Feb. 27, 1934. C. B. REDRUP 1,948,827

SWASH PLATE MECHANISM FOR ENGINES

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Fig. 1.

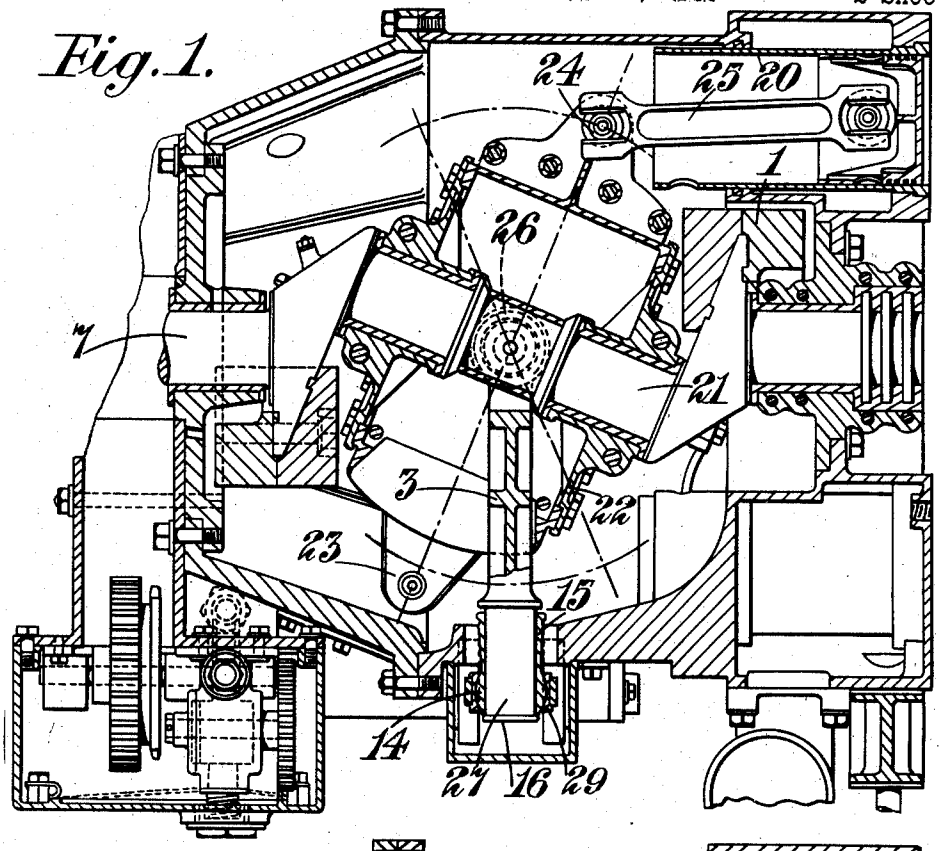
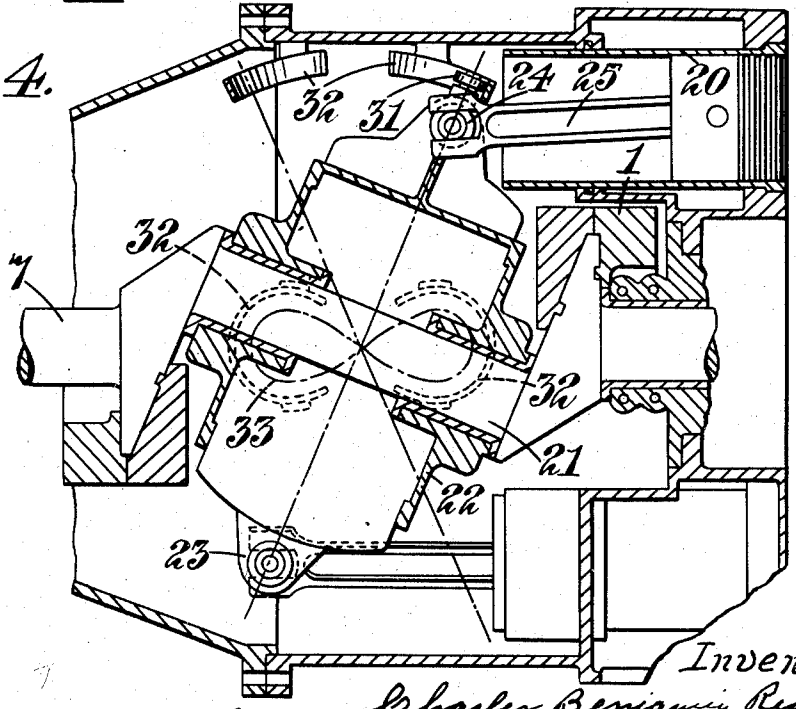


Fig. 4.



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Fig. 2.

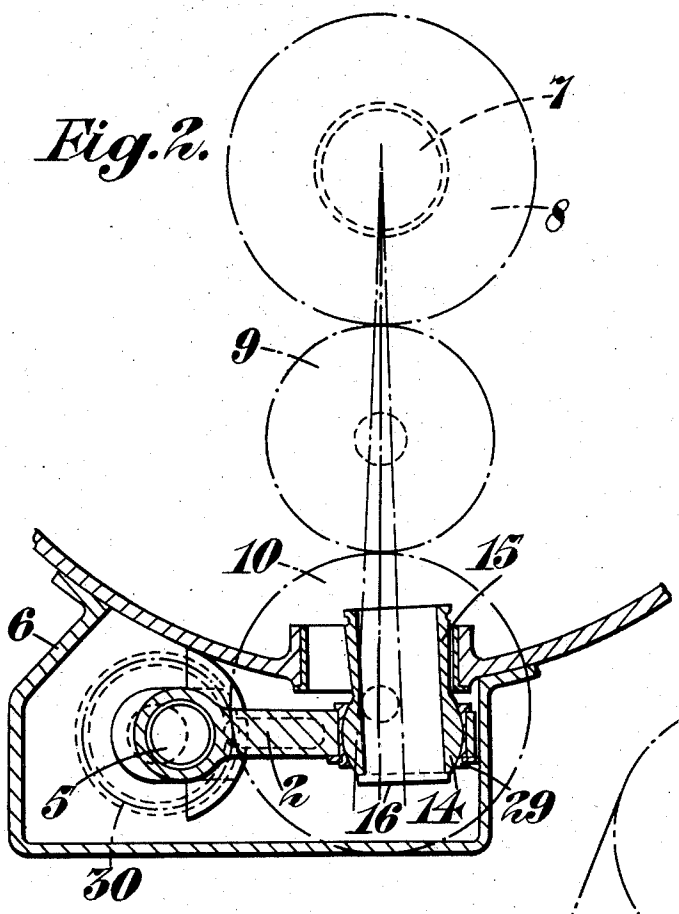
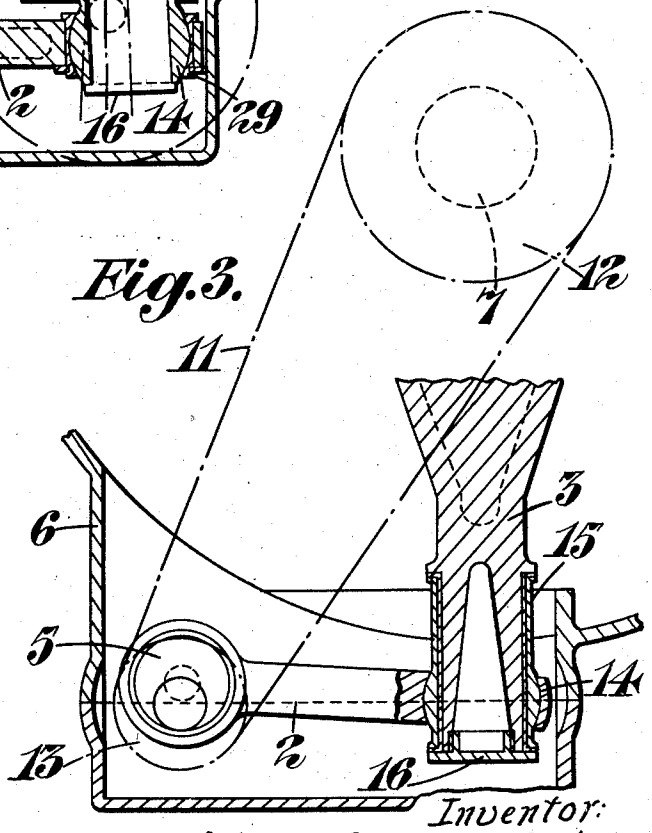


Fig. 3.



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UNITED STATES PATENT OFFICE

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SWASH PLATE MECHANISM FOR ENGINES

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Application March 17, 1933, Serial No. 661,398
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7 Claims. (Cl. 74—14)

This invention is for improvements in or relating to internal-combustion and other engines of the kind wherein the engine connecting rods are articulately connected to a swash member which is so mounted on the engine shaft that relative rotation between these two latter parts takes place about an axis inclined to the engine shaft, and which swash member is so anchored to a part of the engine that substantial rotational movement of the swash member as a whole relatively to the engine cylinders about the engine shaft is prevented. The above mentioned anchorage is required in order that the connecting rods of the engine may be constrained to move in definite paths. Heretofore, the anchorage has been effected mainly in two ways; the swash member has been carried on trunnions which extend at right angles to the engine shaft, and which are so secured to the engine frame as to be rotatable as a whole about an axis at right angles both to the trunnion axis and to the engine shaft. Secondly, an abutment on the swash member has been arranged to travel between guide plates in a direction backwards and forwards along the axis of the engine shaft. Although these arrangements had the effect of constraining the connecting rods to move in definite paths, the path of each rod where it was connected to the swash member differed substantially from the paths of the other connecting rods. Thus, a balancing of the engine could not be effectively brought about.

An object of the present invention is to constrain the connecting rods to move in similar paths. In analyzing the paths of movement of different points on the swash member equidistant from said inclined axis, in the two known arrangements referred to above, it will be found that whereas those points which lie on the trunnion axis in the one construction, and those which lie in a plane containing the engine shaft and the guideways in the other construction, move in arcuate paths, those which are disposed at 90° to the above mentioned path on the swash member move in figures-of-eight.

According to this invention, swash plate mechanism for internal-combustion and other engines of the kind described is characterized in that means are provided for constraining the swash member to move so that all points on a plane transverse to the inclined axis and passing through the intersection of the inclined axis and the engine shaft trace paths of similar lemniscate or figure-of-eight form.

Theoretically, the movement of any one point on the swash member should approximate as nearly as possible to the general expression—

$$y^2=\frac{x^2(R^2\sin^2\theta-x^2)}{R^2(1+\cos\theta)^2}$$

where x and y are rectangular coordinates, θ is the angle the inclined axis makes with the engine shaft and R is the perpendicular distance of the point in question from the said inclined axis. It will be appreciated that the path of movement of the point lies on the surface of a sphere of radius R and the expression given above applies to the projection of the path of movement on to a plane tangential to the said sphere at the point at which the figure-of-eight crosses itself. Thus, if any one point on a plane transverse to the inclined axis and passing through the intersection of the inclined axis and the engine shaft is constrained to move in a path according to the above expression, all other points on the swash member will move in paths of the same shape and proportions but of different dimensions according to their distance from the said inclined axis; at equal distances, the dimensions of the paths are the same.

It will be appreciated, however, that slight deviations from this expression can be made without substantially altering the paths of movement of the connecting rods; thus, mechanisms can be employed giving approximations of the theoretically required movements.

In applying the invention to a swash plate mechanism in which the swash member is carried by trunnions in the manner described above, a feature of the invention consists in that the trunnion axis is given two complete oscillations about said inclined axis for each engine revolution to such an extent as to the figure-of-eight movement referred to above.

In applying the invention to a swash plate mechanism in which the trunnions are formed on an anchor member having a tail-piece mounted in a bearing, the bearing is oscillated. For example, the oscillation may be effected by an eccentric driven at twice engine speed, in which case a collar at one end of the link is arranged to surround said eccentric, while the other end of said link is connected by a universal joint to said bearing. It is usually convenient for the oscillation to be effected in a direction transverse to the engine shaft in a plane at right angles thereto. In such an arrangement, the angle through which the trunnion axis is swung should be approximately 10.34% of an angle between the engine shaft and the aforesaid inclined axis,

in order that an approximation to the above expression may be obtained.

Another constructional form of the invention consists in that one or more abutments fixed to the swash plate is, or are, engaged by a cam surface or surfaces shaped in the manner of a figure-of-eight as described above. For example, one abutment on the swash member might be arranged to be engaged by an S-shaped cam surface representing one half of a figure-of-eight, while another abutment on the opposite end of a diameter of the swash member might be engaged by a complementary S-shaped cam face representing the other half of the figure-of-eight.

The following is a description of an embodiment of the invention as applied to a swash plate type of internal combustion engine, reference being made to the accompanying drawings, in which—

Figure 1 is a cross-section through a part of the engine along a plane containing the engine shaft;

Figure 2 is a detail view illustrating one form of mechanism for oscillating the swash member about the crank-pin;

Figure 3 illustrates another form of mechanism for oscillating the swash member;

Figure 4 is a similar view to Figure 1 showing cam means for constraining the swash member to follow the required movement; and

The engine comprises a number of cylinders 20 disposed around a crank-shaft 7 with their axes parallel thereto. The crank-shaft is provided with an inclined crank-pin 21 on which is mounted a swash member 22. The swash member is provided with a number of lugs 23 around its periphery to which are secured by universal joints 24 the engine connecting rods 25. The swash member is hollow and has two bearing sockets formed on opposite sides of a diameter which extends at right angles to the axis of the engine crank-shaft, and through the centre of the crank-pin. An anchor member 3 is arranged to extend through a slot in the swash member into the hollow interior and is provided at its upper end with trunnions 26 which engage said bearing sockets. The anchor member is provided with a cylindrical tail piece 27 which is carried by a bearing 15, and is provided with a locating head 16. The lower part of the bearing is provided with an external part spherical surface 14 which is mounted in a part spherical socket in a carrier 29. Assuming that the carrier 29 is stationary (which it is not) upon the rotation of the crank-shaft it will be found that the anchor member is oscillated about its longitudinal axis and thus the ends of trunnions 26 trace arcuate paths as do also those lugs 23 of the swash plate which lie on or near the trunnion axis, while those lugs at right angles, viz. at the top and bottom of the swash plate trace figures-of-eight. Thus, different connecting rods under such conditions trace different paths. In order to equalize the paths, the tail-piece is given two complete oscillations for each revolution of the crank-shaft in a direction transverse to the axis of the crank-shaft, whereby the trunnions and the lugs in line therewith are caused to trace a figure-of-eight. At the same time the width of the figure-of-eight traced by the upper and lower lugs is reduced and by suitably selecting the degree of oscillation of the tail-piece, the various lugs and thus the end of the connecting rods may be made to trace approximately the same form of path. It is found in practice that the angular extent of oscillation of the crown member is about 10.34 per cent of the crank angle. In the engine shown in the drawings, the crank angle is 22½° and the extent of oscillation is 2.42°.

The drawings show the anchor member in the mid-point of its oscillation with its axis at right angles to that of the crank-shaft and during one revolution of the crank-shaft it is twice oscillated on either side of this position.

One form of mechanism for oscillating the carrier 29 is shown in Figure 2 and comprises an eccentric 5 which is surrounded by a collar at one end of a link member 2, the other end of which supports said carrier. The eccentric is driven from the crank-shaft by gear wheels 8, 9, 10 and 30 at twice crank-shaft speed, the throw of eccentric being sufficient to impart the required angular movement to the anchor member 3.

The mechanism shown in Figure 3 differs mainly in that the eccentric is driven by a chain 11 and sprocket wheels 12 and 13.

As indicated earlier in the specification, if any one part of the swash member is constrained to move in a particular form of path, all other points will move in substantially the same form of path. In the construction shown diagrammatically in Figures 4 and 5, instead of the movement of the swash member being controlled by an anchor member which is oscillated, it is constrained to move in the required manner by rollers 31 secured thereon which engage suitably shaped cam plates 32.

It will be appreciated that it would be difficult to arrange a roller to follow a cam plate in the complete form of a figure-of-eight, but this is unnecessary if more than one cam plate and one follower is used. In considering the path of movement of points disposed at ninety degrees apart on the swash member, while one point is traversing the curved end portions of the figure-of-eight, the other point at ninety degrees is traversing the cross-over parts of the figure-of-eight. From this it follows that the complete motion can be obtained by arranging a pair of cam plates opposite one another in each of two positions disposed ninety degrees apart, each pair comprising opposed concave surfaces at the ends of the figure-of-eight. These can best be seen in the dotted lines in Figure 4. The corresponding pair of cam plates are shown in part section attached to the engine casing at the top of the drawings.

The figure-of-eight shown in chain line 33 represents the path followed by the centre of the roller 31, and has an exaggerated width, the length should be about ten times the width in the proper proportions.

I claim:—

1. A swash plate mechanism for an engine having pistons, a crank shaft with an inclined crank pin, a swash plate rotatably mounted on the crank pin, actuating connections between the pistons and the swash plate, and means for moving the swash plate when the engine is in operation, which means causes each of the actuating connections between the pistons and the swash plate to follow substantially similar paths.

2. A swash plate mechanism for an engine having pistons, a crank shaft with an inclined crank-pin, a swash member rotatably mounted on the crank-pin, actuating connections between the pistons and the swash member, means for controlling the movement of the swash member, and means for actuating said controlling means when the engine is in operation to cause each of the actuating connections between the pistons

and the swash member to follow substantially similar paths.

3. A swash plate mechanism for an engine having pistons, a crank shaft with an inclined crank-pin, a swash member rotatably mounted on the crank-pin, driving connections between the pistons and the swash member, means for controlling the movement of the swash member, and means for moving the controlling means in timed relation to the crank shaft to equalize the paths of movements of the driving connections between the pistons and the swash member.

4. A swash plate mechanism for an engine having pistons, a crank shaft with an inclined crank-pin, a swash member rotatably mounted on the crank pin, actuating connections between the pistons and the swash member, means for controlling the movement of the swash member, and means for actuating said controlling means when the engine is in operation to cause each of the actuating connections between the pistons and the swash member to follow paths of the figure-of-eight form.

5. A swash plate mechanism for an engine having pistons, a crank shaft with an inclined crank-pin, a swash plate rotatably mounted on the crank-pin, actuating connections between the pistons and the swash plate, and cam means for moving the swash plate, which cam means causes each of the actuating connections between the pistons and the swash plate to follow paths of similar figure-of-eight form.

6. A swash plate mechanism for an engine having pistons, a crank shaft with an inclined crank-pin, a swash member rotatably mounted on the crank-pin, driving connections between the pistons and the swash member, means for controlling the movement of the the swash member, and gearing connecting the crank shaft to the controlling means for moving the controlling means in timed relation to the crank shaft to equalize the paths of movements of the driving connections between the pistons and the swash member.

7. A swash plate mechanism for an engine having pistons, a crank shaft with an inclined crank-pin, a swash member rotatably mounted on the crank-pin, actuating connections between the pistons and the swash member, means for controlling the movement of the swash member, and gearing connecting the crank shaft to the controlling means for actuating said controlling means to cause each of the actuating connections between the pistons and the swash member to follow paths of the figure-of-eight form.

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