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A. G. M. MICHELL

ROTARY RECIPROCATING ENGINE

Filed Jan. 5, 1921

2 Sheets-Sheet 1

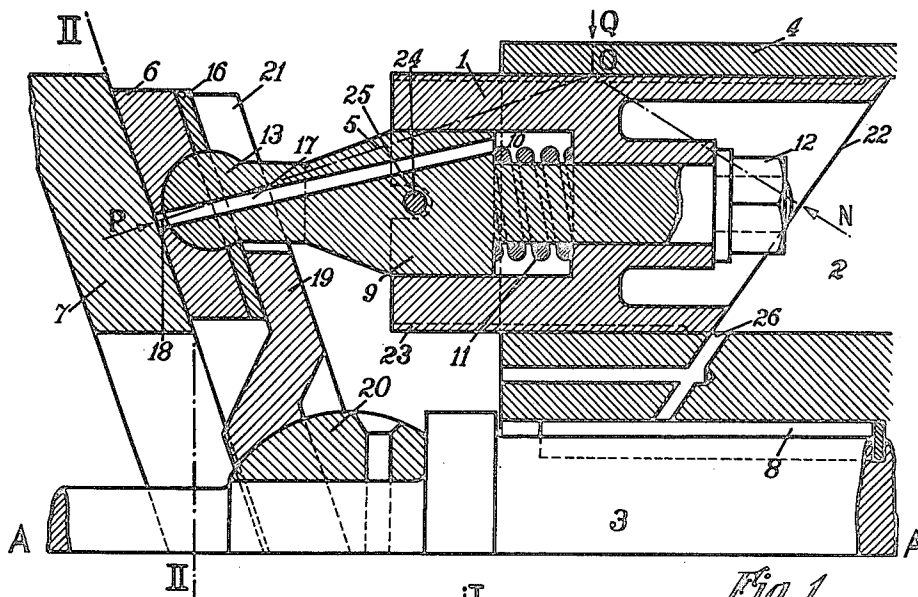


Fig. 1.

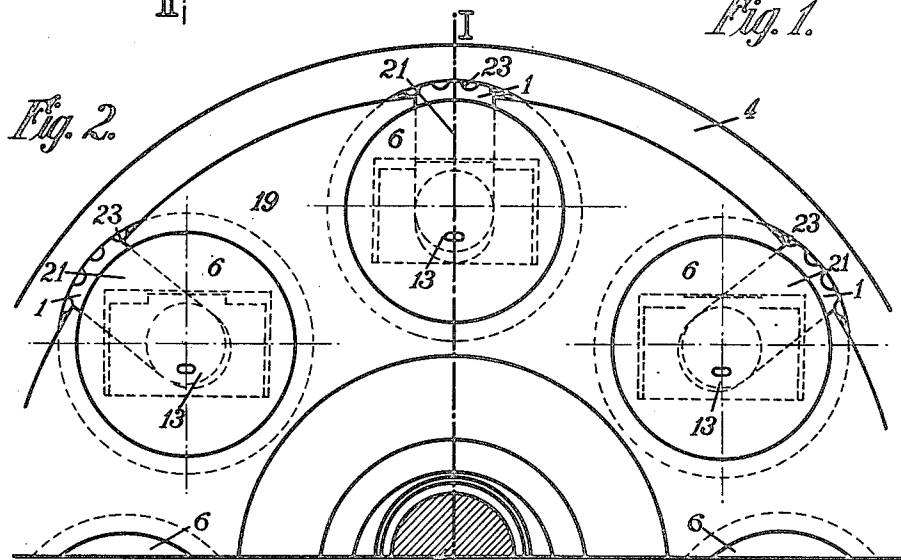


Fig. 2.

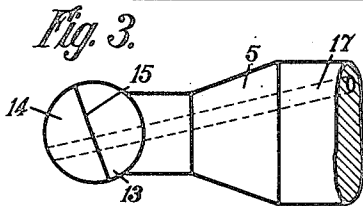


Fig. 3.

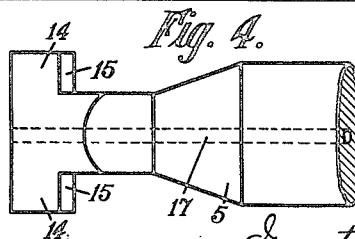


Fig. 4.

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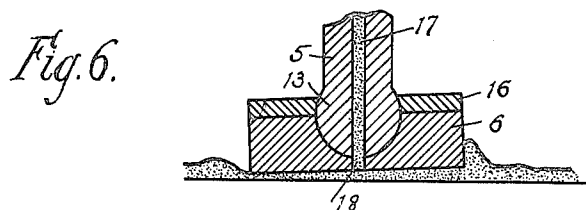
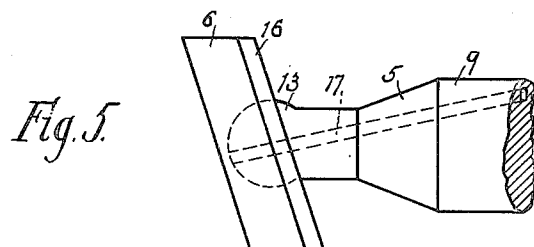
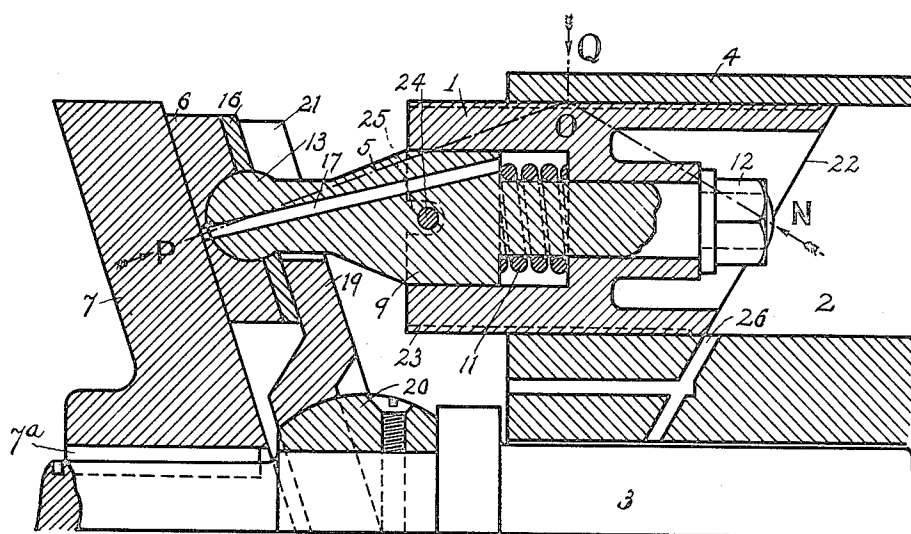
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## ROTARY RECIPROCATING ENGINE

Filed Jan. 5, 1921

2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE.

ANTHONY G. M. MICHELL, OF MELBOURNE, VICTORIA, AUSTRALIA.

## ROTARY RECIPROCATING ENGINE.

Application filed January 5, 1921. Serial No. 435,167.

*To all whom it may concern:*

Be it known that I, ANTHONY GEORGE MALDON MICHELL, of 450 Collins Street, Melbourne, in the State of Victoria, Commonwealth of Australia, have invented certain new and useful Improvements in Rotary Reciprocating Engines, of which the following is a specification.

This invention relates to pistons from whose reciprocating motion a rotary motion is derived by mechanism of the type described in my United States Patent No. 1,409,057, dated March 7, 1922. The mechanism in question comprises an oblique drive plate or swash plate and a slipper element articulated to the piston and making lubricated working contact with the drive plate. The satisfactory operation of such mechanism requires the maintenance of a film of lubricant between the plate and the slipper, which is automatically effected during normal running by the relative movement of these two parts.

The present invention relates to means for the reduction of the friction of the before-mentioned mechanism particularly at the instant of starting and which includes means for effective lubrication of the slippers.

Briefly stated the friction reduction is achieved by a construction wherein any tilting movement of the piston or pistons in each cylinder is eliminated, said construction also including means for the pressure application of lubricant between the co-acting surfaces of the slipper or slippers and the oblique drive plate, said pressure being intensified at the moment of starting the mechanism.

The accompanying drawings depict a practical application of the invention which results in the object stated being attained.

Fig. 1 shows a section (on line 1—1 of Fig. 2) through the axis of a piston of a multi-cylinder engine.

Fig. 2 is a sectional view (on line 11—11 of Fig. 1) showing the slippers of several of the pistons of the machine.

Figs. 3 and 4 are views at different angles of the element with which the slipper makes articulated contact.

Fig. 5 is a detail side view of the slipper and head carrying the same;

Fig. 6 is a section through the head and slipper illustrating the manner in which lubricant is supplied to the face of the slipper;

Fig. 7 is a modification of Fig. 1 showing the swash plate keyed to the main shaft.

As shown in Fig. 1 the piston 1, reciprocates in a cylinder 2, parallel to the axis A—A of the shaft 3 of the engine. The piston is fitted with a plunger or rod 5, so as to form an extension of the piston to which is attached an articulated slipper 6, making contact with the oblique drive-plate or swash-plate 7. As indicated in Fig. 2 several such pistons 1 may be arranged in parallel cylinders 2, bored in a common barrel 4, and the barrel 4 may be rigidly secured, as by key 8, to the shaft 3, and rotate therewith, the plate 7 being stationary. Alternatively without alteration to the relative motions of the parts, the barrel 4, may be stationary, the plate 7 being secured by a key 7<sup>a</sup> on the shaft 3 or otherwise arranged to revolve as shown in Fig. 7.

The piston 1 is bored axially to two different diameters to receive the piston rod 5, an enlargement 9 being formed on the latter to fit the larger bore of the chamber 10 at the front end of the piston. A spiral spring 11 in compression is fitted in the chamber 10 so as to exert a forward pressure on the enlargement 9, while allowing a slight displacement of the rod 5 in the piston 1 as hereafter explained. Such displacement is adjustably limited in one direction by the nut 12 on the rear end of the rod 5, and in the other direction by the restricted clearance between the coils of the spring 11 in the chamber 10. The front end of the rod 5 is formed with a head 13 having a cylindrical surface at right angles to the axis of the rod. Portions 14 (Figs. 3 and 4) of the head 13 project laterally from the rod 5, and these portions are semi-cylindrical, being cut away on their rear sides to the diametral plane 15, 15. The forward semi-cylindrical surface of the head 13, fits in a corresponding recess in the slipper 6, and a cover plate 16, rigidly attached to the rear of the slipper 6, fits over the lateral extensions 14 of the head 13, and secures the slipper 6 to the rod 5, allowing however clearance for a slight relative articulated motion. The slipper 6 and cover-plate 16, have the form of oblique sections or slices of a cylinder co-axial with the piston 1 and piston rod 5. A hole 17 is drilled through the piston rod 5 and its head 13 from the rear side of the enlargement 9, so as to communicate with a hole 18 drilled through

the slipper 6 to its front face which makes lubricated contact with the plate 7. Such contact is maintained, independently of the forces acting through the piston 1 by the retainer plate 19, which may be universally mounted on the ball 20, secured to the shaft 3, so as to permit of the simultaneous reciprocating and rotary motions of the pistons relatively to the cylinders. The retainer-plate 19 is slotted from its periphery as shown 21, to allow of assemblage.

The piston 1 is cut off at its rear end on an oblique plane 22, and it has formed on its periphery a number of longitudinal grooves 23 which terminate short of this oblique end. The end 22 uncovers at its foremost point on the forward end of the stroke of the piston 1 a port 26 formed in the barrel 4. A pin 24 secured in the enlarged part 9 of the piston rod 5 engages in notches 25 in the forward end of the piston 1 and prevents relative rotation of the rod and piston.

The operation of the mechanism is as follows—Lubricant being supplied by the means described in the above named United States patent or otherwise, to the working surfaces of the slippers 6 and plate 7, the latter being assumed to be stationary, and fluid under pressure being, by means of valve-gear not shown, alternately admitted to each of the cylinders 2 during the forward stroke of its piston 1 and exhausted during the backward stroke, the whole of the parts shown in the figures (excepting Fig. 7) with the exception of the plate 7 will be caused to revolve about the axis A A, the pistons 1 with their rods 5 and slippers 6 simultaneously reciprocating in the cylinders 2. In this motion the fluid pressure applied to the rear surface 22 of the piston in the direction of the normal line N O is equilibrated by the reaction between the slipper 6 and the plate 7, acting on the line P O normal to the surface of the latter, together with the reaction between the piston 1 and the barrel 4, acting on the line Q O. The position of the line of reaction Q O, the point O being the intersection of the lines N O and P O, depends on the obliquity of the surface 22.

With a suitable choice of the angle of obliquity the point O may be located as shown near the middle of the length of the piston 1 and within the bore of the cylinder 2, so that the reaction between the piston and cylinder is a well-distributed pressure and tilting and irregular wear of the piston obviated.

While the barrel 4, with piston 1, piston-rod 5 and slipper 6 revolve about the axis A A, the slipper 6 is constrained by the retainer-plate 19, to remain in contact with the plane surface of the plate 7, and consequently maintains the same angular direc-

tion and the heads 13, of the piston-rods 5, always remain horizontal as shown in Fig. 2. The pistons 1 being connected with the rods 5, by the pins 24, are likewise prevented from rotating about their own axes, and maintain a constant angular direction in space while the barrel 4 rotates.

It will be observed that the piston as shown in Fig. 1 is at the end of its forward, or pressure stroke. During this stroke the slipper 6 slides along the working surface of the plate 7, and the point of resultant pressure P is, as shown in the figure, slightly behind the centre of figure of the slipper 6. This being the case pressure will be generated in the film of lubricant between the surfaces and the chamber 10 will be charged therefrom through holes 17 and 18.

When pressure ceases to be applied in the cylinder 2, the piston rod 5 is forced forward relatively to the piston 1 by the expansion of the spring 11, and the chamber 10 thus remains fully charged with lubricant when the machine is stopped. On restarting the fluid pressure applied in the cylinder 2, compresses the spring 11 to the slight extent which the clearance between its coils permits and a small quantity of oil is discharged from the chamber 10 at intensified pressure through the holes 17 and 18 to the surface between the slipper 6 and plate 7, there forming a lubricating film and enabling the motion to start with a minimum of friction until the speed is sufficient to enable the film to be formed automatically as explained above.

The rotation of the piston 1 relatively to the cylinder 2 in conjunction with the oblique form of the end surface 22 of the piston, enables the port 26 to be opened almost instantaneously at the end of the stroke, for exhausting intrapped air in cases where the working fluid is liquid, or for serving as a relief valve where such is required.

The longitudinal grooves 23 in the piston are provided for the purpose of allowing any fluid under pressure which may escape from the cylinder past the oblique rear end of the piston to be discharged freely and without producing any indeterminate fluid pressures around the body of the piston which would conflict with the desired relation of forces and reactions.

I claim:—

1. In a rotary reciprocating engine, the combination of an oblique drive plate, a rotary shaft, a plurality of cylinders arranged around the shaft, pistons movable in the cylinders parallel to the axis of the shaft, piston rods movable axially in the pistons, slipper plates on the piston rods forming sliding connections between the pistons and the oblique drive plate, each piston having

an inclined inner driving end, the pressure of the driving fluid being constantly directed into a path intersecting the line of reaction between the slipper plate and said drive plate.

2. In a rotary reciprocating engine, the combination of an oblique drive plate, a rotary shaft, a plurality of cylinders arranged around the shaft, piston rotatable relatively to the cylinders and movable parallel to the axis of the shaft, piston rods axially movable in the pistons, slipper plates on the piston rods forming sliding connections between the pistons and the oblique drive plate, each piston having an inclined inner driving end, the pressure of the driving fluid being constantly directed into a path intersecting the line of reaction between the slipper plate and said drive plate at a point at the circumference of the piston.

3. In a rotary reciprocating engine, the combination of an oblique drive plate, a rotary shaft, a plurality of cylinders arranged around the shaft, pistons rotatable relatively to the cylinders and movable parallel to the axis of the shaft, piston rods axially movable in the pistons, slipper plates on the piston rods, forming sliding connections between the pistons and the oblique drive plate, each piston having an inclined inner driving end, the pressure of the driving fluid being constantly directed into a path intersecting the line of reaction between the slipper plate and said drive plate, at a point of the piston contacting with the cylinder under all conditions of operations.

4. In a rotary reciprocating engine, the combination of an oblique drive plate, a rotary shaft, a plurality of cylinders arranged around the shaft, pistons rotatable relatively to the cylinders and movable parallel to the axis of the shaft, each piston having a yielding forward extension rod movable axially of the piston, and a slipper articulated to said extension rod forming a sliding connection between the pistons and the oblique drive plate, each piston having an inclined inner driving end for the purpose specified.

5. In a rotary reciprocating engine, the combination of an oblique drive plate, a rotary shaft, a plurality of revoluble cylinders arranged around the shaft, pistons rotatable relatively to the cylinders and movable parallel to the axis of the shaft, an axially movable rod in each piston having a forward cylindrical head, a slipper element articulated to said head and engaging with the forward and rearward sides thereof, said slippers constituting sliding connections between the pistons and drive plate, each piston having an inclined inner end for the purpose specified.

6. In a rotary reciprocating engine, the combination of an oblique drive plate, a ro-

tary shaft, a plurality of revoluble cylinders arranged around the shaft, piston rotatable relatively to the cylinders and movable parallel to the axis of the shaft, a rod in each piston having forward cylindrical head, a slipper articulated to said head forming a sliding connection between the pistons and the oblique drive plate, and means actuated by fluid pressure on the piston for supplying lubricant under intensified pressure to said slipper.

7. In a rotary reciprocating engine, the combination of an oblique driving plate, a rotary shaft, a plurality of revoluble cylinders arranged around the shaft, pistons rotatable relatively to the cylinders and movable parallel to the axis of the shaft, a piston rod movable axially in a lubricant chamber formed in each piston, a spring in the chamber behind the rod, a fluid channel in the piston rod communicating with said chamber, and a slipper plate having sliding contact with the driving plate articulated to the rod.

8. In a rotary reciprocating engine, the combination of an oblique driving plate, a rotary shaft, a plurality of revoluble cylinders arranged around the shaft, pistons rotatable relatively to the cylinders and movable parallel to the axis of the shaft, a piston rod axially movable in a lubricant chamber formed in each piston, a spring in the chamber behind the rod, a fluid channel in the piston rod communicating with said chamber, a slipper plate having sliding contact with the driving plate articulated to the piston rod and supplied with lubricant from said channel, and means whereby the pressure of the driving fluid against the pistons is directed in a path intersecting the line of reaction between the slipper plate and said driving plate at a point of contact between the piston and cylinder.

9. In a rotary reciprocating engine, the combination of an oblique driving plate, a rotary shaft, a plurality of revoluble cylinders arranged around the shaft, pistons rotatable relatively to the cylinders and movable parallel to the axis of the shaft, a piston rod movable axially in a lubricant chamber formed in each piston, a spring in the chamber behind the rod, a fluid channel in the piston rod communicating with said chamber, a slipper plate having sliding contact with the driving plate articulated to the piston rod and supplied with lubricant from said channel, said piston having an oblique rear end, whereby the pressure of the driving fluid against said end is directed in a path intersecting the line of reaction between the slipper plate and the driving plate.

Dated this 23rd day of November, 1920.

A. G. M. MICHELL.