place it will be steam-tight and prevent the steam from passing from the supply to the exhaust without passing around the steam-chest.

K are the packing-rings for the ball J, which rings are located on opposite sides of the ball, and each ring has a bearing-face *k* of a concave shape to receive the ball, and, as shown, the packing-ring on one side has an opening or hole *k*′ for the passage of the piston-shaft.

L is a follower located in the chamber C of the end case A, and having its inner end *l* screw-threaded to enter a screw-threaded opening in the plate E, and at the inner end is a rim or flange *l*′, which bears against the end face of the packing-ring, and a similar follower L′ is located in the chamber C′ upon the opposite side of the ball J, and by means of these followers the packing-rings K can be advanced as required for wear and for the purpose of advancing the followers. Each follower has a series of holes *m*, which come in line with the opening *c*, so that by the use of a lever or other suitable tool each follower can be advanced as required.

M is a cone-shaped hole or opening through the follower L.

N is the piston-shaft, one end of which is firmly secured to the ball J at the center thereof, and this piston-shaft extends out from the ball J and enters the chamber B of the case A, as shown in Fig. 1, and is made to stand at an angle for the side faces *h* of the flange H to lie in contact with the side faces *g* of the steam-chest G and hold the flange at an angle to the center of the steam-chest to preserve a line of contact between the flange and the steam-chest.

O is a cone-shaped head lying in the chamber B and the opening M, and having on one side a groove *o* to receive boxes *n*, in which the piston-shaft N is supported, and these boxes *n* can be an inner and outer box, as shown in Fig. 1, or a continuous box, as shown in Fig. 6.

P is a shaft to be driven, entering at its inner end the head O at the center of the head and secured to the head by a key *p*, and this shaft P and the piston-shaft N are to be in the same plane one with the other, for which purpose the groove *o* and the hole for the shaft P are in line one with the other.

Q is a sleeve, through which the shaft P passes, and this sleeve at its inner end enters

the head O for the head to revolve thereon, and is secured in the hub or center D′ by a set-screw *q*, by means of which the sleeve Q is locked against turning.

R is a channel across the face *f* of the ring F, which channel runs in a straight line across the steam-chest, as shown in Fig. 4.

S is a sliding block located in the channel R and fitting snugly in the channel, so as to be free to move back and forth across the steam-chest. This block has a hole *s*, which receives the end of a pin *r*, firmly secured in the periphery of the flange H.

T is a plate attached to the side of the steam-chest on the ring F and plates E by bolts *t*.

U is an opening in the plate T to receive a pipe for supplying steam to the steam-chest G, which opening U communicates with a supply-port *u* in the ring F, leading into the steam-chest on one side of the abutment I.

V is an opening in the plate T to receive a pipe for the exhaust of the steam, for which purpose the opening V communicates with an exhaust-port *v*, leading from the steam-chest G on the opposite side of the abutment I. The channel or groove R, as shown, is located in line with the exhaust-port *v* and is wider than the exhaust-port, so as to form a bottom for the block S, and, as shown, leading from the exhaust-port on each side of the channel R is a hole W to insure a proper exhaust in case the exhaust-port is not of a sufficient size for exhausting purposes.

W is a base or support on which the engine as a whole is mounted, and to which the engine is secured by the foot *d*, the bolts *d′*, the feet *e*, and the bolts *e′*, as shown in Fig. 1.

The abutment I is held for its end *i″* to be in contact with the face of the ball by adjusting-screws *z*, passing through holes in the plate T and entering screw-threaded holes in the ring F, and, as shown, between the ends of the screws *z* and the edge *i*³ of the abutment are coiled springs *z′*, which give a yielding pressure for the abutment I on the ball J.

The parts are assembled by entering the packing-ring K into its plate E and attaching such plate to the end of the case A by the flange *a′* and the bolts *a*³. The follower L is inserted in the chamber C and screwed into the plate E for its end *l′* to abut against the packing-ring K. The ball J, with the flange H secured thereto, is placed in position for the ball to enter the packing-ring E. The ring F is attached to the plate E by the bolts *f″* to surround the flange H. The abutment I is slipped into place, passing through the slot *i* and entering at its edge *i′* into the groove *g′* for its end *i″* to lie against the ball and its end *i*³ in the groove therefor in the ring F. The plate E, with the wall E′, having the packing-ring K therein, is attached to the ring F by the bolts *f″* for the packing-ring to receive the ball J and the groove *g′* to receive the edge *i′* of the abutment I. The follower L′ is inserted in the chamber C′ and screwed into the plate E for its end *l′* to abut against the packing-ring K. The plate D″ is attached to the end flange of the wall E′ by the bolts *d″* closing that end of the engine. The head O is entered into the chamber B and connected with the shaft N by the groove *o* and the box or boxes *n*. The shaft P is secured in the head O by the key *p*. The sleeve Q is slipped onto the shaft P and into the end of the head O, and the plate D is attached to the end of the case A by the flange *a* and the bolts *a″* with the sleeve Q in the hub or center D′, where it is locked and held by the set-screw *q*, and this sleeve Q can be used to force the head O forward to set the shaft N at the proper inclination, and the plate T is attached in position by the bolts *t*, and when the several parts are together the engine as a whole is attached to the base or support W by the feet *d e* and the bolts *d′ e′*.

The packing-rings K are made to fit the ball J by advancing the followers L and L′, and when the engine is in position a steam-supply pipe is attached to the plate T at the opening U, and a steam-exhaust pipe is attached to the plate T at the opening V, so that steam is supplied through the opening U and the port *u* to the chamber G on each side of the flange H, and steam is exhausted from the chamber G on each side of the flange H through the exhaust-port *v* and the opening V, and the steam supplied through the supply-port *u* will pass entirely around the chamber G to the exhaust-port *v*, and such passage will be continuous.

In use the steam entering the supply-port *u* and passing around in the chamber G to escape at the exhaust-port *v* will carry the flange H back and forth across the steam-chamber G by the steam acting first on one side of the flange H and then on the opposite side as such flange changes its position in relation to the supply-port. This moving of the flange H to and fro across the chamber G causes the faces *h* of the flange to roll against the walls *g* of the steam-chamber on both sides, and this rolling movement is had by the turning of the ball J in its socket, formed by the packing-rings K, and from this rolling movement the end of the piston-shaft N is made to describe a circle, imparting a rotary movement to the head O, which movement is transmitted to the shaft P, driving such shaft.

The flange H and the ball J form a piston, from the movement of which the shaft N is made to describe a circle, and the position of the piston in relation to the abutment and the movement of the piston-shaft in the circle described by its end are shown by the diagrams Figs. 9, 10, 11, and 12. The diagram Fig. 9 shows the flange in relation to the abutment and the position of the piston-shaft N when the flange has moved one-half of the distance across the abutment in the direction of the arrow, or to the right, and in this position the contact-line of the flange with the walls of

the steam-chest is one-quarter of the distance around, and steam is supplied to the chamber G through the port *u* on both sides of the flange H, and steam is exhausted from both sides of the flange H through the port *v* when the parts are as shown in Fig. 9. The continued movement of the flange H in the direction of its travel to the right carries the flange over the abutment to the right-hand side, as shown in Fig. 10, in which position the contact-line between the flange and the walls of the steam-chest has been advanced another quarter and the shaft N has been carried to the position shown in Fig. 11, which is a half-revolution, and with the parts in the relation of Fig. 11 the periphery of the flange on the right-hand edge has passed both the inlet-port *u* and the exhaust-port *v* and closed both of such ports at the right-hand side of the abutment. At this point the flange H begins its return movement across the steam-chest over the abutment I in the direction of the arrow in Fig. 11, and when the contact-line between the flange H and the walls *g* of the steam-chest G has been advanced another quarter the flange H has traveled across the steam-chest to the position shown in Fig. 11 and the shaft N has been carried around to the position of Fig. 11 and has described a three-quarter revolution, and with the parts in this position steam is supplied through the port *u* to both sides of the flange H and steam is exhausted from both sides of the flange H through the port *v*. The advance of the contact-line between the flange and the walls of the steam-chest for another quarter carries the parts into the position shown in Fig. 12, in which the flange has traveled back across the steam-chest and over the abutment I to close the supply-port *u* and the exhaust-port *v* on the left-hand side of the abutment, and in this position the flange H has made an entire traverse across the steam-chest and is ready to be carried back in the direction of travel shown in Fig. 9, and with this direction of travel the contact-line between the flange H and the walls of the steam-chest G when carried around another quarter will bring the parts into the position shown in Fig. 9, and these movements of the flange back and forth across the steam-chest will continue as long as steam is supplied to the chamber G. The position shown in Fig. 9 may be regarded as having the contact-line between the flange H and the steam-chest G advanced one-quarter around from the starting point, which is the abutment, and in this position the end of the shaft N has described a quarter-circle, and with the parts as shown in Fig. 10 the contact-line between the flange and the walls of the steam-chest has advanced one-half the distance around and the shaft N has described half a circle, and with the parts as shown in Fig. 11 the contact-line between the flange and the walls of the steam-chest has advanced three-quarters of the distance around and the shaft N has described three-quarters of a circle, and with the parts as shown in Fig. 12 the contact-line between the flange and the walls of the steam-chest has completed its travel around and the shaft has described a complete circle when the abutment is used as a starting-point.

It will be seen from the foregoing description and the diagram illustrations that, except at two points—namely, the limit of the travel of the flange H in both directions across the steam-chest G—steam is admitted on both sides of the flange at the supply-port at all times and travels around from the supply side of the abutment in the space between the flange H, the side walls of the steam-chest, and the abutment on both sides of the flange to the exhaust-port, the result being a constant supply of steam, which travels continuously, moving the flange H to and fro across the steam-chest through the pressure of the steam in the chest against the abutment on the supply side and against the walls of the steam-chest and the faces of the flange, and it will be seen that in the initial start in either direction the opening for the steam is very small and gradually widens as the flange is carried across the steam-chest until half a circle has been described, when the steam space between the flange and the wall of the steam-chest gradually narrows for the remaining travel of the flange.

The piston formed by the flange H and the ball J is supported in the steam-chest G for the flange to have a contact-line with the walls of the steam-chest by the piston-shaft N and the head O, and the steam-chest is divided by the abutment I, so as to have a supply and exhaust side.

The angle of the piston-shaft N is changed for the proper contact between the flange H and the walls *g* of the steam-chest by adjusting the head O through the sleeve Q or in any other suitable manner, and the ball J is held in position by the packing-rings K, which form a socket for the ball, by which the ball is supported, and in case of wear the packing-rings can be advanced to take up the wear by turning the followers L and L′ through the holes *m* and a suitable lever inserted through the opening *c* into a hole *m* in line with such hole, and after the follower has been advanced the tool can be removed and the hole *c* closed by the cap or cover *c′*, and this advance of the packing-rings K through the followers L will be uniform and equal at all points by reason of the engagement of the rim *l′* with the packing-ring its entire circle.

The flange H should move over the abutment without contact, and this end is secured by means of the channel R and the block S, which travels back and forth in the channel by reason of its attachment to the flange H through the pin *r*, and as the channel R is in a straight line across the steam-chest G and the block S moves in this channel it follows that the flange H must also move in a straight

line across the steam-chest, which line is likewise the line of the abutment I, and as the space or opening *i* in the flange H is a trifle wider than the thickness of the abutment I the edges of the flange at the opening *i* will not come in contact with the abutment I, as the flange cannot vary in its course across the steam-chest. The connection of the shaft N with the head O, as shown in Fig. 1, is by an inner and outer box *n* and the groove *o*, and, as shown in Fig. 6, this connection is had by the use of a continuous box *n* and the groove *o*, and in place of using these boxes *n* the shaft N can be connected with the head O by a hole formed in the head to receive the end of the shaft; but in any event the groove *o* and the hole in the head O, which receives the ends of the shaft P, must be in the same plane one with the other, with the hole for the shaft P at the center of rotation of the head O, which center is the center of the ball J. The attachment of the shaft N to the head O by the boxes *n* enables any slight variation in the alignment to be readily taken up by setting the box *n* accordingly, and for this reason the boxes *n* afford the best means for attaching the piston-shaft N to secure proper alignment.

The wear on the edge or periphery of the flange H is compensated for by the packing-rings *h''*, which are held against the wall *f* of the chamber G by the action of the springs *h'*, preventing the passage of steam from one side to the other of the flange H, except by passing around from the supply to the exhaust side of the abutment and what little steam passes through the opening *i*. Such steam will in no way affect the operation of the piston, as the pressure of the steam on both sides of the flange H is always in a direction to move the flange in the same direction, and by holding the flange H clear of the abutment at the opening *i* wear on the abutment from the travel of the flange H is prevented, and consequently wear on the flange to increase the size of the opening *i*.

The word "diagonal" in connection with an abutment is a defining word, indicating the position of the abutment in relation to the flange and steam-chest as tangential with its outer or starting point in line, or nearly so, with the periphery of the ball, and its inner or terminal point in or near a vertical line from the center of the ball for the line of the abutment to be outside of the piston-shaft, as clearly shown in Fig. 2, and the line of tangentity is one at an angle of forty-five degrees, or approximately so, to a horizontal base or other line. This diagonal abutment is in no sense a straight-line radial abutment nor an inclined-line radial abutment, in both of which constructions the radiation is in a direct line from the piston-shaft, and with such direct-line radiation the abutment is subjected to a blow from the piston at each revolution because of the drop of the piston, and the result of the continuous blows is a wearing out of the abutment at the center, allowing an increased back swing for the piston, and such back swing produces a backlash on the piston-shaft, causing an uneven motion and not a true circle traverse of the shaft, and the travel of the piston over the abutment is a broken interrupted one by reason of the drop off and the wearing of the abutment out at the center and produces more or less jar and concussion. The diagonal abutment obviates all these defects of a radial abutment, as it gives a continuous unbroken support, over which the piston constantly travels without any drop, thus preventing back swing of the piston and backlash of the shaft and giving the shaft a true circle of rotation.

What I claim as new, and desire to secure by Letters Patent, is—

1. The combination, in an engine, of an annular steam-chest, a piston in the steam-chest formed of a flange and a ball, with the flange at the center of the ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, and a piston-shaft projecting at one side of the piston from the center of the ball transversely to the flange, substantially as and for the purposes specified.

2. The combination, in an engine, of a steam-chest, a piston in the steam-chest formed of a flange and a ball, with the flange at the center of the ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball transversely to the flange, and a head receiving and supporting the piston-shaft in an inclined position, substantially as and for the purposes specified.

3. The combination, in an engine, of a steam-chest, a piston formed of a flange and a ball, with the flange at the center of the ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball transversely of the flange, a head receiving and supporting the piston-shaft, and a center bearing for the ball, substantially as and for the purposes specified.

4. The combination, in an engine, of a steam-chest, a piston in the steam-chest formed of a flange and a ball, at the center of which the flange is located and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball transversely to the flange, a head receiving and

supporting the piston-shaft, a center bearing for the ball, and a connection between the piston-flange and the steam-chest, substantially as and for the purposes specified.

5. The combination, in an engine, of a steam-chest, a piston in the steam-chest formed of a flange and a ball, with the flange at the center of the ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball transversely to the flange, a center bearing for the ball, a connection between the flange and the face of the steam-chest, and a driven shaft connected to the head, substantially as and for the purposes specified.

6. The combination, in an engine, of a steam-chest having convex contact-walls, a piston in the steam-chest formed of a flange having concave side faces and a ball, with the flange at the center of the ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, and a piston-shaft projecting at one side from the center of the ball transversely of the flange, substantially as and for the purpose specified.

7. The combination, in an engine, of a steam-chest having convex contact-walls, a piston in the steam-chest formed of a flange having concave side faces and a center ball traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball, and a head receiving and supporting the piston-shaft, substantially as specified.

8. The combination, in an engine, of a steam-chest having convex contact-walls, a piston in the steam-chest formed of a flange having concave side faces and a center ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball, a head receiving and supporting the piston-shaft, and a center bearing for the ball, substantially as and for the purposes specified.

9. The combination, in an engine, of a steam-chest having convex contact-walls, a piston in the steam-chest formed of a flange having concave side faces and a center ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball, a head receiving and supporting the piston-shaft, a center bearing for the ball, and a connection between the flange and the face of the steam-chest, substantially as and for the purposes specified.

10. The combination, in an engine, of a steam-chest having convex contact-walls, a piston in the steam-chest formed of a flange having concave side faces and a center ball and traversing the steam-chest on straight lines and rolling against the walls of the steam-chest, an abutment cutting the flange diagonally at one side of the center of the piston, a piston-shaft projecting at one side from the center of the ball, a head receiving and supporting the piston-shaft, a center bearing for the ball, a connection between the flange and the face of the steam-chest, and a driven shaft connected to the head, substantially as and for the purposes specified.

11. The combination, in an engine, of a piston formed of a flange and a center ball, a piston-shaft projecting at one side from the center of the ball, and a head receiving and supporting the projected part of the piston-shaft at both the outer and inner ends and holding the piston inclined, substantially as and for the purposes specified.

12. The combination, in an engine, of a piston formed of a flange and a center ball, a piston-shaft projecting at one side from the center of the ball, a head receiving and supporting the projected part of the shaft at both the outer and inner ends, and a shaft secured to the head and driven thereby, substantially as and for the purpose specified.

13. The combination, in an engine, of a piston formed of a flange and a center ball, a piston-shaft projecting at one side from the center of the ball, a head receiving and supporting the shaft, and a connection between the piston-flange and steam-chest, substantially as and for the purposes specified.

14. The combination, in an engine, of a piston formed of a flange and a center ball, a piston-shaft projecting at one side from the ball at the center, a head receiving and supporting the piston-shaft, a driven shaft connected to the head, and a connection between the flange of the piston and the wall of the steam-chest, substantially as and for the purposes specified.

15. The combination, in an engine, of a piston formed of a flange and a center ball, a piston-shaft projecting at one side from the center of the ball, and a cone-shaped head receiving and supporting the piston-shaft at both the outer and inner ends in an inclined relation, substantially as and for the purposes specified.

16. The combination, in an engine, of a piston formed of a flange and a center ball, a piston-shaft projecting at one side from the center of the ball, a cone-shaped head receiving and supporting the piston-shaft at both the outer and inner ends, and a driven shaft connected with the head, substantially as and for the purposes specified.

17. The combination, in an engine, of a piston formed of a flange and a center ball, a

piston-shaft projecting at one side from the center of the ball, a cone-shaped head receiving and supporting the shaft, and a connection between the piston-flange and the wall of the steam-chest, substantially as and for the purposes specified.

18. The combination, in an engine, of a piston formed of a flange and a center ball, a piston-shaft projecting at one side from the center of the ball, and a cone-shaped head receiving and supporting the piston-shaft, a driven shaft, and a connection between the flange and face of the steam-chest, substantially as and for the purposes specified.

19. The combination, in an engine, of a piston-shaft and a head receiving and supporting the projected part of the piston-shaft at both the outer and inner ends for maintaining the shaft at an inclination, substantially as and for the purpose specified.

20. The combination, in an engine, of a piston-shaft, a head receiving and supporting the projected part of the piston-shaft at both the outer and inner ends, and a connection between the piston and the wall of a steam-chest, substantially as and for the purpose specified.

21. The combination, in an engine, of a piston-shaft, a head receiving and supporting the projected part of the piston-shaft at both its outer and inner ends, a driven shaft attached to the head, and a connection between the piston and the wall of the steam-chest, substantially as and for the purpose specified.

22. The combination, in an engine, of a piston-shaft and a cone-shaped head receiving and supporting the shaft at both its outer and inner ends and attached to a shaft to be driven, substantially as and for the purpose specified.

23. The combination, in an engine, of a piston-shaft, a cone-shaped head receiving and supporting the piston-shaft at both the outer and inner ends and attached to a shaft to be driven, and a connection between the piston and the face of the steam-chest, substantially as and for the purpose specified.

24. The combination, in an engine, of a flange and a ball forming a piston, a piston-shaft projecting at one side from the center of the ball, an abutment cutting the flange diagonally, and a cone-shaped head receiving and supporting the piston-shaft and attached to a shaft to be driven, substantially as and for the purposes specified.

25. The combination, in an engine, of a flange and ball forming a piston, a piston-shaft projecting at one side from the center of the ball, an abutment cutting the flange, and a head receiving and supporting the piston-shaft and attached to a shaft to be driven, and a connection between the flange and the face of a steam-chest, substantially as and for the purpose specified.

27. The combination, in an engine, of a flange and ball forming a piston and a connection between the flange and face of a steam-chest for holding the piston in straight-line travel, substantially as specified.

28. The combination, in an engine, of a steam-chest having contact-walls with a diagonal groove and an abutment held by the diagonal grooves and dividing the steam-chest, substantially as and for the purposes specified.

29. The combination, in an engine, of a piston formed of a flange and a center ball, an abutment cutting through the flange and engaging the face of the ball, and devices for moving the abutment to preserve the contact with the ball, substantially as and for the purposes specified.

30. The combination, in an engine, of a piston formed of a flange and a center ball, an abutment cutting through the flange and bearing against the face of the ball, and adjusting-screws for advancing the abutment to compensate for wear against the ball, substantially as and for the purposes specified.

31. The combination, in an engine, of a piston formed of a flange and a center ball, an abutment cutting through the flange and bearing against the face of the ball, set-screws for advancing the abutment, and tension-springs for holding the abutment in contact with the ball, substantially as and for the purposes specified.

32. The combination, in an engine, of the piston-shaft N, projecting at one side of the piston, and the head O, receiving and supporting the projected part of the piston-shaft at both the outer and inner ends, substantially as and for the purposes specified.

33. The combination, in an engine, of the piston-shaft N, projecting at one side of the piston, the head O, receiving and supporting the projected part of the piston-shaft N at both its outer and inner ends, and the driven shaft P, connected with the head O, for holding the shaft N at an inclination, substantially as and for the purpose specified.

34. The combination, in an engine, of the flange H and ball J, forming a piston, the piston-shaft N, projecting at one side of the piston, the head O, receiving and supporting the shaft N, and the sliding block S, connecting the flange with the wall of the steam-chest, substantially as and for the purpose specified.

35. The combination, in an engine, of the steam-chest G, the flange H, and ball J, forming a piston, the piston-shaft N, projecting at one side of the piston, the head O, receiving and supporting the shaft N, the channel R, and the sliding block S, connected with the flange H, substantially as and for the purposes specified.

36. The combination, in an engine, of the steam-chest G, flange H, and ball J, forming a piston, the piston-shaft N, projecting at one side of the piston, head O, receiving and supporting the shaft N, driven shaft P, channel R, and sliding block S, substantially as and for the purpose specified.

37. The combination, in an engine, of the steam-chest G, having walls *g*, flange H, having faces *h*, and ball J, forming a piston, the piston-shaft N, projecting at one side of the ball J, head O, receiving and supporting the piston-shaft, the shaft P, and the channel R, and sliding block S, forming a connection between the flange H and the steam-chest, substantially as and for the purpose specified.

38. The combination, in an engine, of the steam-chest G, having convex side walls *g*, the flange H, having concave side faces *h*, and the ball J, forming a piston, the abutment I, cutting the flange diagonally at one side of the center, and the piston-shaft N, projecting at one side from the center of the ball J and supported by the head O, substantially as and for the purpose specified.

39. The combination, in an engine, of the steam-chest G, the piston formed of the flange H and the center ball J, the packing-rings K, receiving the center ball J, and the screw-threaded followers L and L′, forming a firm backing for and simultaneously and uniformly advancing the packing-rings to take up wear, substantially as specified.

40. The combination, in an engine, of the steam-chest G, the piston formed of a flange H and a center ball J, the packing-rings K, receiving the center ball J, the piston-shaft N, projecting at one side from the center of the ball J, and the head O, receiving and supporting the shaft N at both its outer and inner ends, substantially as and for the purpose specified.

41. The combination, in an engine, of a steam-chest G, the piston formed of the flange H and a center ball J, the abutment I, the packing-rings K, receiving the center ball J, the piston-shaft N, projecting at one side from the center of the ball J, and the head O, receiving and supporting the shaft N at both its outer and inner ends, substantially as and for the purposes specified.

42. The combination, in an engine, of a steam-chest G, the piston formed of the flange H and a center ball J, the abutment I, the packing-rings K, the screw-threaded followers L L′, engaging the full face of and forming a firm backing for the packing-rings, the piston-shaft N, projecting at one side from the center of the ball J, the head O, receiving and supporting the piston-shaft, the shaft P, and the channel R, and block S, substantially as and for the purpose specified.

43. The combination, in an engine, of a steam-chest, having contact-walls, a piston in the steam-chest formed of a flange and a center ball, and an abutment dividing the steam-chest and cutting the flange of the piston on a diagonal line for giving the piston an uninterrupted traverse, substantially as and for the purposes specified.

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Witnesses:
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