Dec. 23, 1952 F. E. MYARD 2,622,567

ROTATABLE PISTON MACHINE

Filed May 26, 1951 7 Sheets-Sheet 1

Fig. 1.

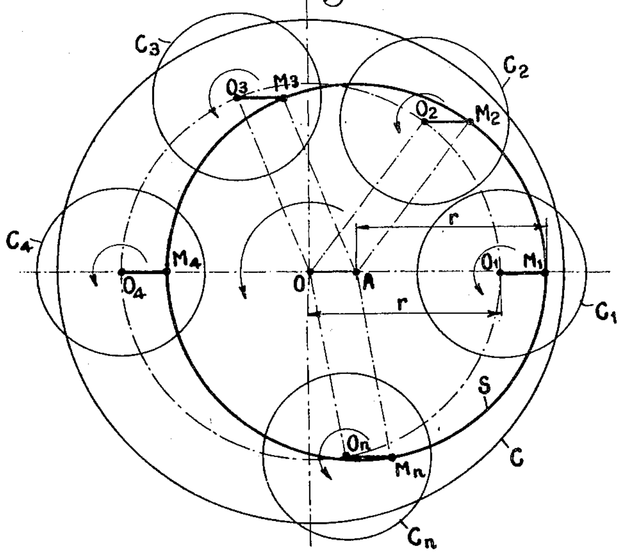
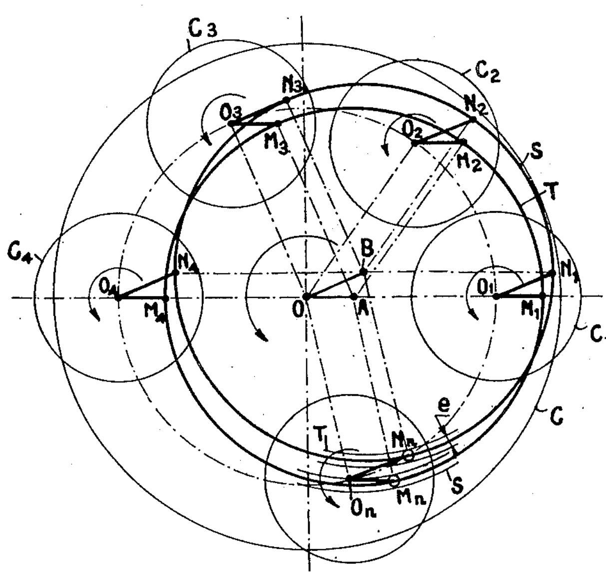


Fig. 2.



INVENTOR
FRANCIS EMILE MYARD
By:
Haseltine, Lake & Co.
AGENTS

Dec. 23, 1952

F. E. MYARD

2,622,567

ROTATABLE PISTON MACHINE

Filed May 26, 1951

7 Sheets-Sheet 2

Fig.3

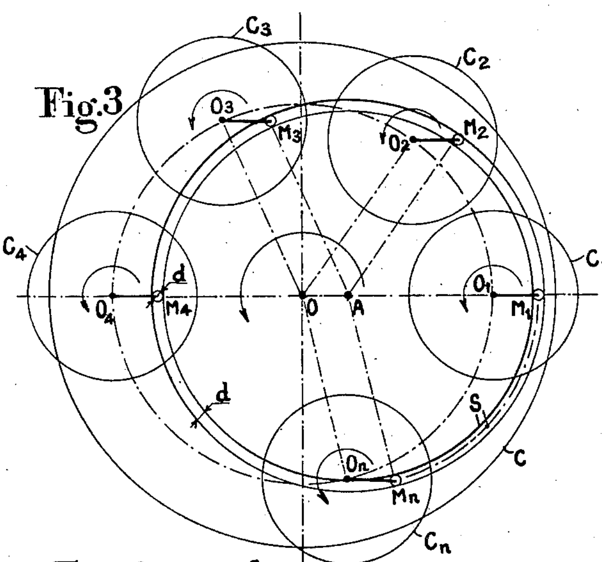
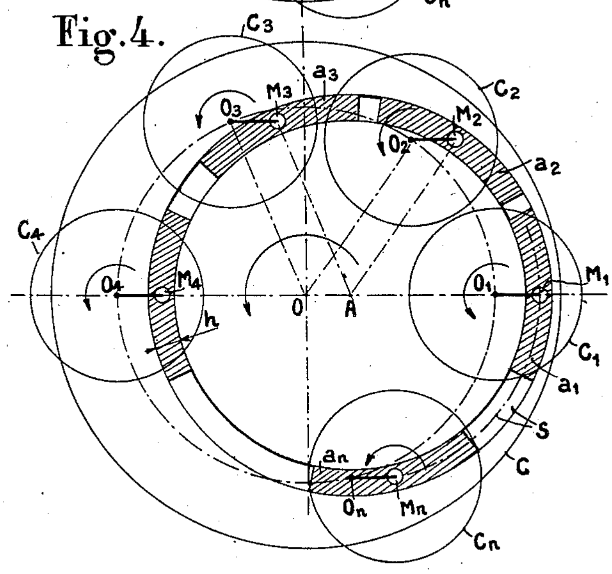


Fig.4.



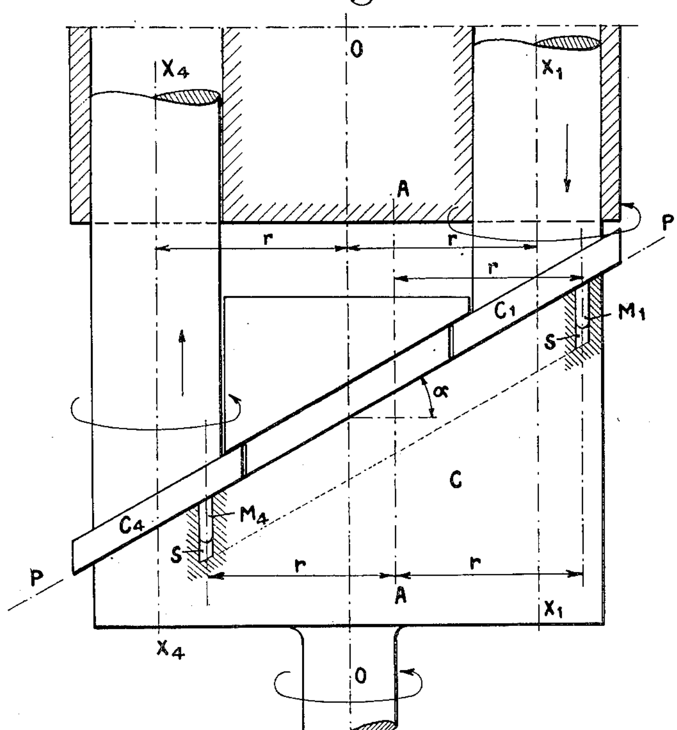
INVENTOR
FRANCIS EMILE MYARD
By:
Haseltine, Lake & Co.
AGENTS

Dec. 23, 1952 F. E. MYARD 2,622,567

ROTATABLE PISTON MACHINE

Filed May 26, 1951 7 Sheets-Sheet 3

Fig. 5.



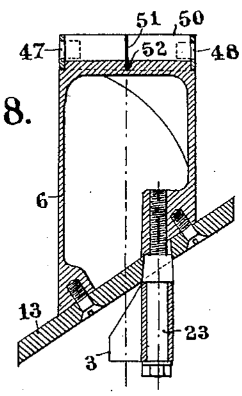
INVENTOR
FRANCIS EMILE MYARD
By:
Haseltine, Lake & Co.
AGENTS

Dec. 23, 1952 F. E. MYARD 2,622,567

ROTATABLE PISTON MACHINE

Filed May 26, 1951 7 Sheets-Sheet 4

Fig. 8.



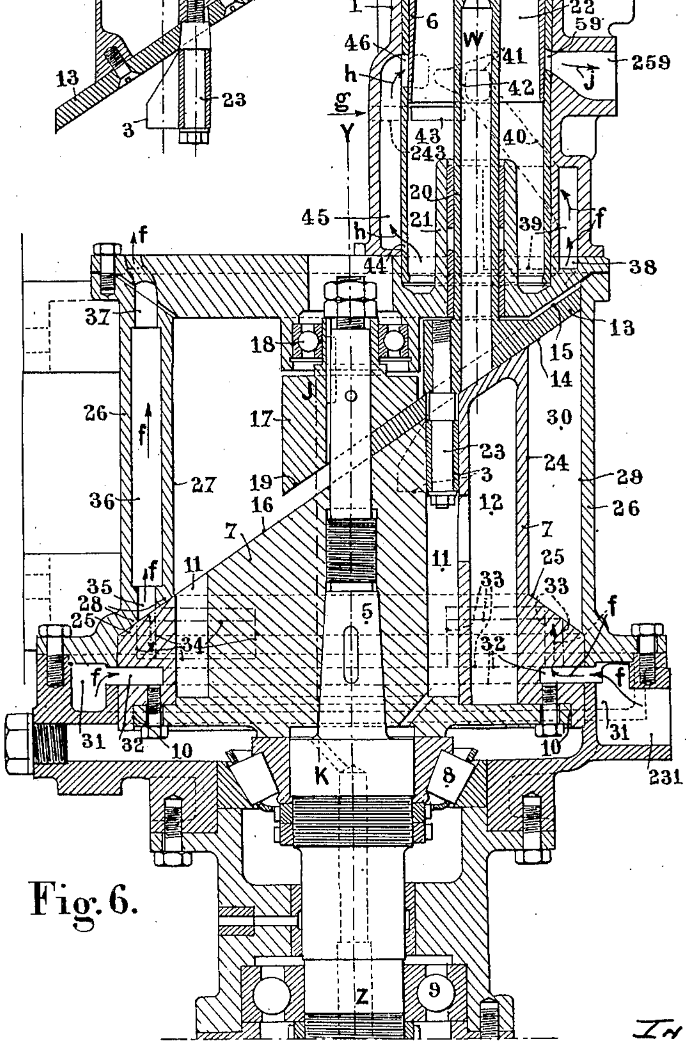


Fig. 6.

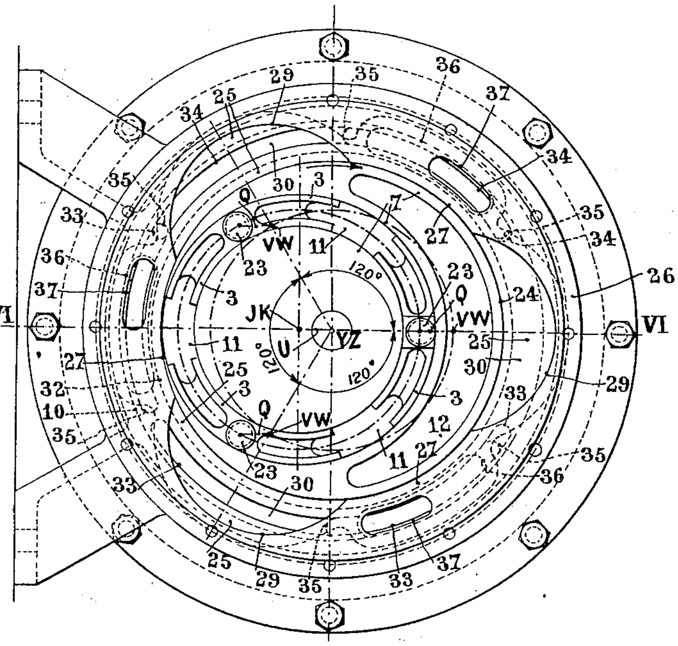
INVENTOR
FRANCIS EMILE MYARD
By: Haseltine, Lake & Co.
AGENTS

Dec. 23, 1952 F. E. MYARD 2,622,567

ROTATABLE PISTON MACHINE

Filed May 26, 1951 7 Sheets-Sheet 5

Fig. 7.



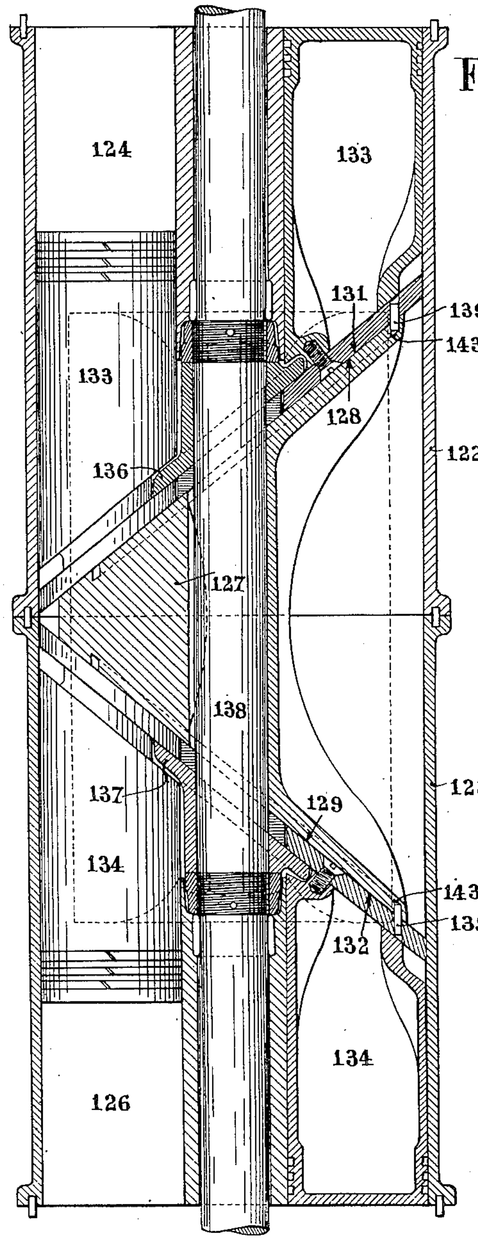
INVENTOR
FRANCIS EMILE MYARD
By:
Haseltine, Lake & Co.
AGENTS

Dec. 23, 1952 F. E. MYARD 2,622,567

ROTATABLE PISTON MACHINE

Filed May 26, 1951 7 Sheets-Sheet 6

Fig. 9.



INVENTOR
FRANCIS EMILE MYARD
By: Haseltine, Lake & Co.
AGENTS

Fig. 10.

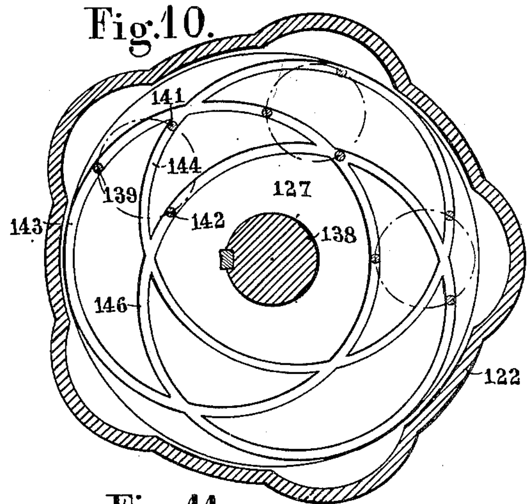


Fig. 11.

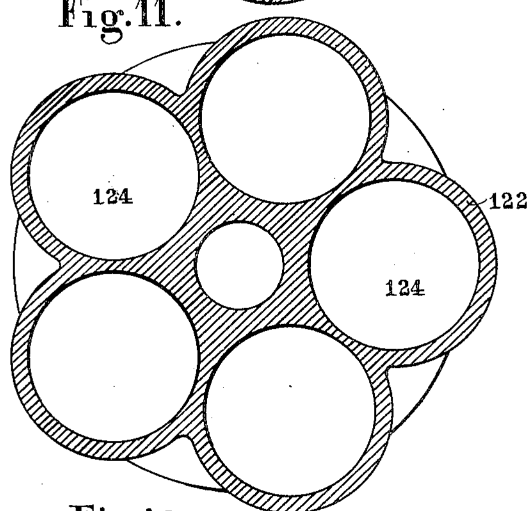
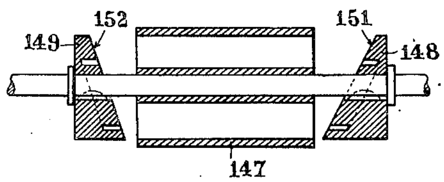


Fig. 12.



INVENTOR
FRANCIS EMILE MYARD
By: Haseltine, Lake & Co.
AGENTS

Patented Dec. 23, 1952

2,622,567

UNITED STATES PATENT OFFICE

2,622,567

ROTATABLE PISTON MACHINE

Francis Emile Myard, Paris, France

Application May 26, 1951, Serial No. 228,435
In France May 30, 1950

6 Claims. (Cl. 121—101)

1

My invention relates to a mechanism for use generally in such rotatable-piston machines as engines or pumps and more particularly in a 2-cycle barrel engine. The purpose of the mechanism according to my invention is essentially to establish a reversible kinematic connection between a continuous rotary motion and a number n of rectilinear reciprocatory motions, n being any desired whole number.

The said mechanism for the establishment of a reversible kinematic connection between one or several rotatable pistons carried by a first machine element and a second machine element mounted for rotary motion about a main axis relative to said first element is characterized thereby that said second element comprises at least one plane face which is oblique or skew relative to said main axis while one or several pistons are mounted in said first element for reciprocatory and rotary motion along and about individual axes distributed around and parallel with the said main axis, said pistons being provided each with a likewise skew end face which permanently rests on a corresponding skew face of said second element and with a dog which projects from said end face and is slidably received in a groove milled in the skew face of said second element.

Such a mechanism may usefully be incorporated in the design of many piston machines and more particularly of internal combustion engines.

Further features of my invention will become apparent in the course of the following disclosure wherein reference is had to the drawings appended hereto, in which:

Figures 1 to 4 inclusive are diagrams related to the preliminary exposition of what will now be referred to as the rotary circle theorem.

Figure 5 is a diagrammatical longitudinal section of a mechanism according to my invention.

Figure 6 is a similar view taken on line VI—VI in Fig. 7, of a 2-cycle 3-cylinder barrel engine incorporating a mechanism according to my invention.

Figure 7 is an end view of the same engine with the cylinder block removed.

Figure 8 illustrates a simplified modification of a piston for use in a similar engine.

Figure 9 is an axial section of an axially balanced engine incorporating my invention, which comprises a pair of barrels including five cylinders arranged coaxial each to each.

Figure 10 shows the piston dog guiding grooves.

Figure 11 illustrates one of the barrels in cross-sectional view.

2

Figure 12 is a diagram showing how another balanced mechanism incorporating my invention could be designed.

A full and preliminary discussion of the aforementioned rotary circle theorem discovered by the inventor is deemed to be necessary for a satisfactory understanding of his invention which is a direct application of the same. The said theorem may be worded as follows:

Given a plane represented in Figs. 1 to 4 by a circle C rotatable about its centre O and given a whole number n of planes represented by circles $C_1, C_2, \ldots C_n$ rotatable about their centres $O_1, O_2, \ldots O_n$ located at the same distance r from said centre O and at any desired distances from one another and compelled to rotate about their own centres at the same angular speed $+\omega$ as said circle C about its own centre C, it will always be possible to find in each of the n rotary circles any desired number of points such as $M_1, M_2, \ldots M_n$ which will follow a common circular path S having a radius r partaking of the rotary motion of the plane C with which it is rigid, and this, at an angular speed $-\omega$.

In the case considered the application of the aforesaid geometrical property is contemplated in connection with any desired number of circles $C_1, C_2, \ldots C_n$ to respective points $M_1, M_2, \ldots M_n$ of which one and the same path on the circle C is ascribed. For that purpose it is necessary and sufficient that with the centres $O_1, O_2, \ldots O_n$ located at a common distance r from O as already stated all the vectors $O_1—M_1$, $O_2—M_2$, $\ldots O_n—M_n$ shall be equal in length and assume the same original position. This means that they will move parallel to one another throughout their displacements; this means also that the n points $M_1, M_2, \ldots M_n$ will move around the circumference S having its centre at A and r for its radius, which circumference partakes of the rotary motion of plane C about the centre O and the angular velocity of which is $+\omega$, at a relative angular velocity $-\omega$.

This fact is evidenced by Fig. 1 which clearly shows that the quadrilaterals $O—O_1—M_1—A$, $O—O_2—M_2—A, \ldots O—O_n—M_n—A$ are linked parallelograms. It will also be appreciated that as many series of n points such as $M_1, M_2, \ldots M_n$ may be provided, to each of which corresponds a circumference similar to S, which are equal in radius to r while their centres A are defined in each particular case by a vector O—A which is equal and parallel to all the vectors $O_1—M_1$, $O_2—M_2, \ldots O_n—M_n$ belonging to the same series of n points although said vectors O—A may be unequal from one series to the other.

Fig. 2 gives an example of two series of n points $M_1, M_2, \ldots M_n$ and $N_1, N_2, \ldots N_n$ which respectively describe the circular paths S and T, the vectors in the one series being unequal to those in the other.

Reference will now be had to Fig. 3. It will be assumed that the rotary plane of the first circle C already referred to is materialized as a first disc and the rotary planes of the n circles $C_1, C_2, \ldots C_n$ distributed around the common centre O as as many discs having their plane faces in contact with that of said first disc in the plane of Fig. 3 and that the n points $M_1, M_2, \ldots M_n$ are replaced by and materialized as as many cylindrical dogs having a diameter d and arranged at right angles to the plane of the figure, it will be appreciated that disregarding the necessary clearances the circumference S can be materialized as an annular groove having a width d and a sufficient depth which is milled in the face of said disc C and by which each dog $M_1, M_2 \ldots M_n$ is guided at a relative angular velocity $-\omega$.

It will likewise be appreciated that if in accordance with Fig. 2 a further series of n dogs $N_1, N_2, \ldots N_n$—the diameter e of which may not be equal to d—be suitably arranged and carried each by one of the aforesaid discs $C_1, C_2, \ldots C_n$ the said dogs will likewise be guided at an angle velocity $-\omega$ in a circular path by an annular groove T having a width e and the same radius r as S and which is likewise milled in the disc C; in fact, any desired number of series of n dogs co-operating with as many grooves may be provided.

From the foregoing, it will readily be understood that the operative connection at a common angular speed $+\omega$ between the disc C and the n discs $C_1, C_2, \ldots C_n$ can be secured in a reversible manner through the medium of dogs and grooves by using:

Either one single series of n dogs $M_1, M_2, \ldots M_n$ cooperating with one single groove S, in which case however each dog should provide a pivot for such arcuate slides as $a_1, a_2, \ldots a_n$ which are guided in the annular grooves S, and this, in order that the crossing of the dead centres be ensured;

Or several series $M_1, M_2, \ldots M_n$; $N_1, N_2, \ldots N_n$; and so on, of n dogs co-operating with as many guide grooves S, T, and so on by which a similar common kinematical connection is obtained and the multiplicity of which will ensure the crossing of the dead centres.

Following these considerations which belong to plane geometry and referring now to Fig. 5, it may be conceived that a number n of so-called "planet" cylinders are arranged within a so-called main cylinder with their axes $X_1, X_2, \ldots X_n$ parallel to the axis X of the main cylinder, at the same distance from the said axis, so that their sections are related to that of said main cylinder just the same as the aforesaid circles $C_1, C_2, \ldots C_n$ are related to circle C, and it may also be conceived that the said n "planet" cylinders have a common plane base which intersects an angle $90° - \alpha$ with the common direction of the axes $X, X_1, X_2, \ldots X_n$.

On the basis of these assumptions it is thus true to state that:

(a) If the $n+1$ cylinders are moved simultaneously at one and the same angular velocity $+\omega$ about their respective axes the skew bases of the n planet cylinders will at all times remain coincident with the skew base of the main cylinder.

(b) Since the skew bases of said planet cylinders will remain parallel with one another it becomes possible to keep them permanently in engagement with that of the main cylinder by allowing said cylinders to move axially relative to the main cylinder, with the result that in addition to the planet cylinders being rotated at a speed $+\omega$ about their own axes relative to the main cylinder which itself rotates at the same angular speed $+\omega$ they will be reciprocated relative to the same according to a common sinusoidal law, the amplitude of which is $2r \tan\alpha$, the phase difference between the various movements being determined by the angular displacement between the axes of the various planet cylinders relative to the axis of the main cylinder.

(c) Such a simultaneous rotation at a common angular speed $+\omega$ of the $n+1$ cylinders about their parallel axes is a direct consequence of the aforementioned so-called rotary circle theorem. Effectively, since whatever has been said about the latter may rightfully be regarded as its translation on such planes of projection as those of Figs. 1, 2, 3 and 4 and consequently translatable to and valid for any desired skew plane of projection, which means that each planet cylinder as shown in Fig. 5 can be provided with one or several cylindrical dogs extending parallel to the common direction of the axes and co-operating with as many grooves milled in the skew base of the main cylinder parallel to said common axis.

Generally, one single series of dogs co-operating with one single guide groove will prove sufficient on condition as already stated that each dog provides a pin for an arcuate slide to rock about. At all events, a reliable power transmission is secured in this manner.

In view of the preceding explanations it will be readily appreciated that the mechanism described as yet theoretically can usefully be applied to a great many piston machines, e. g. engines, pumps, compressors and the like, and more particularly to a 2-cycle internal combustion barrel engine into which the low- or high-boiling fuel may be either sucked or injected.

The mechanism thus comprises a cylindrical member provided with a plane end face which intersects an angle of $90° - \alpha$ with the axis O of said member and a coaxial barrel, any one of said members being capable of rotating relative to the other e. g. at an angular velocity $+\omega$; the barrel is formed with a number n of bores having their axes parallel to the common axis O and located around the same at the same distance r. Received in each of said bores is a piston the plane skew end face of which intersects with the axis of said piston the same angle $90° - \alpha$ as does the face of said member with its own axis, owing to which said piston and said cylindrical member are and remain in engagement with each other at all points; projecting longitudinally, i. e. parallel to the common axis O, from the piston skew end faces are one or several series of dogs which are arranged in such a manner that all the dogs belonging to any particular series shall be guided in a particular groove in the skew end face of the aforesaid member with or without the medium of an arcuate slide pivoted thereon for the purpose already stated; where such slides are provided, no more than one single series of n pivoted slides guided in one single groove will be sufficient. The pistons are kept in contact with the skew end face of said member by means of a further skew surface parallel with and braced to the same. The said further skew surface extends around the axis O and engages a further skew end surface parallel with and remote from the main skew main bearing surface of the same.

Reference will firstly be had to Figs. 6 and 7 in which the mechanism according to my invention is shown in its incorporation to a 3-cylinder 2-cycle engine.

The engine comprises a fixed barrel-shaped cylinder block 1 which is rigid with the engine frame. Bored in said cylinder block are three cylinders 2 the axes V—W of which are parallel with and equidistant from the axis Y—Z and angularly spaced by 120°. One single cylinder 2 is visible in Fig. 6 since the latter as already stated is a longitudinal section taken on line VI—VI in Fig. 7. Each cylinder 2 is lined with a sleeve 4 fixedly fitted therein. Slidably and rotatably received in each of the said sleeves is a piston 6, the one shown in Fig. 6 occupying its top dead center position. The three said pistons 6 as well as their respective equipments are wholly similar and so are their cycles of operation except they are out of phase by 120° relative to one another.

The motor shaft 5 is mounted in the cylinder block 1 coaxial with Y—Z in antifriction bearings 8, 9 adapted to deal with the axial and the radial forces as well as with the resulting bending stresses. A skew-faced rotary member 7 is secured to said shaft 5 coaxial therewith. For the sake of conciseness said member 7 will hereinafter be referred to as the rotor. It is made up of two parts assembled along the centering face 10 in order to facilitate the machining of the annular groove 11; however the rotor could as well be a one-piece part. Anyhow, care is to be taken in designing it to ensure that once machined it will be perfectly balanced about its axis Y—Z, for the purpose of which it is provided with a recess 12.

Each piston 6 is rigidly connected with a skew sole 13 which may be regarded as delimited in a cylinder between two parallel oblique planes 14 and 15, the slope of which is equal to that of the rotor skew face. Consequently, the lower face 14 of the sole 13 has an elliptical outline and will remain in permanent engagement with the likewise elliptical top face of the rotor 7. Similarly, the part 17 is a cylinder truncated by a plane skew face 19 parallel with face 16 and permanently in engagement with the annular plane face 15 of sole 13. Said part 17 is rigid with the shaft 5 and is mounted in an antifriction bearing 18. Its lower face 19 is provided for the positive returning of the piston 6 to its bottom dead center.

Each skew sole 13 is braced to the related piston 6 by a tubular rod 20 which as shown is solid with the sole although it might as well be secured thereto. Each rotary element thus composed of a piston and parts carried thereby is balanced as well as possible.

Each rod 20 is mounted for sliding and rotary motion in the lining of a guide sleeve 21 solid with the cylinder block 1 and consequently with the engine frame. By the provision of such a guide the buckling stresses on the tubular rod are effectively counteracted, in addition to which the lower chamber 22 which is swept up and down by the skirt of the piston becomes available for the compression of the scavenging air. Secured to and downwardly projecting from each skew sole 13 is a cylindrical dog 23 which consequently is rigid with the related piston 6. Pivotally mounted on said dog is an arcuate slide which is slidably received in and guided by the annular groove 11. Said slide also is effective to counteract radial forces. The pitch circle of the groove 11 and the positions of the various dogs 23 in their common groove are defined mathematically in accordance with the principles from which the mechanism described in the foregoing is derived.

This means on the one hand that the pitch circle of said annular groove 11 is given by the orthogonal projection of the intersection of the plane skew face 16 of the rotor 7 with a cylindrical surface the axis J—K of which is parallel to Y—Z and that its radius is equal to the eccentricity of the axes V—W of the various cylinders 2 and pistons 6 relative to the axis Y—Z of the cylinder block 1 and on the other hand that the eccentricity of the dogs 23 relative to the corresponding axes V—W is equal to that of the said axis J—K relative to said axis Y—Z. The planes Q through the axes of the pistons 6 and the axes of the related dogs 23 are parallel with and extend in the same direction as the plane U through the axis Y—Z of the rotor 7 and the axis J—K.

The cylindrical upper portion 24 of the rotor 7 is delimited at its top by a skew end face 16 and extends at its bottom in a frusto-conical portion 25 the slope of which is equal to that of the skew end face 16 in order to diminish as much as possible the clearance between said frusto-conical portion and the soles 13 of the pistons 6 in the bottom dead center of the latter.

The rotor 7 is mounted in a casing 26 rigid with the cylinder block 1 and with the engine frame, which casing comprises:

1. A cylindrical portion in which the cylindrical portion 24 of the rotor 7 is rotatably received.
2. A frusto-conical portion 28 in which the frusto-conical portion 25 of said rotor is rotatably mounted.
3. Three portions 29 having the shape of cylindrical segments in each of which the skew sole 13 of the related piston 6 is rotatably and slidably received.

In the up-and-down displacement of each sole 13 within the casing 26 a chamber 30 of crescent section is swept the volume of which should preferably be as large as possible and can easily be managed to be larger than the volume displaced by the top side of the piston 6 rigid with the sole 13 considered.

Extending around the casing 26 is an annular recess 31 into which an air-fuel mixture is fed through a duct 231 from any suitable carburettor (not shown). The rotor 7 is formed in its bottom with a peripheral recess 32 which complements said recess 31 to an annular passageway. The rotor 7 is formed moreover with a pair of inlet annular groove sections 33, 34 leading from and to the outside of the frusto-conical surface 25 of rotor 7. The major cross-sectional dimensions of the grooves 33, 34 are directed at right angles to the major cross-sectional dimension of the recess 32. The groove 33 opens into the recess 32 while groove 34 is blind. For the sake of readability said grooves 33, 34 as shown in dot-and-dash lines in Fig. 6 are assumed to occupy a position which is displaced by an angle of 90° around the axis Y—Z relative to their actual position which is the one corresponding to the top dead center of the piston 6 shown in Fig. 6; actually, said grooves 33, 34 occupy the position shown in Fig. 7. The length of each of the groove sections 33, 34 measured on its pitch circle is slightly less than one half of their mean circumference minus the length of the arc of equal radius which is comprised in any one of the equal crescents in the shape of which the sections of the chambers 30 are delimited (see Fig. 7.)

The casing 26, which as already stated is rigid with both the cylinder block 1 and the engine frame, moreover comprises three identical sets of successive passageways 35, 36, 37, 38, 39, 40 each of which is assigned to one of the cylinders 6. For the sake of clarity Fig. 6 only shows those passageways which belong to one of the three cylinders. As to those which actually belong to the cylinder shown, they are angularly displaced by 120° relative to the ones shown and are indicated in Fig. 7.

The passageways 35 start from a place on the frusto-conical surface 28 of the casing 26 which is located opposite the path of the groove sections 33, 34 milled in the frusto-conical surface 25 of the rotor 7. Said passageways 35 communicate with the passageways 36, 37, 38, 39, 40 which lead through an intake port 41 provided in the sleeve 4 of the related cylinder 2 and divided by a bar 42 intended to facilitate the crossing of the port by the piston split rings. The shape and position of the intake port 41 are so chosen that the flow of the mixture therethrough can take place as efficiently as possible in view of the composite sliding and rotary motion of the piston 6 within the cylinder.

Provided likewise in said sleeve 4 is an air-intake port 43 which communicates with the open air through a passageway 243. The sleeve 4 is provided with a bottom aperture 44 and a top aperture 46 which communicate with each other through a passageway 45 provided in the cylinder block 1.

In addition, an exhaust port 59 is provided in cylinder 2 which leads to an exhaust pipe 259.

Cut in the top edge of the piston are a pair of diametrically opposite bevel notches 47, 48. Although a rather good seal is obtained between the piston and its cylinder owing to the combined rotary and reciprocating motion of the one relative to the other, it is made still more reliable by the provision of packing rings 49 which however should be retained from creeping around by means of stop studs in view of the rotary motion of the piston.

Many modifications of the piston may be contemplated. Thus, in the embodiment shown in Fig. 8, the piston is provided with a broad ring 50 slit at 51, arrested by a stud 52 and provided with the aforesaid ports 47, 48.

A sparking plug 53 connected through a lead 54 to an ignition device (not shown) is screwed through the head of each cylinder 2.

The operation of the engine described hereinbefore is as follows:

It will be assumed that the rotor 7 provided with the annular guideway or groove 11 and carried by the shaft 5 is rotated about the axis of the latter in the casing 26; the slide 3 will be caused to move along the guide groove 11 while rotating about the dog 23, whereby said dog in turn will cause the related piston 6 to rotate within the sleeve 4. During this movement the sole 13 rigid with the piston is positively kept parallel with the skew face of the rotor 7 as explained hereinbefore and consequently in engagement therewith. This is true of every one of the three pistons 6 and parts 13, 23, 3 carried thereby.

Conversely, if the pistons 6 be urged successively towards their bottom dead centers, they will be caused to rotate about their own axes and at the same time will cause the rotor 7 and the shaft 5 rigid therewith to rotate about the axis of the latter, which means that the whole mechanism is reversible.

From the carburetor the air-fuel mixture is led through the pipe 231 into the recesses 31—32 and the groove section 33, and this, irrespective of the angular position of the rotor 7 relative to the axis of its shaft 5.

The way in which the air-fuel mixture is supplied to any particular cylinder will now be described from the moment when the piston therein occupies its bottom dead center position.

The uniform rotational motion of the rotor 7 about the axis of its shaft 5 causes the piston 6 to ascend while rotating within the sleeve 4 towards its top dead center and consequently the sole 13 to suck mixture into chamber 30 through the groove section 33 the angular extension of which has been specified in the foregoing and which remains in communication with said chamber 30 for about one half of a revolution of the rotor, that is, for the entire suction stroke of the piston 6.

At the beginning of the second half of the revolution the groove section 33 clears the crescent-sectioned chamber 30 (see Fig. 7); instead, the blind groove section 34 is now in communication with said chamber 30; during this second half of the revolution the piston 6 and the sole 13 rigid therewith are moved in corkscrew motion towards the bottom dead center position of the piston while forcing the mixture from chamber 30 towards the groove section 34 and thence towards the passageway 35 in the related cylinder 2, which passageway at that time is swept by said groove 34. The mixture is thus forced through the passageways 35, 36, 37, 38, 39, 40 and ports 41 in the cylinder 2 in the direction shown by the arrows at the time when the notch 48 in the top of piston 6, which goes on moving in corckscrew motion towards its bottom dead center, come into register with and uncover the ports 41.

Once the piston has reached its bottom dead center and closed the port 41 it will force the mixture into the combustion chamber in its re-ascending stroke at the same time as the sole 13 will suck a new charge into chamber 30.

The expansion and scavenging processes will now be described.

A little while before piston 6 reaches its top dead center position the sparking plug 53 will ignite the compressed charge, after which the piston moves past its top dead center. By that time the piston skirt has already uncovered the port 43 leading scavenging air into the bottom chamber 22 as shown by the arrow *g*. As the piston moves downwards its skirt closes said port 43 and the air already sucked therethrough into said chamber 22 is compressed therein by the lower side of said piston.

As the piston 6 goes on moving downwards the notch 47 in its top edge comes into register with and clears the exhaust orifice 59; however, a little while after the said orifice 59 began to be uncovered, the companion notch 48 in the piston top edge will uncover the port 46, as a result of which the air previously compressed in chamber 22 will rush through the aperture 44 and passageway 45 as shown by the arrows *h* and through the port 46 into chamber 22 to blow the combustion gases therein out of the same through the exhaust orifice 59 as shown by the arrow *j*.

The fact should not be overlooked in the following that the piston in its corkscrew motion within its cylinder is reciprocated according to a sinusoidal law while its rotary motion is throughout uniform.

At the same time as the notch 47 clears the orifice 59 which thenceforth will be closed by the solid portion of the piston the notch 48 similarly clears the port 46 which thenceforth will be similarly closed. Immediately thereafter the notch 48 will uncover the port 41 through which the mixture is thus allowed to flow; the piston then reaches its bottom dead center, the port 41 is once more covered by the piston and the aforedescribed cycle of operation is repeated.

The doing away with any overlapping of the intake with the exhaust phases is made possible owing to the fact that the angular speed of the piston remains constant even as the latter reaches its bottom dead center. Effectively, this is the reason why port 41 will not be uncovered until after the orifices 46, 59 have been closed, although said port is arranged substantially on a level with said orifices.

A first and capital advantage of the mechanism according to my invention in its application to a 2-cycle engine is that it does away with the drawbacks involved by the overlapping of the intake period and the exhaust period and inherent to every conventional 2-cycle engine. A further advantage resides in the fact that such a mechanism makes it possible to design highly supercharged and plentifully scavenged engines. Still a further advantage is afforded by the fact that owing to the "corkscrew" motion of the piston the various ports can be shaped, dimensioned and located in such a manner that intake, exhaust and scavenging shall begin and end at the most favorable times.

As already stated, the cycle of operation thus described in connection with one particular engine cylinder remains exactly the same in the cases of the two others, except they are out of phase by 120° relative thereto. The supply grooves 33, 34 are common to the three supply systems the passageways 35 of which however are angularly spaced by 120°, as already pointed out, around the frusto-conical portion 28 swept by the orifices of said gooves 33, 34.

Of course, the mixture supply system may be designed in a great many different manners. Thus, as far as the scavenging air intake aperture 43 is concerned, the piston skirt might be provided with a port adapted in the ascending corkscrew motion of the piston to move along and remain in register with a sinusoidal slit milled in the cylinder wall, whereby the filling of cylinder 22 would be ensured for substantially the whole extent of the stroke.

Instead of using one single aperture 48 in the piston to take care now of the intake and now of the scavenging it is also optional to use two separate apertures adapted to register with the orifices 46 and 41 respectively, same being correspondingly located in the cylinder.

In the embodiment described hereinbefore the chamber 30 serves for both the suction and the delivery of the mixture while the chamber 22 serves for both the suction and the delivery of the scavenging air. Their functions might as well be interchanged, when aperture 43 would be connected with the carburetor and the duct 231 would be opened to the outside; of course, the shape and location of the various apertures in the cylinder would also have to be altered correspondingly.

It might as well be contemplated to do away with the scavenging process and consequently with the scavenging air chamber 22 and the related apertures, in which event it would only be necessary to use a piston similar to the one shown in Fig. 8, this resulting in a simplification of the engine design.

It has been assumed that the engine is supplied with an air-fuel mixture delivered by a carburetor and is provided with ignition means. Since such an engine can be highly supercharged and plentifully scavenged, it can be arranged to work on injected fuel which may or not be ignited positively depending on whether it is of low or high boiling point character.

The fuel may be injected into a passageway leading to either the aperture 41 or to aperture 46 where it is of low boiling point character or it may be injected into the combustion chamber itself. An engine of the kind described can be run quite advantageously on injected heavy fuel.

Anyhow, every engine involving the use of the power transmission principle according to my invention can be so designed as to work in a perfect state of balance, for which purpose it is only necessary to duplicate the mechanism in such a manner that it is symmetric relative to a median plane at right angles to the common longitudinal axis. With this end in view, a pair of barrel-shaped cylinder blocks of the kind described may be arranged opposite one another to drive one common shaft.

Figs. 9, 10, 11 illustrate such a balanced arrangement as applied in the simple case of a 4-cycle engine composed of a pair of opposite barrels 122, 123 each of which comprises a set of five cylinders 124, 126.

The said Figures 9, 10 and 11 clearly show that the rotor 127 is formed with oppositely inclined working faces 128, 129 adapted to co-operate with the similarly inclined faces 131, 132 of the pistons 133, 134. The pistons 133, 134 are held in sliding engagement with the skew faces 128, 129 of said rotor 127 by means of keeper members 136, 137 rigid with the shaft 138 and consequently with the said rotor 127.

It has already been stated that in order to positively compel each piston sole to revolve and rotate in parallel motion same may be provided with one or more dogs guided with or without the aid of an arcuate slide in as many grooves such as 143, 144, 146 provided in the skew faces 128, 129 of the rotor 127. At any rate, where each piston is provided with a plurality of dogs such as 139, 141, 142, same should preferably be unequal in length and be guided in grooves of corresponding depths in order that at each groove crossing each dog shall remain in the groove assigned thereto.

As shown diagrammatically in Fig. 12, a similar "flat-twin"-like, i. e. axially balanced system may be obtained by arranging a twin cylinder block 147 between a pair of rotors 148, 149 having their respective inner skew end faces 151, 152 inclined in opposite directions.

The numerous advantages and the simpleness of my motion-converting mechanism will appear quite evidently from the foregoing. Where it is limited to one single piston working in one single cylinder it will perform the same function as a single-rod single-crank motion-converting mechanism, which makes it suitable for many uses, notably where more than one cylinder are provided.

Above all, the mechanism described affords the following main advantages:

(a) Owing to the combined rotary and sliding motion which occurs between each piston and the related cylinder, each piston skew end face and the rotor skew end face, each dog or slide and the walls of the related guide groove, friction is lessened quite considerably, so that the mechanism remains reversible even where the plane of the skew surfaces relative to the direction of the reciprocatory movement is substantially higher or less than 45°.

(b) The reactions consequent to the obliqueness of the skew piston and rotor surfaces are taken care of to a large extent by dogs or the arcuate slides carried thereby.

(c) Owing to the corkscrew motion of each piston in its cylinder bored in a fixed barrel-like cylinder block no pop valves are necessary and both intake and exhaust are set once for all.

(d) In the case of a liquid-operated machine, which may be either a pump or a motor, the rotatable member may as well be the casing while what has been referred to as the "rotor" may be fixed, and the distribution may here again be taken care of without the aid of pop valves, when the plane face of the casing remote from the skew face would rotate in contact with the related plane face of a cover provided with ports arranged in a well-known manner.

(e) Owing to the fact that the number of cylinders may be chosen as desired, a great many different single- or multi-cylinder machines can be designed, notably of the so-called "flat-twin" type or in which a considerable number of cylinders are crowded around and parallel to a common shaft, which is particularly valuable in aircraft engineering.

(f) A perfect radial balance of all the rotary members can always be obtained.

(g) Rods and crankshafts are done away with altogether.

(h) A perfect balancing of the thrusts developed in the machine can likewise be secured by arranging a pair of cylinder blocks at either side of one single rotor formed with symmetrically inclined skew working faces co-operating with the set of pistons reciprocated in the related cylinder block.

What I claim is:

1. A mechanism for obtaining a reversible operative connection between any desired number of pistons mounted for both reciprocating and rotary motion in a first machine element and a second machine element mounted for rotary motion relative to said first element, wherein said second machine element has at least one plane end face which is inclined relative to the main axis of the machine, said first machine element has at least one set of any desired number of cylinders having their axes directed parallel to and located at the same distance from said main axis and having one of said pistons mounted in each of them, each piston having an oblique end face adapted to co-operate with the related and correspondingly oblique end face of said second machine element, means to keep the oblique end faces of said pistons in sliding engagement with the related oblique end face of said second element, at least one dog projecting from the oblique end face of each piston parallel to said main axis and as many circular dog-guiding grooves in the related end face of said second machine element co-operating with the related set of pistons as dogs are present on each piston end face and extending likewise parallel to said main axis.

2. A mechanism for obtaining a reversible operative connection between any desired number of pistons mounted for both reciprocating and rotary motion in a first machine element and a second machine element mounted for rotary motion relative to said first element, wherein said second machine element has at least one plane end face which is inclined relative to the main axis of the machine, said first machine element has at least one set of any desired number of cylinders having their axes directed parallel to and located at the same distance from said main axis and having one of said pistons mounted in each of them, each piston having an oblique end face adapted to co-operate with the related and correspondingly oblique end face of said second machine element, means to keep the oblique end faces of said pistons in sliding engagement with the related oblique end face of said second element, at least one dog projecting from the oblique end face of each piston parallel to said main axis and as many circular dog-guiding grooves in the related end face of said second element co-operating with either end face of said second element co-operating with the related set of pistons as dogs are present on each piston end face and extending likewise parallel to said main axis, the lines joining the axes of the pistons to the axes or the related dogs being parallel with and equal to those which join said main axis with the related centres of the circular dog-guiding grooves and being directed similarly.

3. A mechanism according to claim 1 wherein arcuate slides are pivoted on the dogs, which in turn are guided in the grooves in said second machine element instead of said dogs.

4. A mechanism according to claim 1 wherein each piston is provided with a plurality of unequally long dogs guided in correspondingly deep grooves.

5. A mechanism for obtaining a reversible operative connection between any desired number of pistons mounted for both reciprocating and rotary motion in a first machine element and a second machine element mounted for rotary motion relative to said first element, wherein said second machine element has at least one plane end face which is oblique relative to the main axis of the machine, said first machine element has at least one set of any desired number of cylinders having their axes directed parallel to and located at the same distance from said main axis and having one of said pistons mounted in each of them, each piston having an oblique end face adapted to co-operate with the related and correspondingly oblique end face of said second machine element, a cylindrical sole with parallel plane oblique end faces rigid with the oblique end of each piston and larger in diameter than the latter co-operating with the related oblique end face of said second machine element and rotatably fitted in a cylindrical recess with an oblique plane bottom milled in and parallel with the oblique face of said first machine element adacent to the related oblique face of said second element, at least one dog projecting from the oblique end face of each sole parallel to said main axis and as many circular dog-guiding grooves in the related end face of said second machine element adapted to co-operate with the related set of pistons as dogs are pres-

ent on each sole and extending likewise parallel to said main axis.

6. In an internal combustion engine incorporating a mechanism as claimed in claim 5, the provision in the cylinders of said engine of ports communicating with distribution means and in the related rotary pistons of notches adapted to co-operate with said ports.

FRANCIS EMILE MYARD.

REFERENCES CITED

The following references are of record in the file of this patent:

14

UNITED STATES PATENTS

Number	Name	Date
1,300,098	Almen	Apr. 8, 1919
1,491,651	Van Reede	Apr. 22, 1924
2,352,396	Maltby	Feb. 27, 1944

FOREIGN PATENTS

Number	Country	Date
20,446	Great Britain	July 9, 1898