J. M. K. PENNINK.

DISK ENGINE.

APPLICATION FILED FEB. 24, 1917.

1,323,907.

Patented Dec. 2, 1919.

3 SHEETS—SHEET 1.

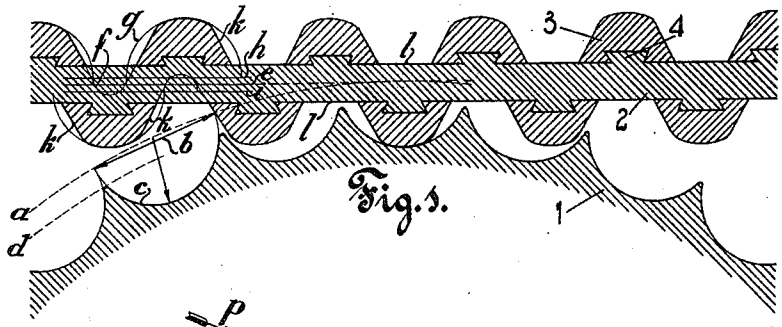


Fig. 1.

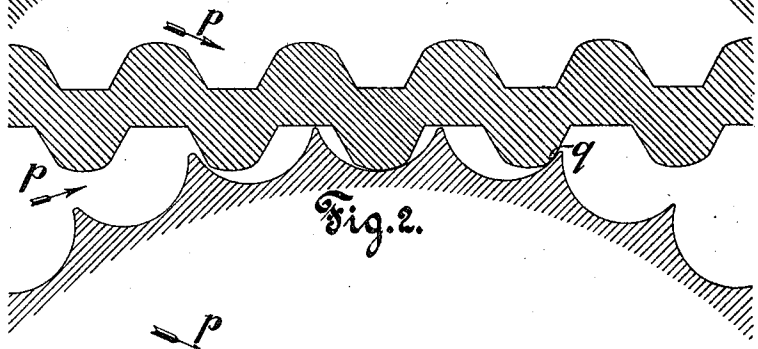


Fig. 2.

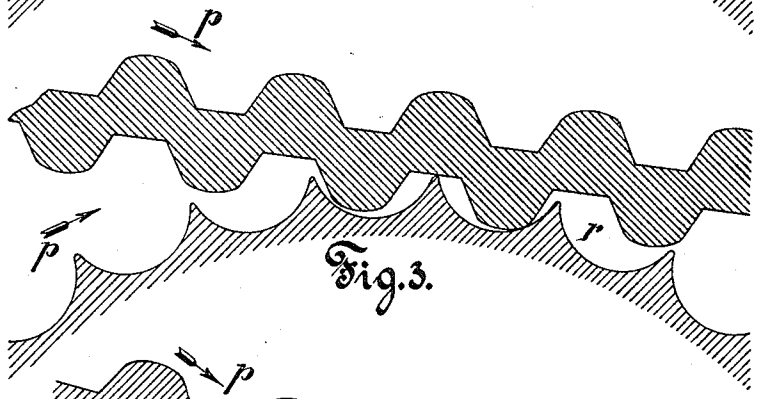


Fig. 3.

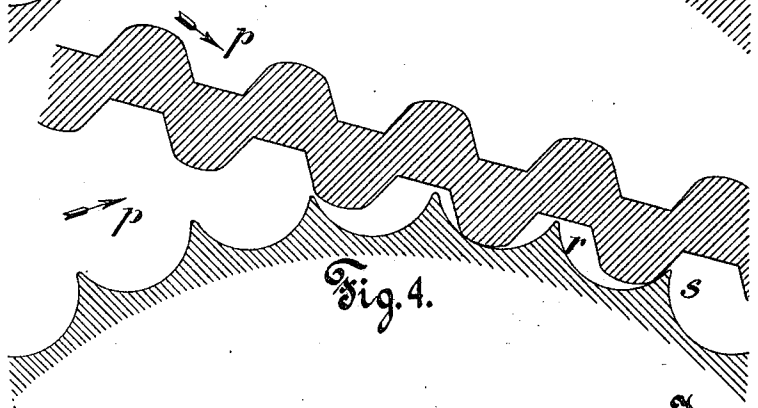


Fig. 4.

Witnesses

M. E. McNabb

C. Kesler

Inventor

Johan M. K. Pennink

by James L. Norris,

Attorney.

J. M. K. PENNINK.

DISK ENGINE.

APPLICATION FILED FEB. 24, 1917.

1,323,907.

Patented Dec. 2, 1919.

3 SHEETS—SHEET 2.

Fig. 5.



Fig. 6.

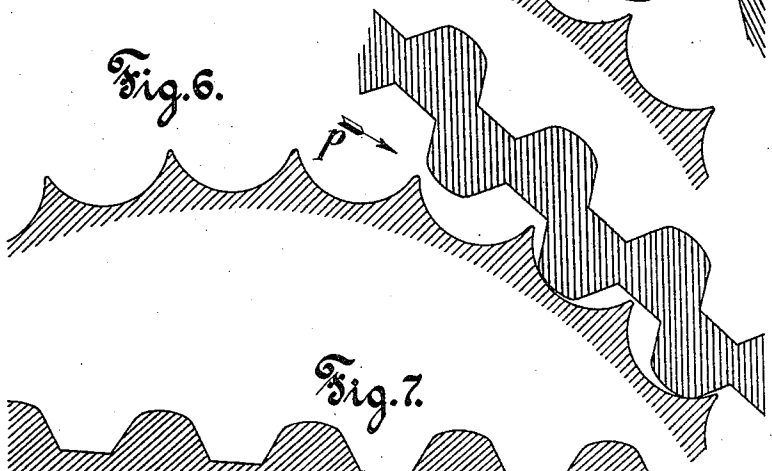
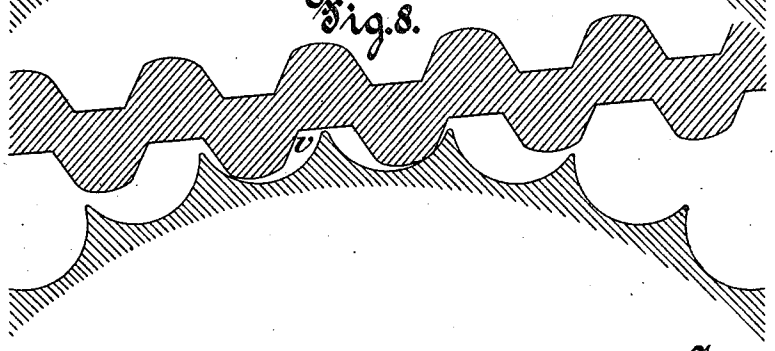


Fig. 7.



Fig. 8.



Witnesses

M. E. McDale.

C. L. Kesler

Inventor

Johan M. K. Pennink

by James L. Norris.

Attorney.

J. M. K. PENNINK.

DISK ENGINE.

APPLICATION FILED FEB. 24, 1917.

1,323,907.

Patented Dec. 2, 1919.

3 SHEETS—SHEET 3.

Fig. 9.

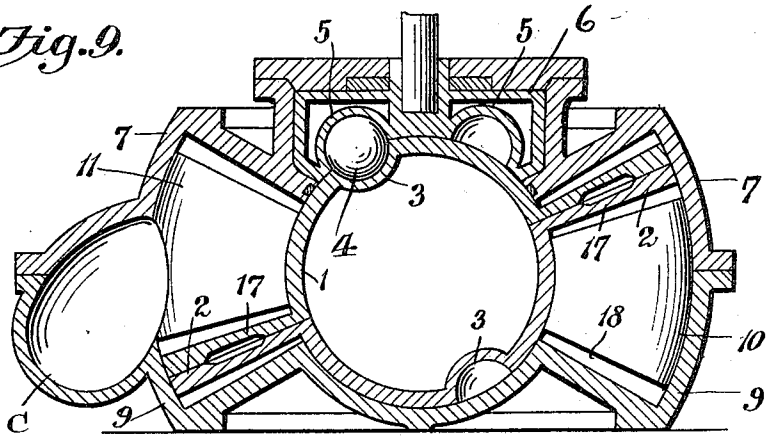
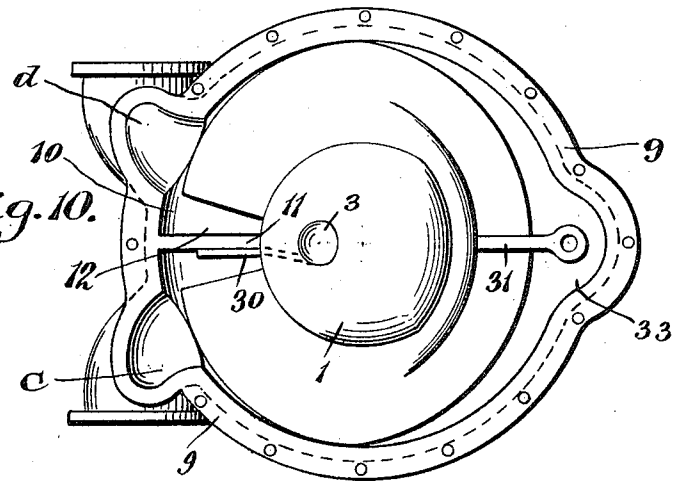


Fig. 10.



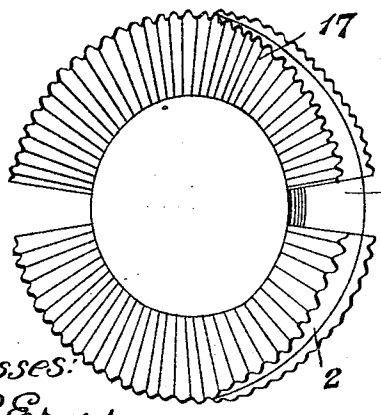


Fig. 11.

Witnesses:

F. P. Emery.

Inventor:

Johan M. K. Pennink

by James L. Norris,

Attorney.

UNITED STATES PATENT OFFICE.

JOHAN MATHIAS KAREL PENNINK, OF AMSTERDAM, NETHERLANDS.

DISK ENGINE.

1,323,907. Specification of Letters Patent. Patented Dec. 2, 1919.

Application filed February 24, 1917. Serial No. 150,861.

To all whom it may concern:

Be it known that I, JOHAN MATHIAS KAREL PENNINK, subject of the Queen of the Netherlands, residing at Amsterdam, Kingdom of the Netherlands, have invented certain new and useful Improvements in and Relating to Disk Engines and the like, of which the following is a specification.

This invention relates to disk engines and the like having a disk formed by a ring, surrounding a ball or sphere and arranged in an equator plane of said ball or sphere, and two cone surfaces which are in permanent rotative engagement with said ring formed disk by means of teeth or folds provided both in or on the surface of the disk and in or on same of the cones. These teeth or folds distribute the shifting movement of the disk with regard to the cone surfaces, due to the fact that the periphery at the base of the cones is smaller than same of the disk, uniformly, so that the movement of the disk is rendered uniform, the exactness of this distribution being dependent on the number of teeth or folds and increasing with said number. The engagement of the disk and the cone surfaces thus obtained is a particularly tight one. For though the play between the teeth produces a passage for the fluid between the disk and the surfaces of the cones when the engine is at rest, said passage will be closed as soon as the pressure at the inlet end of the engine rises, the disk then being turned a little about its pole axis, thus causing the teeth to engage each other.

The shape of the teeth or folds in known disk engines is the same for the disk and the cones and comprises triangular teeth with rounded edges and an obtuse top, which may be interchangeable. This shape is not fit for practical use as on the one hand it produces too much friction and on the other hand it does not insure a fluid tight engagement to be obtained, the latter fact being a serious objection particularly when high pressures are employed.

The object of the invention is to overcome this objection and at the same time to provide a form of folds and teeth which may be employed for disk engines of large dimensions, without complicating their construction.

According to the invention there are provided on the cone surfaces a number of folds of circular or approximately circular cross section, said folds converging to the top of the cones, while the disk is formed by a flat plate having a number of radially converging teeth, either integral with the plate or interchangeable, equal to the number of folds in the cone surfaces, the cross section of each tooth being shaped substantially as an isosceles trapezium with base angles of 60° and a top rounded in conformity with the shape of the folds in the cone surfaces. This shape of teeth avoids jamming and also secures a very tight engagement.

The present invention relates to improvements on the structure of disk engines disclosed by my prior British Patent No. 11,825 of 1914. In this patent the shape of the teeth of the disk 2 is the same as the folds in the surface of the cones 18. This shape is not adapted to be applied to disk engines of larger dimensions and operating with a greater difference between the inlet and exhaust and pressure. The present invention also embodies improvements on the structure disclosed in my U. S. Patent, No. 1,182,033, dated May 9, 1916. The present improvements give the disk engine a larger scope and are adapted to compensate for a greater difference between inlet and exhaust and pressure than contemplated by the said previous foreign and U. S. patented structures.

The invention will now be described with reference to the annexed drawings.

Figures 1–8 represent a diagrammatic view of the teeth and folds obtained by developing the teeth on rotative member having a cylindrical surface the axis of which coincides with the pole axis of a disk movably coöperating with said member.

Figs. 1–6 show the invention as adaptable to an engine operated as a motor.

Figs. 7 and 8 show the invention adaptable to an engine operated as a pump.

Fig. 1 also shows the way in which the shape of the teeth and folds is designed.

Fig. 9 is a vertical section through a water meter embodying the features of the invention.

Fig. 10 is a plan view of the lower half of the meter with the disk removed.

Fig. 11 is a detail view of the disk.

As in the structure of my British patent hereinbefore mentioned and of which the present invention is an improvement, there

is provided in the present instance a hollow ball or sphere, or member 1 of metal of comparatively large diameter and has the improved disk 2 mounted to operate therein. The disk 2 is preferably made in two halves, and then accurately finished. The ball at two diametrically opposite places is provided with hemispherical recesses 3, in one of which the ball 4 is inserted which rests in a hemispherical recess 5 of the crank disk 6. The latter in the upper portion 7 of the measuring chamber box, touches the ball surface on the side facing the same, and is packed by suitable means, *i. e.* rendered leakage tight both in relation to the ball 4 as well as in the box 7. The disk crank 6 is provided with several recesses 5, because the bearing surfaces wear out comparatively quickly.

In the working chamber 10 of the casing 7—9 there is provided a radial partition 11 extending up to the surface of the ball 1 and engaged or embraced by the disk 2, which latter is radially slotted at this point without, however, the disk touching the partition. The disk may turn about and is not jammed either diametrically or axially, or it may freely roll and execute a swinging or rocking movement.

The top 15 and the bottom 16 of the casing 7—9 which if desired may be made in several parts, are cone-shaped and limit the throw of the disk 2, both in an upward direction and in a downward direction. In large meters the measuring chamber 10 is made fluid tight in relation to the disk crank preferably by means of packings.

At both sides of the partition 11, the inlet *c* and the outlet *d* respectively for the driving medium open into the working chamber 10 of the casing. Assuming the disk occupies the position shown in Fig. 1, so that it bears on the right hand side of the top, and on the left hand side at the bottom against the cones 15, 16 and assuming that the inlet *c* is now opened, then a rolling movement about the two cones is imparted to the disk by the entering current of gas or liquid. The disk may move either forwardly or backwardly with material advantage in connecting the machine to a motive medium supply source.

In order to render the water meter watertight at the commencement of the measuring operation, the ball or sphere 1 may be allowed to bear by means of a plate spring 30 against the partition 11, which spring may, if desired, be secured to the sphere 1. By this means the disk will be pushed toward the left so that at least one tooth of the disk bears against one tooth of the conical surface, thus forming a leakage-tight joint, so that the rolling movement of the disk immediately commences when the water starts to flow.

The non-symmetry of the disks 2 forms a disadvantage for a very rapid movement, which particularly occurs with gas currents. This disadvantage may be eliminated in the following simple manner, namely by arranging a second partition 31 diametrically opposite the partition 11. The disk 2 is then provided on this side with a slot 32 similar to the slot 12 provided on the left hand side, the same, however, being made not so broad. The gas current is passed around the partition 31 through a side channel 33. By means of this arrangement the disk 2 is completely balanced. The cone surface which is in rotative engagement with the disk is indicated by *a*. After having adopted a number of teeth for the disk and of folds for the cones, the periphery of the base of each cone is divided in a corresponding number of equal portions *b*, semi-circles *c* being described on each portion *b*. The radius of these semi-circles *c* decreases in the direction of the top of the cone, that means that the cross-section of the folds in the cone surfaces decreases toward the cone tops (the cone top is an imaginary point as the cone surfaces belong to truncated cones). The edges between the folds are rounded so that the rounded edges are situated on a circle *d*.

The plane *e* in the middle of the thickness of the disk 2 is a tangent plane to the circle *a*. If this plane *e* is folded so as to form folds of a semi-circular cross section, the diameter of which is comprised in the periphery of the disk an equal number of times as the diameter of the folds in the cone surfaces is comprised in the periphery of the base of said cones and if furthermore the folded plane *e* thus obtained is given a certain thickness by forming on either side of said folded plane *e* equidistant folded surfaces, the cross section of the folds of said surfaces being formed by circles *f* having a smaller and circles *g* having a larger radius than the imaginary folds of the plane *e*, and if finally the geometrical locus *h* of the centers of the circles *g* and *f* forming the folds on one side of the disk are shifted a predetermined distance vertically to the geometrical locus *i* of the centers of the circles forming the folds on the other side of the disk, a profile or section is obtained from which the profile or section according to the invention may be derived by flattening the folds symmetrically along tangent lines *k* to the smaller circles *f*, said tangent lines inclosing an angle of approximately 60° with the plane *e*. If the top of the teeth 3 of the disk might differ too much from the shape of the folds *c* in the cones, the top of the teeth is rounded accordingly, whereas the superfluous depth of the folds in the disk is cut off along tangent lines *l* to the

circle *d*, which is the geometrical locus of the tops of the rounded edges of the cone surfaces. The distance between these tangent lines *l* may be used for giving the required constructional thickness to the body of the disk 2. The teeth 3 of said disk may be either integral with the body 2 of the disk or they may be formed as separate pieces connected *e. g.* by means of dovetail connections to the body 2 of the disk, the latter construction being preferred for large engines. In the drawings the projecting parts of the dovetail connections are integral with the body of the disk, the grooved parts of the connections being provided in the teeth; it will be understood, that it would be possible to form the grooves in the body of the disk and to provide the projecting dovetails to the teeth.

The position of the disk as illustrated in Fig. 1 is the position of rest, *i. e.* the teeth of the disk and the folds of the cone are not yet pressed upon each other and consequently there is a free passage left between the disk and the cones.

As soon as (assuming motor operation) the disk 2, 3 is subject to a pressure operating in the direction of the arrows *p*, the disk is turned a small amount about its pole axis and is pressed at *q* onto the surface of the cone (Fig. 2). Then the disk begins to rotate and it takes up successively the positions shown in Fig. 3 and in Fig. 4. In the latter position the room *r* inclosed between two successive teeth and the corresponding folds is decreased, or in other words the fluid contained in said room *r* is compressed. During rotation always the foremost point of contact is the axis of momental rotation and consequently the contact between cone and disk will be tight at that point. Consequently the decrease of volume of the room *r* and the compression produced by said decrease will make the pressure of the foremost teeth against the corresponding edge of the cone increase and at the same time said compression will avoid any direct passage of high pressure fluid to the exhaust side. In short the compression will always operate exactly in the direction opposite to the direction in which high pressure fluid will try to reach the exhaust.

In comparing Figs. 4, 5, and 6 a similar compression will be found to be produced when the next teeth are engaging the next folds, this time the compression being effected in the room *s*. By choosing the dimensions of the disk in such a manner, that at normal pressure a slight deformation or bending is obtained the engagement will be still more tight.

When the engine operates as a motor the direction of rotation of the disk is the same as the direction of decrease of pressure. When however the engine is operated as a pump the direction of rotation is opposite to the direction of decrease of pressure. Figs. 7 and 8 relate to the operation of the engine as a pump. In Fig. 7 the direction of compression is indicated by the arrow *t* the fluid trying to escape to the low pressure or suction side in the direction of the arrow *u*. As a pump (rotation to the left) the disk has its point of close contact with the cone always at the last teeth which is in engagement with the folds, consequently the room *v* in which compression takes place is closed tightly at the suction side. Then the compression itself insures a tight engagement. The direction in which the fluid compressed in the room *v* will try to escape from said room is opposite to the direction in which leakage from inlet to exhaust of the pump would take place. The operation of the leakage excluding arrangement might be considered as a labyrinth packing, which may be understood best if water or another inelastic fluid is assumed as pressure fluid.

Finally it is to be remarked, that the different points of the periphery of the disk describe curves having substantially the form of lemniscates. The theoretically exact shape of the folds in the cone surfaces would be the shape which corresponds exactly with the lemniscates described by the teeth of the disk. The shape of teeth and folds according to the invention however insures a practically fluid tight engagement together with a minimum of friction and by natural wear it approximates the theoretically exact shape mentioned.

To render the edge of the disk fluid tight with respect to the housing it may be provided with one or more piston springs.

What I claim is:

1. In a device of the class specified, a spherical casing, a disk member, and a pair of cone devices substantially semi-circular in cross-section and having surfaces in rotative engagement with said disk member and provided with folds having a cross section decreasing toward the top of said cone devices, the disk member having radially converging teeth on opposite sides with rounded top to form a fluid tight engagement with the folds of the cone devices, the folds of the cone devices being shaped to correspond substantially to the curves described by the teeth of the disk member during rotation of the latter.

2. In a device of the class specified, a spherical casing, a disk member having radially converging teeth at opposite sides thereof, the said teeth being substantially of isosceles trapezium shape with base angles of approximately 60° and a rounded top, and a pair of cone devices having folds substantially semi-circular in cross section and decreasing toward the top of said cones, the

said folds being in engagement with the disk and the folds thereof shaped to correspond substantially to the curves described by the teeth of the disk during rotation.

3. A device of the class set forth comprising a spherical casing having a disk consisting of a flat annular plate surrounding the same and arranged substantially in an equator plane thereof, the disk provided with radially converging teeth having a cross section of substantially isosceles trapezium shape with base angles of approximately 60° and a rounded top, the teeth of the disk being removably associated with the latter through the medium of interacting dovetail projections and grooves, and a pair of cone devices having surfaces in rotative engagement with the disk and formed with folds of a substantially semi-circular cross sectional contour decreasing toward the top of the cone devices and shaped to correspond substantially to the curves described by the teeth of the disk during rotation.

4. A device of the class set forth comprising a spherical casing having a disk consisting of a flat annular plate surrounding the same and arranged substantially in an equator plane thereof, the disk provided with radially converging teeth having a cross section of substantially isosceles trapezium shape with base angles of approximately 60° and a rounded top, the teeth of the disk being removably associated with the latter through the medium of interacting dovetail projections and grooves, a pair of cone devices having surfaces in rotative engagement with the disk and formed with folds of a substantially semi-circular cross sectional contour decreasing toward the top of the cone devices and shaped to correspond substantially to the curves described by the teeth of the disk during rotation, and spring means inserted between the disk and the casing.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

JOHAN MATHIAS KAREL PENNINK.

Witnesses:

D. KLEŸN,

EUGENE NABEL.