May 7, 1940. B. FIALA-FERNBRUGG 2,199,625

DOUBLE-PISTON INTERNAL COMBUSTION ENGINE

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Fig.1

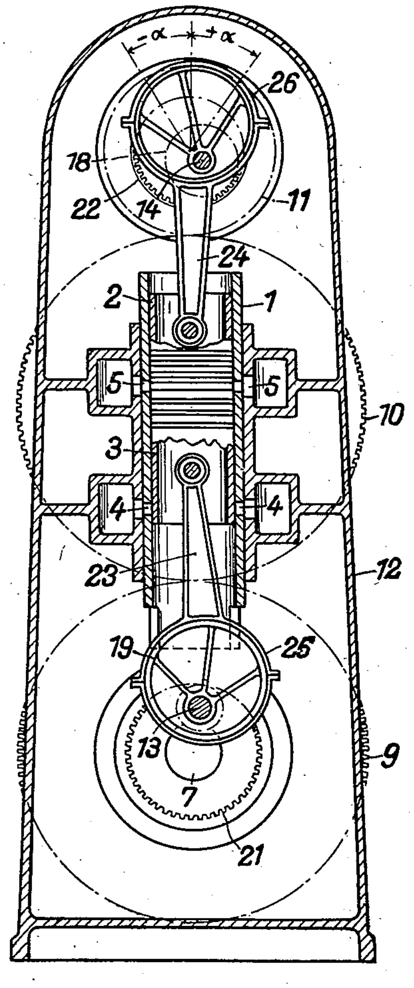
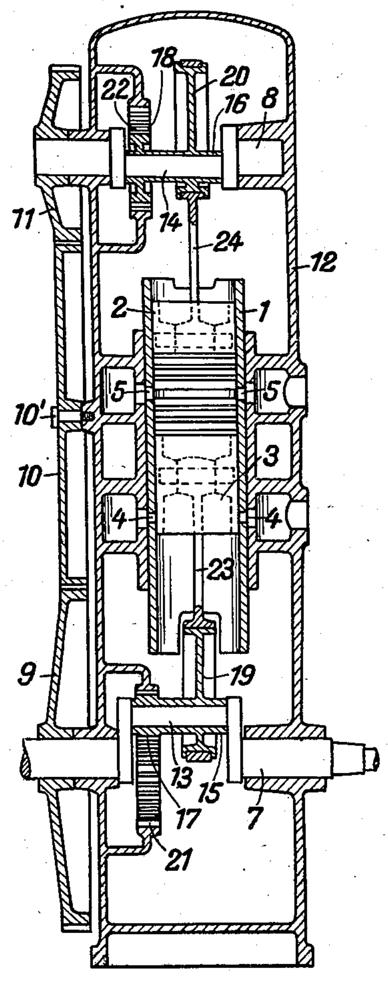


Fig.2



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DOUBLE-PISTON INTERNAL COMBUSTION ENGINE

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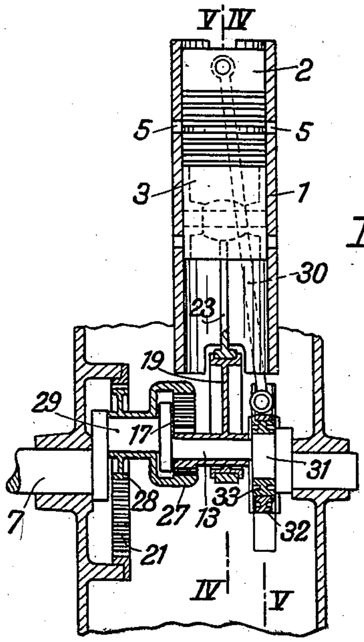

Fig. 3

Fig. 4

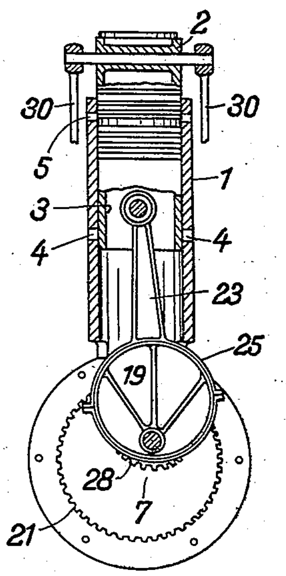

Fig. 5

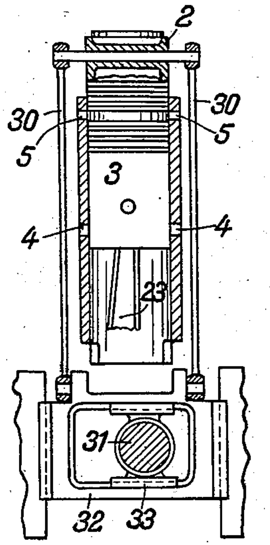

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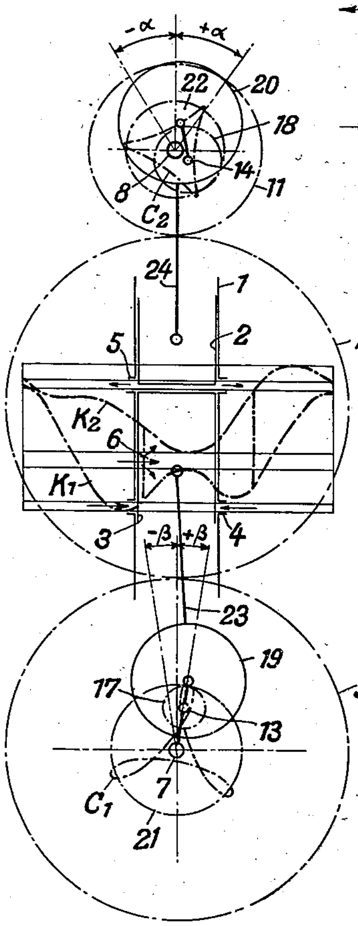
Fig. 6



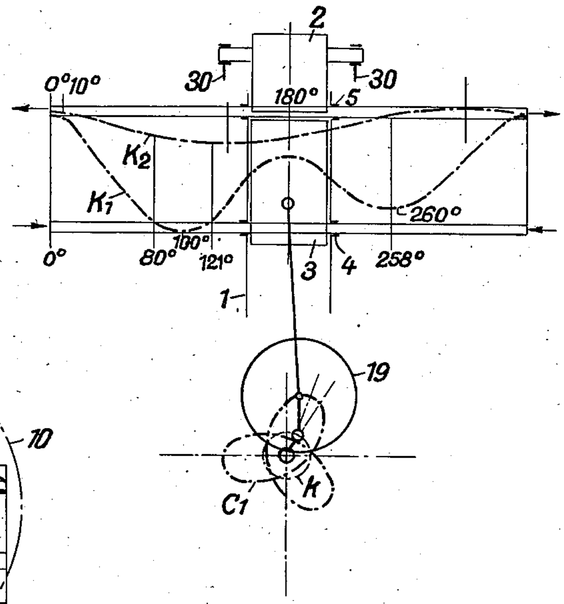


Fig. 7

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UNITED STATES PATENT OFFICE

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DOUBLE-PISTON INTERNAL COMBUSTION ENGINE

Benno Fiala-Fernbrugg, Vienna, Germany

Application June 4, 1938, Serial No. 211,765
In Germany, formerly Austria, June 11, 1937

7 Claims. (Cl. 123—51)

My invention relates to a double-piston internal combustion engine, that is to say an internal combustion engine, wherein two pistons work in a common cylinder and drive different crank shafts or a common crank shaft. Hitherto, in such double-piston internal combustion engines the ordinary crank drive was employed for taking the drive from the pistons, that is to say, a crank drive, wherein the crank pins move on circular paths.

My invention differs from the known double-piston internal combustion engines in that for the drive of at least one of the two pistons a piston drive operating according to the cycloid system is provided, wherein the crank pin describes a cycloid, for example a hypocycloid.

Where the two pistons drive a common crank shaft, the cycloid drive is conveniently employed in conjunction with the inner piston, and possibly also in conjunction with the outer piston.

If a separate crank shaft is provided for each piston, the cycloid crank drive may be employed in conjunction with one of the crank shafts or in conjunction with both crank shafts.

In the case of a multi-cylinder engine with aligned cylinders, the cycloid crank drives may be alternately employed for driving one and the other of the crank shafts, for a favorable distribution of the masses.

In some cases it is of advantage to construct the cycloid crank drive encased.

The cycloid system crank drive is known in itself, but hitherto it has not been employed in conjunction with double-piston internal combustion engines. In such engines however, its employment offers distinct technical advantages, as will be explained hereinafter.

In the drawings accompanying this specification and forming part thereof two embodiments of double-piston internal combustion engines according to my invention are illustrated diagrammatically by way of example.

In the drawings:

Figs. 1 and 2 show a double-piston internal combustion engine, wherein each piston actuates a separate crank shaft, the figures being sections in planes perpendicular to one another.

Figs. 3 to 5 are similar representations of a double-piston internal combustion engine according to my invention, wherein the pistons actuate a common crank shaft, Fig. 4 being a section in the plane IV—IV of Fig. 3 and Fig. 5 a section in the plane V—V of Fig. 3.

Figs. 6 and 7 indicate the paths of the crank pins and of the pistons of the engines shown in Figs. 1 and 2 and Figs. 3 to 5 respectively.

In all Figures 1 to 5, 1 is the cylinder, in which the upper piston 2 and the lower piston 3 move. The mixture is drawn in through suction slots 4 and the combustion gases are expelled through exhaust slots 5. The mixture is ignited by means of a spark plug indicated at point 6 in Fig. 6 and disposed in the wall of the cylinder 1 in a position between the inner dead centres of the working surfaces of the pistons.

In the embodiment shown in Figs. 1 and 2 each piston actuates a separate crank shaft 7 and 8 respectively. The crank shafts are interconnected by means of gears 9 to 11 of a suitable ratio, for example 1 to 2, the intermediate gear 10 rotating about an axle 10′ (Fig. 2) fast on the casing 12, while the other two gears are keyed to their associated crank shafts. The crank shafts themselves are suitably mounted in a rotatable manner in the casing 12.

In the embodiment shown in Figs. 1 and 2 each of the pistons 2 and 3 is connected to the associated crank shaft through a hypocycloid crank drive. For this purpose each of the crank pins 13 and 14 of the crank shafts 7 and 8 carries loosely a sleeve 15 and 16 respectively, each of which carries a gear 17 and 18 respectively and an eccentric 19 and 20 respectively, the gear 17 and eccentric 19 on the one hand and the gear 18 and the eccentric 20 on the other hand being rigidly interconnected. The gears 17 and 18 roll on the fixed internally toothed annuli 21 and 22 respectively. The connecting rods 23 and 24 of the pistons 3 and 2 embrace with their big ends 25 and 26 the eccentrics 19 and 20 respectively.

The operation of this arrangement is as follows: The combustible mixture is drawn into the cylinder through the suction slots 4, ignited with the aid of the sparking plug 6 and the combustion gases are expelled from the cylinder through the exhaust slots 5. The reciprocatory movement of the pistons 2 and 3 is transmitted through the hypocycloid crank drive to the crank shafts 7 and 8. During the clockwise rotation of the crank shaft 7 the gear 17 rotatably mounted on the crank pin 13 rolls on the annulus 21, so that the centre of the associated eccentric 19, which is rigidly connected to the gear 17, describes the cycloid C_1 illustrated in Fig. 6. The associated piston 3 describes at uniform rotational speed of the crank shaft 7 the time-distance diagram K_1 shown in Fig. 6. C_2 and K_2 are the corresponding diagrams for the upper eccentric 20 and the upper piston 2.

In the embodiment shown in Figs. 1 and 2 the two pistons are connected to their crank shafts through respective hypocycloid crank drives, but it is possible, without deviating from the spirit of my invention, to substitute one of these crank drives by an ordinary crank drive, wherein the crank pin describes a circle. An embodiment of this nature is shown in Figs. 3 to 5 in conjunction with an engine, wherein both pistons act upon a common crank shaft 7. In this embodiment only the lower piston 3 is connected to the crank shaft 7 through a hypocycloid drive, which comprises, as the embodiment previously described, an eccentric 19, a gear 17 rigidly connected thereto and an internally toothed annulus 21. But the gears 17 and 21 are not in direct engagement, they are interconnected through change speed gears 27 and 28, which are fast with one another, the gear 27 being an internally toothed annulus and meshing with the gear 17 and the gear 28 meshing with the annulus 21. The gears 27 and 28 are loosely rotatable about a crank element 29, which connects the crank shaft 7 to the crank pin 13, on which the gear 17 and the eccentric 19 are freely rotatable. The upper piston 2 is connected to the crank shaft 7 through an ordinary circular crank drive of infinite connecting rod length, comprising links 30 engaging a slide 32, in which a crank pin 31 of the shaft 7 reciprocates with the aid of a cross slide 33. In such a crank drive the higher harmonics do not arise.

The ratio between the gears 17 and 27 and 28 and 21 respectively is preferably such that the total ratio is 1 to 3.

The operation of the engine according to Figs. 3 to 5 is in principle similar to that of the engine shown in Figs. 1 and 2. The centre of the eccentric 19 describes the cycloid C_1 shown in Fig. 7 and the piston 3 connected to the eccentric 19 describes the time-distance curve K_1 also shown in Fig. 7. The centre of the crank pin 31 describes the circle k shown in Fig. 7 and the time-distance curve of the piston 2 is indicated in this figure at K_2.

The connection of the outer piston 2 to the crank shaft 7 might also be effected with the aid of two cranks and two connecting rods of finite connecting rod length.

Figs. 6 and 7 show that as regards the lower piston 3, there are four piston strokes of different lengths at each complete revolution of the associated crank shaft, (see time-distance diagrams K_1 for the piston 3). Consequently, the double piston engine according to my invention has a characteristic which is substantially different from that of the known double-piston engines. The time-distance diagrams of the piston of a double-piston engine according to my invention present the picture of a two-stroke engine with practically complete expulsion of the combustion gases without scavenging pump and with inner cooling of the cylinder by an expansion stroke.

Further, in the double-piston engines according to my invention the suction volume is smaller than the working expansion volume, so that the operating pressures are well utilized, which is particularly important in the case of compression engines. Moreover, the engine according to my invention requires no control elements and the working pistons pass by the suction and exhaust slots, which are so disposed that the engine can operate according to the continuous flow principle.

The engine according to my invention may be constructed as a carburetter, Diesel or semi-Diesel engine, possibly with water injections.

If the annuli of the hypocycloid crank drives are so disposed in conjunction with elastically damping springs, rubber buffers, oil dampers or the like that they may yield elastically rocking about their shafts, it is possible to transmit shock-action piston forces, such as arise particularly in high speed Diesel engines, springily to the crank shafts.

If the annuli are so disposed that they may be deliberately and fixably rotated about their axes in the direction of rotation of the crank shaft or in the opposite direction, that is to say if the angles α and β (Fig. 6) through which the cycloid lines of symmetry deviate from the cylinder axis are variable, the compression ratio of the double-piston engine may be altered during running or while stationary, for example it may be increased or decreased. If the engine and the device for turning and fixing the annuli are suitably constructed, the engine may be changed over to reverse rotation by turning the annuli about their axes opposite the direction of rotation of the engine, i. e. by altering the sign of α or β.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described for obvious modifications will occur to a person skilled in the art.

In the claims appended to this specification no selection of any particular modification of the invention is intended to the exclusion of other modifications thereof and the right to subsequently make claim to any modification not covered by these claims is expressly reserved.

I claim:

1. In an internal combustion engine, the combination of a crank shaft, a cylinder, opposing pistons in said cylinder having a combustion chamber between them, a driving means between said pistons and said crank shaft comprising a cycloid drive for one of said pistons adapted to reverse the direction of movement of said piston in said cylinder at least four times for each rotation of said crank shaft so as to give four piston strokes of said piston for each such crank shaft rotation.

2. An internal combustion engine as set forth in claim 1 in which the cycloid drive is hypocycloid and is set with relation to the crank shaft to give unequal piston strokes of its corresponding piston.

3. An internal combustion engine as set forth in claim 1 in which the cycloid drive includes a generating gear and an annulus and a change speed gearing disposed between the generating gear and the annulus.

4. In an internal combustion engine, the combination of a crank shaft, a cylinder, opposing pistons in said cylinder having a combustion chamber between them, a driving means between said pistons and said crank shaft comprising a cycloid drive for each of said pistons, said drives being adapted to give two stages of approach of said cylinders toward each other for each rotation of the said crank shaft.

5. An internal combustion engine as set forth in claim 4 in which the driving means between the pistons and the crank shaft are hypocycloid crank drives.

6. In an internal combustion engine, the combination of a crank shaft, a cylinder, opposing pistons in said cylinder having a combustion chamber between them, a driving means between said pistons and said crank shaft comprising a cycloid crank drive for an inner piston adjacent said crank shaft and a circular crank drive for the other outer piston at greater distance from said crank shaft.

7. An internal combustion engine as set forth in claim 6 in which said driving means between the pistons and the crank shaft embody a connecting rod of infinite length employing a crank loop around the crank shaft having a transverse sliding movement relative to said crank shaft.

BENNO FIALA-FERNBRUGG.