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(71) Applicant
Fichtel & Sachs AG,
62 Ernst-Sachs-Strasse,
Schweinfurt, Germany
(72) Inventors
Wolfgand Baier,
Ulrich Husse
(74) Agent
Matthews, Haddan & Co.,
Haddan House, 33
Elmfield Road, Bromley,
Kent BR1 1SU

(54) Balancing Reciprocating-piston Mechanisms

(57) A two cylinder reciprocating piston mechanism is balanced by three meshing gear-wheels 10, 12 and 14, each of which carries a balance weight 11, 13 and 15 respectively. Gear wheel 10 is mounted on the crankshaft and all the wheels run at crankshaft speed and are arranged in one plane. Balance weight 13 balances 50% of the oscillating forces and weight 11 and 15 each balance 25%. If the inertia force F1 associated with piston 2 is different from that of piston 4 (F2) then the plane in which the balancing wheels are arranged is moved axially of the crankshaft so that F1×A1=F2×A2.

Fig.1

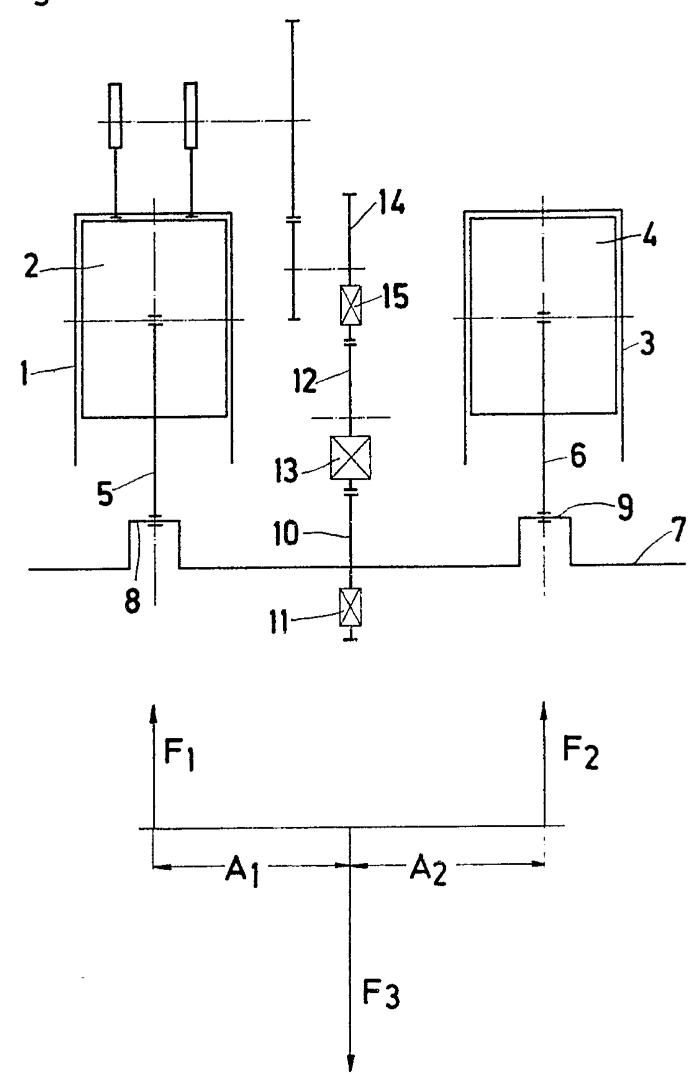

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Fig.1

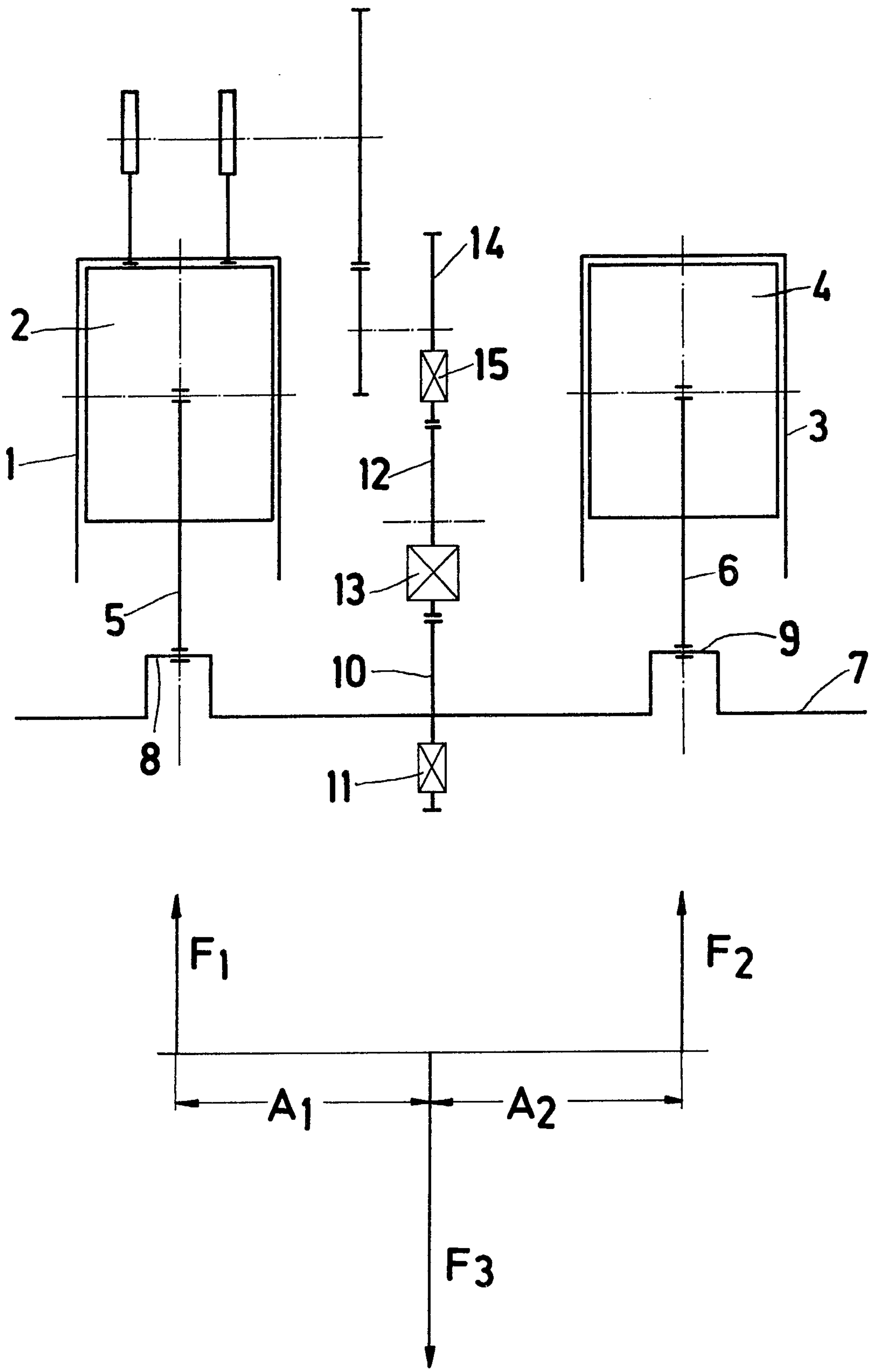

Fig. 2

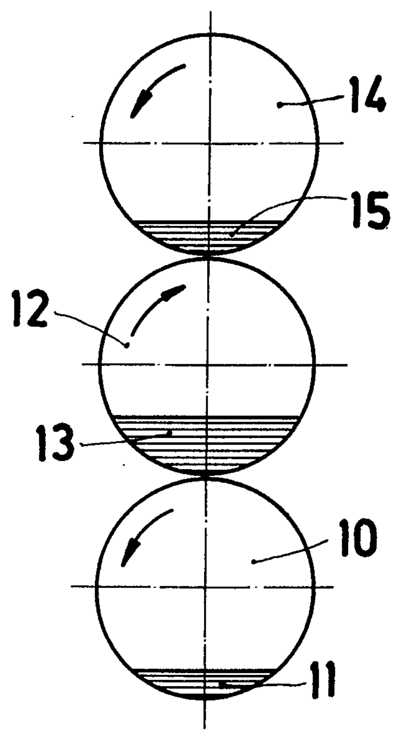

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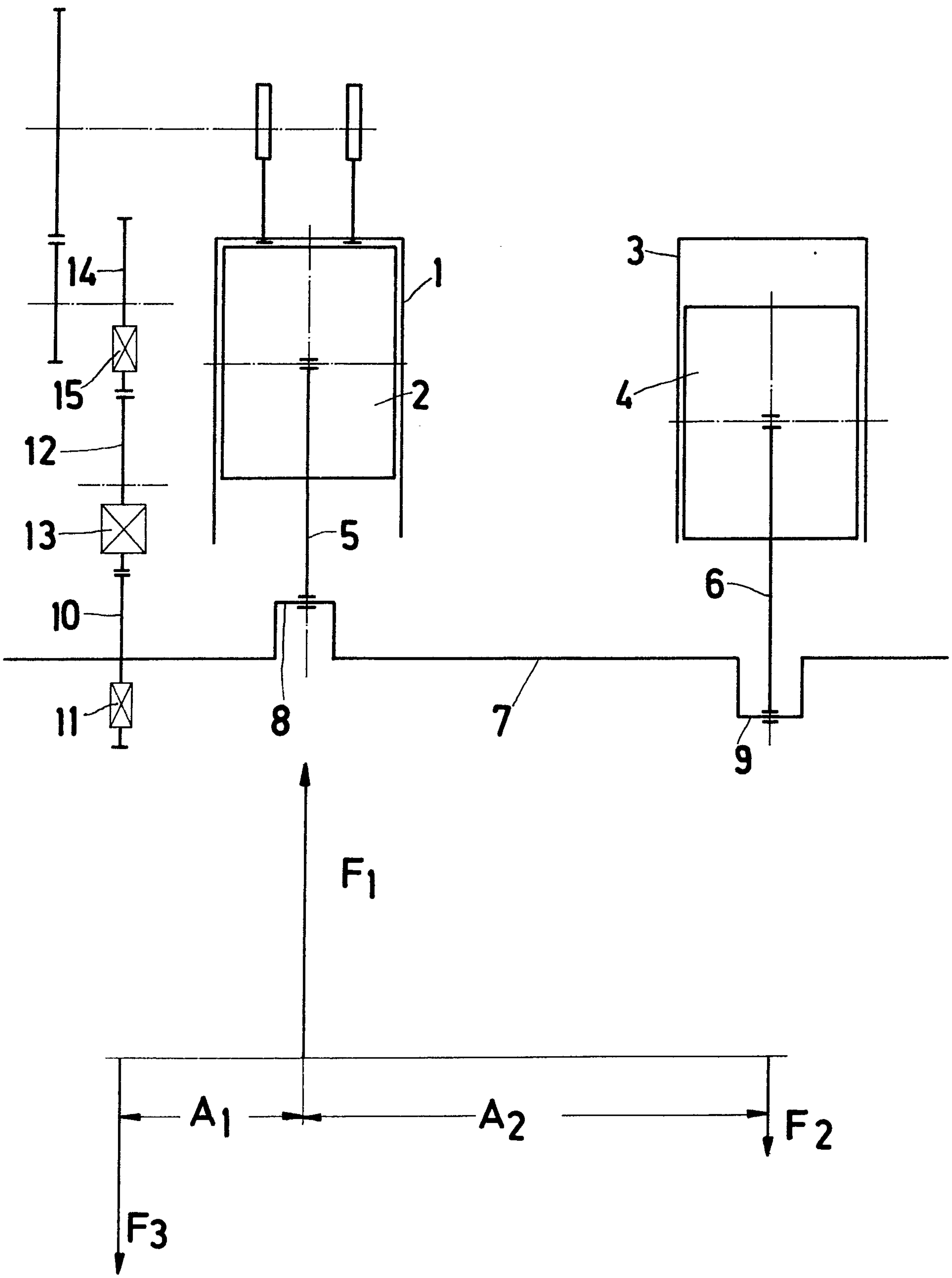
Fig. 3



SPECIFICATION

A Reciprocating-piston Engine

The present invention relates to a reciprocating-piston engine consisting of at least two cylinders, in which there slide pistons which are connected to a crank shaft, while the forces due to inertia are counteracted by rotating balancing weights which are arranged on the crank shaft and/or separately therefrom.

For balancing the inertia forces caused by the reciprocating components, the crank cheeks are usually designed as counterweights, which makes it impossible to bring about a complete balancing of the inertia forces and the moments, for example on a two-cylinder reciprocating-piston engine. It is furthermore known to secure on shafts, which are provided in addition to the crank shaft, four balancing weights which rotate at the crank-shaft speed and the inertia forces of which are active in the opposite direction to the oscillating forces of the reciprocating-piston engine. For this purpose, two balancing weights are arranged on a shaft at a distance from each other and the shafts rotate in opposite senses of rotation. For balancing the masses of multi-cylinder reciprocating-piston engines, the known mass balancing systems are arranged in several planes and the constructional expenditure as well as the space requirement of such constructions is very large.

It is the object of the present invention to provide, with simple means, a complete balancing of the masses and moments for a reciprocating-piston engine consisting of at least two cylinders, for which purpose as small a constructional space as possible is required.

According to the invention, this problem is solved in that, for the complete balancing of the oscillating forces as well as of the moments of the reciprocating-piston engine, the rotating balancing weights are formed by three balancing wheels which rotate at the crank-shaft speed and which carry counterbalance weights and are arranged in one plane. The distances between the reciprocating masses of the three balancing wheels lying in one plane have been chosen to be such that, in addition to the forces, the moments are also balanced by these balancing wheels.

As another feature of the invention shows, the balancing wheels are formed by toothed gears, the central gear balancing approximately 50% of the oscillating forces of the reciprocating-piston engine and the other two gears each balancing approximately 25% thereof. Such a division of the counterbalance weights on the balancing wheels has the effect that the balancing-wheel system does not form a moment.

As the invention shows, the balancing wheels are provided between the cylinders of a two-cylinder engine, with the pistons of the two-cylinder engine moving in the same direction according to another feature, which means that the two pistons have the same positions in the cylinders. If the reciprocating masses of each cylinder are identical, then the balancing-wheel system is in the centre between the cylinders, that is to say the distance of the balancing wheels from each piston axis is the same.

In another constructional form of the reciprocating-piston engine, for example one cylinder is designed as a reciprocating-piston internal-combustion engine, while the second cylinder is used as a compressor, provision being made according to the invention for the pistons of the two-cylinder reciprocating-piston engine to move in opposite directions and for the balancing wheels serving for the balancing to be arranged at the free front end of the cylinder unit that is subjected to the greater inertia force. Such an arrangement of the balancing wheels, which is favourable in opposite-stroke two-cylinder reciprocating-piston engines wherein the inertia forces per cylinder unit are different, allows an easy assembly and maintenance of these parts.

According to further features of the invention, a further simplification of the construction is obtained in that the balancing wheels serve for driving auxiliary units, such as the oil pump, ignition system, generator, water pump, fuel pump and the like, or in that the balancing wheels serve for driving the cam shaft.

Further design possibilities and advantageous effects will emerge from the description of the construction and the mode of operation of the constructional forms of the invention illustrated hereinafter by way of example. In the drawings:

Figure 1 shows a two-cylinder reciprocating-piston engine in a diagrammatical representation;

Figure 2 shows the arrangement of the balancing wheels; and

Figure 3 shows a two-cylinder reciprocating-piston engine which is designed so as to work in opposite directions and has laterally arranged balancing wheels.

The two-cylinder reciprocating-piston engine shown in Fig. 1 consists of the left-hand cylinder 1, in which the piston 2 slides this piston 2 being mounted through the connecting rod on the crank 8 of the crank shaft 7. This cylinder unit is constructed, for example, as an internal-combustion engine, while the crank shaft 7 drives the piston 4, which slides in the cylinder 3, through the crank 9 and the connecting rod 6 mounted thereon. This right-hand cylinder unit is designed, for example, as a compressor and has smaller oscillating masses then the left-hand cylinder assembly. Between these two cylinders 1 and 3, there are located the three balancing wheels 10, 12 and 14 which lie in a plane which is vertical to the drawing plane and extends parallel to the piston axes. This two-cylinder reciprocating-piston engine is designed so as to work in the same direction, that is to say the cranks 8 and 9 of the crank shaft 7 point in the same direction and the pistons 2 and 4 are in the top dead centre at the same moment. For balancing the reciprocating masses of the two-cylinder reciprocating-piston engine, the balancing wheels 10, 12 and 14 are provided with the counterbalance weights 11, 13 and 15. The balancing wheel 10 is non-rotatably connected to the crank shaft 7 and the balancing wheels 12 and 14 also rotate at the crank-shaft speed since they have the same diameters as the the balancing wheel 10. In the present exemplified embodiment, these balancing wheels are shown as gears which mesh with one another, thus causing the balancing wheel 14 to be given the same direction of rotation as the balancing wheel 10, while the central balancing wheel 12 has a direction of rotation that is opposite to that of these two gears. The counterbalance weights 11, 13 and 15 of the balancing wheels 10, 12 and 14 are so designed that the sum of the oscillating inertia forces becomes zero. If the inertia force originating from piston 2 and the connecting-rod proportion 5 is designated F1 and the inertia force formed by the piston 4 and the proportion of the connecting rod 6 is designated F2, then the counterforce F3 originating from the counterbalance weights 11, 13 and 15 of the balancing wheels 10, 12 and 14 must correspond to the sum of the inertia force F1 and F2 and must be oppositely directed to these. The shown position of the pistons 2 and 4 in the top dead centre makes it necessary for the counterbalance weights 11, 13 and 15, which are arranged on the balancing wheels, to lie in the lower position of the balancing wheels 10, 12 and 14. For balancing the moments, that is to say that the sum of all moments is equal to zero, the condition that the moment $F1 \times A1$ corresponds to the moment $F2 \times A2$ must be fulfilled.

For driving the cam shaft, for example the balancing wheel 14 is non-rotatably connected to another gear which meshes with the gear of the cam shaft. Of course, further auxiliary assemblies, such as the oil pump, an ignition system, a generator, a water pump, a fuel pump or similar units, can be driven by the balancing wheels 10, 12 and 14 which are designed as toothed gears.

In Fig. 2, the arrangement of the balancing wheels 10, 12 and 14 and the counterbalance weights 11, 13 and 15 is shown in a different view. As has already been described in Fig. 1, the balancing wheel 10 is non-rotatably connected to the crank shaft and, since all three balancing wheels are designed as toothed gears, engages in the balancing wheel 12 and this latter engages in the balancing wheel 14. The position of the counterbalance weights 11, 13 and 15, which are secured on top of the balancing wheels 10, 12 and 14, corresponds to a position of the upper dead centre of the pistons 2 and 4 shown in Fig. 1. If the crank shaft, and thus the balancing wheel 10, now rotates in the anti-clockwise sense, then the balancing wheel 12 rotates in the clockwise sense and the balancing wheel 14, in turn, rotates in the anti-clockwise sense. A rotational movement of the balancing wheel 10 through 90° causes the counterbalance weight 11 to come to lie on the right-hand side, while the counterbalance weight 13 of the balancing wheel 12 lies on the left-hand side and the counterbalance weight 15 of the balancing wheel 14, in turn, lies on the right-hand side. In order to ensure that these counterbalance weights do not produce any moment, they are so designed that the counterbalance weights 11 and 15 arranged on the balancing wheels 10 and 14 each balance 25% of the oscillating forces and the central balancing wheel carries a counterbalance weight 13 which balances 50% of the oscillating forces. A complete balancing of the forces and moments is obtained in this way.

In the constructional form shown in Fig. 3, the reciprocating-piston engine is designed so as to work in opposite directions, with the crank-shaft cranks 8 and 9 on the crank shaft 7 pointing in opposite directions. When, in operation, the piston 2 slides upwards in the cylinder 1, the piston 4 moves downwards in the cylinder 3. Furthermore, the inertia forces of the reciprocating masses originating from the piston 4 and the proportion of the connecting rod 6 are smaller than those originating from the piston 2 and the connecting-rod proportion 5. For balancing the forces and moments, there are also arranged three balancing wheels 10, 12 and 14 on the left-hand side of the cylinder 1. In order to obtain a complete balancing of forces here, too, the inertia force F1 that is associated with the cylinder 1 is oppositely directed to the inertia forces F2 and F3, F2 being the inertia force formed by the piston 4 and the proportion of the connecting rod 6 and F3 being the force produced by the counterbalance weights 11, 13 and 15 of the balancing wheels.

The balancing of the moments is provided when $F2 \times A2$ is equal to $F3 \times A1$.

In the piston position shown in this Figure 3, the counterbalance weights 11, 13 and 15 arranged on the balancing wheels 10, 12 and 14 are in the positions shown in Fig. 2. The size of the counterbalance weights of the construction shown in Fig. 3 is considerably smaller than that of the constructional form shown in Fig. 1. Since the balancing wheels are easily accessible from the front end of the reciprocating-piston engine, not only the assembly and maintenance are rendered easy but there thus also comes about an easy connection for the drive of auxiliary units or an easily accessible drive for the cam shaft.

It is readily possible to use the afore-described balancing of the first order forces due to inertia for more than two-cylinder constructions of the reciprocating-piston engine. For example, there may be arranged on the crank-shaft crank 9 another connecting rod which acts on another cylinder/piston unit which is located opposite to the cylinder 3 and the piston 4.

Claims

1. A reciprocating-piston engine consisting of at least two cylinders, in which there slide pistons which are driven through crank shafts, the forces due to inertia being counteracted by rotating balancing weights which are arranged on the crank shaft and/or separately therefrom,

characterised in that, for the complete balancing of the oscillating forces as well as of the moments, the rotating balancing weights are formed by three balancing wheels (10, 12, 14) which rotate at the crank-shaft speed and which carry counterbalance weights (11, 13, 15) and are arranged in one plane.

2. A reciprocating-piston engine as claimed in Claim 1, characterised in that the balancing wheels (10, 12, 14) are formed by toothed gears, the central gear (12) balancing approximately 50% of the oscillating forces originating from the reciprocating-piston engine and the other two gears (10, 14) each balancing approximately 25% thereof.

3. A reciprocating-piston engine as claimed in Claims 1 and 2, characterised in that the balancing wheels (10, 12, 14) are arranged between the cylinders (1, 3) of a two-cylinder engine.

4. A reciprocating-piston engine as claimed in Claims 1 to 3, characterised in that the pistons (2, 4) of the two-cylinder engine work in the same direction.

5. A reciprocating-piston engine as claimed in Claims 1 to 4, characterised in that the reciprocating masses of the two-cylinder reciprocating-piston engine are different for each cylinder.

6. A reciprocating-piston engine as claimed in Claims 1, 2 and 5, characterised in that the pistons (2, 4) of the two-cylinder reciprocating engine work in opposite directions and in that the balancing wheels (10, 12, 14) are arranged at the free front end of the cylinder unit which is subjected to the larger inertia force.

7. A reciprocating-piston engine as claimed in Claims 1 to 6, characterised in that the balancing wheels (10, 12, 14) serve for driving auxiliary assemblies.

8. A reciprocating-piston engine as claimed in Claims 1 to 7, characterised in that the balancing wheels (10, 12, 14) serve for driving the cam shaft.

9. A reciprocating-piston engine substantially as described herein with reference to the accompanying drawings.

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