July 2, 1935. E. DASSET 2,006,498

INTERNAL COMBUSTION ENGINE

Filed March 19, 1934 2 Sheets-Sheet 1

Fig. 2

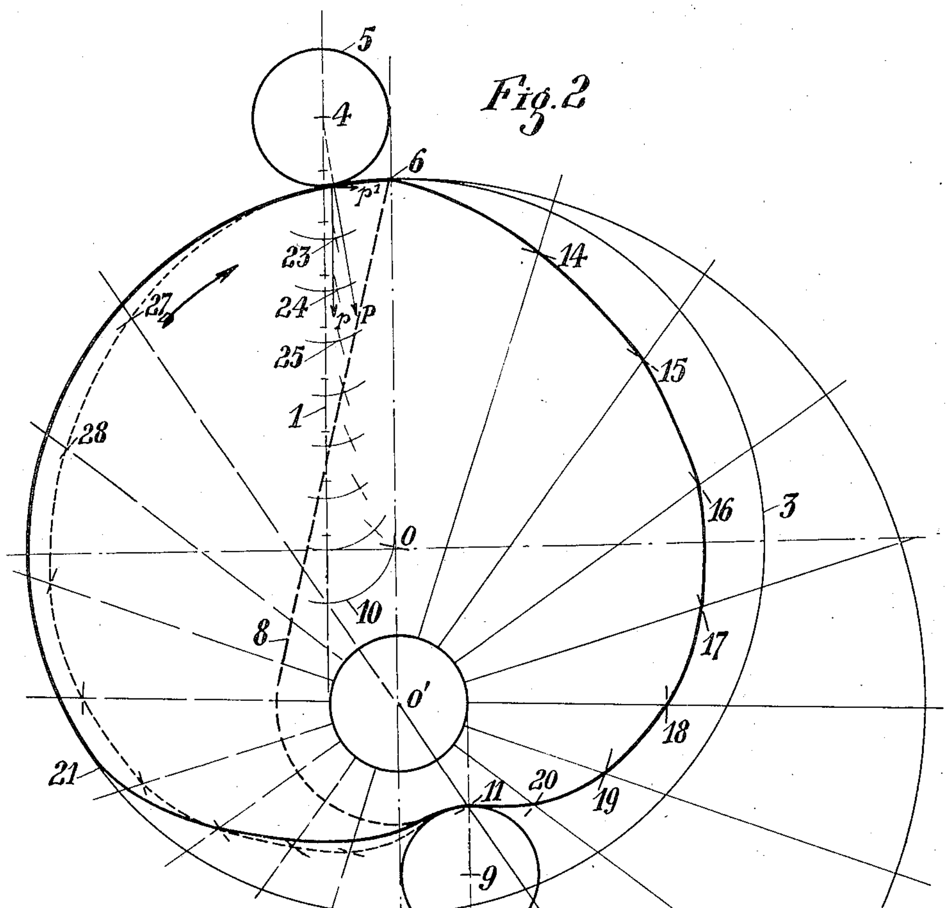

Fig. 1

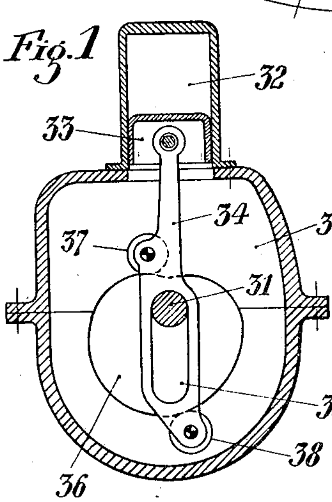

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Fig. 3

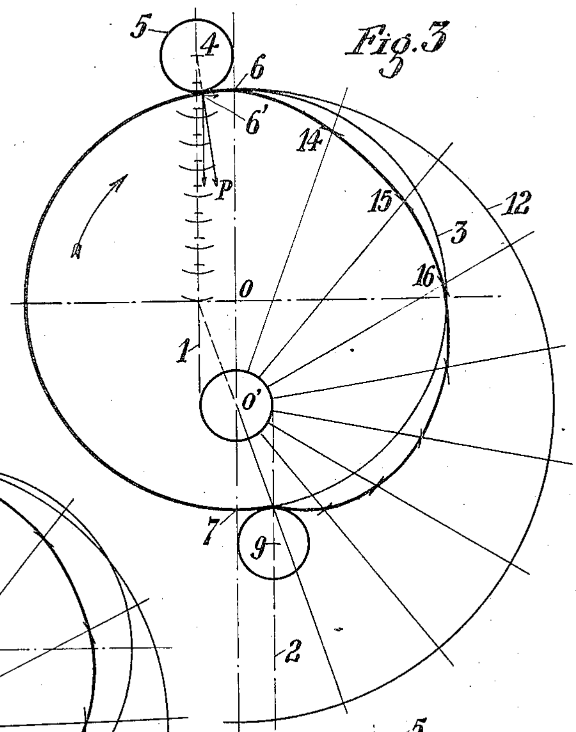


Fig. 5

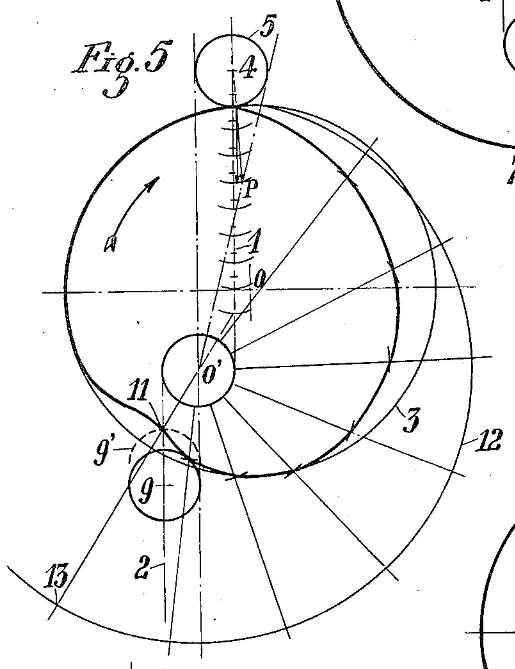


Fig. 4

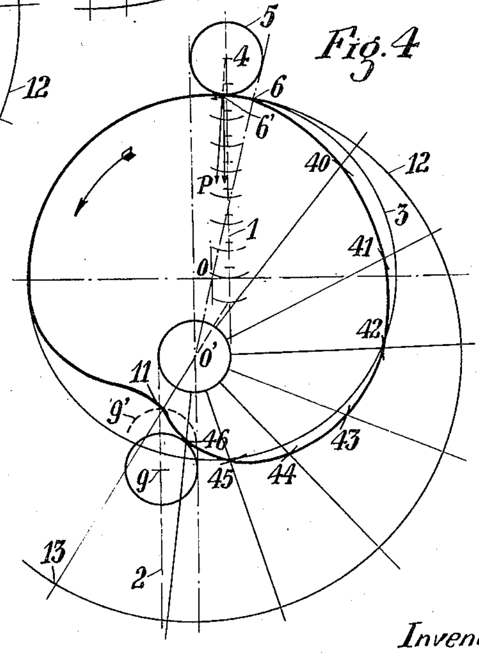
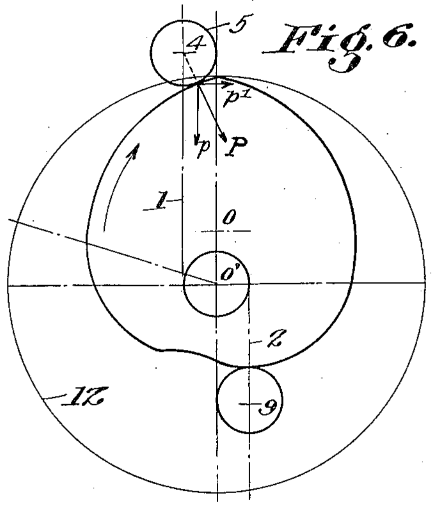


Fig. 6.



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Patented July 2, 1935 **2,006,498**

UNITED STATES PATENT OFFICE

2,006,498

INTERNAL COMBUSTION ENGINE

Emile Dasset, Brussels, Belgium

Application March 19, 1934, Serial No. 716,385
In Belgium January 15, 1934

3 Claims. (Cl. 74—55)

This invention relates to improvements in internal combustion engines and explosion motors.

The transformation of rotary into reciprocating motion by means of cams, namely the transmission of motion from a revolving shaft to reciprocating pistons by means of cams secured on said shaft and in engagement with rollers carried by said pistons, is well known, and has found use for instance in pumps and in compressors. In theory the reverse transformation by the same means is considered as not being mechanically efficient. However various devices have been proposed for internal combustion engines and explosion motors, according to which the pistons generally diametrically opposed with relation to the shaft, operate by means of rollers mounted at the ends of the piston rods, and bearing on cams secured on the shaft. These engines or motors have not found practical application. Generally in engines of this type with diametrically opposed cylinders, diametrically opposed pistons are connected in pairs and the two piston rods each carry a roller which rolls on the periphery of a cam secured on the shaft. To avoid the use of double cams, one has proposed a single cam for the two cylinders; the shape of this cam is such that the line which joins the centers of the two rollers passes by the axis of the shaft; a sinusoidal speed motion of the pistons may then determine a constant angular speed rotation of the shaft. In all the applications which have been contemplated for twin cylinders, it was necessary to ensure permanent contact of both rollers with their common cam; this condition restricted the profile chosen for the cam and required cams of large dimensions which increased the bulk of the engine and did not permit of transforming crank-shaft into cam-shaft engines without changing the whole casing. Neither was it possible to obtain at the start a powerful motor torque. All the cams proposed up to this day and designed for a four-stroke engine have a regular profile, the three-quarters of which generally is a portion of a circle. Also in the design of these profiles, the motive torque, principally at the start, or the heating of the engine, or the loss of power in the periods during which the cam is motive with relation to the rollers, are not taken into consideration, and none of the solutions proposed up to this day have been found applicable.

The present invention is the result of long and numerous experiments on newly constructed engines, as well as on transformed existing motors; these experiments have given unexpectedly good results, particularly with old engines which having been transformed and simplified by the present invention have run for thousands of miles, with greater efficiency than when they were new, noticeably with complete absence of vibrations.

The invention is designed to be applied more particularly to engines with cylinders in a row, each piston acting upon a separate cam; the invention can however be applied to engines with radially disposed cylinders, but each piston must work independently. The invention is characterized essentially by the fact that the motive roller of each piston, that is the roller which thrusts against the corresponding cam during the expansion stroke of the piston, is shifted laterally in relation to the straight line which is parallel to the axis of the cylinder and intersects the axis of the shaft.

In other words, if one considers a piston movable along a vertical line, the shaft being horizontal, the motive roller is outside the vertical line passing through the axis of rotation. This can be constructed, either by keeping the axis of the piston in the vertical line passing through the axis of the shaft and laterally displacing with relation to that line the axis of the motive roller, or by mounting the axis of the roller in the axis line of the piston which is then displaced laterally to the vertical line passing through the axis of rotation of the cam. Preferably the motive roller is combined with a guide roller carried by a rigid element supporting the motive roller, and disposed in such a manner that the cam is located between the two rollers; the said guide roller can be displaced laterally like the motive roller, but in opposite direction. When a single sided cam surface is used the second guide roller is necessary, unless there are two oppositely disposed cylinders, in which case the motive roller of each piston is a guide roller for the other piston. The guide-roller fulfills several functions: In the first place it produces the admission stroke of the piston, secondly it limits the exhaust stroke of the piston and prevents same from knocking against the piston-head by force of inertia. Contrarily to what has been hitherto proposed it is not necessary to maintain both rollers in permanent contact with the cam; contact is sufficient at the ends of the piston strokes and this allows to obtain profiles for the cam which are much more interesting than those obtained up till now, particularly when it is required to transform a crank-shaft motor wherein space is limited by the existing casing.

The said lateral displacement of the motive roller allows to obtain, even with a predetermined profile of the cam, a motor torque much more powerful at the start; it also allows to establish cam profiles which at the start of the downward stroke of the piston (expansion) produce a rapid displacement of the piston, thereby a quick expansion stroke and gives greater mechanical efficiency with less heat. Motors according to this invention have worked for several hours at full power without artificial cooling and have remained comparatively cool.

The lateral displacement or shift of the motive roller enables to obtain an infinite number of profiles for the cam giving high mechanical efficiency; it also enables, for a determined length of the stroke, considerably to reduce the space required for the cams, and to avoid undesirable reactions principally when the cam acts upon the rollers for the exhaust, admission and compression strokes.

Concerning the reactions and loss of power due to the action of the cam upon the rollers, an important feature of this invention is that the profile of the cam, in the portion thereof which engages the roller or rollers to force displacement of the piston, is established in such a manner that at each instant the point of contact between the cam and the respective roller is on the line described by the centre of the respective roller, or at the utmost on the straight line which joins the centre of the respective roller to the centre of the shaft.

Contrarily to what has been done up till now, the design of the profile of the cam is devised, besides with the above mentioned conditions, with consideration of the available space for the casing, the length of piston stroke, and the diameter of the shaft. Cams according to this invention as well as the manner of obtaining same, and the disposition of the rollers have been illustrated by way of example in the appended drawings wherein:

Fig. 1 is a schematical view in section of an engine of the type considered in this specification,

Figs. 2 to 6 are profiles of cams with the rollers, and show the manner of obtaining same.

In each case the same stroke of the piston will be considered, also a lateral displacement of each roller equal to the radius of the rollers, the two rollers having the same radius. Also the vertical lines passing through the axis of rotation of the cam and the axis of the motive roller are distant by a length equal to the radius of the shaft. It will be assumed that each roller has a diameter equal to the diameter of the shaft, and that both rollers move vertically.

Fig. 1 schematically illustrates the mounting of a cylinder and piston in relation to the corresponding cam. **30** is the casing of the engine, inside which is mounted the power shaft **31**. The cylinders **32** are mounted in a line above the casing; the piston **33** has pivotally connected thereto the piston rod **34** which extends right into the casing **30** and is provided with a slotted portion through which extends the shaft **31**. The slot **35** has an inner width equal to the diameter of the shaft and a length equal to the stroke of the piston. Preferably the extended portion of the piston rod comprises two identical and parallel slotted portions disposed on either side of the cam **36** secured on the shaft **31** and rigidly connected at both ends. At both ends and outwardly of the slot **35** are disposed the pins on which are rotatably mounted the rollers **37** and **38** rolling on the periphery of the cam **36**; the profile of the cam and the exact position of the rollers are determined hereafter.

With reference to Fig. 2, from a point O taken as centre, a circle **3** having a radius equal for instance to ⅞ of the piston-stroke is described. The vertical diameter is drawn, and on either side of this vertical diameter, at a distance equal to the diameter of the power shaft, the two vertical lines **1**, **2** are drawn. On the left-hand side line **1**, a centre **4** outside circle **3** is chosen in such a manner that a circle **5** described from such a centre, with the radius of the motive roller, is tangent to circle **3**. This circle **5** shows the motive roller in the position it will occupy at the instant of the explosion, or a moment after. The point **6** which is at the intersection of circle **3** and the vertical diameter being chosen as the apex of the cam, the centre of rotation O′ of the cam is determined by taking on the vertical diameter, below point O, a distance equal to half the radius of circle **3**, minus $\frac{1}{16}$ of the stroke of the piston, that is ⅜ of the stroke.

If one consider the portion of the circle **3** comprised between the point **6** and the point **7** as being a portion of the profile of the cam, it will be seen that in the position illustrated for the motive roller the explosion will develop a pressure of the roller upon the cam according to force P at the point of contact and directed along the line **4**—O joining the centres of the two circles. This force can be decomposed into a vertical component p and a horizontal component p^1; each component produces a torque given by the moment of the component about axis O′. It is immediately apparent that the moment of p^1 about O′ is greater than the moment of p about O′. The two torques being in opposite senses, the cam will rotate according to p^1, clockwise, and the operation of the cam by the roller may be compared to a reaction. The same operation will take place for the whole portion of the circle comprised between **6** and **7** on the left, with a resultant torque decreasing from **6** to **7**, and for all the points comprised within said portion of circle, with an increased resultant torque, that is to say for the profiles of cam comprised within the portion **6**—**7** of the circle, and in which the distance to the centre O′ decreases from O′**6** to O′**7**. The power receiving portion of the cam, that is the portion of the cam engaged by the motive roller during the expansion will be a curve with a continuously decreasing radius in relation to point O′, and which is comprised between the half circle **6**—**7**, and a straight line **6**—**8** ending in a portion of a circle around axis O′.

The position of the centre of the lower roller **9** is determined as follows: from a centre taken on line **1** there is described a portion **10** of a circle corresponding to the lower position of the roller **5**; from O′ as centre there is described a circle having a radius equal to the distance between O′ and the point where the line **1** intersects the circle **10**. On the vertical line **2** there is obtained point **11** which is the point of tangency of the lower roller with the cam.

As aforesaid, the non-motive portion of the cam must be such that on all those points the contact with the motive roller and with the lower roller is on the lines **1** and **2** respectively. In order to determine this curve, from O′ a centre with a radius O′**6** a circle **12** is described; radius O′**11** intersects the circle **12** at point **13** and arc **6**—**13** is divided equally, for instance in eight equal portions. Radii are drawn through the points of division. On one of the lines **1** or **2**, eight centres are marked, corresponding to the positions of the centre of the upper roller after each successive eighth of the stroke; the circles, or portions of circles representing the roller in the successive positions are drawn as illustrated, and with O' taken as centre, the points of intersection of the said circles with vertical line 1 or 2 are transferred to the respective eight radii successively, which gives the points 14 to 20 which are the required points of the curve.

In Fig. 2 the motive portion of the cam has been illustrated as being formed of an arc of circle 6, 21, and of a curve 21—11 traced empirically but with a radius decreasing from 21 to 11. With a motive curve of this type there is no permanent contact of both rollers with the cam; the simultaneous contact of both rollers only takes place at the end of the stroke which is sufficient as the lower roller acts only to prevent the piston from striking the head of the cylinder at the end of the exhaust stroke. When the cam operates the admission stroke, the upper roller can remain out of contact with the cam.

If desired, to avoid noise, a permanent contact of both the rollers with the cam may be provided; the motive portion of the cam is determined according to this invention by extending the radii which have given the points 11 and 14 to 20. On the vertical line 1 are drawn the arcs of circles corresponding to the different portions of the roller at each successive eighth of the stroke, and one joins point O' with the various points occupied by the centre of the roller on the vertical line 1. These lines intersect the respective circles at points 23, 24, 25 etc. From O' as a centre 23 is transferred to 27, 24 to 28 and so on, which provides the dotted line curve shown in Fig. 2, not very different from the full line curve.

The tracing of curve 6—11 of the cam has been determined whilst assuming a constant speed of the piston when the cam operates one of the rollers. In the same manner one could determine a profile 6—11 corresponding to the essential condition given above for the forces, but which would also ensure a variable speed of the piston during the whole stroke or during a portion thereof, by action on the lower roller (admission) as well as on the upper roller (exhaust and compression). The same thing could be done for the motive portion of the cam, for instance to allow right at the beginning of the explosion stroke a high speed of the piston, which tends to increase the mechanical efficiency of the engine and to decrease the heating of same.

Fig. 3 shows an example of a cam profile determined as the full line portion of Fig. 2, but with this difference that the radius of the primitive circle 3 is equal, not to 7/8ths of the stroke but to the whole stroke. In this case portion 6—7 of the cam coincides exactly with the left hand half portion of circle 3, whereas the nonmotive portion of the cam, determined as in Fig. 2 by the points 14—15 and under the same conditions intersects the circle 3. Such a profile of cam ensures an absolutely constant speed of the piston during the expansion.

In Fig. 4 a modification has been illustrated, according to which the rollers have been disposed the other way round in relation to the axis of rotation of the cam, with a different lateral displacement for each roller. From the centre O, with a radius equal to the 7/8ths of the stroke, a circle 3 is described. On the right hand side of this centre and at a distance equal to half the radius of the motive shaft, the vertical line 1 is drawn, whereas the vertical line 2 is drawn on the left hand side at a distance equal to 3/2 of the radius of the motive shaft. The centre O' of the shaft is determined as in Fig. 2 on the vertical line at equal distance from lines 1 and 2. The centre of the bottom roller for the higher position thereof is determined as in Fig. 2, which gives the position 9' in dotted lines. For a downward movement of the piston at constant speed during the expansion, the right hand portion 6, 11 of the curve is determined in the same way as before, by dividing the arc 6—13 into eight equal portions to obtain points 40, 41, 42 . . . etc. It will be seen that the position of the bottom roller corresponding to the upper position of roller 5 is not 9', but 9 corresponding to the tangent position in 46, not in 11. The point 11 constitutes the point of inflexion for the connection with the left hand side of the cam which, for the major part, is the circle 3 except from 11 to 21. It will be verified that the sense of rotation is opposite to the sense of rotation in Fig. 2 and that there is a wider range for giving advance to the ignition than in Figs. 2 and 3, in which the angle of advance can correspond to portion 6, 6' at the utmost. In the example of Figs. 2 and 3, if it be assumed that the explosion takes place at the instant the mechanism is in the position illustrated, it can be seen that at that instant the piston has already commenced the downward stroke, whereas in Fig. 4 it has not yet arrived at the end of the compression stroke.

In Figs. 2 and 3, as well as in Figs. 5 and 6, the engine always runs with late ignition, whilst always giving a direct torque at the instant the explosion occurs. This arrangement is specially favourable because it completely avoids the vibrations due, in engines of the usual type which have to work with advance at the ignition, to the reaction betwen the vis viva of the piston at the end of the compression stroke and the force of explosion directed against the former.

Fig. 5 shows a modification of Fig. 4, according to which the centre O of circle 3 is on the right hand side of all the centres, of the rollers as well as of centre O'. In this case the sense of rotation is reverse as compared with Fig. 4 and the engine functions with retardation as in Figs. 2 and 3. The portion of the cam that acts upon the bottom roller for the admission is determined as previously under the same conditions of being tangent whereas the other portion is practically identical to the corresponding portion in Fig. 4. The position of the bottom roller which corresponds to the upper position of roller 5 is again angularly displaced with relation to the extreme upper portion 9' of the lower roller.

Fig. 6 gives an example of a cam devised for producing a powerful engine torque at the beginning of the stroke or at the explosion, together with a rapid descent of the piston at the beginning of the expansion stroke. It will be obvious that these conditions would be best fulfilled by the cam profile 6—8 in Fig. 2, but this profile has the inconvenience of producing knocks on account of the successive losses of contact between the rollers and the cam.

In Fig. 6 the motive portion of the cam has been determined in such a manner that for the first 72° of rotation of the shaft, the upper roller and consequently the piston describes half of the stroke, whereas the other half is performed by the next 108° of rotation. The other portion of the cam is established as in Fig. 2. The profile of this cam does not comprise any portion of a circle and it will be seen that at the start the torque is very powerful. Whilst remaining within the limits indicated in Fig. 2 concerning the motive portion of the cam, a whole series of profiles answering to various conditions for the cooling of the engine, or for the motive torque at various instants of the expansion torque, may be devised still producing a uniform speed of the shaft. Also the other portion of the cam which acts for the admission can, in combination with the motive portion, and still answering to the condition of tangency, be determined under special consideration for the duration or speed of the admission stroke.

Having now fully described my said invention what I claim and desire to secure by Letters Patent is:

1. Internal combustion engine comprising in combination a power shaft, a piston movable in a plane perpendicular to said shaft, a piston rod terminating with a slotted portion, said power shaft being engaged through the slot and the slot having a length equal to the stroke of the piston plus the diameter of the power shaft and a width equal to the diameter of the powershaft, a cam secured on the power shaft, a roller freely rotatably mounted at each end of the slotted portion of said piston rod and rolling on the periphery of the said cam whereby said piston operates said power shaft, the two rollers of said piston rod being of equal diameter and at an equal distance on either side of the straight line which passes through the axis of rotation of the cam and is parallel to the direction of displacement of the piston, the point of contact between the cam and the roller which forces displacement of the piston by the action of the cam, in said forced displacement of the piston, being comprised between the line described by the centre of the roller and the straight line joining the centre of said roller to the centre of the shaft.

2. Internal combustion engine comprising in combination a power shaft, a piston movable in a plane perpendicular to said shaft, a piston rod terminating with a slotted portion, said power shaft being engaged through the slot and the slot having a length equal to the stroke of the piston plus the diameter of the power shaft and a width equal to the diameter of the power shaft, a cam secured on the power shaft, a roller freely rotatably mounted at each end of said slotted portion of said piston rod and rolling on the periphery of the said cam whereby said piston operates said power shaft, the two rollers of said piston rod being of equal diameter and at an equal distance on either side of the straight line which passes through the axis of rotation of the cam and is parallel to the direction of displacement of the piston, the said cam being excentered with relation to the axis of the power shaft, and having a portion, corresponding to the explosion stroke of the piston, formed of a curve of constantly decreasing radius in relation to the centre of the power shaft, from an apex corresponding to the beginning of the explosion stroke, to a point of minimum radius corresponding to the end of the explosion stroke, said cam having another portion, whereby it operates the roller for the compression stroke of the piston, such that the point of contact with said roller is constantly on the straight line described by the centre of said roller.

3. Internal combustion engine comprising in combination a power shaft, a piston movable in a plane perpendicular to said shaft, a piston rod terminating with a slotted portion, said power shaft being engaged through the slot and the slot having a length equal to the stroke of the piston plus the diameter of the power shaft and a width equal to the diameter of the power shaft, a cam secured on the power shaft, a roller freely rotatably mounted at each end of the slotted portion of said piston rod and rolling on the periphery of the corresponding cam whereby said piston operates said power shaft, the two rollers of said piston rod being of equal diameter and at an equal distance on either side of the straight line which passes through the axis of rotation of the cam and is parallel to the direction of displacement of the piston, the said cam for said piston having a portion upon which acts the motive roller of the piston to force rotation of the power shaft formed of a portion of a curve comprised between a circle excentered with relation to the axis of the power shaft and a straight line joining the portion of large radius to the portion of smaller radius of the cam, and a portion which acts upon the other roller to operate compression stroke of the piston, such that the point of contact with the latter roller is comprised between the straight line described by the centre of said roller and the straight line joining the centre of said roller to the centre of the shaft.

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