No. 635,558. Patented Oct. 24, 1899.

F. KRÜGER.

ROTARY STEAM ENGINE.

(Application filed Dec. 30, 1897.)

(No Model.)

Fig. 1.

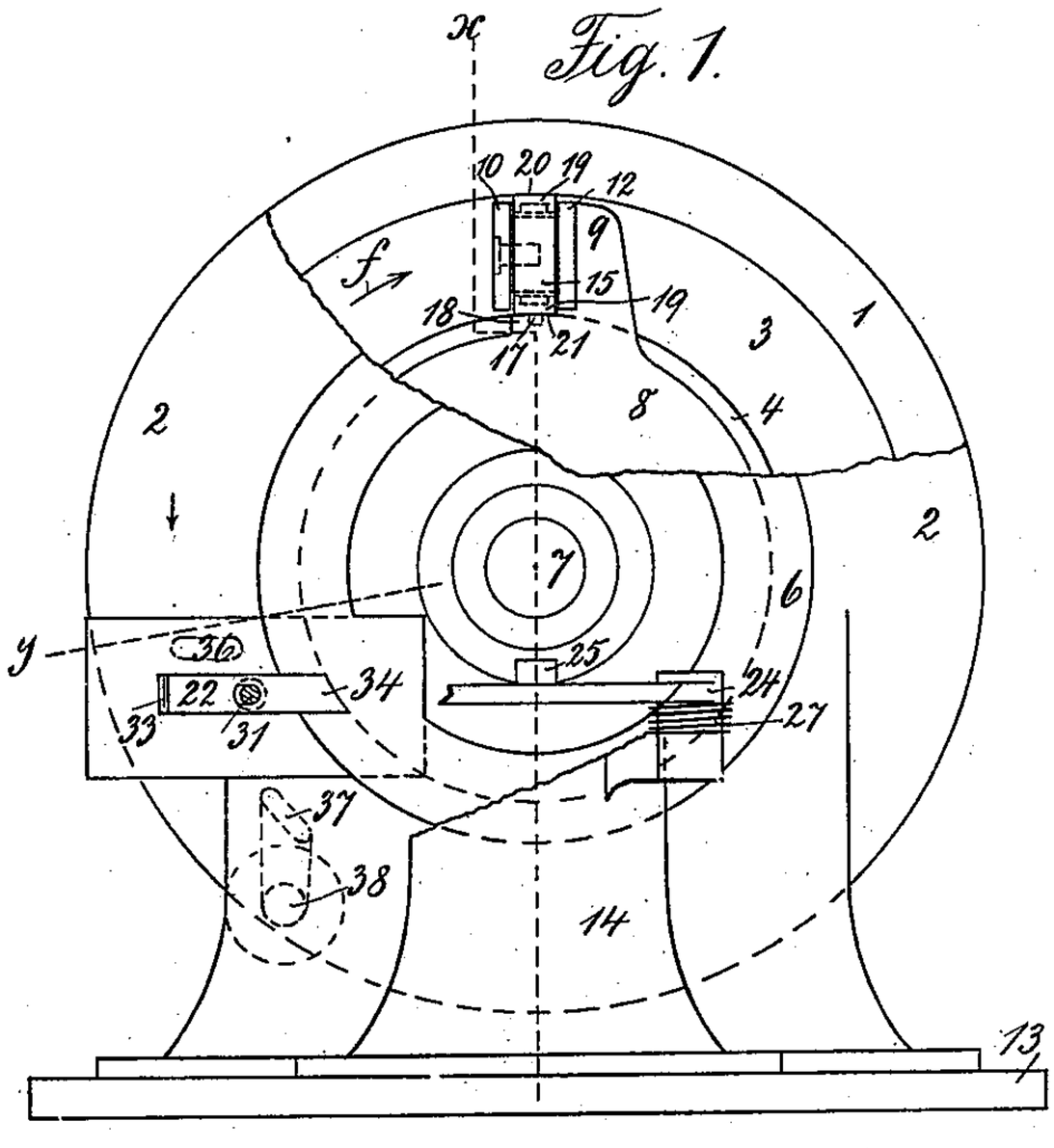


Fig. 2.

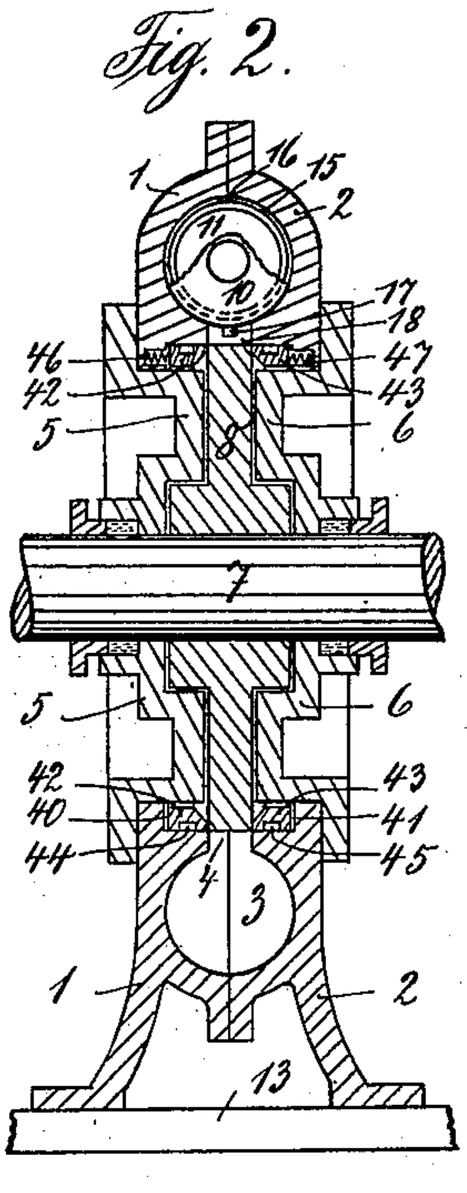


Fig. 3.

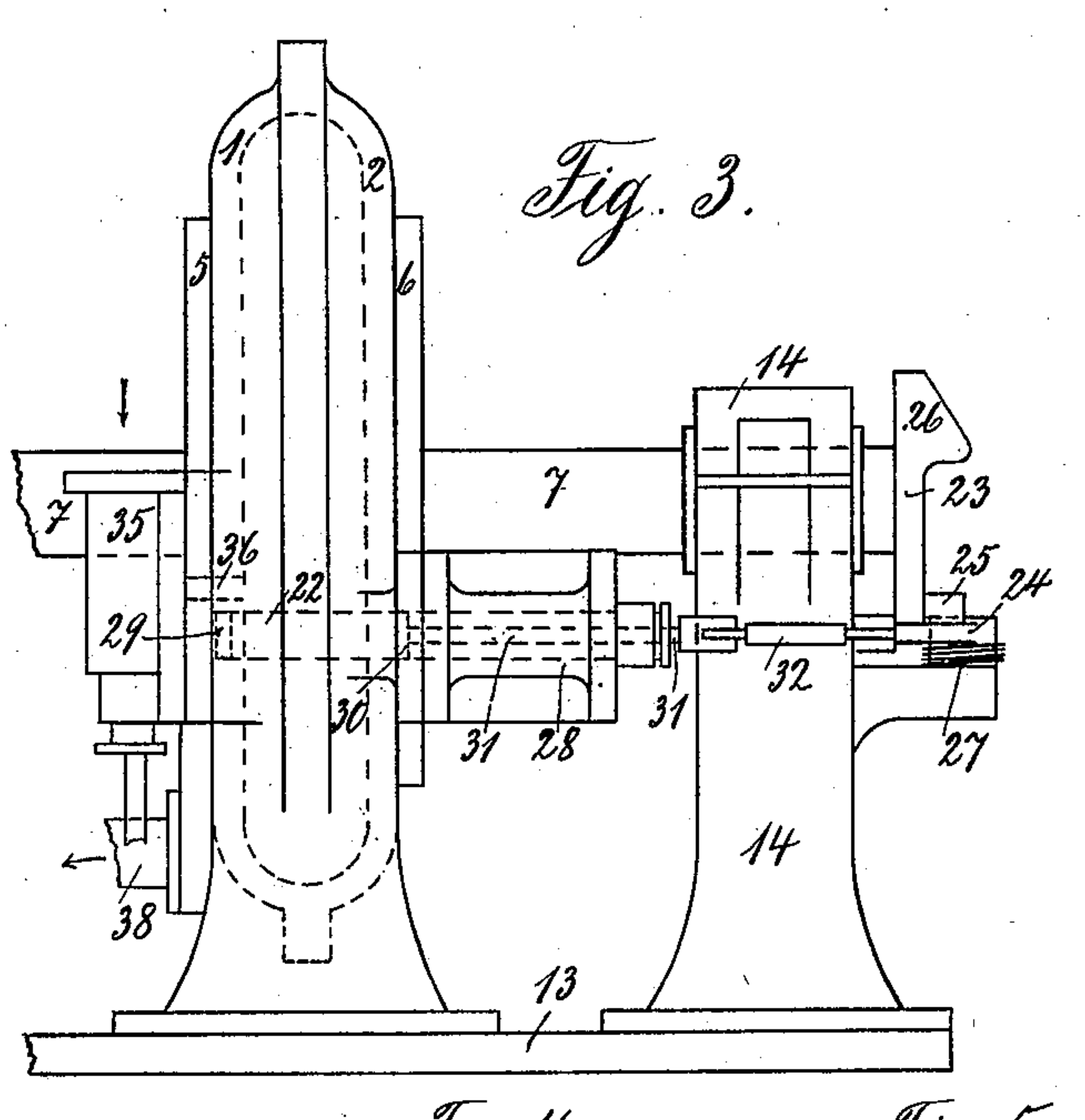


Fig. 6.

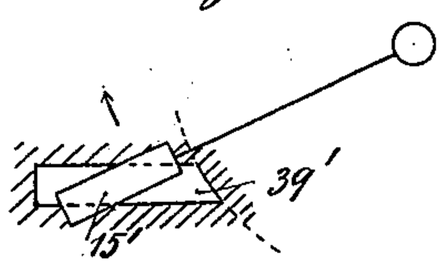
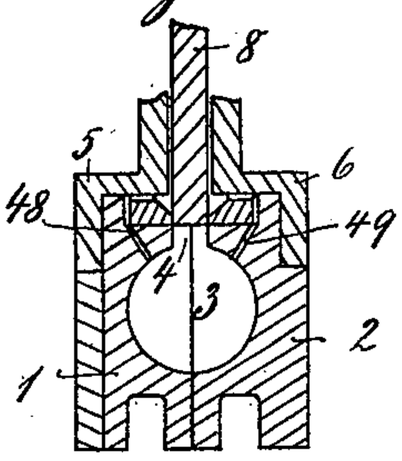


Fig. 7.



Witnesses.
Julius Lutz.
J. M. Hanaford

Fig. 4.

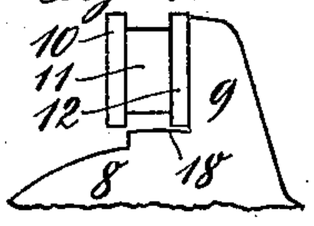
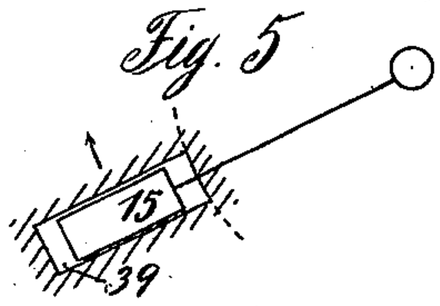


Fig. 5



Inventor.
F. Krüger
By. Munn
Attorneys.

UNITED STATES PATENT OFFICE.

FERDINAND KRÜGER, OF BERLIN, GERMANY.

ROTARY STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 635,558, dated October 24, 1899.

Application filed December 30, 1897. Serial No. 664,684. (No model.)

To all whom it may concern:

Be it known that I, FERDINAND KRÜGER, a subject of the German Emperor, residing at Berlin, Germany, have invented new and useful Improvements in Rotary Steam-Engines, of which the following is a specification.

My invention relates to rotary steam-engines in which a revolving piston is carried by a piston-disk mounted on a shaft, the said piston, piston-disk, and shaft being inclosed in a circular casing; and the objects of my invention are, first, to provide perfect and reliable packings between the revolving parts and the casing, so as to avoid escape of steam; second, to provide means for protecting the said packings against wear in order to permanently maintain the machine in a perfect working condition, and, third, to simplify its construction. I attain these objects by the means illustrated in the accompanying drawings, in which—

Figure 1 is a side view of the entire machine, some of its parts being partially broken; Fig. 2, a vertical section thereof on the line *x* of Fig. 1 seen from the left; and Fig. 3, a front view of Fig. 1, likewise seen from the left. Figs. 4 to 7, inclusive, are detail and diagrammatical views hereinafter explained.

Similar figures refer to similar parts throughout the several views.

The casing consists of two semi-annular parts 1 2, forming hollow spaces 3 4, and of two circular covers 5 6, connected to the parts 1 2. A main driving-shaft 7 passes through the center of the casing, and a piston-disk 8 is mounted thereon and provided with a projecting arm 9, carrying a piston 10 11 12. (Plainly represented in the detached view, Fig. 4.) The casing is mounted upon a base-plate 13, carrying at the same time supports 14 for the main driving-shaft.

The packing of the piston consists of a spring-ring 15, split at 16 in the well-known ⅂ shape, surrounding with play the middle reduced portion 11 of the piston and kept in position by collars 10 12, allowing likewise of a slight play of the ring, so that steam can enter between collar 10 and ring 15, as well as between stem 11 and the ring. The latter is provided with a stud 17, Figs. 1 and 2, engaging with a groove of a projecting part 18 of disk 8, a turning of ring 15 on stem 11 thus being prevented. Any other means may be provided for accomplishing this purpose without departure from my invention. Ring 15 is preferably covered with a layer 19 of soft metal applied to its outer surface. By these means when pressure of steam is applied to the piston and the latter revolved in the direction of arrow *f*, Fig. 1, ring 15 will be closely pressed against collar 12 and at the same time expanded so as to closely fit in the hollow space 3 of the casing, provided that the outer surface of ring 15 exactly conforms to the curvature of the hollow space 3, the latter gradually changing from concavity on its outer portion 20 to convexity on its inner portion 21. To attain this, the ring will be conformed as much as possible to the peculiar inner surface form of space 3 when casting the soft metal around it, and then fitted therein by grinding.

In order to permanently maintain a close fitting of the ring and a perfect working condition of the machine, I have secured ring 15 against turning in its revolving movement by the above-mentioned stud 17. For the geometrical condition of a smooth and free movement of the ring within space 3, consisting in that the ring be deprived of any tendency to turn, if there were not provided means to prevent this, clamping and wear by friction would take place, so as to deform the contact-surface of the ring and loosen the packing. There is another tendency to destroy the piston-packing in rotary steam-engines of this kind resulting from the usual arrangement of the slide-valve for periodically closing the steam-chamber 3 of the casing. In the drawings the said slide-valve 22 is controlled by a cam-disk 23, provided with a cam 26 and mounted on shaft 7, and by a spring-actuated lever 24, bearing with a roller 25 against the cam-surface of cam-disk 23. Slide-valve 22 is guided in a slot penetrating the chamber-walls 1 2 and in a box 28, screwed to the casing, as represented in Fig. 1, box 28 being removed in this figure, and in Fig. 2 in dotted lines. The inner edge 34 of the slide-valve is slightly excavated, so as to closely bear against the edge of piston-disk 8 under the pressure of a flat spring 33. A rod

31 passes loosely through a longitudinal slot of the slide-body, taking along with it the slide by means of collars 29 30. Rod 31 is connected to lever 24 by a link 32. By these means slide 22 will be periodically shifted toward the right of Fig. 3 in order to allow of the passage of arm 9 and the piston and at once driven toward the left by spring 27 in order to close again the steam-chamber. At the same time the usual steam-admitting valve provided in a steam-chest 35 is shifted and live steam supplied through opening 36 to chamber 3, and as the latter is closed by slide 22 the pressure of the steam causes the piston to travel around. The exhaust-steam is discharged through an opening 37 and a pipe 38. At each revolution piston-ring 15 will therefore pass once, the guide-slot of the slide penetrating the chamber-walls 1 2. If now, as usually and represented in the diagram Fig. 5, slot 39 is radially directed toward the center of revolution, ring 15 when passing the slot will momentarily register with the latter and therefore be caught by the slot, as the ring expands by elasticity. A shock will therefore arise whenever the ring passes the slot and a perfect working condition can never be attained. On the other hand, by the repeated shocks the ring will be shortly deformed and worn out, so as to reduce the efficiency by escape of steam. In order to overcome these inconveniences, I have disposed the said slot obliquely—that is, at an angle to a radial line—as represented in Fig. 1 and diagrammatically shown in Fig. 6. From the latter figure it will appear that even though the ring 15′ should be of smaller size than the width of slot 39′ it never could be caught by the slot, but will cross the same during its whole passage, so that there would be no moment in which the ring should be fully released from the surrounding wall of the casing. By this feature of my invention I therefore attain and permanently maintain a smooth and uniform working of the machine, any shock being avoided and the piston-packing protected against wearing out and being destroyed.

The above-mentioned inconveniences could be partially overcome by enlarging ring 15, Fig. 5, beyond the width of slot 39; but as slide 22 should preferably be made of a comparatively large width in order to present a large packing-surface 34 to the edge of piston-disk 8 (and in consequence thereof the slot likewise should be made as wide as possible) a still larger size of the ring should be required. On the contrary, there are important reasons for making the ring as narrow as possible—first, in order to reduce the resistance by friction, and, second, to reduce the weight of the ring, of the piston, and of arm 9, as these parts must be counterbalanced, and care is to be taken to reduce as much as possible the weight of the parts in any machine. While these conditions are at variance with each other in the arrangement represented, Fig. 5, they fully harmonize in my invention.

I will now describe the packing between the edge of piston-disk 8 and the corresponding parts of the casing. For this purpose annular grooves 40 41 are provided between the parts 1 2 of the casing and either of the covers 5 6. The outer sides of the said grooves formed by the parts 1 2 are smooth, and rigid rings 42 43 fit in the said grooves, so as to lie with their cylindrical outer surfaces in close contact with the smooth sides of the grooves and with their smooth inner sides in close contact with the outer faces of the edge at piston-disk 8. There are spaces left between the cylindrical inner sides of the rings and the opposite sides of the covers 5 6 and between the outside of the rings and the opposite sides of parts 1 2. Rings 42 43 perform, therefore, fully the function of packing-rings, and they may be provided, too, with packing spring-rings 44 45, as usual in pistons for steam-engines. There are a number of springs 46 47 disposed along and bearing against the packing-rings 42 43 and slightly pressing the same against piston-disk 8, the pressure of the said springs being only sufficient to overcome the friction of packing-rings 44 45 and not sufficient to establish heavy friction between rings 42 43 and piston-disk 8. By these means the packing-rings 42 43, although always remaining in close contact with the outer cylindrical sides of channels 40 41 and with the piston-disk 8, are yet capable of slight oscillations, following any slight lateral oscillation of disk 8 in its revolving movement.

In order to prevent escape of steam between the inside edges of the pistons 42 43 and disk 8, for which purpose the slight pressure of springs 46 47 might not suffice, the hollow space 3 is brought into communication with the space behind the packing-rings 42 43 by means of narrow channels 48 49, Fig. 7, provided in the parts 1 2 and in proximity to the steam-supplying opening 36, Fig. 7, representing a partial section through the casing on line *y* of Fig. 1. (Seen as indicated by the arrow.) By these means the steam is likewise allowed to enter the space behind the packing-rings 42 43, in which space therefore always the same pressure will be maintained as in the space 3; but as the packing-rings 42 43 are rigid and solid the steam-pressure cannot expand them so as to increase the friction on their outer cylindrical surface, but only actuate them in that direction in which they are free of giving way—*i. e.*, toward piston-disk 8; but as the steam is forced by the same pressure to enter between disk 8 and the inner edges of the packing-rings 42 43 the latter will be actuated from opposite sides by nearly the same pressure. In consequence thereof the packing rings 42 43 are practically released from the steam-pressure and subjected only to the slight pressure of springs 46 47, whatever pressure there may be main-

tained in the hollow space 3 of the casing. By these means I attain a perfect and permanent packing of but little resistance.

An escape of steam entering the space behind packing-rings 42 43 between the covers 5 6 and disk 8 is prevented by stuffing-boxes surrounding shaft 7, while cocks or valves may be provided for removing from time to time the water condensed therein.

What I do claim as my invention, and desire to secure by Letters Patent, is—

A rotary engine, comprising a casing with an annular chamber at its periphery, a radial chamber communicating therewith, packing-chambers located laterally of said radial chamber, an inlet leading into the annular chamber to admit the motive agent, a piston mounted to revolve in said annular chamber, a disk rigid with the piston and rotatable in the radial chamber, a packing surrounding the piston and held against turning relatively thereto, packing-rings held in said lateral chambers, means for controlling the admission and exhaust of the motive agent, and channels leading behind the packing-ring piston from the back or outer portion of the lateral chambers to the annular chamber in close proximity to the inlet for the motive agent, substantially as described.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

FERDINAND KRÜGER.

Witnesses:

CHARLES H. DAY,

HENRY HASPER.