

May 9, 1939.

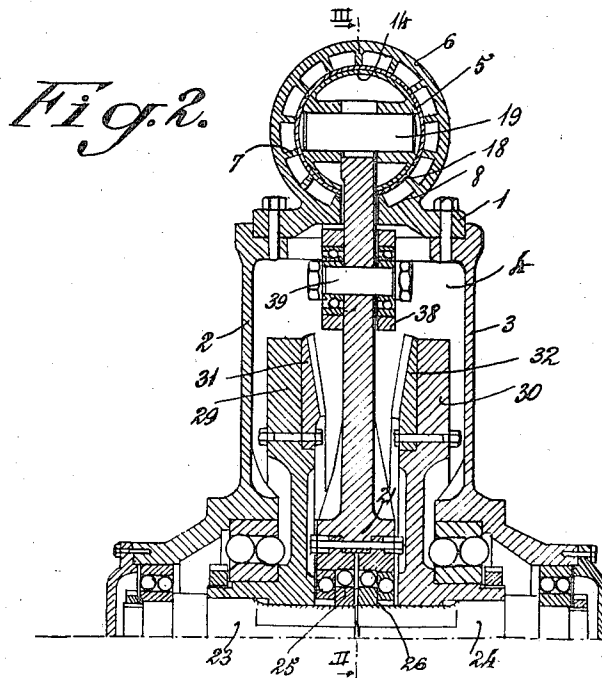
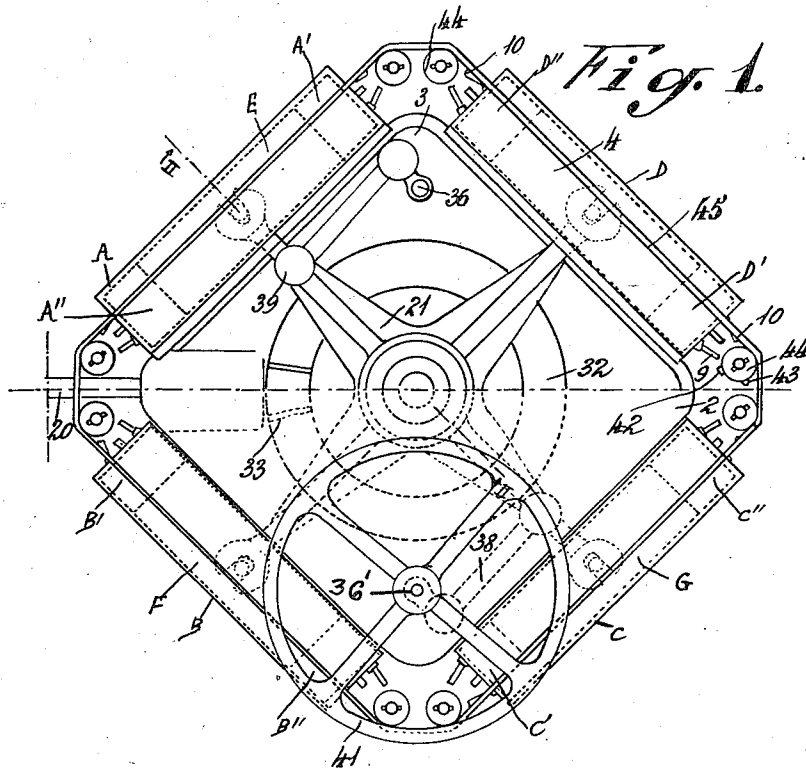
G. R. LANGROGNET

2,157,764

INTERNAL COMBUSTION ENGINE

Filed Aug. 8, 1936

3 Sheets-Sheet 1



Inventor

Georges Raymond Langrognet,
by *Guind M. Lacordelle*
Attorney

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3 Sheets-Sheet 2

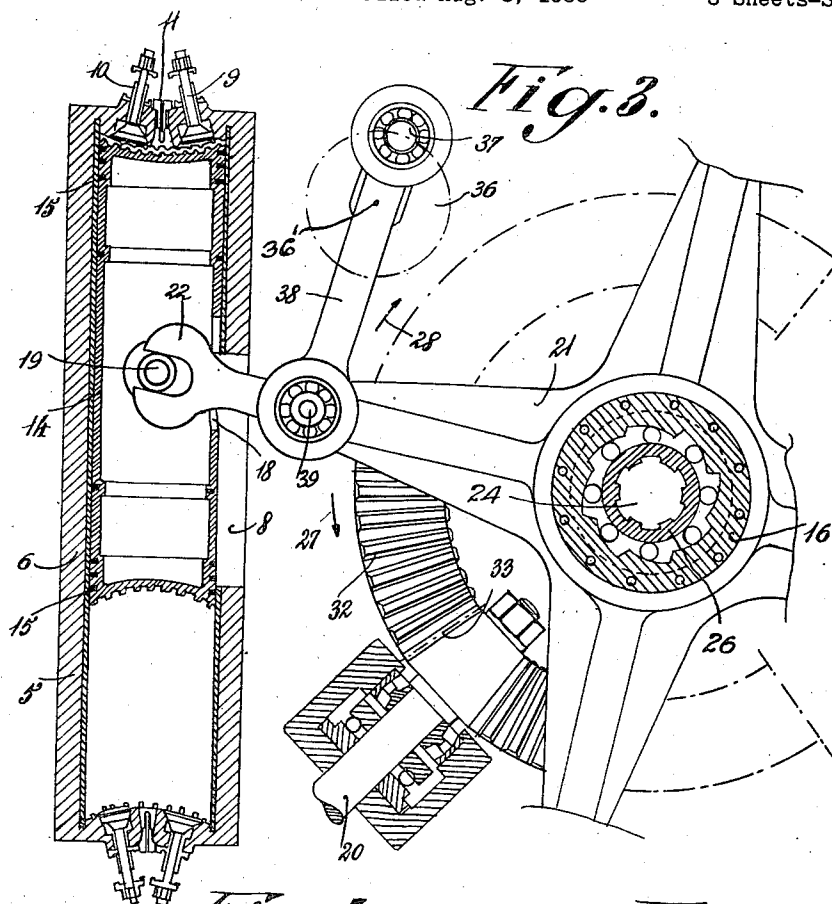


Fig. 4

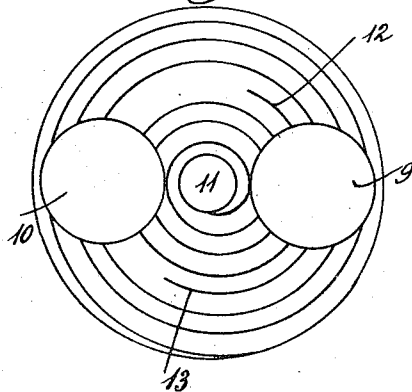
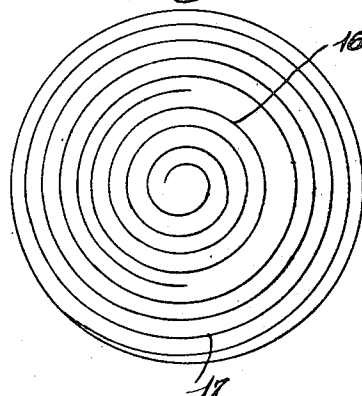


Fig. 5



Inventor
Georges, Raymond Langrognel
by Guido M. Sacerdote
Attorney

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3 Sheets-Sheet 3

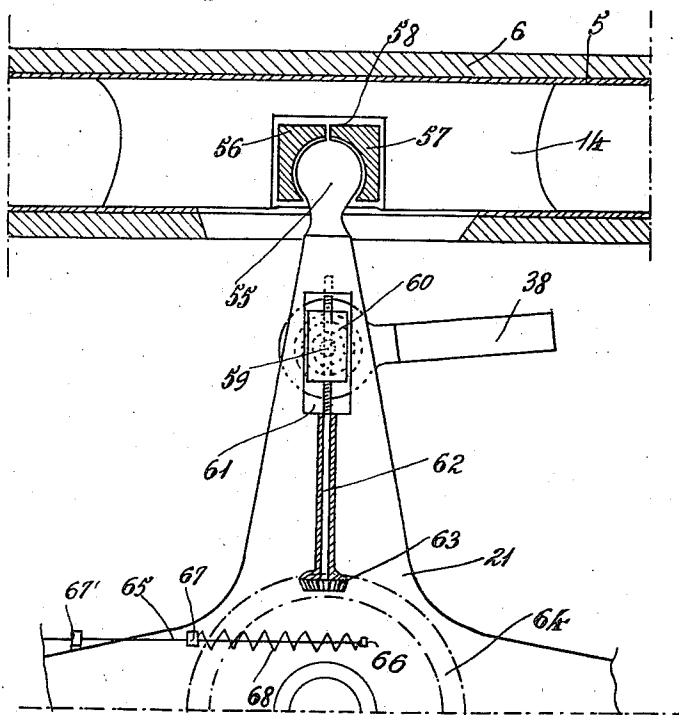
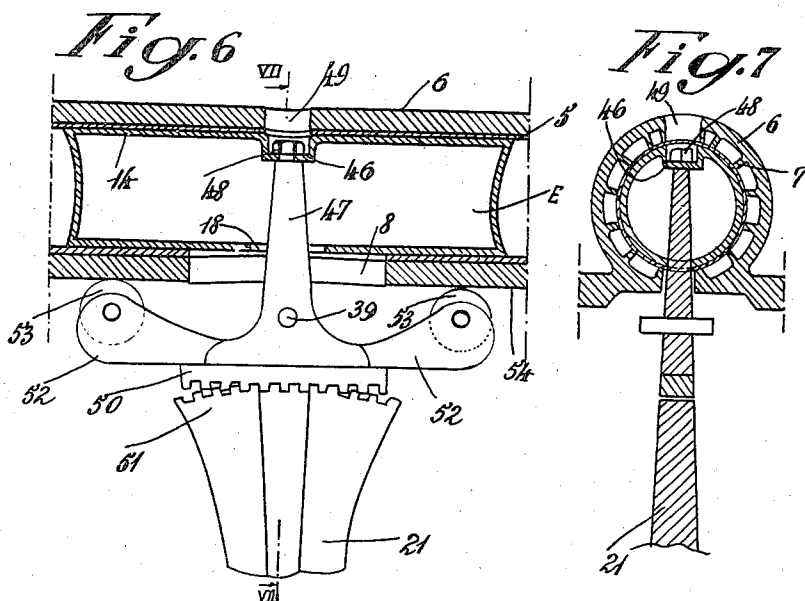


Fig. 8.

Inventor
 Georges, Raymond Langrognet
 by Guido M. Lacerdoty
 Attorney

UNITED STATES PATENT OFFICE

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INTERNAL COMBUSTION ENGINE

Georges Raymond Langrognet, Orleans-Loiret,
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11 Claims. (Cl. 123—54)

The present invention relates to an internal combustion engine of the type comprising double-acting pistons, the motive strokes of which are transmitted to the motor shaft by means of oscillating levers.

The invention has for its object to produce a motor adapted to operate with heavy oil or petrol, said motor, particularly intended for aviation, being very light and permitting the collection by the power take off shaft of great power with a reduced linear speed of the pistons.

The motor according to the invention is essentially characterized by its cylinders being arranged according to the sides of a regular polygon and being contained in the same plane, its various pistons being connected to the motor shaft by an oscillating cross head and the power take off shaft being parallel to the said plane.

In the accompanying drawings given simply by way of example:

Fig. 1 is a general view from the side of the motor, one of the sides of its casing being supposed as being partially removed;

Fig. 2 is a sectional view on line II—II of Fig. 1;

Fig. 3 is a sectional view on line III—III of Fig. 2, the cylinder in question being represented in a vertical position;

Figs. 4 and 5 are, respectively, plan views of the inner face of a cylinder head and one of the faces of the corresponding piston;

Fig. 6 is a partial sectional view showing a variation in the connection of the pistons with the cross head;

Fig. 7 is a sectional view on line VII—VII of Fig. 6; and

Fig. 8 is a view partly in section showing another embodiment of the connection of the pistons with the cross head and also a device permitting the variation while running of the amplitude of stroke of each piston in its cylinder.

According to the example shown in Figs. 1 to 3, the motor is constituted by four cylinders, A, B, C, and D, inclined by 45° to the horizontal, so as to form the four sides of a quadrilateral, preferably a square. The cylinders, which are all in the same plane, are each fixed by means of a base, such as 1 (Fig. 2), on two parallel side pieces 2 and 3 forming with the four bases of the cylinders, a closed casing 4.

Each cylinder, the cylinder A, for example, shown in detail in Figs. 2 and 3, is constituted by a tube 5 fitted in a liner support 6, having apertures and preferably made of light metal, said support being made with partitions or longitudinal ribs 7 so as to constitute a sleeve for the circulation of the cooling agent, preferably air.

The tube 5 and the support 6 are provided with a slot 8 permitting as will be presently seen, the displacement of a lever or connecting rod attached to the piston mounted in the cylinder A

and intended for the transmission of the movements of the piston to the motor shaft.

The mortice or slot 8 is symmetrical with respect to the central plane of cylinder A.

The cylinder A is provided at each end with a cylinder head which, in the case of a motor utilizing heavy oil as fuel, comprises an air admission valve 9, an exhaust valve 10, and, between the two valves, a fuel injector 11. In order to insure an intimate mixture between the combustible and the air, the inner face of the cylinder head is provided with grooves 12 and 13 (Fig. 4) made in the form of two spirals of opposite direction, said grooves breaking up and intermingling the bodies of air and atomized fuel.

Within each cylinder is mounted a double acting piston. The four pistons corresponding to the four cylinders, A, B, C and D, are indicated respectively on the drawing (Fig. 1) by E, F, G and H. Each piston delimits within the corresponding cylinder two combustion chambers indicated, respectively, by A' and A'', for the cylinder A, B' and B'' for the cylinder B, C' and C'' for the cylinder C, and D' and D'' for the cylinder D.

Each piston (Figs. 2 and 3) is constituted by a cylindrical tube 14 closed at its two ends and is shorter than tube 5. The outer diameter of the tube 14 is approximately equal to the inner clearance of the cylinder in which the piston is mounted. The tight fit between the piston and the corresponding cylinder is obtained by means of rings, such as 15, mounted, in the example shown, on the piston.

In order to also cooperate in the mixing of the fuel and air, the two extreme faces of each piston (Fig. 5) are provided with grooves made in the form of two spirals 16 and 17, running in opposite directions. It is to be noted that the groove 16 of the face of the piston runs in a direction opposite to that of the groove 12 of the cylinder head with which it cooperates. In the same way, the groove 17 runs in a direction opposite to that of groove 13.

The wall of the piston is formed on the side of the slot 8 of the cylinder with an opening 18, and the said piston is provided on the inside, midway of its length, with a cross pin 19 fixed thereto, intended for its connection with the corresponding lever of the transmission mechanism.

In the case of the four-cylinder motor having eight combustion chambers as shown, the four levers transmitting the motive strokes of the pistons E, F, G and H to the motor shaft are constituted by the four arms of a cross head or spider 21, which is mounted so as to be able to oscillate about a shaft arranged in the centre of the quadrilateral formed by the four cylinders A, B, C and D.

The connection of each arm of the cross head

21 with the corresponding piston is obtained by means of a fork 22 provided at the outer end of each arm and engaging with the corresponding cross pin 19.

5 The central or motor shaft on which the cross head 21 oscillates is made in two sections 23 and 24 arranged end to end and mounted by means of suitable ball bearings in the sides 2 and 3 of the motor casing.

10 As shown (Fig. 2) the cross head 21 is mounted on the sections of shafts 23 and 24, so that its hub extends over the inner end of both sections by a similar amount. The hub of the cross head 21 is made in such manner as to permit the

15 mounting in position of two ball clutch mechanisms 25 and 26 operating in opposite directions, said clutches being adapted to alternately connect the cross head 21 with one or the other of the two sections 23 and 24 on each oscillation of the

20 said cross head. In other words, the ball clutches 25 and 26 are so arranged that when the cross head oscillates in the direction of the arrow 27 (Fig. 3) it actuates the shaft section 23 and when it oscillates in the direction of the arrow 28 it

25 actuates the shaft section 24, the ball clutch 25 having its ball wedging surfaces inclined in the direction opposite to that of the ball wedging surfaces of clutch 26, as will be readily understood.

The transmission mechanism is completed by 30 two fly wheels 29 and 30 keyed respectively on the sections 23 and 24 and each provided with a toothed rim 31 and 32 engaging with a bevel pinion 33 keyed on the power take-off shaft 20. The latter is therefore parallel to the plane of 35 the cylinders.

It will be easily understood that by virtue of the arrangement shown whatever the direction of oscillation of the cross head 21 the driven shaft 20 will always rotate in the same direction, 40 the pinion 33 engaging with the two toothed rings 31 and 32 arranged oppositely to each other and rotating in opposite directions.

In order to regulate the stroke of the pistons in their cylinders, an arrangement is provided in 45 connection with each of any two of the arms of the cross head 21 extending in opposite directions.

Each of these regulating devices is constituted by a crank plate 36 with an adjustable crank pin 37 connected to a fixed pin 39 integral with the 50 corresponding arm of the cross head, by means of a connecting rod 38. The plate 36 rotates about a fixed axis, for example, a shaft 36' rotatably mounted in the casing.

It will be understood that by varying the position of the crank pin 37 with respect to the center of the crank plate 36 it is possible to limit 55 the oscillating movement of the cross head 21.

The regulation of the movement of the power take-off shaft is obtained on the one hand by means of the two fly wheels 29 and 30 and on 60 the other hand by means of two fly wheels 41, each keyed on the shaft 36' of the corresponding crank plate.

The control of the admission valve 9 and the exhaust valve 10 corresponding to the same explosive chamber is obtained by means of two 65 cams 42 and 43 keyed on the same shaft which shaft also carries a sprocket.

The driving of the sprocket 44 (to the number of eight in the example chosen and corresponding to a four-cylinder double-acting motor) is effected by an endless chain 45 itself driven 70 in rotation by any suitable means.

In order to prevent accidents resulting, for 75 example, from a breakage of the chain 45, there

may be used for the control of the shafts of the cams 42 and 43, two endless parallel chains 45 each controlling a sprocket keyed on each cam-shaft.

The motor described is a four-cycle motor. Its 5 operation is apparent from the preceding description. By way of example, it will be pointed out that the sequence of the cycles in the eight combustion chambers, assuming that chamber A' is at compression, is as follows: 10

	1st cycle	2nd cycle	3rd cycle	4th cycle
Chamber A'-----	Comp-----	Exp-----	Exh-----	Adm-----
Chamber A''-----	Exp-----	Exh-----	Adm-----	Comp-----
Chamber B'-----	Comp-----	Exp-----	Exh-----	Adm-----
Chamber B''-----	Exp-----	Exh-----	Adm-----	Comp-----
Chamber C'-----	Exh-----	Adm-----	Comp-----	Exp-----
Chamber C''-----	Adm-----	Comp-----	Exp-----	Exh-----
Chamber D'-----	Exh-----	Adm-----	Comp-----	Exp-----
Chamber D''-----	Adm-----	Comp-----	Exp-----	Exh-----

There is shown in Figures 6 and 7 a variation of the connection of the pistons to the cross head 21. 20

In this modification, the piston 14 comprises an interior boss or shoulder 46. To the piston 25 14 is secured a rack carrying member 47 for example by means of a nut 48 located in the interior of the boss 46.

The placing in position of the nut 48 can be effected by providing an aperture 49 in the liner 30 support 6 and the tube 5 constituting the cylinder.

The member 47 is provided at its inner end with a rack 50 engaging with the teeth of a segment 51 provided on the outer end of each arm 35 of the cross head. The teeth of the rack 50 are in a straight line, the teeth of segment 51 being in a circular line, the center of which coincides with that of the cross head 21.

The part 47 moving at the same time as the piston 14 imparts through the members 50 and 51 a reciprocating movement to the cross head 21. 40

In order to avoid abnormal work of the pistons in their cylinders, on account of the reaction between the interengaging teeth tending to deflect 45 member 47, said member 47 is formed with two longitudinal extensions 52, each carrying at its outer end a roller 53 moving on the rolling path 54 provided on the casing 6 of the cylinder.

It is to be noted that the pin 39 for the connecting rod 38 is, in the embodiment shown, carried by the part 47 and not by the cross head 21. In this manner, the stroke of the piston is limited 50 in a precise manner unaffected by the possible play between the interengaging teeth of the toothed elements 50 and 51.

By virtue of the arrangement described, knocking of the piston against the bottoms of the cylinder at the end of its stroke is avoided. This 60 method of connection, furthermore, prevents the piston from being angularly displaced, due to the effect of the component of rotation resulting from the cutting of spiral windings in opposite directions on the bottoms of the cylinders.

In the second embodiment shown in Fig. 8, the 65 connection between the piston 14 and the cross head 21 is effected by a knuckle joint system. In this case, the end of each arm of the cross head 21 is formed as a spherical element 55 which fits between two parts 56 and 57 adapted to slide in a suitable recess 58 made in the interior of the piston 14. 70

To permit varying, whilst running, the amplitude of the stroke of the pistons in their cylinders, each connecting rod 38, connected at one 75

of its ends to crank pin 37 (not shown) is connected at its other end to a stud 59 carried by a slide 60 lodged in a groove 61 provided on one of the arms of the cross head 21.

5 The slide 60 is retained in position by means of a threaded rod 62 passing through it from side to side and arranged radially with respect to the cross head 21. The mounting of the rod 62 on the cross head 21 is effected in such manner
10 that the rod can be rotated while it is restrained against axial displacement.

The inner end of the rod 62 is provided with a bevel pinion 63 engaging with a toothed rim 64, the axis of which coincides with that of the cross
15 head 21.

The toothed rim 64 can rotate about its axis, but is connected to the cross head 21 through the intermediation of a rod 65. The latter can
20 slide in two bearings, 67, 67' of the cross head 21 and is attached at its inner end to a fixed point 66 of the rim 64. Between the point of attachment 66 and the bearing 67 there is inserted a spring 68.

The displacements of the rod 65 are controlled
25 directly by the driver of the motor through the intermediation of a flexible control.

Owing to the arrangement shown, the rim 64 shares all the movements of the cross head 21 without affecting the position of the slide 60,
30 with respect to the rod 62.

On the other hand, when the rod 65 is acted upon either by traction or by thrust, the toothed rim 64 is moved with respect to the cross head 21. According to the direction of movement of said
35 rim, the threaded rod 62 rotates either to the right or to the left, causing either an inward or outward displacement of the slide 60 and consequently a change in the position of the point of attachment of the connecting rod 38 with
40 respect to the cross head 21.

It is thus possible to vary while the motor is running the amplitude of the movement of the cross head 21 and consequently the amplitude of movement of the piston in their cylinder. This
45 permits of utilizing different fuels for the operation of the motor and by varying the degree of compression to compensate for the variations of atmospheric pressure when the motor is mounted, for example, on an aircraft.

50 The motor according to the invention presents the great advantage of being free of vibration, due to the fact that only the power take-off shaft rotates at the rate of speed used, the other members, in particular the pistons, operating at
55 a low speed which, furthermore, permits of obtaining a complete utilization of the charge, without compressor.

The consumption of fuel and lubricant are low, whilst the exhaust is silent without loss of power.

60 Naturally, the motor could comprise a greater or lesser number of cylinders than four, symmetrically arranged in a common plane about a central axis. Furthermore, the transformation of the oscillating movements of the levers or
65 connecting rods into a movement of rotation of the power take-off shaft could be obtained by a mechanical transmission different from that shown. Finally, the motor could be equipped so as to operate with petrol.

70 It is obvious that the invention is in nowise limited to the embodiment which has been more especially described by way of example, and that it extends to all possible modifications coming, fairly, within the scope of the appended
75 claims.

I claim:

1. In an internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, and an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means interposed between said oscillatable member and said power take-off shaft converting the oscillatory movement of the former into a rotatory movement of the latter in a continuous direction, and means for adjusting the range of oscillation of said oscillatable member and
15 pistons.

2. In an internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, and an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take off shaft having its axis in the same plane as the axes of said cylinders, and
25 power transmitting means interposed between said oscillatable member and said power take-off shaft converting the oscillatory movement of the former into a rotatory movement of the latter in a continuous direction.

3. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft having its axis in the same plane as the axes of said cylinders, means for adjusting the range of oscillation of said member and pistons, and power transmitting means interposed between said oscillatable member and said power take-off shaft converting the oscillatory movement of the former into a rotatory movement of the latter in a continuous direction.

4. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means comprising two rotatable elements coaxial with said oscillatable member, interposed between said member and
55 said power take-off shaft, and a unidirectionally operative clutch device interposed between said oscillatable member and each rotatable element, adapted to transmit movement from the former to the latter, said clutch devices being operative in directions opposite one to the other.

5. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means comprising two bevel gears coaxial with said oscillatable member, one at each side thereof, and a bevel pinion interposed between and meshing with said gears driving said power take-off shaft for
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transmitting movement from said oscillatable member to said power take-off shaft, and a unidirectionally operative clutch device interposed between said oscillatable member and each rotatable element, adapted to transmit movement from the former to the latter, said clutch devices being operative in directions opposite one to the other.

6. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means comprising two rotatable elements coaxial with said oscillatable member, interposed between said member and said power take-off shaft, operatively associated with said power take-off shaft, a unidirectionally operative clutch device interposed between said oscillatable member and each rotatable element, adapted to transmit movement from the former to the latter, said clutch devices being operative in directions opposite one to the other, and means for adjusting the range of oscillation of said oscillatable member and pistons.

7. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means comprising two rotatable elements coaxial with said oscillatable member, interposed between said member and said power take-off shaft, operatively associated with said power take-off shaft, a unidirectionally operative clutch device interposed between said oscillatable member and each rotatable element, adapted to transmit movement from the former to the latter, said clutch devices being operative in directions opposite one to the other, and means for adjusting the range of oscillation of said oscillatable member and pistons, said means comprising a crank pin rotatable about a fixed center, means for adjusting the distance between said crank pin and said fixed center, and a connecting rod extending between said crank pin and said oscillatable member.

8. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means comprising two bevel gears coaxial with said oscillatable member, one at each side thereof, and a bevel pinion interposed between and meshing with said gears driving said power take-off shaft for transmitting movement from said oscillatable member to said power take-off shaft, a unidirectionally operative clutch device interposed between said oscillatable member and each rotatable element, adapted to transmit movement from the former to the latter, said clutch devices being operative in directions opposite one to the other, and means for adjusting the range of oscillation of said oscillatable member and pistons.

9. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means comprising two rotatable elements coaxial with said oscillatable member, interposed between said member and said power take-off shaft, operatively associated with said power take-off shaft, a unidirectionally operative clutch device interposed between said oscillatable member and each rotatable element, adapted to transmit movement from the former to the latter, said clutch devices being operative in directions opposite one to the other, and means for adjusting the range of oscillation of said oscillatable member and pistons, said means comprising a crank pin rotatable about a fixed center, a connecting rod extending between said crank pin and said oscillatable member, and means for varying the distance between the point of attachment of said rod to said oscillatable member and the center of oscillation of said member.

10. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, an oscillatable member having arms operatively associated with said pistons, mounted on said shaft, a power take-off shaft, power transmitting means comprising two rotatable elements coaxial with said oscillatable member, interposed between said member and said power take-off shaft, a unidirectionally operative clutch device interposed between said oscillatable member and each rotatable element, adapted to transmit movement from the former to the latter, said clutch devices being operative in directions opposite one to the other, and means for adjusting the range of oscillation of said oscillatable member and pistons, said means comprising a crank pin rotatable about a fixed center, a connecting block carried by and radially slidable with respect to said oscillatable member, a connecting rod extending between said crank pin and said connecting block, a radially directed adjusting screw mounted on said oscillatable member controlling the position of said block, a pinion carried by the inner end of said screw, an angularly displaceable toothed ring, coaxial with said oscillatable member, engaging said pinion, and means for controlling the angular adjustment of said ring.

11. An internal combustion engine comprising a shaft, an even number of cylinders symmetrically arranged in a common plane so as to form the sides of a regular polygon, said plane being at right angles to said shaft, a reciprocating piston in each cylinder, a toothed rack integral with each piston, an oscillatable member having segmental toothed portions in mesh with said racks, mounted on said shaft, means for adjusting the range of travel of said pistons and power transmitting means interposed between said oscillatable member and said power take-off shaft converting the oscillatory movement of the former into a rotatory movement of the latter in a continuous direction.

GEORGES RAYMOND LANGROGNET.