(No Model.) 3 Sheets—Sheet 1.

H. KNEBEL & A. HENNING.

ROTARY ENGINE.

No. 420,347. Patented Jan. 28, 1890.

Fig. 1.

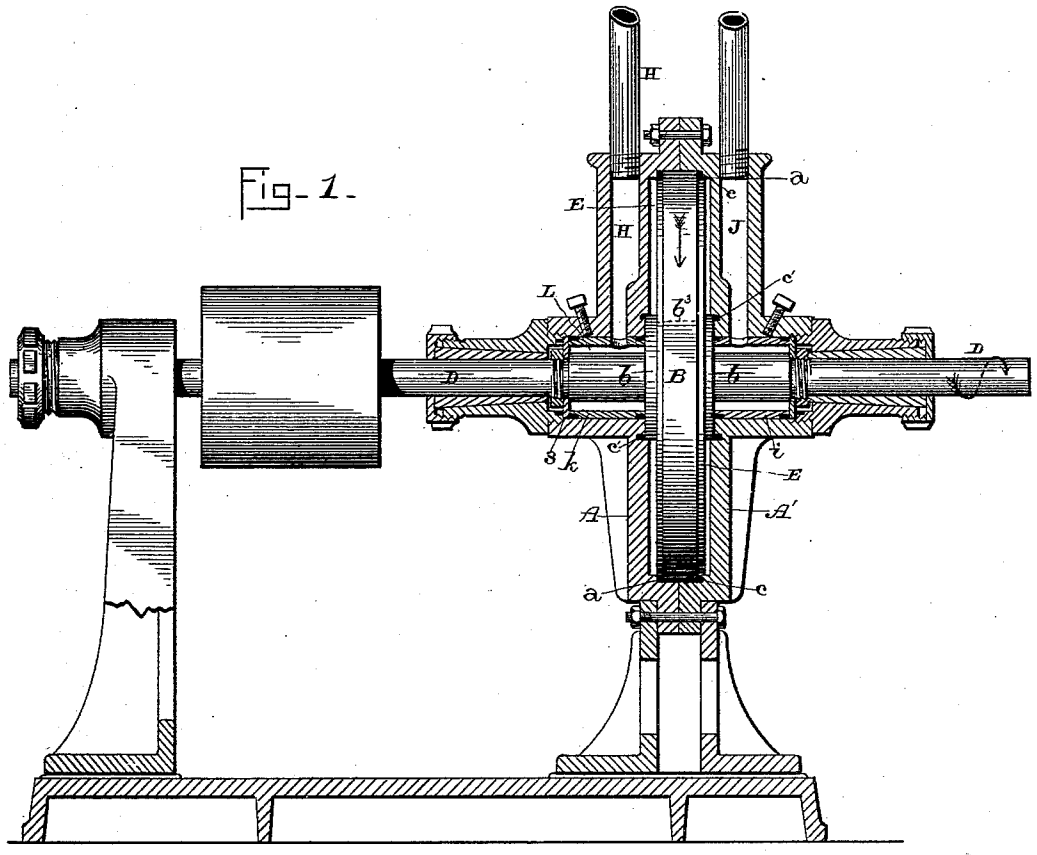


Fig. 2.

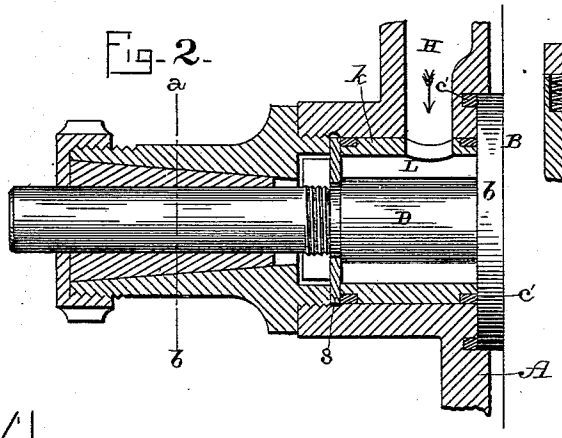


Fig. 2a.

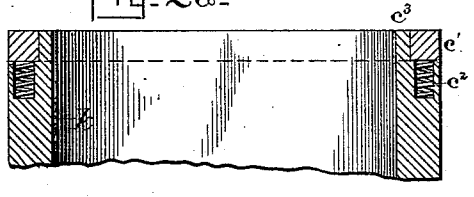
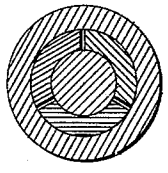


Fig. 3.



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Fig. 7.

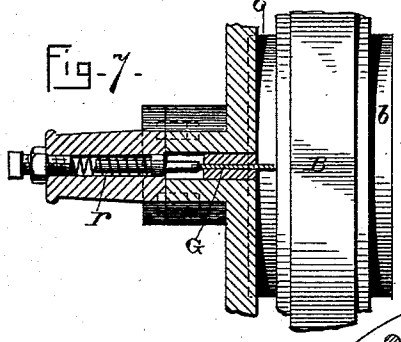


Fig. 6.

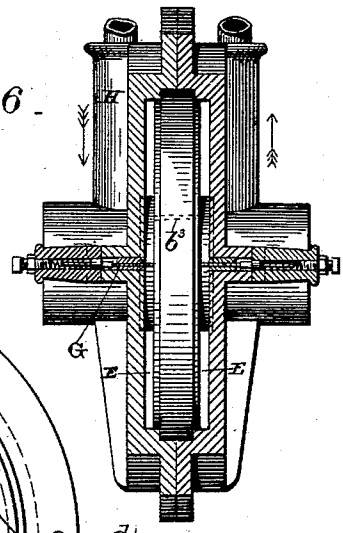


Fig. 4.

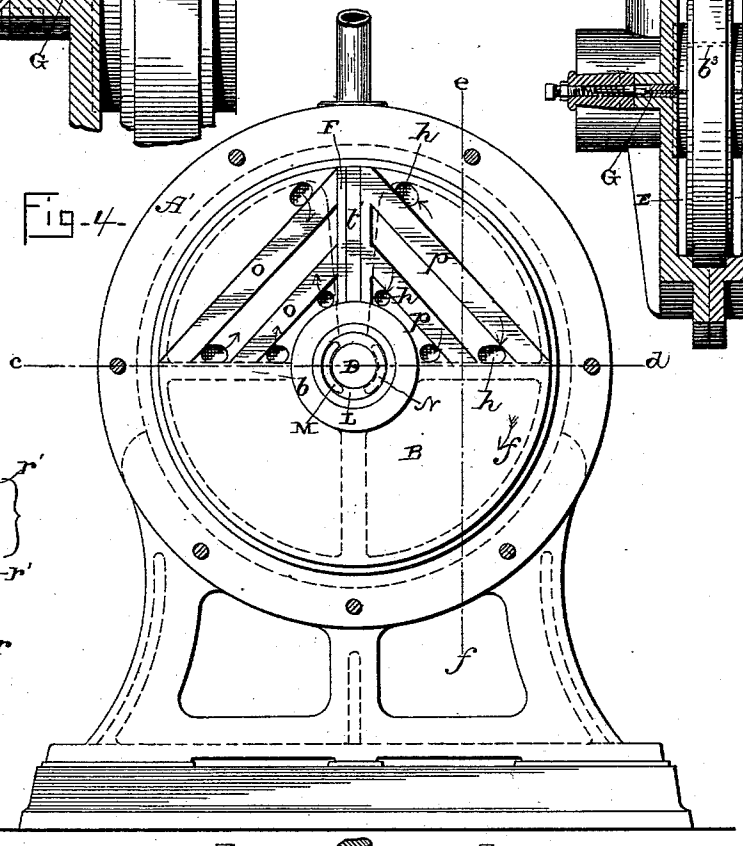


Fig. 8.

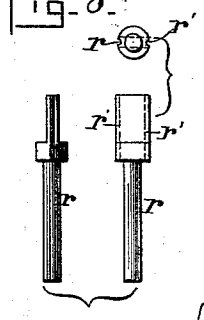
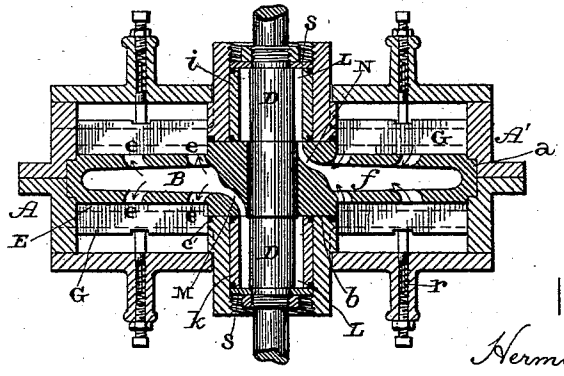


Fig. 5.



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Fig. 9.

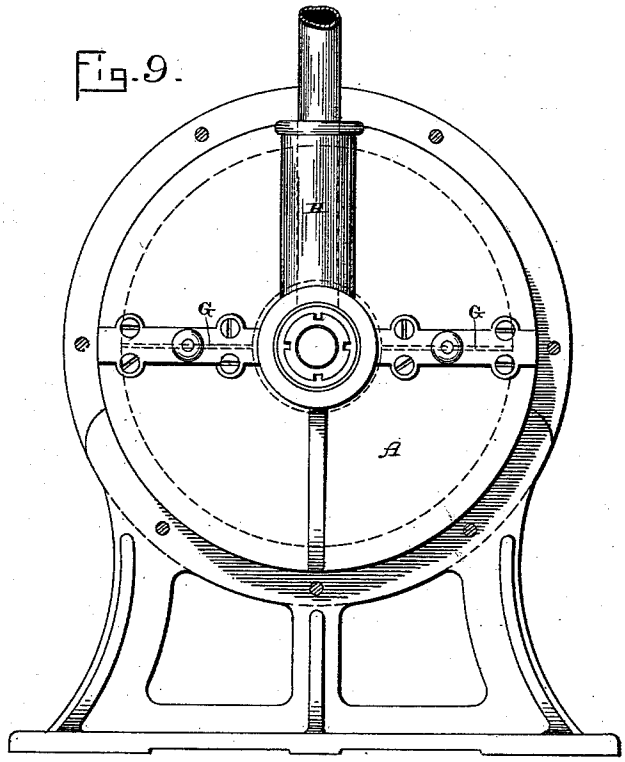


Fig. 10.

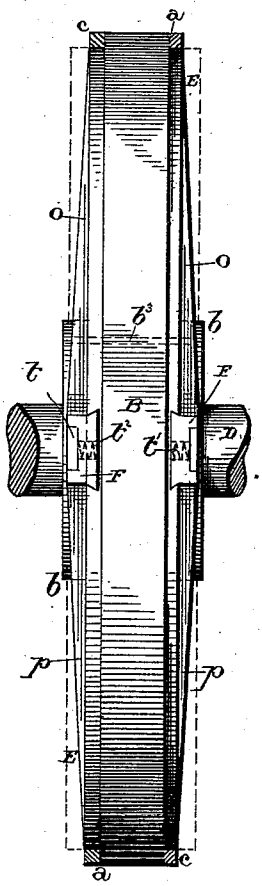
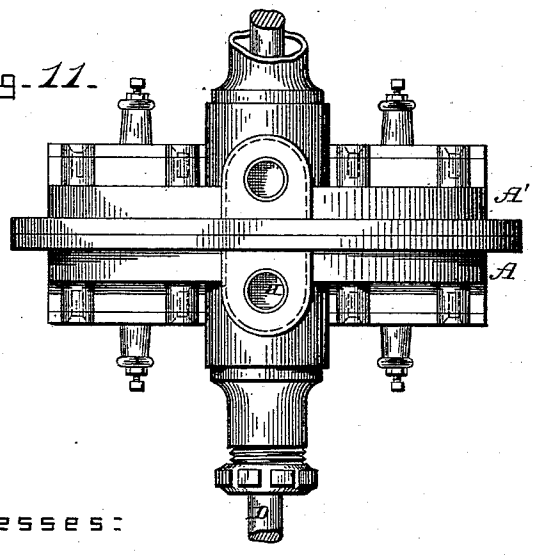


Fig. 11.



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UNITED STATES PATENT OFFICE.

HERMAN KNEBEL AND AUGUST HENNING, OF BIRMINGHAM, ALABAMA, ASSIGNORS TO THE BIRMINGHAM ROTARY MOTOR COMPANY.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 420,347, dated January 28, 1890.

Application filed February 21, 1889. Serial No. 300,785. (No model.)

To all whom it may concern:

Be it known that we, HERMAN KNEBEL and AUGUST HENNING, both residing at Birmingham, Jefferson county, in the State of Alabama, have invented a new and useful Rotary Motor, of which the following is a specification.

Our invention relates to improvements in rotary motors in which a fluid under pressure, be it steam, water, gas, air, or the like, is acting upon a directly-rotating piston within a casing, in conjunction with reciprocating plates which we call "head-plates," which divide the annular space within which the piston rotates into two compartments, and which are pushed aside automatically by cams connected with the piston in such a way as to allow the piston to pass them and immediately afterward close behind the piston.

The objects of our improvements are, first, to provide for continuous pressure of the driving-fluid on one side of the piston and for a continuous exit of the fluid after its action upon the piston; second, to reduce as far as possible the momentum of the reciprocating head-plates by reducing to the practicable limits their weight as well as the length of their stroke, in order to be enabled to run the motor at an extremely-high speed without danger to the good working order of the parts in movement; third, to provide for suitable packing devices in order to obtain a gas or water tight joint between the movable and the stationary parts without causing an excess of friction; fourth, to provide for means to counterbalance and equalize the pressure of the driving-fluid upon said packing devices, so that any unnecessary friction is avoided, and fifth, to provide for such an arrangement of the structure as to avoid pressure upon the shaft of the motor. We attain these objects by the construction illustrated in the accompanying drawings, in which—

Figure 1 is a vertical section of the motor, taken in a plane in line with the axis of rotation. Fig. 2 is an enlarged section of the journal-boxes of the shaft and of the packing devices of the latter. Fig. 2^a is a section showing a detail of the packing devices. Fig. 3 is a section on line *a b* of Fig. 2, showing the segments of the metal bearing arranged around the shaft. Fig. 4 is a front view of the motor, one side of the casing being removed, showing face of rotating parts. Fig. 5 is a horizontal section on line *c d* of Fig. 4. Fig. 6 is a section on line *e f* of Fig. 4. Fig. 7 shows enlarged the arrangements of the head-plates, seen also in Fig. 6. Fig. 8 is an enlarged detail of the head-plate mechanism. Fig. 9 is a front view of the motor. Fig. 10 is a side view of the rotating disk and piston. Fig. 11 is a top view of the motor, showing the principal part of it.

Similar letters refer to similar parts throughout the several views.

A and A′, Fig. 1, are the equally-shaped parts of the casing flanged together in a vertical plane to the axis.

B is a disk fastened to and rotating with the shaft D. It is on its circumference provided with an annular projection *a*, which fits in a corresponding groove in the middle of the casing.

c c represent packing-rings effecting an air or water tight contact in the said groove with the possible minimum of friction. The disk has on each side a hub *b*, fitting in a recess on the inner sides of the casing. Packing-rings *c′ c′* serve the same purpose as the before-mentioned ones. Disk and casing have smooth and correctly-worked surfaces. As shown in the drawings, and especially by Figs. 1 and 6, a space E is left between the casing and the disk on each side of the latter. In this annular space is running the piece which serves the purpose of piston, and which we will call, therefore, "piston" in the course of this specification. Such a piston moves in each of the two spaces E. Each consists of a rectangular block F, Figs. 4 and 10, of suitable width and in its length and thickness fitting exactly in the section of the space E, and is securely screwed or dovetailed to the face of disk B. The face toward the casing is provided with an elastic packing-plate in order to secure an air and water tight joint on the side, as well as the circumference of the casing. This packing-plate will be more fully described later on in this specification.

On each of the two faces of the casing A A′ and rectangular to the disk B are cut two slots, (shown distinctly in Figs. 5, 6, 7, and 9,)

in each of which is inserted a thin straight rectangular plate G, preferably made of tempered steel, which is made to reciprocate in the said slot easily but snugly toward and from the face of the disk B, the front edge of the plate bearing against the face of the disk or in turn against the cams *o* and *p*. These plates, lying in a plane coinciding with the axis of the disk, divide the space E into two halves. We call them "abutments," on the ground of their analogy to the cylinder-heads in a common reciprocating engine. This will be seen by the following: The driving medium, be it steam, water, gas, air, or the like, enters the casing through a pipe H, Figs. 1 and 2, goes through a perforation in the ring *k* into annular space L around the shaft, from where it enters a port M in face of the hub *b*, (see Figs. 4 and 5,) which leads to the interior of hollowed-out disk B. Fig. 4 shows in dotted lines four hollowed-out spaces. The upper one to the left hand is the receiver of the driving-fluid. The upper right-hand one is the receiver of the exhaust or waste fluid, from where it escapes to the atmosphere. The two lower ones are solely made for the purpose of counterbalancing the disk—that is to say, to have its center of gravity coincident with its geometrical center. The arrows in Figs. 5 and 6 indicate the direction of the driving-fluid. It enters through the ports *e* from the interior of the disk the space E on each side of the said disk, thus admitting the fluid into the space between the head-plates G on the left and the piston F, driving the latter forward in the direction of the arrow *f* and carrying the disk with it. The ports *h* on the right side of the piston F take up the exhaust-fluid behind the piston and conduct it into the interior of the upper right-hand quarter of the disk, from where it is carried through a port N, similar in size and shape to the port M, and through another in the ring *i* into the exhaust-pipe J. The ports in the face of the disk, those in the face of the hub thereof, as well as those in the rings *k* and *i*, are in shape, position, and size the same on both sides of the disk. It will be seen therefrom that the motor can easily be reversed by changing the direction of the driving-fluid, thus reversing inlet into outlet. It is obvious that this can be done by a reversing-valve which connects inlet with outlet pipe, and vice versa.

In the position of the disk B as shown in Figs. 4 and 5 the four head-plates G bear against the plane face of the disk, thus dividing the interior of the casing into an upper and a lower compartment; but as the disk goes on with its revolution in the direction of the arrow *f* the cam-plates *p*, which taper from a point in line with the smooth face of the disk up to the thickness of the piston F, will wedge between the head-plates (on the right hand this time) and push them aside, thus making way for the passage of the piston F. The points of the tapered cams are, however, a certain distance apart from the dividing-line which the head-plates occupy, and this arrangement effectuates the escape of the waste fluid from the lower compartment immediately before the head-plates separate. This is analogical to the exhaust of the steam in an ordinary engine before the piston reaches the end of its stroke. The exit of the waste fluid will continue during the entire passage of the cams *h* and *o* and piston F through the cam-plates on the left side. At the end of this passage the cams and the piston will have the reverse position from that they occupy in Fig. 4. The head-plates on the right hand will have closed upon the face of the disk and the pressure of the fluid will find an abutment on them in pushing the piston forward. This shows that the head-plates are analogical to the cylinder-heads in an ordinary engine in respect to the piston thereof. Then the exhaust-ports next to the tapering end of the cams will pass first and then the cams *o* will begin to push aside the head-plates on the left hand, and the above-described operation of the exit will take place in the upper compartment above the head-plates.

From the above description it will be clearly seen that there is no dead-space or lost space, the channels through which the live fluid enters always being filled with live fluid or steam and the exhaust-channels always being connected with the atmosphere. There is nothing in this motor to prevent connection of a condenser with it in case it is desirable to operate it with a condensible fluid. That the supply can be cut off at any point of a half-revolution (from head-plate left to head-plate right hand) and the remainder of the half-revolution can be worked by expansion is easily conceivable. The device to operate a cut-off will be described later on.

It remains to describe now some details of the construction. Disk, piston, and cams are shown in Fig. 4. The disk, as already stated, is a hollow circular flat plate shrunk and fastened to its shaft. The circumference fits and rotates in a groove of the casing. A spring-ring on each side of the disk performs the function of preventing any escape of pressure. The hub on its outer rim bears equally against a spring-ring *c'*, as shown in Figs. 1 and 5. The hub of the casing, in conjunction with a ring *k*, called by us the "bull-ring," form a hollow space around the shaft. The bull-ring is on each of its ends provided with a spring-ring, one of which bears against the face of the hub of the disk, the other one bearing against a washer *s*, rigidly secured to the shaft by a nut. These spring-rings are constructed in the manner in which ordinary piston-rings are made. They are elastic and split open and spring in the direction of their circumference. Small spiral springs in the bottom of the grooves in which these rings are embedded press the flat faces of these rings against the face of the body where

a water or air tight connection is desirable or necessary. (See Fig. 2^a.) It is necessary to provide an exit for such steam, water, &c., that may happen to enter into these grooves, in order to leave the springs their free play. For this purpose small channels are worked in the bottom of the grooves to release the steam or other fluid inclosed behind the ring. In Fig. 2^a such an arrangement is shown, where c' represents a piece of the spring-ring, c^2 the spiral spring, and c^3 the channel for the escape of the inclosed fluid.

The piston F, Figs. 4 and 10, is a rectangular block of suitable metal, preferably tempered steel, mortised or dovetailed into the face of the disk. (See Fig. 10.) The front face of the piston is provided with a slot through its entire length, in which is inserted a flat key t'. This latter is pressed against the face of the housing by one or more small spiral springs t^2. A similar arrangement is made on the end face of the piston-block where it touches the circumference of the casing. This arrangement, being quite analogous to the one just described, is not shown in the drawings, and hardly needs any particular description.

In Figs. 1, 10, and 6 is shown a small passage b^3, leading from one face of the hub of the disk to the other face. It has the purpose of equalizing the pressure against these faces, and thus preventing the disk from being pushed sidewise. By the described arrangement of the two bull-rings with their spring-rings on the hub of the disk, the spring-rings on the end toward the washer, the spring-rings on the circumference of the disk, and, finally, the above-mentioned spiral springs and small channels and the passage for the escape and the equalizing of the pressure the disk is permitted to rotate freely in the casing. The arrangement provides for steam and water tight contact of the moving faces with the stationary faces and does away with all superfluous pressure and friction. The cams o and p, which serve the purpose of lifting or pushing the head-plates aside to make way for the piston, are shown from the front in Fig. 4 and from the side in Fig. 10. They are made of steel and tempered and shaped in such a way as to give the head-plates a steady motion and to bear on the front edge of the head-plates throughout their entire contact with them. They may be curved instead of being straight, as in the drawings, or they may be made in one piece and fill out an entire quarter, and then be shaped accordingly to touch the whole edge of the head-plate equally during the passage. We prefer to make them in the way they are shown in the drawings. They may be screwed on or dovetailed in, as it suits the cases.

The abutments: One of the most important features in the construction of this motor are the so-called "abutments." We derive the name from the cylinder-head of an ordinary engine on which the steam finds an abutment in moving the piston. These abutments are pressed on by spiral springs wound around a stud r, which move in a box attached to the cover that closes the slot. This slot is lined with Babbitt metal, giving a smooth bearing for the abutment. A small channel is made in the lining, allowing the pressure to equalize itself in front and behind the plate. For the same purpose a channel r' is mortised in the side of the stud. (See Fig. 8, which represents this stud on an enlarged scale.)

The bearing of the shaft is shown in Figs. 1, 2, and 3. It is a self-centering one, as will be understood from the drawings. By tightening the cap the conical segments will advance toward the center, thus embracing the latter all around.

Having now described fully the nature of our invention, it remains for us to mention the advantages of our construction. We are enabled to obtain a high speed. Indeed, we obtained with our experimenting motor with steam a speed exceeding by far three thousand revolutions per minute with perfect security. This high speed we owe to the perfect balance of pressure and the balance of all working parts, and the reduced momentum of the head-plates, which obey the action of a small spring in the most admirable manner. The comparative short motion of the head-plates as a consequence of the piston being purposely made in such small dimensions enables us to gain by high speed what we lose in surface of the piston. The initial pressure as well as the speed in our motor may be increased to an extraordinary degree without danger to the stability of the structure. This motor may also be used as compound engine with a high-pressure and low-pressure separate casing and a condenser attached to it. It may even be used as blower, exhauster, and pump, as will be understood from its construction. These points show this motor in a most favorable light, as it indeed combines all the advantages claimed for rotary motors in general and avoiding the disadvantages that have prevented their adoption for practical use.

We are aware that prior to our application rotating motors with rotating disks in connection with pieces which perform the function of pistons attached to them and with sliding plates analogous in purpose to our head-plates have been made. We do not claim, therefore, this combination broadly; but

What we do claim as our invention, and desire to secure by Letters Patent, is the following:

1. In a rotary motor, the combination of a flat cylindric casing in two halves A and A', flanged together on their circumference, a hollowed-out disk B, rotating in the axis of the casing and bearing on its flat faces opposite each other two piston-blocks F, fitting in the annular space E left between the inner flat faces of the housing and the disk, with the in-

let-pipe H on one face of the casting and the outlet-pipe J on the other face opposite, all arranged substantially as set forth.

2. The combination of the hollowed-out disk B, the cams *o* and *p*, set opposite each other and occupying the same half of the face on each side of the disk, with four reciprocating abutments G rectangular to the face of the disk and which are situated opposite each other in a plane that coincides with the axis of rotation of the disk, all arranged substantially as set forth.

3. The combination of the hollowed-out disk B, with its pistons F, applied directly to its opposite sides, and the inlet-ports *e* opposite one edge of the piston and the outlet-ports *h* opposite the other edge of the piston, substantially as set forth.

4. The combination of the disk B, the pistons F, applied to its opposite sides, the inlet-ports *e*, and the outlet-ports *h*, with the main inlet-port in face of the hub on one side and the main outlet-port in face of the hub on the other side, all arranged substantially as set forth.

5. In a rotary motor, four abutments made of thin sheet metal each in connection with springs acting on one edge and a cam acting on the other edge, said cam in face of the rotary disk, and the abutments arranged opposite each other in a plane coinciding with the axis of rotation of such disk, for the purpose and substantially as set forth.

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