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INTERNAL COMBUSTION ENGINE

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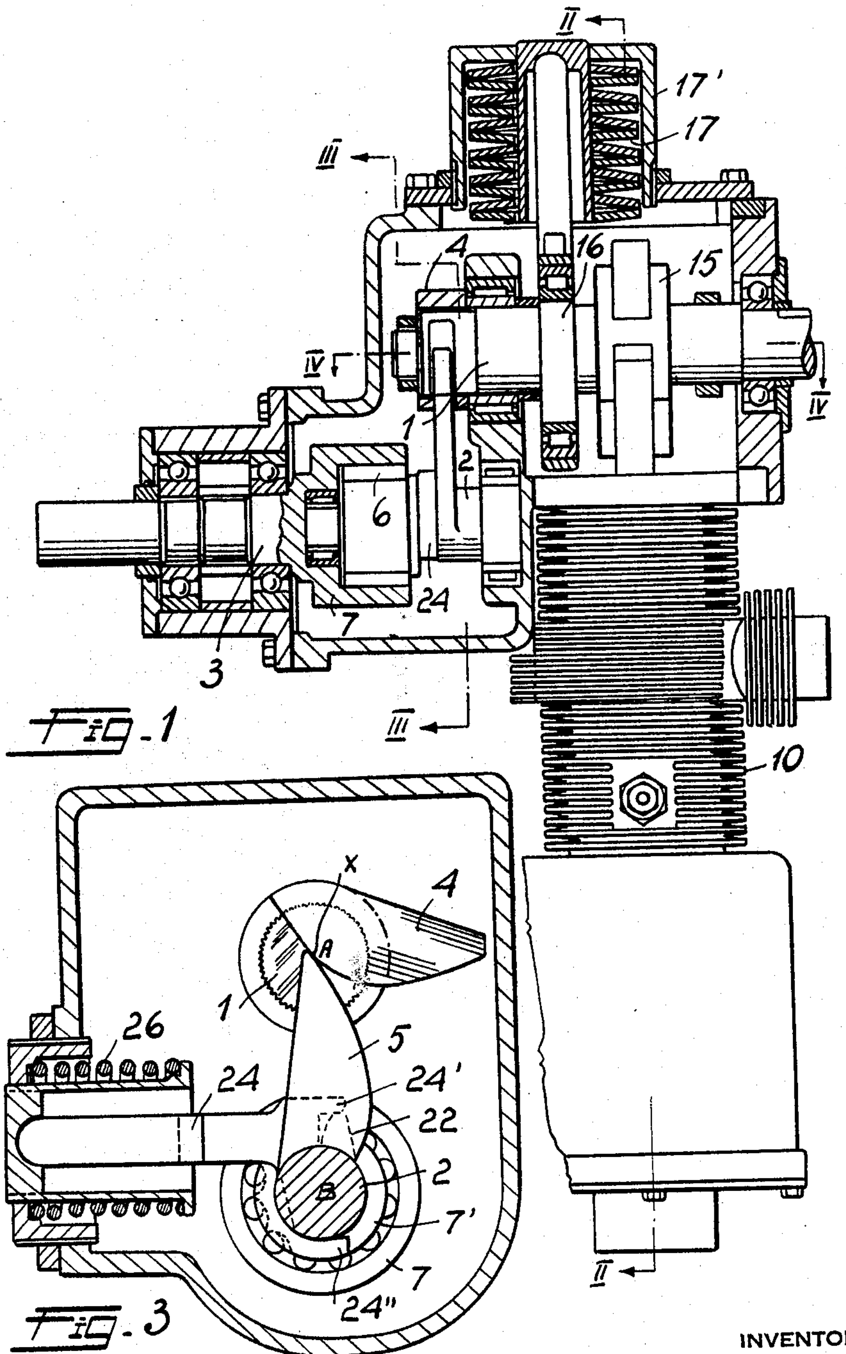

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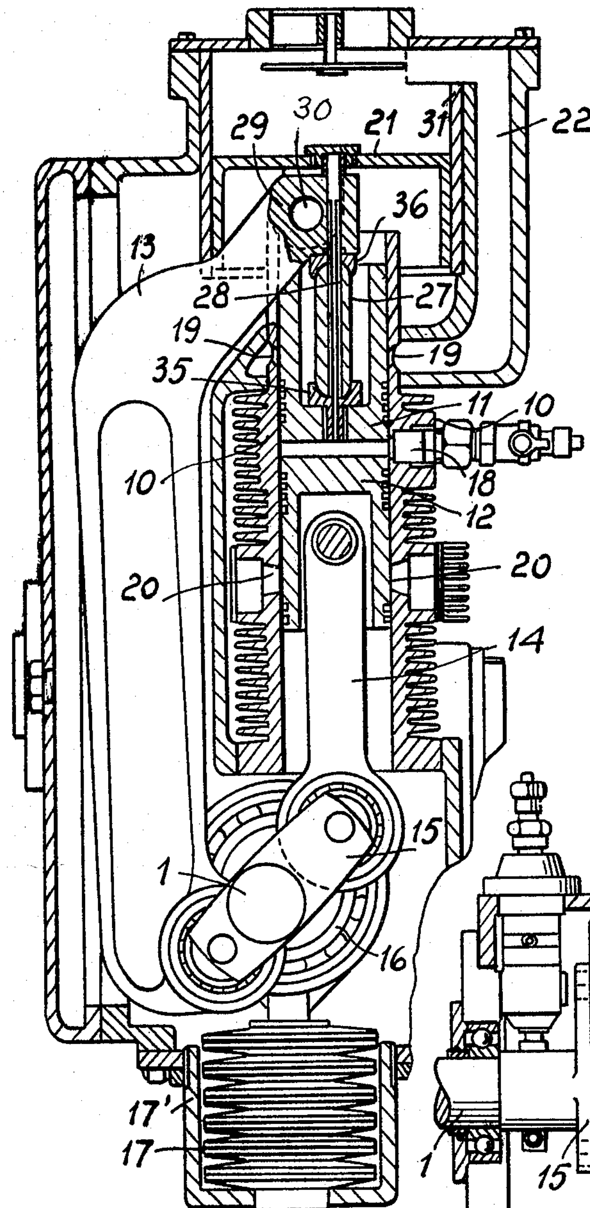

Fig. 2

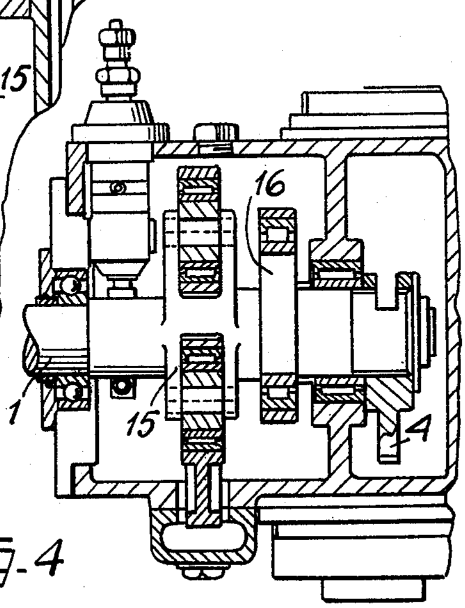

Fig. 4

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INTERNAL COMBUSTION ENGINE

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This invention relates to an internal combustion engine of the type comprising one or more pistons, in which the number of revolutions of the output shaft is not determined by the frequency of explosions, and the power obtained on the engine drive shaft can to a large extent be independent of the number of revolutions.

Such an engine may be accordingly adapted for several kinds of applications, and more particularly for traction, marine and industrial purposes. Accordingly to the invention there is provided an internal combustion engine in which the drive from the piston or pistons is transmitted to the output shaft by means of a device for converting the oscillatory movement of the piston or pistons to a second oscillatory movement in such a way that the speed of the second oscillatory movement increases relatively to the first oscillatory movement during the power stroke of the piston or pistons, and by means of a unidirectional coupling device which permits the second oscillatory movement to drive the output shaft in one direction only. Preferably, the device for converting the first oscillatory movement to the second oscillatory movement comprises two interengageable cams mounted for rotation about parallel axes and having track profiles such that their line of contact lies in the plane containing the two axes whereby only rolling friction occurs between the two cams. For this purpose, the cams preferably have profiles which are logarithmic spiral.

A preferred embodiment of the invention is illustrated, by way of example, in the accompanying drawings, in which:

FIG. 1 is a side view, partially in section, of an internal combustion engine according to the invention;

FIG. 2 is a cross section along the line II—II of FIG. 1;

FIG. 3 is a section along the line III—III of FIG. 1; and

FIG. 4 is a section along the line IV—IV of FIG. 1.

As illustrated in the drawings, an internal combustion engine comprises essentially a cylinder **10**, preferably provided with cooling fins, in which two pistons **11** and **12** slide. The fuel can be injected through a nozzle **18** into the cylinder **10** between the crowns of the pistons **11**, **12**. The pistons **11**, **12** are interconnected as follows. The piston **12** is coupled directly to a connecting rod **14** by means of a gudgeon pin and the other end of the rod **14** is connected to an oscillating rocker arm **15** keyed on a shaft **1**. The other piston **11** is coupled through a stem with a connecting rod **13** which is connected in turn with the other end of the arm **15**. An eccentric **16** is mounted on the shaft **1** in such a way that it can exert a compressing action on a washer-type spring assembly **17** enclosed within a casing **17'**.

The engine represented is a two-cycle one of the diesel type, wherein the pistons **11** and **12** themselves uncover the inlet port **19** and the outlet port **20** through which the compressed air is introduced and the exhaust gas removed respectively. In combination with the piston **11**, there is a further piston **21** which compresses the scavenging and charging air arriving through the duct **22** and reaching the inlet port **19** in the cylinder **10**.

The rocker arm **15** in the example shown oscillates through about 90° while the pistons perform drive strokes away from each other and the energy stored up when the spring assembly **17** is compressed is used, during the following phase of the operating cycle, to move the pistons towards each other and compress the air supplied to the cylinder **10**.

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The shaft **1** carrying the rocker arm **15** constitutes a drive member and also carries a first cam **4** (see FIG. 3) which co-operates with a second cam **5** on a shaft **2** parallel to the shaft **1** (see also FIG. 1) in order to transmit the motion to the drive shaft **3** of the engine. Both the cams **4** and **5** have particular track profiles such that their line of contact x (FIG. 3) is always situated on the straight line or plane connecting the rotational centres or axes A and B of the shaft **1** and **2** respectively. The profiles may, for example, correspond to a logarithmic spiral and are, in any case, such as to transmit the motion with a suitable increase in speed and by the rolling of one profile on the other without any sliding (the friction occurs as a rolling and not a sliding one), so that the power output to the shaft **3** will be a maximum. Cams **4** and **5** form between shafts **1** and **2** a transmission means whose ratio varies during each stroke.

Of course, as the shaft **1** effects an oscillatory movement, the shaft **2** will make a similar oscillatory movement. This second oscillatory movement has to be converted into a unidirectional rotary movement of the output shaft **3**. For this purpose, a unidirectional coupling device or clutch **7**, which can be of any conventional kind, is provided. For example, as illustrated, it comprises sliding rollers within sawtooth cavities, the rollers being pressed against the rim of the device **7** in the direction of rotation in which power is to be transmitted.

The cam **5** on the shaft **2** is constantly maintained in contact wtih the cam **4** by means of a spring **26** acting through a shaft **24** which terminates in two catches **24'** and **24''** and which co-operates with a cam **22**. The shafts **2** and **3** therefore engage one another for rotation in one direction and disengage in the other direction.

The operation of the assembly is as follows. The shaft **1** by means of its oscillations transmits an oscillatory rotary movement to the shaft **2** and, since the contact line x is situated in the plane A–B, this line moves from A towards B so that an increasing speed and transmission ratio is obtained which causes the acceleration of the shaft **2** during each drive stroke. As soon as the speed of rotation of the shaft **2** reaches that of the drive shaft **3**, the shaft **2** will be coupled with output shaft **3** by means of the coupling clutch **7** so that the shaft **2** can no longer accelerate. This tends to cause the slowing down i.e. the deceleration, of the shaft **1** which thus gives up its kinetic energy and the kinetic energy of the pistons and connecting rods to the shaft **2** and therefore to the shaft **3**.

The shaft **3** thus receives periodical rotational impulses and rotates in only one direction at a number of revolutions within a certain range variable in relation to the load. The number of revolutions is consequently not based upon the frequency of the explosions and the number of drive strokes, the power acting on the shaft **3** being constant.

Further details of the invention will now be described with reference to the drawings.

One of these details is the method of connecting the piston **11** to the connecting rod **13** and the connection between the rod **13** and the piston **21**. The piston **11** is mounted on the connecting rod **13** through an articulated rod system comprising two opposed hemispherical seatings **35** and **36** between which there is located a rod **27** having correspondingly rounded ends. The rod **27** and the seatings **35** and **36** are held together in contact by means of a steel cable **28** which passes through them. The seating **36** is fixed to the end portion **29** of the large connecting rod **13** and pivoted at **30** to the piston **21**. The piston **21** which provides the scavenging air, is slidable within the cylinder **31** which communicates with ducts **22** for feeding the air to the engage cylinder **10**. The injection pump is driven by a cam keyed on the shaft **1** (see FIG. 4).

The operation of the described engine will be clear from the drawings and the corresponding description of the invention. When the engine has to be started, the first step is to preliminarily compress the springs **17** by oscillating the rocker arm **15** in the required direction and releasing it so as to cause the automatic injection of the fuel into the combustion chamber of the engine at the beginning and at the end of the compression stroke of the pistons. With the first self-ignition of the injected fuel, both pistons **11** and **12** will slide violently away from each other within the cylinder **10** thus oscillating the rocker arm **15** through about 90° through the combined action of both the connecting rods **13** and **14**. In this manner, the shaft **1** will be rotated with the rocker arm **15** so compressing the spring assembly **17** by means of the eccentric. Meanwhile, the pistons **12** and **11** will have uncovered respectively the exhaust ports **20** and the scavenging air inlet ports **19** while the piston **21**, under the action of the piston **11**, forces the scavenging air into the cylinder **10**.

When the pistons **11** and **12** have reached the ends of their strokes, they are forced back towards one another by the energy stored in the spring assembly **17**, so that they compress the air which has been injected into the cylinder **10**. A second explosion takes place and the aforesaid operations will be repeated, and the periodic rotational forces are accumulated on the shaft **3**.

Of course, the mass of the two pistons **11** and **12** may not be equivalent the mass will be in an inverse ratio to the length of the required strokes for each one of said pistons.

The operation of the engine will not substantially change if, instead of two pistons, only one is provided within the cylinder **10**, and furthermore the construction details and members can be changed without departing from the spirit of the scope of the invention.

It is also possible to substitute a leverage and connecting rod system for the logarithmic spiral cams.

I claim:

1. Apparatus for transforming an oscillatory motion into a unidirectional rotation, comprising, in combination, a drive member; means for oscillating said drive member at a selected number of drive strokes per time unit; rotary means; transmission means connecting said drive member with said rotary means, and including means for varying the transmission ratio of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each stroke thereof at a varying angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

2. Apparatus for transforming an oscillatory motion into a unidirectional rotation, comprising, in combination, a drive member; means for oscillating said drive member at a selected number of drive strokes and return strokes per time unit; rotary means; transmission means connecting said drive member with said rotary means, and including means for increasing the transmission of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each alternate stroke thereof at an increasing angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

3. Apparatus for transforming an oscillatory motion into a unidirectional rotation, comprising, in combination, a drive member; means for oscillating said drive member at a selected number of drive strokes per time unit; rotary means; transmission means connecting said drive member with said rotary means, and including a pair of cooperating rotary cams having curned cam tracks engaging each other along a line of engagement traveling from the axis of one of said cams toward the axis of the other cam during each drive stroke for varying the transmission ratio of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each stroke thereof at a varying angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

4. Apparatus for transforming an oscillatory motion into a unidirectional rotation, comprising, in combination, a drive member; means for oscillating said drive member at a selected number of drive strokes per time unit; rotary means; transmission means connecting said drive member with said rotary means, and including a pair of cooperating rotary cams having curved cam tracks shaped as a logarithmic spiral engaging each other along a line of engagement traveling in a plane from the axis of one of said cams toward the axis of the other cam during each drive stroke for varying the transmission ratio of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each stroke thereof at a varying angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

5. An internal combustion engine comprising, in combination, a cylinder; a piston in said cylinder; means for causing combustion of fuel in said cylinder and thereby reciprocation of said piston at a selected number of drive strokes per time unit; a rotary drive member; means connecting said piston with said drive member for oscillating the same at said selected number of drive strokes; rotary means; transmission means connecting said drive member with said rotary means, and including means for increasing the transmission ratio of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each alternate stroke thereof at an increasing angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

6. An internal combustion engine comprising, in combination, a cylinder; a piston in said cylinder; means for causing combustion of fuel in said cylinder and thereby reciprocation of said piston at a selected number of drive strokes per time unit; a rotary drive member; means connecting said piston with said drive member for oscillating the same at said selected number of drive strokes; rotary means; transmission means connecting said drive member with said rotary means, and including a pair of cooperating rotary cams having curved cam tracks engaging each other along a line of engagement traveling from the axis of one of said cams toward the axis of the other cam during each drive stroke for increasing the transmission ratio of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each alternate stroke thereof at an increasing angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

7. An internal combustion engine comprising, in combination, a cylinder; a pair of pistons in said cylinder; means for causing combustion of fuel in said cylinder between said pistons for moving the same away from each at a selected number of drive strokes, per time unit; means for moving said pistons in return strokes toward each other; linkage means connecting said pistons; a rotary drive member operatively connected with said linkage means to be oscillated at said selected number of drive strokes; rotary means; transmission means connecting said drive member with said rotary means, and including means for varying the transmission ratio of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each stroke thereof at a varying angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

8. An internal combustion engine comprising, in combination, a cylinder; a pair of pistons in said cylinder; means for causing combustion of fuel in said cylinder between said pistons for moving the same away from each other at a selected number of drive strokes, per time unit; means for moving said pistons in return strokes toward each other; linkage means connecting said pistons; a rotary drive member operatively connected with said linkage means to be oscillated at said selected number of drive strokes; rotary means; transmission means connecting said drive member with said rotary means, and including means for increasing the transmission ratio of said transmission means during each drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each alternate stroke thereof at an increasing angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

9. An internal combustion engine comprising, in combination, a cylinder; a pair of pistons in said cylinder; means for causing combustion of fuel in said cylinder between said pistons for moving the same away from each other at a selected number of drive strokes, per time unit; means for moving said pistons in return strokes toward each other; linkage means connecting said pistons; a rotary drive member operatively connected with said linkage means to be oscillated at said selected number of drive strokes; rotary means; transmission means connecting said drive member with said rotary means, and including a pair of cooperating rotary cams having curved cam tracks engaging each other along a line of engagement traveling from the axis of one of said cams toward the axis of the other cam during each drive stroke for varying the transmission ratio of said transmission means during each drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each stroke thereof at a varying angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

10. An internal combustion engine comprising, in combination, a cylinder; a pair of pistons in said cylinder; means for causing combustion of fuel in said cylinder between said pistons for moving the same away from each other at a selected number of drive strokes, per time unit; means for moving said pistons in return strokes toward each other; linkage means connecting said pistons; a rotary drive member operatively connected with said linkage means to be oscillated at said selected number of drive strokes; rotary means; transmission means connecting said drive member with said rotary means, and including a pair of cooperating rotary cams having curved cam tracks shaped as a logarithmic spiral engaging each other along a line of engagement traveling in a plane from the axis of one of said cams toward the axis of the other cam during each drive stroke for increasing the transmission ratio of said transmission means during each said drive stroke so that said rotary means turns in a rotary oscillatory motion and moves during each alternate stroke thereof at an increasing angular speed; an output shaft; and unidirectional clutch means connecting said rotary means with said output shaft so that the same rotates in one direction at a rotary speed independent of said selected number of drive strokes of said drive member.

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