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INTERNAL COMBUSTION ENGINE

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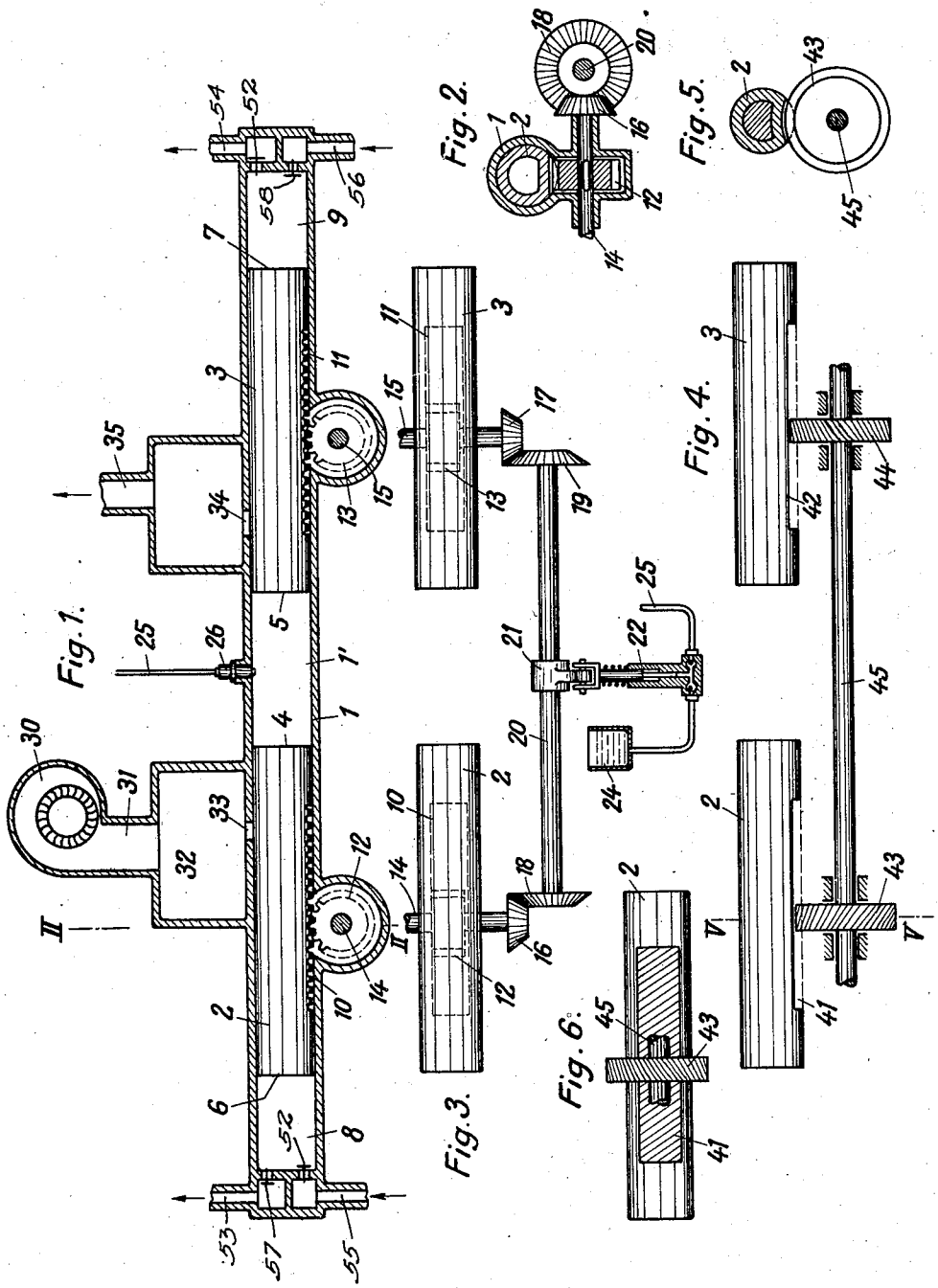

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INTERNAL-COMBUSTION ENGINE.

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My invention refers to internal combustion engines and more especially to engines of the type in which two pistons are freely arranged for reciprocation in a cylinder, these pistons being designed to move in opposite directions, and in my invention quite especially concerns the means whereby the two pistons are coupled for positive cooperation. The term "free piston" is herein used to refer to an arrangement where the pistons do not function to transmit power to a crank shaft by connecting rods, the construction in reality being crankless.

In similar free piston engines such coupling of the pistons has hitherto been effected by means of rocking levers or rods arranged for parallel motion relative to the pistons, reversing gear being inserted between these rods.

The arrangements involve the disadvantage that besides the piston also the comparatively large masses of rock levers or rods must reciprocate, whereby the number of strokes per unit of time is reduced. A further disadvantage consists therein that cross-heads must be provided for the connection of the rods, such cross-heads being guided in longitudinal slots provided in the cylinder, whereby part of the cylinder cannot be utilized in the production of power, so that the length of the cylinder is greatly increased. Another disadvantage is created by the fact that the rock levers, rods and the like must be provided on both sides of the engine, whereby this latter, and more especially the controlling means are rendered less readily accessible.

The present invention obviates this drawback inasmuch as the masses which reciprocate in opposite directions are substantially coupled only by means of rotary members. As compared with reciprocating coupling means the rotary members have comparatively small masses and therefore permit obtaining a larger number of strokes. They can be arranged on one side only and substantially at any desired distance from the other parts of the engine, so as not to reduce the accessibility. The long slits previously provided in the cylinders can be greatly reduced, whereby a considerable saving in weight, space and cost is obtained. The fact that the pistons can be made shorter and lighter results in a further increase of the number of strokes per unit of time, which in turn results in a corresponding increase in the efficiency of the engine.

The rotary coupling members preferably have the form of toothed gear wheels or helical gear wheels cooperating with corresponding racks and coupled by suitable shafts, the racks or the like being formed on or forming part of the pistons themselves.

In the drawings affixed to this specification and forming part thereof two modifications of an engine embodying my invention are illustrated diagrammatically by way of example.

In the drawings—

Fig. 1 is an axial section,

Fig. 2 is a cross-section on the line II—II in Fig. 1, and

Fig. 3 is a plan view of the movable parts of one modification, while

Figs. 4, 5 and 6 are similar views of the second modification.

Referring first to Figs. 1–3, 1 is a cylinder and 2 and 3 are pistons arranged in this cylinder for reciprocative motion in opposite directions, their adjoining ends 4 and 5 defining the combustion chamber 1′ of the cylinder, while their outer ends 6 and 7 act on compressor cylinders 8 and 9, respectively. The pistons 2 and 3 have equal diameters at the inner and outer ends and are provided at the bottom each with teeth 10, 11, respectively, meshing with toothed wheels 12, 13, keyed onto shafts 14, 15, respectively. These shafts project sideways and have mounted on their ends bevelled gear wheels 16, 17, meshing with similar wheels 18, 19, which latter are keyed onto a common shaft 20. Obviously the two pistons 2 and 3 are coupled for absolutely uniform motion in opposite directions.

By using pistons having end faces of equal size for the working and for the compressor cylinders I obtain the advantage that the working chambers 1′ and 8, 9 of the cylinders can extend close to the toothed wheels 12 and 13, gearing with the pistons 2 and 3, so that sideways of these gear wheels only the space for the packing of the pistons is required. It is true that in the case of two-stroke engines separate means for feeding scavenging air are required. In the present instance a scavenging air blower 30 is shown, which is driven by any suitable means and supplies scavenging air through the conduit 31 into the container 32, from which the air passes through the ports 33 into the working

chamber 1′ when the pistons have reached their outer dead centre positions, while the exhaust gases escape on the other side through port 34 into the exhaust conduit 35. The rotary parts of the coupling gear are further adapted for driving auxiliary devices, such as, for instance, cooling water pumps, fuel pumps, scavening air pumps, and the like. For instance in Fig. 3 a cam 21 is shown as being mounted on the shaft 20, this cam operating a fuel pump 22 which is supplied with fuel from a container 24 and forces the fuel through conduit 25 towards the injection nozzle 26.

The bevelled gearing and shaft shown in Figs. 1–3 might also be replaced by an even number of ordinary pinions. The operation of this machine is the following: Assuming combustion of a gas mixture to have taken place in the space 1′ enclosed between the pistons 4 and 5, while these pistons were in their inner dead centre position, the expansion of the combustion gases will force the pistons 2, 3 asunder. The outer end faces 6, 7 of the pistons will now compress the air or other gases enclosed in the compressor cylinders 8, 9 and will force them through the pressure valves 51, 52 into the pressure pipes 53, 54 which lead to some place of consumption of the compressed gas or air thus produced. While the pistons 2, 3 are moving outwards, the pressure in 1′ diminishes and the inner edge of piston 3 will uncover the exhaust port 34, allowing the gases of combustion to escape through pipe 35. Directly thereafter the piston 4 will uncover the port 33 of the scavenging air container 32 and a current of scavenging air will now flow through the cylinder 1 in the direction from 33 to 34, carrying along with it the rest of exhaust gases which still remained in the cylinder. During the outward stroke of the pistons the kinetic energy imparted to them by the combustion gases is converted into compressive energy in the cylinders 8, 9 and the pistons will come to a stillstand directly after having uncovered the ports 33 and 34. They are now acted upon by the compressed air which remained over in the dead spaces of the compressor cylinders 8, 9 and this air now forces the pistons back. On their inward stroke the pistons will compress the scavenging air enclosed between them to such an extent that the fuel which is injected by means of pump 22 through pipe 25 and nozzle 26 into the cylinder space 1′ towards the end of the inward stroke, is ignited, thereby forcing the pistons asunder again. During the inward stroke of the pistons the pressure in the dead spaces of the compressor cylinders 8, 9 is gradually diminished until it has become as low as the pressure in the suction pipes 55, 56. From this point on owing to their momentum the pistons on their inward stroke generate a vacuum in the compressor cylinders, whereby the suction valves 57, 58 are opened and the compressor cylinders 8, 9 are filled with fresh air or other gas to be compressed during the outward stroke of the piston which now follows. The pistons during their movements in opposite directions are continuously coupled by the gearing 14—20 in such manner that they are compelled to always move in unison, so that small inequalities in the friction arising between the pistons and the cylinder walls or in the operation of the compressor cylinders cannot bring forth any irregularity of movement of the pistons. However, this gearing does not serve for transmitting the full energy of combustion acting on the pistons to the outside, this transmission of energy being effected by means of the compressed air or compressed gas through pipes 53, 54.

It will be obvious that in the operation of the gearing coupling the pistons, said gears partake of the reciprocatory motion of the pistons, converting the same into what I term "oscillatory" movement in that the gears may rotate in one direction one or more revolutions followed by a rotation of one or more revolutions in the opposite direction, as distinguished from a continuous rotation in one direction. It is in this sense that the term "oscillatory" is employed in the appended claims to define the reverse rotary motion of the gear couplings.

Figs. 4–6 illustrate an arrangement which is distinguished by a further reduction of the movable parts. The pistons 2 and 3 are here provided each with a screw rack 41 and 42, respectively, cooperating with helical wheels 43, 44, rigidly connected by an intermediate shaft 45. The screw faces of the two gearings 41, 43 and 42, 44, respectively, have opposite pitches, so that in this case also the pistons 2 and 3 are coupled for exact motion in opposite directions.

Preferably the teeth forming part of the pistons are arranged as shown in Figs. 2 and 5, where the end faces of the teeth are shown to be formed in accordance with the circumference of the cylinder 1. For in this case the teeth also contribute to packing the pistons relative to the cylinder and can also be made to extend across ports and the like in the cylinder wall without causing any considerable losses.

By correspondingly choosing the ratio of transmission and of the screw pitch I am enabled also to utilize the new coupling of the pistons in such cases, where the two masses shall have strokes of different length.

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 modification will occur to a person skilled in the art.

I claim:—

1. An engine comprising a cylinder, a pair

of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions and oscillatory means for coupling said pistons.

2. An engine comprising a cylinder, a pair of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions, a rack formed in the body of each piston, a gear wheel meshing with each rack and oscillatory means coupling said wheels.

3. An engine comprising a cylinder, a pair of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions, a rack formed in the body of each piston, a gear wheel meshing with each rack and oscillatory means including an intermediate shaft coupling said wheels.

4. An engine comprising a cylinder, a pair of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions, rack teeth formed in the body of each piston, a gear wheel meshing with each rack and an intermediate shaft coupling said wheels.

5. An engine comprising a cylinder, a pair of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions, a rack teeth formed in the body of each piston, a gear wheel meshing with each rack and oscillatory means coupling said wheels, the circumferential faces of said rack teeth being formed in accordance with the circumference of said piston.

6. An engine comprising a cylinder, a pair of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions, oscillatory means for coupling said pistons and an auxiliary device operatively connected with said oscillatory means.

7. An engine comprising a cylinder, a pair of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions, oscillatory means for coupling said pistons and a pump operatively connected with said oscillatory means.

8. An engine comprising a cylinder, a pair of free pistons arranged in said cylinder for simultaneous reciprocation in opposite directions and oscillatory means including racks and gears for coupling said pistons, both ends of each piston being equal in diameter.

9. In an engine of the type described, a cylinder of uniform diameter throughout its length and formed with pockets intermediate the ends thereof, a pair of free pistons disposed in said cylinder and provided with racks intermediate their ends, gear members disposed in the pockets and projecting through openings in the wall of the cylinder into coacting relation with the racks aforesaid, and connections between the gear members to effect simultaneous rotation of the gear members alternately in opposite directions incident to the movement of the pistons.

10. In an engine construction of the class described, a cylinder of uniform diameter throughout its length, a pair of free pistons arranged in said cylinder, a rack on each piston substantially spaced from the ends thereof, the tip faces of the rack teeth conforming to the circumferential face of the piston, and gear connections between the racks of the pistons to insure simultaneous travel of the same during reciprocation.

11. In an engine construction of the class described, a cylinder of uniform diameter throughout its length and having spaced pockets in the wall thereof, a pair of free pistons arranged in the cylinder, a rack on each piston intermediate the ends thereof, the tip faces of the teeth of the racks conforming with the circumferential face of the pistons, gear members disposed in the pockets aforesaid adjacent the walls of the cylinder and projecting through openings in the latter into engagement with the racks of the pistons, and a driving connection between the gear members for causing simultaneous rotation of the gear members alternately in opposite direction and corresponding movement of the pistons in opposite directions.

In testimony whereof I affix my signature.

HUGO JUNKERS.