Sept. 4, 1934. A. B. GARDNER 1,972,335

ROTARY ENGINE

Filed July 11, 1929 2 Sheets-Sheet 1

Fig. 6.

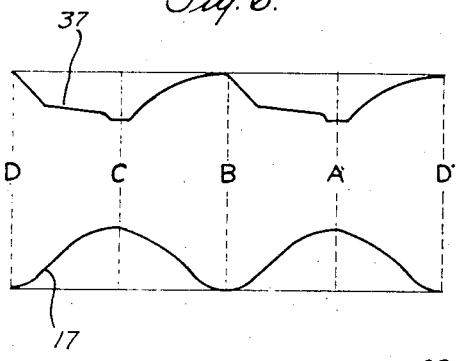


Fig. 1.

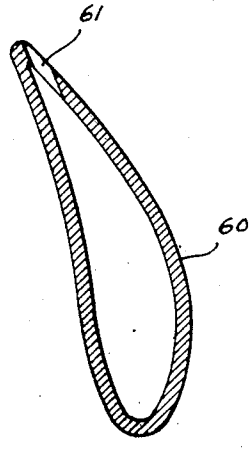


Fig. 5.

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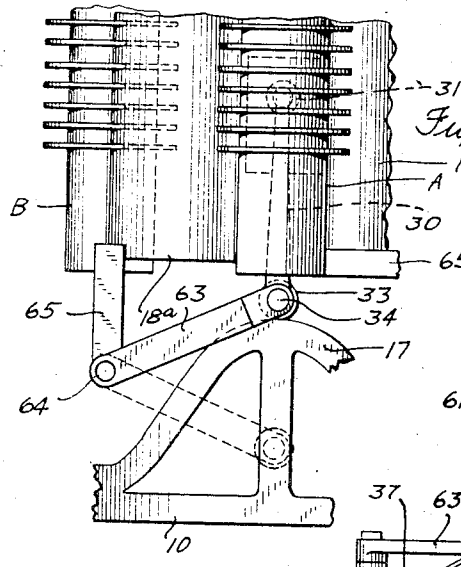


Fig. 4.

Fig. 2.

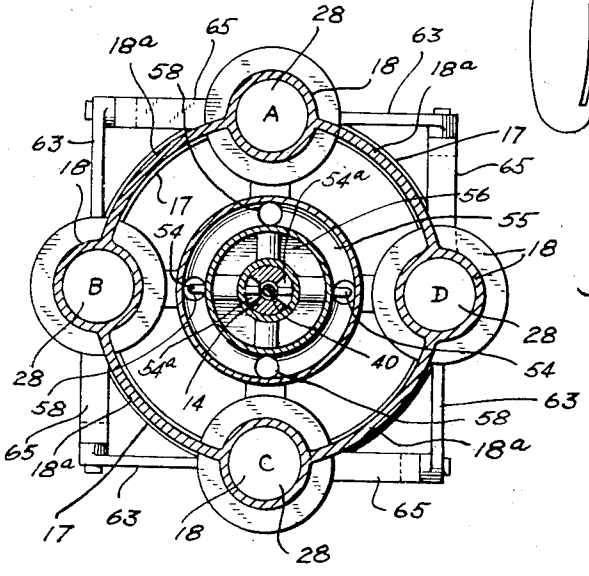


Fig. 3.

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Patented Sept. 4, 1934 1,972,335

UNITED STATES PATENT OFFICE

1,972,335

ROTARY ENGINE

Albert B. Gardner, Racine, Wis.

Application July 11, 1929, Serial No. 377,471

18 Claims. (Cl. 123—43)

This invention relates to internal combustion engines but more particularly to such as are adapted for use in aircraft of either the heavier or lighter than air type.

One of the objects of the invention is to provide a simple and compact form of engine construction which will be efficient and economical in operation.

Another object is to provide an engine of the rotary type in which the reciprocating movement of the piston is converted into rotary motion by means of one or more cams.

Another object is to provide an effective means for controlling the timing of the exhaust and the firing of the charge within the cylinder.

Another object is to provide an effective means for varying the compression pressure while the engine is in operation.

Further objects are to provide an efficient means for scavenging the exhaust gases from the cylinders and drawing in a fresh charge of the explosive mixture, to provide an improved form of valve construction, to provide high speed expansion and consequent thermal efficiency during the power stroke, to provide a more silent exhaust without loss of power, to permit the charge of explosive mixture to be zoned, to provide more power strokes for each piston during a revolution of the engine shaft, to permit quick raising of the compression pressure at the time of ignition of the charge.

Other objects will be in part obvious and in part pointed out in the specification.

The invention accordingly consists in the features of construction, combination of elements and arrangements of parts, all as will be herein illustratively described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings in which are shown the features of a selected embodiment of this invention:

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

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

Fig. 3 is a sectional view on the line 3—3 of Fig. 1.

Fig. 4 is a fragmentary plan view.

Fig. 5 is a detail sectional view, and

Fig. 6 is a diagrammatic view illustrating the relation of the cams.

Referring to the drawings, the engine is provided with a base 10 which may be secured by any convenient means such as bolts 11 to the frame or body 12 of the aeroplane, gondola or other part of the aircraft. On this base 10 is provided a tubular support as 13 through which extends a shaft 14 on which the rotary portion of the engine revolves. The fuel enters the engine from a supply tank (not shown) by way of a tube 16 which projects through an arcuate slot 18*b* in the shaft 14 and communicates with the bore of said shaft. A cam as 17 is mounted on the base 10 and this cam coacts with the pistons in the manner which will be presently described to impart rotary motion to the engine. Stuffing boxes at 16*a* retain the fuel within the shaft 14.

The engine in the present embodiment is of the four cylinder two cycle type although it will be obvious that more or less cylinders may be used. The cylinders as 18 are arranged about the axis of the shaft 14 with arcuate connecting webs 18*a* and supported at their opposite ends by bearing sleeves 19 and 20 to which they are each connected by means of corresponding posts as 21 and 22 respectively. Suitable bearings as 23 and 24 of the ball or roller type may be interposed between the shaft 14 and the corresponding bearing sleeves 19 and 20. A thrust bearing 25 acts between an annular flange 26 on the sleeve 19 and a flanged shaft 27 secured on the sleeve 14.

In each of the cylinders 18 are pistons 28 and 29 acting in opposition, the piston 28 being a power piston and the piston 29 forming a piston-valve. Each of the pistons 28 is provided with a piston rod 30 which is pivotally connected thereto at 31 and carries in its forked outer end 32 a roller 33 adapted to travel upon the operating face of the cam 17. This roller 33 is revolubly mounted on a pin 34 having its end seated in the end of the piston rod. The piston 29 is provided with a corresponding rod 35 which carries in its forked end a roller 36 adapted to ride upon the cam 37 similar in character to the cam 17 at the opposite end of the engine. This cam 37 is connected by suitable supporting arms 38 with a sleeve 39 fitting about and longitudinally slidable on the shaft 14.

A cam 37*a* may be provided to cause the rollers 36 to be held in contact with the cam 37 at all times and thus insure positive movement of the valve pistons 29 in both directions. Rollers 36*a* on an extension of the pins carrying the rollers 36 coact with the cam 37*a* for this purpose. The cam 37*a* has its operating face parallel with the cam 37 and acts in the reverse direction.

The sleeve 39 carrying the cam 37 is movable longitudinally of the axis of the shaft 14 by means of a manually operable rod 40. This rod extends through the bore of the shaft 14 and is provided

at its outer end with an operating wheel 41 preferably located within the body of the aeroplane or other aircraft in a position to permit it to be conveniently manipulated by the operator. A portion of this rod 40 is threaded as at 42 to fit within a correspondingly threaded lug 44 preferably formed and integral with the sleeve 39 and projecting through a slot 44*a* in the shaft 14 so that rotation of this rod will provide movement of the cam longitudinally of the shaft 14, in either direction. The rod is supported at its ends by plates 45 and 46, each having a bushing extending into and fitting within the corresponding end of the bore of the shaft 14. A nut 47 and a hub 48 on the wheel 41 prevent longitudinal movement of this rod. In order to permit the timing of the explosions to be varied, the shaft 14 may be rotated in the support 13 to shift the position of the cam 37. This either retards or advances the action, depending on the direction of rotation. A manually operable worm 14*a* coacting with a worm wheel 14*b* on the shaft or any other suitable means may be provided for this purpose. This worm also acts normally to hold the shaft stationary relative to the support. The lug 44, prevents relative rotation of the cam 37 and this shaft.

A frame 49 is connected to one end of the cylinders 18 and on this frame is formed a hub 50 which rotates upon the corresponding end of the shaft 14. Bearings as 51 of the ball or roller type may be interposed between these elements. A power takeoff flange 52 is provided on this hub 50 to enable a propeller as 53 to be connected thereto.

Fuel is admitted to the cylinders from the bore of the shaft 14 by means of a pair of nozzles 54 which have their inner ends projecting through the corresponding arcuate slots 54*a* in the shaft 14 and extend into the annular passage 55 having an open end 57. Hollow rings as 56 fit about the shaft 14 and are disposed on opposite sides of the nozzles 54. Air enters the passage 55 through end 57 thereof where it is preferably mixed to pass into the cylinders through inlet ports 58. The products of combustion leave the cylinders through outlet ports 59 which communicate with the interior of hollow vacuum producing blades 60 mounted on the corresponding cylinders and resembling in form the usual propeller blades. These blades have on their trailing edge a slot as 61 and the rapid rotation of such blades causes a partial vacuum to be produced within the interior thereof, which acts to draw the products of combustion from the cylinders and a new charge therein after the completion of the power stroke of the pistons 28 in the manner which will be presently described. The ignition of the fuel charge in the cylinder is produced by compression as in a Diesel or semi-Diesel engine although electrical or other form of ignition mechanism may be used in place thereof. The nozzles 54 may be brought close to the inlet ports 58 to permit zoning of the fuel for in this case there is action on the nozzles only when such nozzles are opposite the ports. An injector for the fuel may be used as in the Diesel engine.

The skirts of the pistons 28 and 29 may be slotted as at 28*a* and 29*a* respectively and these slots arranged to register with the inlet and exhaust ports. By having these slots extend almost to the piston rings, a beneficial scavenging action is obtained within the cylinders. This makes use of the kinetic energy developed by the sudden checking of the flow of air through the ports as the piston rings are passing these ports.

The engine illustrated in the drawings is of the two cycle type so that two explosions occur in each cylinder during each revolution of the rotary portion of the engine. As viewed in Fig. 1 of the drawings, the upper cylinder is in firing position. The piston 28 and the piston 29 have been moved respectively by the cams 17 and 37 so that the gas which has entered the cylinder from the carbureter has been fully compressed.

The explosion of the compressed gases between the piston and the valve causes the piston rod 30 to be forced outwardly in the cylinder or to the left (Fig. 1) and the roller 33 is thus forced against the downwardly sloping face of the cam 17 thus causing the rotary portion of the engine to be revolved about the axis of the shaft 14. The roller 33 during this movement is guided by an arm 63 which is pivotally connected to the piston rod 30 by means of the pin 34 on which the roller is mounted. The opposite end of this arm 63 is pivotally mounted at 64 on a post 65 formed on or attached to the next adjacent cylinder on one side thereof. The swinging movement of the arm 63 is permitted by the pivotal connection of the piston rod at 31. While the roller is thus moving on the cam 17, the roller 36 on the rod 35 of the piston 29 rolls downwardly on the face of the cam 37 and thus allows this piston to move to the right and to open the exhaust port 59 so that the products of combustion may pass from the cylinder.

The cylinder at the bottom of Fig. 1 illustrates the position of the pistons 28 and 29 at the end of the power stroke. The products of combustion are passing from the cylinder aided by the partial vacuum produced in the blades 60 and at the same time a charge is being drawn from the nozzle 54 through the inlet port 58 by the rush of air. The rollers 33 and 36 now proceed to ride upwardly on their respective cams as the rotary motion of the engine continues and the piston 28 and piston 29 are forced toward each other until they reach the next firing position previously described.

In order to make clear the action of the engine, the four cylinder positions in Fig. 3 have been designated A to D. The A and C positions are firing positions or that in which the parts are as indicated in the upper cylinder of Fig. 1. The positions B and D are exhausting and charging positions or that in which the parts are as indicated in the lower cylinder of Fig. 1. The form and relation of the cams 17 and 37 is diagrammatically illustrated in Fig. 6 of the drawings and the positions A, B, C and D are indicated thereon.

While the engine is here shown provided with the propeller 53 mounted on the power takeoff flange 52, this may be dispensed with and larger propeller blades substituted for the small blades 60 which will not only perform the scavenging and charging action within the cylinders but provide the driving action for the aircraft. Where the propeller 53 is used, the blades 60 assist somewhat in the driving action and thus more than overcome the wind resistance provided thereby.

By transforming the reciprocating motion of the pistons to rotary motion in the driving shaft through the medium of cams the usual cranks are eliminated and the number of parts is materially reduced. The piston-valves control the timing of the exhaust as well as the firing of the charge within the cylinder. The longitudinal shifting of the cam 37 permits the compression pressure to be varied while the engine is in operation or at any time that may be desired by the operator, as for example, at different altitudes or for different kinds of fuel. The rotation of the shaft 14 within the support 13 acts to change the

timing of the cylinders. A fuelizer of any suitable type may be provided to assist in gasifying the fuel. The cylinders perform the function of a fly wheel.

The passage of air through the inlet and exhaust ports during the compression stroke of the pistons as indicated by the arrows in the upper cylinder of Fig. 1, very materially assists in cooling the parts of the engine.

While the engine forming the subject matter of this invention is well adapted for use in aircraft of either the heavier or lighter than air type, it will be evident that it is capable of a much larger field of usefulness and the application described is merely for the purpose of illustration. The construction of the engine is simple and compact and capable of efficient and economic operation. The imparting of rotary motion to the engine through the medium of cams coacting with the power pistons, simplifies the construction and provides high speed expansion and consequent thermal efficiency during the power stroke and less loss of power in compression. The engine efficiently operates on the two cycle principle and thus makes possible two power strokes of each piston during each revolution of the engine. The exhausting into a partial vacuum very materially silences the exhaust.

It will be seen that there is provided a construction of an essentially practical nature in which the several objects of this invention are attained.

As many other embodiments may be made of the features of the above invention without departing from the scope of the invention, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In an internal combustion engine of the rotary type, in combination, a cylinder mounted for revolution about an axis parallel with the axis of the cylinder, inlet and outlet ports communicating with said cylinder and means for aiding the withdrawal of the products of combustion from said cylinder, including a propeller blade mounted on said cylinder and having an exhaust passage leading substantially from the feathering edge thereof to and communicating with said outlet port, said propeller blade being so shaped that movement of the blade with the cylinder produces a partial vacuum within said passage.

2. In an internal combustion engine of the rotary type, in combination, a shaft, a cylinder revolubly mounted on said shaft with its axis substantially parallel with the axis of the shaft, a power piston in said cylinder, a second piston in said cylinder forming a control valve, a cam at right angles to the stroke of and in operative relation to said valve piston, and means for moving said cam toward or away from said cylinder to vary the compression in said cylinder.

3. In an internal combustion engine of the rotary type, in combination, a shaft, a cylinder revolubly mounted on said shaft with its axis substantially parallel with the axis of the shaft, a power piston reciprocating in said cylinder, a second piston in said cylinder acting in opposition to said power piston and forming a control valve, a cam supported by said shaft and coacting with said valve piston to shift the position thereof within said cylinder, and means for regulating the position of said cam relative to said cylinder.

4. In an internal combustion engine of the rotary type, in combination, a shaft, a cylinder revolubly mounted on said shaft with its axis substantially parallel with the axis of the shaft, a power piston reciprocating in said cylinder, a second piston in said cylinder acting in opposition to said power piston and forming a control valve, a cam supported by said shaft and coacting with said valve piston to shift the position thereof within said cylinder as said cylinder revolves, and means for regulating the position of the portion of the face of said cam opposite said cylinder.

5. In an internal combustion engine of the rotary type, in combination, a cylinder mounted for revolution about an axis parallel with the axis of the cylinder, inlet and outlet ports communicating with said cylinder, and means for aiding the withdrawal of products of combustion from said cylinder including a substantially hollow vane projecting from said cylinder with its interior communicating with said outlet port and having its wall slotted adjacent the feathering edge thereof, said vane being so shaped that its revolution in the atmosphere produces a siphon action within the vane to draw exhaust gases through said outlet port to the atmosphere.

6. In an internal combustion engine of the rotary type, in combination, a revoluble cylinder, inlet and outlet ports communicating with the interior of said cylinder, and means for providing suction within said outlet port as the cylinder is revolved including a hollow slotted vane having the general shape of a propeller mounted on said cylinder and fitting over said outlet port, said vane being so shaped that upon revolution with said cylinder a partial vacuum is created therein to facilitate the removal of waste gases from said cylinder.

7. In an internal combustion engine of the rotary type, in combination, a shaft, a cylinder rotatably mounted upon said shaft and having its axis substantially parallel thereto, a piston slidably mounted within said cylinder, a cam member having its cam surface facing one end of said cylinder and being relatively fixed with respect to said cylinder, said piston being operatively related to said cam, a cam positioned at the opposite end of said cylinder and being relatively fixed with respect to said cylinder, said cam having its cam surface facing said last-mentioned end of said cylinder, a piston valve mounted within said cylinder and positively related to said last-mentioned cam, said piston and said piston valve engaging the walls of said cylinder, and an outlet port for said cylinder positioned near one end thereof whereby upon movement of said piston toward said first-mentioned cam rotary motion is imparted to said cylinder about said shaft and said piston valve travels along said cylinder to act as a valve member for said outlet port.

8. In an internal combustion engine of the rotary type, in combination, a fixed shaft, a series of cylinders rotatably mounted about said shaft, each of said cylinders having slidably mounted therein a pair of pistons, said pistons being independent of each other and each engaging the wall of said cylinder, outlet ports positioned substantially near one end of said pistons, a pair of cams disposed at the opposite ends of said cylinders and having their cam surfaces facing the ends of said cylinders, said cams being relatively fixed with respect to said cylinders, means for opera-

tively associating the pistons upon one side of said cylinders with one of said cams, and means slidably connecting the other group of said pistons with the other cam whereby said first-mentioned group of said pistons acts as drivers against said first-mentioned cam surface to impart rotation to said cylinders while the other group of said pistons act as valve members for said outlet ports.

9. In an internal combustion engine of the rotary type, in combination, a fixed shaft, a series of cylinders rotatably mounted about said shaft, each of said cylinders having slidably mounted therein a pair of pistons, said pistons being independent of each other and each engaging the wall of said cylinder, outlet ports positioned substantially near one end of said pistons, a pair of cams disposed at the opposite ends of said cylinders and having their cam surfaces facing the ends of said cylinders, said cams being relatively fixed with respect to said cylinders, means for operatively associating the pistons upon one side of said cylinders with one of said cams, means slidably connecting the other group of said pistons with the other cam, and vane members associated with said outlet ports so shaped that upon rotation through the atmosphere a partial siphon action is created therein to facilitate the withdrawal of gaseous waste therethrough, whereby said first-mentioned group of said pistons acts as drivers against one of said cam surfaces to impart rotation to said cylinders while the other group of said pistons act as valve members for said outlet ports.

10. In an internal combustion engine of the rotary type, in combination, a cylinder rotatably mounted upon an axis substantially parallel to the axis of the cylinder, said cylinder having an outlet port near one end thereof and an inlet port near the other end thereof, a piston mounted in the portion of said cylinder containing said inlet port, a piston mounted in the portion of said cylinder containing said outlet port, and a pair of cams disposed at the opposite ends of said cylinder and relatively fixed with respect thereto, one of said pistons whose path of travel extends over said inlet port being operatively associated with one of said cams while the other of said pistons whose path of travel extends over said outlet port is slidably connected to said other cam whereby upon the firing of said cylinder said first-mentioned piston in association with said first-mentioned cam imparts rotation to said cylinder in its movement toward the end thereof and acts as a valve for said inlet port and said second-mentioned piston acts as a valve for said outlet port.

11. In an internal combustion engine of the rotary type, in combination, a fixed shaft, a cylinder rotatably mounted upon said shaft, said cylinder having open ends, a pair of cams disposed at the opposite ends of said cylinder and being relatively fixed with respect to said cylinder, the surfaces of said cams running in a direction parallel to the axis of said cylinder, a pair of pistons slidably mounted within said cylinder, said cylinder having an outlet port positioned in the path of one of said pistons and an inlet port positioned in the path of the other of said pistons, one of said pistons whose path of travel extends over said inlet port being operatively associated with one of said cams while the other of said pistons whose path of travel extends over said outlet port is slidably connected to said other cam and means associated with said outlet port to produce a siphon action when said port is open to facilitate the removal of gaseous waste from said cylinder, whereby upon firing said last-mentioned piston acts as a driver to impart rotation to said cylinder through the agency of one of said cams and also acts as a valve member for said inlet port while the other of said pistons being controlled by said other cam acts as a valve member for said outlet port.

12. In an internal combustion engine of the rotary type, in combination, an engine including a series of cylinders adapted to rotate about a fixed axis, said cylinders having outlet ports, and parts corresponding in shape to portions of a propeller associated with said outlet ports, said parts having slots so shaped and positioned as to create a partial vacuum therein upon movement of said parts through the atmosphere.

13. In an internal combustion engine of the rotary type, in combination, a cylinder rotatably mounted upon a fixed axis substantially parallel with the axis of said cylinder, a pair of pistons slidably mounted within said cylinder, a cam relatively fixed with respect to said cylinder and disposed at one end thereof, one of said pistons being in operative association with said cam, a second piston slidably mounted within said cylinder, a second cam disposed at the opposite end of said cylinder and operatively related to said last-mentioned piston, means for holding said last-mentioned cam against rotation, and means for moving said last-mentioned cam toward or away from said cylinder to regulate the compression of said cylinder.

14. In an internal combustion engine of the rotary type, in combination, a fixed shaft, a series of cylinders rotatably mounted upon said shaft, pistons disposed within said cylinders, a cam relatively fixed with respect to said cylinders and disposed at one end thereof, said cam having its surface running in a direction substantially parallel to the axis of said shaft, means connected to said pistons and operatively related to said cam whereby upon longitudinal movement of said pistons in said cylinders rotation of said cylinders takes place, a second group of pistons mounted within said cylinders, a positive cam disposed at the opposite end of said cylinders and having its cam surface running substantially parallel to the axis of said shaft, means connecting said positive cam to said last-mentioned group of pistons, and means for regulating the longitudinal position of said positive cam with respect to said cylinders.

15. In an internal combustion engine of the rotary type, in combination, a fixed shaft, a series of cylinders rotatably mounted upon said shaft, pistons disposed within said cylinders, a cam relatively fixed with respect to said cylinders and disposed at one end thereof, said cam having its surface running in a direction substantially parallel to the axis of said shaft, means connected to said pistons and operatively related to said cam whereby upon longitudinal movement of said pistons in said cylinders rotation of said cylinders takes place, a second group of pistons mounted within said cylinders, a positive cam disposed at the opposite end of said cylinders and having its cam surface running substantially parallel to the axis of said shaft, means connecting said positive cam to said last-mentioned group of pistons, means for regulating the longitudinal position of said positive cam with respect to said cylinders, and means for rotating said positive cam and for maintaining it at any point in its path of rotation.

16. In an internal combustion engine of the rotary type, in combination, a fixed shaft, a series

of cylinders rotatably mounted upon said shaft, pistons disposed within said cylinders, a cam relatively fixed with respect to said cylinders and disposed at one end thereof, said cam having its surface running in a direction substantially parallel to the axis of said shaft, means connected to said pistons and operatively related to said cam whereby upon longitudinal movement of said pistons in said cylinders rotation of said cylinders takes place, a second group of pistons mounted within said cylinders, a positive cam disposed at the opposite end of said cylinders and having its cam surface running substantially parallel to the axis of said shaft, means connecting said positive cam to said last-mentioned group of pistons, and means for regulating the position of said positive cam along the axis of said shaft to regulate the compression of said cylinders.

17. In an internal combustion engine of the rotary type, in combination, means including a plurality of cylinders rotatably mounted upon a fixed axis substantially parallel to the axes of said cylinders, a series of power pistons each located in one of said cylinders, a cam member facing said cylinders, means operatively associating said power pistons with said cam member, a group of valve pistons each located in one of said cylinders, a cam member facing the end of said cylinders opposite said first-mentioned cam member, and means operatively associating said valve pistons with said last-mentioned cam member, said cam members being so shaped that as said power pistons move into their innermost position at a substantially constant rate said valve pistons move through the first portion of their stroke at a proportionately faster rate and then lag at an intermediate position until said power pistons have almost reached their innermost or firing position when said valve pistons move to their innermost position rapidly to remain substantially at said innermost position during the firing and for a moment thereafter while said power pistons start their outward movement.

18. In an internal combustion engine of the rotary type, in combination, a plurality of cylinders rotatably mounted upon a fixed axis, a series of power pistons each mounted in one of said cylinders, a series of valve pistons each mounted in one of said cylinders, said pistons in each cylinder adapted to slide toward and away from each other so that an explosion forces the pistons toward the opposite ends of said cylinders, a relatively fixed cam whose cam surface faces one end of said cylinders, means operatively associating said power pistons with said cam, a relatively fixed cam at the opposite end of said cylinders and having its cam surface facing said cylinders, and means operatively associating said valve pistons with said last-mentioned cam, said cam surfaces being so shaped that as said power pistons reach substantially their innermost position a portion of said valve pistons' stroke is incompleted but is completed very quickly and so that said valve pistons remain in said innermost position for a moment after the firing and after said power pistons start their outward movement.

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