

A. LLEÓ AND C. BARADAT.
INTERNAL COMBUSTION ENGINE.
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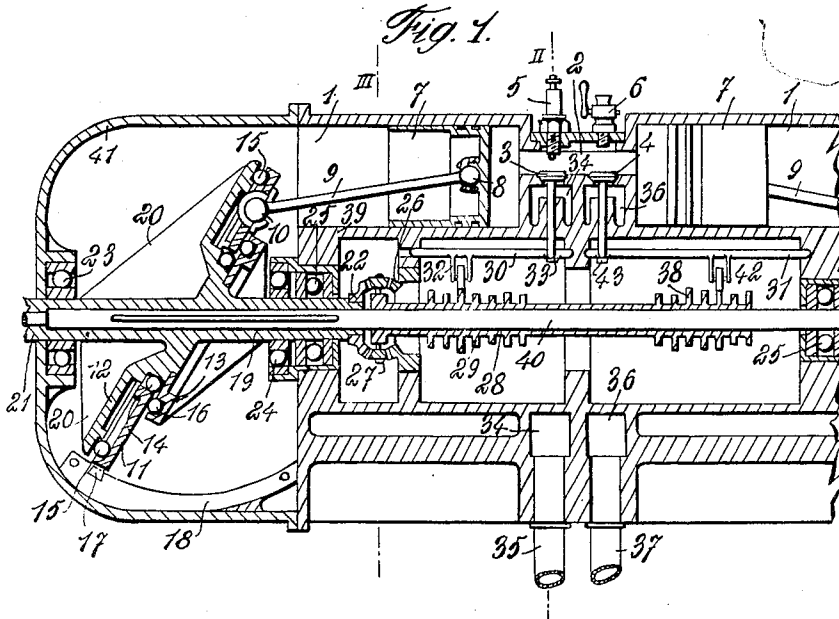
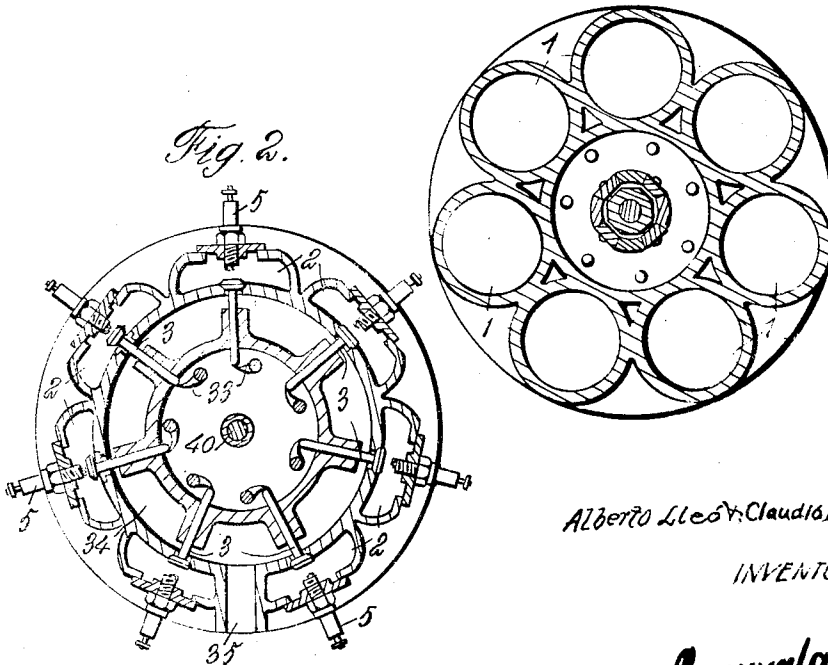


Fig. 3.



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INTERNAL-COMBUSTION ENGINE.

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To all whom it may concern:

Be it known that we, ALBERTO LLEÓ and CLAUDIO BARADAT, subjects of the King of Spain, residing at Barcelona, Spain, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

Our invention relates to multicylinder internal combustion engines, and its object is the construction of an engine of this class for special use on motor-cars, motor-boats and flying machines, and capable of being put to many other uses.

Our invention essentially consists in placing the several cylinders of the engine in a parallel direction with its shaft and distributed around the same, in connection with a ring-piece placed on a circular support fixed to the shaft and forming with it a certain angle. The above mentioned ring-piece is joined with the connecting-rods of the several cylinders and mounted in such a way as to prevent it going around the shaft, but allowing it to oscillate following the movements of the connecting rods.

Owing to the disposition of this ring-piece joined with the connecting-rods of the cylinders, and to the circular support fixed on the shaft at a certain angle, the rectilinear movement of the pistons is transformed into a rotatory movement of the engine shaft.

Another characteristic of our invention is that the distribution mechanism for the operation of the inlet and exhaust valves is also disposed around the engine shaft in such a way that the cams that lift the valves are placed on a sleeve which is rotated around the shaft through a differential gear giving the correct speed required for the operation of the valves. All the inlet valves have a communication with a circular passage to which is connected the intake pipe that draws in the explosive mixture; the exhaust valves have a similar communication with another circular passage joined with the exhaust pipe that drives out the burnt gases.

This engine may be single or double, or in other words built with one or two sets of cylinders distributed around the shaft. In the first case the shaft has only at one of its ends one circular support with the corresponding ring-pieces to which the connecting rods of the pistons are joined; the circular passages for the inlet and exhaust valves being arranged at the other end of

the engine. In a double engine, the cylinders on both sets are so disposed that each cylinder of one set is built on the same axis as the corresponding cylinder on the other set and opposite to it; the engine shaft having at each end a circular support with the ring piece joined with the connecting rods of the cylinders. Each pair of opposite cylinders in this case works simultaneously having a common head and combustion space on which are placed the inlet and exhaust ports and the sparking plug for igniting the mixture. Owing to this disposition and the simultaneous firing of each pair of opposite cylinders the axial strains produced by the explosion are efficiently checked. Our invention is represented in the accompanying drawings in the form of a double engine, that is, an engine with two symmetrical sets of cylinders.

Figure 1 is a sectional view along the engine shaft, with some parts broken away. Fig. 2 is a sectional view along the line II of Fig. 1. Fig. 3 is another sectional view along the line III of Fig. 1.

The engine shown is a double engine; the shaft 40 may be seen in the drawings, with a series of combustion chambers 2 disposed around the same, in parallel relationship with each other. On either side of the combustion chambers 2 are placed the cylinders 1, each cylinder having its piston 7; thus, as shown in Fig. 2, seven pairs of cylinders are distributed around the shaft 40.

It can be seen by the accompanying drawings that the cylinders 1 of each set are symmetrical and have a common combustion chamber 2, as also a common sparking plug 5, exhaust and inlet valves 3 and 4 and tap 6. Each piston 7 has its own connecting rod 9 articulated by a spherical knuckle 8; the other end of the connecting rod forming also another spherical knuckle 10, which is duly articulated with the ring 11.

This rests on the circular support 12—13 which is fixed to the shaft by means of its hub 19 and a key. The ring 11 bears on the circular support 12 by means of the ball bearings 14—15 and on the circular support 13 by means of ball bearing 16. The ring 11 has on its flange a roller 17 that fits inside the guide 18 so that the ring cannot turn around and has only an oscillatory movement imparted by the connecting rods 9. Only one connecting rod 9 belonging to piston 2, is shown in Fig. 1; but is easily

understood, that the number of connecting rods articulated to each ring 11 is the same as the number of pairs of cylinders of the engine; which is seven in the case shown in the drawings.

The ball bearing 14 placed between the circular support 12 and the ring 11 takes up the radial thrust; and the ball bearings 15 and 16 take up the axial stresses. The circular support 12 is built with reinforcements 20 so as to avoid deformation that might be produced by the thrust of the explosion.

The circular support 12—13 is inclined to the shaft 40; according to the stroke of the pistons. The ring 11 follows the same angle as the circular support.

The sleeve or hub 19, made in one piece with the circular support, is fixed to the shaft 40 having at its end 21 the propeller not shown in the drawing, or other mechanism for the transmission of the movement. This sleeve has at the inner end a bevel gear 22 which meshes with gear 26, fixed to the engine body, by means of the intermediate planetary pinions 27 mounted on pins over the sleeve 28 concentric with the shaft 40 on which it turns around.

Two ball bearings 24 and 25 are interposed between the sleeve 19 and the body of the engine 39; another ball bearing 23 is placed between the sleeve 19 and the cover of the engine 41; this, not only enables the rotatory movement of the sleeve 19, but also takes up the axial stress which tends to thrust apart the extreme circular supports although in the case of a double engine, the extreme circular supports being both fixed to the shaft 40, the stresses produced by the thrust of the two sets of pistons are most efficiently balanced.

The sleeve 28, on which is mounted the planetary pinion 27, turns around at half the shaft speed owing to the differential gear formed by bevel gears 22—26 and the planetary pinions 27.

The sleeve 28 carries the cams 29; the number of these cams being equal to the number of pairs of cylinders of the engine; each cylinder has a shaft 30 which carries the small arms 32 with a roller placed between them, which roller bears on the cams 29. Each shaft 30 has a lever 33 for the operation of the corresponding exhaust valve 3.

On the sleeve 28 is further arranged a number of cams 38 equal to the number of pairs of cylinders. Each of the cams 38 coöperates with a roller 42 mounted on the arms of a shaft 31 of a corresponding pair of cylinders, and actuates a lever 43 carried by the shaft 31 to operate the inlet valve 4.

All the levers 33 are situated in one plane as shown in the view in Fig. 2 and all of the levers 43 are similarly situated; but all

of the cams 29 and 38 are placed in different planes or cross sections of the engine, the corresponding rollers 32 and 42 for every pair of cylinders being also situated in the same several planes as the cams on which they bear.

All the exhaust valves 3 are communicated with a circular passage 34 to which is connected the exhaust pipe 35; all the inlet valves 4 having a similar communication with another circular passage to which is attached the intake pipe 37.

The accessory parts of the engine, such as the magneto, oil pump, water pump and others, are not shown in the drawings, as it has not been deemed necessary for the understanding of our invention.

The working of a double engine, as specified above, is as follows: When the explosion takes place in the combustion space 2 the two pistons 7 are thrust in opposite directions and the corresponding connecting rods 9 that are now at the end of the stroke, or dead point, press forward the corresponding ring pieces 11. Each ring, by the thrust imparted to it, has a tendency to go around the shaft 40 slipping parallelly over the circular support 12 on which it rests, through the ball bearing 15; but, as the roller 17 with its guide 18 prevents this rotatory movement, the reaction of the balls over the circular support 12 causes it to go around instead of the ring 11; this latter being then imparted an alternative oscillatory movement along the guide 18. This movement, as the system is perfectly symmetrical, is the same in every one of the points of the ring 11 where the spherical knuckles for the articulation of the several connecting rods of the engine are placed; as a result of it, this oscillatory movement of the ring will take place causing at the same time a continual variation of the angle formed by the ring plane and the shaft 40; this oscillatory movement, as it has been said before, being transformed into a rotatory movement of the circular support 12 and thereby of the sleeve 19 and the engine shaft 40.

The ball bearing 16 is not absolutely necessary as the thrust of the connecting rods is directly applied on the circular support 12, but the momentum of the pistons might produce at certain moments an opposite reaction on the circular support 13. As to ball bearing 15 its function is the one of an ordinary ball bearing, as the ring 11 is not revolving and on the contrary the circular support 12 turns around on it.

We have shown and described a double engine, or an engine with two sets of cylinders, but, it is easily understood, that an engine may be built with only one set of cylinders. In this case one end of the engine carries the circular support with the ring to which are imparted the thrusts of

the connecting rods generating the rotatory movement of the shaft; the circular passages that communicate with the inlet and exhaust valves being placed at the other end.

5 When applying our invention use could also be made of the well known principle of the inversion of the movement; this could be done by fixing the engine shaft and letting the engine go around; the body of the engine bearing in this case, the propeller or other mechanism for the transmission of the movement. This could not alter the essential part of the invention; it only being necessary to arrange a hollow shaft for the inlet of the mixture, as usually done in this type of engines.

The type of engine shown in the accompanying drawings, and herein described, is only one example of execution of the invention, as it is easily understood, that it is possible to vary the disposition of certain parts of the engine, for instance by using rotatory valves, without altering the essential conditions of the invention.

25 We claim:

1. In an internal combustion engine, a plurality of cylinders placed around the engine shaft and parallel thereto, a plurality of pistons and connecting rods in said cylinders, means to transmit to the engine shaft the motion of said pistons, transforming it into a rotary movement, a plurality of combustion chambers for the several cylinders and provided with spark plugs and inlet and exhaust valves, all said valves being disposed radially with their stems directed toward the engine shaft, an annular conduit for the mixture of air and fuel communicating with all the inlet valves, an annular conduit communicating with all the exhaust valves and connected to the exhaust pipe, both conduits being disposed between the engine shaft and the combustion chambers, a sleeve loosely mounted on the engine shaft and rotated to actuate the several valves, a plurality of cams arranged on said sleeve, a plurality of shafts parallel to the engine shaft, each provided with an arm engaging with a cam on said sleeve and with another arm that actuates the corresponding valve, said sleeve and said shafts being disposed in the space between the cylinders and the engine shaft.

2. In an internal combustion engine, a plurality of cylinders parallel to the engine shaft and placed in pairs around it, the cylinders of each pair being juxtaposed coaxially, a plurality of pistons and connecting rods in said cylinders, means adapted to impart to the engine shaft the motion of said pistons, transforming it into rotary movement, a combustion chamber connecting the head of each pair of cylinders and provided with a spark plug and inlet and exhaust valves, all said valves being dis-

posed radially and with their stems directed toward the engine shaft, an annular conduit for the mixture of air and fuel communicating with all the inlet valves, an annular conduit communicating with all the exhaust valves and connected with the exhaust pipe, both conduits being disposed between the engine shaft and the combustion chambers, a sleeve adapted to be rotated from the engine shaft by means of a differential gear, a plurality of cams on said sleeve adapted to actuate all the inlet and exhaust valves, a shaft for each valve, said shaft being parallel to the engine shaft and provided with an arm on one end which is actuated by the corresponding cam and an arm on the other end which transmits this motion to the valve, said sleeve, differential gear and shafts being disposed in the space between the cylinders and the engine shaft.

3. An internal combustion engine having a plurality of cylinders disposed around the engine shaft and parallel thereto, said cylinders being arranged in opposed pairs each pair having a common combustion chamber, a plurality of pistons in said cylinders connected with the engine shaft so as to drive the same, and intake and exhaust valves for said chambers, in combination with valve controlling means disposed radially within the space between the engine shaft and the cylinders, and axially within the length of the cylinders, said valve controlling means comprising a sleeve formed with cams, mounted on the engine shaft and driven thereby to rotate relatively thereto, and shafts parallel to the engine shaft and each provided with an arm for engaging one of said cams and another arm for engaging the stem of one of the valves.

4. An internal combustion engine having a plurality of cylinders disposed around the engine shaft and parallel thereto, said cylinders being arranged in opposed pairs, each pair having a common combustion chamber, a plurality of pistons in said cylinders connected with the engine shaft so as to drive the same, intake and exhaust valves for said chambers, an annular passage for the incoming fuel and air, another annular passage for the exhaust, said passages being disposed in the space between the opposed cylinders and within the combustion chambers, in combination with valve controlling means disposed radially within the space between the engine shaft and the cylinders, and axially within the length of the cylinders, said valve controlling means comprising a sleeve formed with cams, mounted on the engine shaft and driven thereby to rotate relatively thereto, and shafts parallel to the engine shaft and each provided with an arm for engaging one of said cams and another arm for engaging the stem of one of the valves, the annular passages for fuel and ex-

haust being disposed closer to the cylinder of the engine than the valve operating means.

5. An internal combustion engine having a plurality of cylinders disposed around the engine shaft and parallel thereto, said cylinders being arranged in opposed pairs, a plurality of pistons in said cylinders connected with the engine shaft so as to drive the same, and valves for said cylinders, in combination with valve controlling means disposed radially within the space between the engine shaft and the cylinders and axially within the length of the cylinders.

6. An internal combustion engine comprising a mechanism including casing, a plurality of cylinders disposed around the engine shaft and parallel thereto and within the casing, a plurality of pistons in said cylinders connected with the engine shaft so as to drive the same and a pair of valves for each cylinder disposed between the pistons therein and having stems extending from the valves radially of the cylinders, said casing so formed as to provide an internal chamber between the cylinders on opposite sides of the shaft and of substantially the length of the cylinders, valve controlling means being disposed within said chamber.

7. An internal combustion engine according to claim 6, having an inwardly extending flange on the casing, which flange divides the chamber into two compartments, the one of which houses the valve controlling means, driving mechanism for said means being housed in the other compartment.

8. An internal combustion engine according to claim 7, in which the valve controlling means comprises a sleeve rotatably mounted on the engine shaft, cams on said sleeve, a shaft parallel to the engine shaft and having an arm engaging one of said cams and an arm engaging one of the valve stems, said sleeve provided with planetary pinion, a gear fixed to said flange and a gear rotating with the engine shaft, said planetary pinions meshing with said engine shaft gear and said stationary gear, said gearing housed in said other compartment.

9. In an internal combustion engine and in combination, a casing, a plurality of cylinders around the engine shaft and parallel thereto and arranged in opposed pairs, a plurality of pistons in said cylinders connected with the engine shaft so as to drive the same, intake and exhaust valves for said cylinders, an internally extending central flange on the casing, a similar flange on the casing to one side of the first mentioned flange, a third flange on the casing adapted to support an engine shaft bearing, valve controlling means in a compartment provided between said first and second mentioned flanges, driving mechanism for said

valve controlling means housed in a compartment provided between said second and third mentioned flanges, said valve controlling means comprising a sleeve rotatable on the engine shaft, planetary pinions on said sleeve, cams on said sleeve, a driving gear on said engine shaft, a stationary gear on said second mentioned flange, said planetary pinions meshing with said stationary and driving gears, a plurality of shafts parallel with said engine shaft and mounted in said first and second mentioned flanges, each of said shafts having an arm for engaging one of said cams and an arm for engaging one of said valves.

10. In an internal combustion engine, the combination of a substantially cylindrical, mechanism-containing casing, a shaft rotatably mounted for movement about the axis of the casing, a plurality of explosive chambers within the casing adjacent the central portion of the same and encircling said shaft, a reeling plate at each end of the casing operatively connected for translating the reciprocatory movement of the adjacent pistons into rotary movement of the shaft, shaft-driving and valvular-control mechanisms having a looking-glass symmetry on opposite sides of a medial plane perpendicular to the axis and passing through the explosive chambers, said shaft-driving mechanism including a pair of balanced pistons in each chamber, valvular mechanism on each side of the medial plane including a valve for each chamber, valvular actuating mechanism for each valve and a single cam control sleeve provided with a plurality of cams one for each of the several valvular actuating mechanisms, said sleeve carried by the shaft, positioned between the reeling plates and a drive at one end of the sleeve for driving the same from the shaft.

11. In an internal combustion engine, the combination of a driven shaft, a plurality of explosive cylinders disposed about the shaft and extending longitudinally thereof, shaft-driving mechanism, and valvular control mechanism each having a looking-glass symmetry on opposite sides of a medial plane perpendicular to the shaft and passing through the explosive chambers, said shaft-driving mechanism including balanced pistons in each cylinder and a reeling plate at opposite ends of the cylinders, and operatively connected to translate reciprocatory movement of the adjacent pistons into rotary movement of the shaft, said valve actuating means including a valve for each cylinder, a set of cams, one cam for each valve and connected to work in unison, said sets being each carried by the shaft and spaced apart thereon between the reeling plates and a plurality of cam controlled valve actuating means one of such means disposed between each valve and its corresponding cam and

a driving connection between said shaft and said sets of cams connected to the shaft adjacent one end thereof.

12. In an internal combustion engine, the combination of a driven shaft, a plurality of explosive chambers encircling said shaft and extending in parallel relation thereto, a pair of balanced pistons in each cylinder and means including a reeling plate on opposite sides of the chambers for translating the reciprocatory movement of the adjacent pistons into rotary movement of the shaft, each cylinder provided with a valve mounted for movement to and from its seat radially of the shaft, said valves being disposed substantially in a plane perpendicular to the shaft, a cam sleeve positioned on the driving shaft between the reeling plates and provided with a plurality of longitudinally spaced apart cams offset circumferentially in order to cause a periodic movement of the valves, and a connection between each cam and a corresponding valve whereby the rotary movements of the cam shaft is translated into movements of the valves in the chambers, and means for driving the cam shaft from the driven shaft.

13. In an internal combustion engine, the combination of a driven shaft, a plurality of explosive chambers encircling said shaft and extending in parallel relation thereto, a pair of balanced pistons in each cylinder and means including a reeling plate on opposite sides of the chambers for translating the reciprocatory movement of the adjacent pistons into rotary movement of the shaft, each cylinder provided with a pair of radially movable valves positioned relatively close together, the valves constituting two sets disposed in parallel planes perpendicular to the shaft, each of the valves provided with a valve actuating means extending longitudinally of the shaft and in an outward direction away from the other valve in the cylinder and revolving cams spaced apart longitudinally of the driven shaft between the reeling plates and operatively connected to be driven in unison with the driven shaft, said cams being in control of said valve actuating means whereby the closely positioned valves are actuated by cams distributed along the length of the driven shaft facing the length of the explosive chambers.

14. In an internal combustion engine of the four-cycle type, the combination of a driven shaft, an explosive cylinder extending longitudinally of the shaft and spaced therefrom to provide a valvular control containing space therebetween, a pair of balanced pistons in said cylinder, means at opposite ends of the cylinders for translating the reciprocatory movement of the adjacent pistons into rotary movement of the shaft, said cylinder provided with a valve having a stem projecting radially

from the cylinder into the said space, a valvular control including a cam mounted on the portion of the shaft within the length of the cylinder and operatively connected to be rotated by the shaft and valve actuating means contained in the space between the cam and cylinder connecting the cam with said valve stem, whereby the rotation of the shaft will cause the valve to function periodically.

15. In an internal combustion engine, of the four-cycle type, the combination of a member mounted for rotary movement about its axis and provided with two sets of valve controlling cams mounted thereon, a plurality of explosive chambers extending parallel to said cam member and encircling the same, a pair of balanced pistons in each chamber, two sets of valves disposed in parallel planes perpendicular to the cam member and constituting inlet and exhaust valves for each chamber opening into the same between the pistons therein, and positioned relatively close together, certain of the controlling cams being spaced longitudinally of the valves controlled thereby and connecting members extending longitudinally of the member and actuated by the cams to cause the valves to actuate in proper timed sequence and mechanism driven from said pistons.

16. In an internal combustion engine, the combination of a driven shaft, a plurality of cylinders disposed about said shaft and extending parallel thereto, a casing provided within its outlines with an annular gas-containing passageway provided with ports opening into each of said cylinders and disposed in a plane perpendicular to the shaft, valves for controlling the ports, means actuated from the shaft for controlling said valves, a pair of pistons in each cylinder disposed on opposite sides of the valve-controlled port in the chamber and a driving connection between the shaft and each of said pistons.

17. In an internal combustion engine, the combination of a driven shaft, a plurality of cylinders disposed about said shaft and extending parallel thereto, a casing provided within its outlines with an annular gas-containing passageway provided with ports opening into each of said cylinders and disposed in a plane perpendicular to the shaft, valves for controlling the ports, means actuated from the shaft for controlling said valves, a pair of pistons in each cylinder disposed on opposite sides of the valve-controlled port opening into each cylinder and a driving connection between the shaft and each of said pistons, and said casing provided with a radially extending conduit opening from said annular-gas-containing passage to the exterior of the engine.

18. In an internal combustion engine, the

combination of a driven shaft, a plurality of cylinders disposed about said shaft and extending parallel thereto, a casing provided within its outlines with two annular gas
 5 containing passageways one adapted to constitute the fuel intake and the other adapted to constitute the fuel discharge, ports opening from each of said passageways into each cylinder, valves for controlling said ports,
 10 a pair of pistons in each cylinder, disposed on opposite sides of the pair of valve controlled ports in each cylinder, a reeling plate connecting between each piston and the shaft and means between the reeling plate
 15 for actuating the valves in proper sequence from the shaft to alternately admit fuel to each cylinder in succession and to discharge the fired fuel in each cylinder.

19. In an internal combustion engine of the four-cycle type, the combination of a casing provided with a driven shaft, an annular gas-containing passageway disposed in a plane perpendicular to the shaft, a plurality of explosive chambers encircling said
 25 annular passageway, ports in the inner side of said chambers, providing communication between said passageway and each of said explosive chambers, valves for controlling said ports, a pair of piston cylinders disposed lengthwise of the shaft at opposite
 30 ends of each of said chambers and open thereto whereby both pistons are actuated by the explosion in the common chamber, said piston cylinders having a greater cross-sectional area than the corresponding explosive chamber, a driving connection between each piston and the shaft, and a valvular control driven from the shaft and operatively connected to the valves to actuate the
 40 same in their proper sequence.

20. In an internal combustion engine, the combination of a casing, a shaft rotatably mounted in said casing at two spaced apart points, a plurality of explosive chambers
 45 encircling the portion of the shaft between said mounting points, piston cylinders extending lengthwise of the shaft at opposite ends of said explosive chambers, balanced pistons in each of said cylinders, means including reeling plates positioned to the outside of each of said points and disposed in close juxtaposition thereto for translating the reciprocatory movement of the adjacent pistons into rotary movement of the shaft, a
 55 gas passageway encircling the shaft and encircled by the circle of explosive chambers, a valve controlling sleeve loose on said shaft and including a plurality of cams, a differential driving connection between the sleeve and the shaft positioned relatively close to one of said shaft mounting points, valve controlled ports between said gas passageway and each of said explosive chambers and valve control means for each valve operatively associated with the cams on the sleeve
 65

to control the passage of gas from the passageway to the several explosive chambers.

21. In an internal combustion engine, a main casing, including an inner, cylindrical mechanism containing shell, a driven shaft
 70 disposed in the axis of said shell, a pair of anti-friction mountings for the shaft spaced apart in said shell to support the shaft from the casing, a plurality of longitudinally extending piston cylinders encircling said
 75 shaft between its mountings, fuel controlling valves for the cylinders having stems projecting into the interior of said shell, a valve controlling sleeve positioned on the part of the shaft between the mountings and operatively connected to be driven by the shaft
 80 and valve stem actuating connections between each valve stem and said sleeve.

22. In an internal combustion engine, the combination with a main substantially cylindrical, centrally disposed casing, shaft bearings at opposite ends of said casing, end heads at opposite ends of said casing and each provided with a shaft bearing, a shaft mounted in the four bearings and projecting
 90 exteriorly of the end heads, said casing formed within its outlines with a centrally disposed gas passageway encircling said shaft, and with a plurality of explosive chambers encircling the gas passageway, valve controlled means for placing the passageway in fluid communication with the explosive chambers, a pair of piston cylinders confined within the outlines of the main casing and disposed at opposite longitudinal
 100 ends of each of said explosive chambers, and each piston cylinder opening into the adjacent end head, a piston in each of said cylinders having its rod projecting therefrom substantially parallel to the shaft, and
 105 means in each end-head and including a wabbling plate for translating the reciprocatory movement of the pistons into rotary movement of the shaft.

23. An internal combustion engine casing
 110 including three main pieces, a central strain receiving cylindrical piece and two end pieces, said central piece being in the form of a hollow casting provided with an annular gas conducting passageway, a ring of
 115 explosive chambers extending in longitudinal, parallel relation to each other and encircling said conducting passageway, the partition between the passageway and the chambers provided with a ring of valve-controlled ports for placing the passageway in fluid communication with each of the chambers, said central piece provided with means for supporting balanced pistons at opposite ends of each of said explosive
 120 chambers and said central piece coacting with the end pieces at each end for supporting piston driven mechanism in each end piece.

24. An internal combustion engine includ- 130

ing a cylindrical casting formed in effect of three concentrically disposed shells, means for dividing the space between the outer and the intermediate shell into a plurality of explosive chambers, the space between the intermediate and the inner shell being divided perpendicularly to the axis of the casing to form a fuel chamber and an exhaust chamber, the space within the inner shell constituting a valve-control mechanism containing space.

25. An internal combustion engine including a cylindrical casting formed in effect of three concentrically disposed shells, means for dividing the space between the outer and the intermediate shell into a plurality of explosive chambers, the space between the intermediate and the inner shell being divided perpendicularly to the axis of the casing to form a fuel chamber and an exhaust chamber, the space within the inner shell constituting a valve-control mechanism containing space, said outer shell provided with openings extending therethrough into the explosive chambers and adapted to receive spark plugs for firing the charge in the chambers and disposed in position accessible from the outside of the engine.

26. In an internal combustion engine of the balanced piston type, the combination of a driven shaft, a plurality of explosive chambers encircling said shaft and spaced therefrom, a pair of piston cylinders open to said explosive chamber at opposite ends thereof, pistons mounted in said cylinders, a driving connection between said pistons and said shaft, a gas passageway disposed within the circle of said explosive chambers and positioned between the ring of chambers and said shaft, radially extending valves for controlling the gas flow between the passageway and the explosive chambers, mechanism for actuating said valves disposed between the shaft and the valves and operatively connected to the shaft to be driven thereby, the outer wall of one of said explosive chambers having an opening facing one of the valves therein and having a dimension to permit the valve to be withdrawn from its seat through said opening without affecting said valve actuating mechanism.

27. In an internal combustion engine of the balanced piston type, the combination of a driven shaft, a plurality of explosive chambers encircling said shaft and spaced therefrom, a pair of piston cylinders open to said explosive chamber at opposite ends thereof, pistons mounted in said cylinders, a driving connection between said pistons and said shaft, a gas passageway disposed within the circle of said explosive chambers and positioned between the ring of chambers and said shaft, radially extending valves for controlling the gas flow between the pas-

sageway and the explosive chambers, mechanism for actuating said valves disposed between the shaft and the valves and operatively connected to the shaft to be driven thereby, the outer wall of one of said explosive chambers having an opening facing one of the valves therein and having a dimension to permit the valve to be withdrawn from its seat through said opening without affecting said valve actuating mechanism and closure means for said opening provided with a heat radiating extension tending to cool the outer wall of the explosive chamber.

28. In an internal combustion engine of the balanced piston type, the combination of a driven shaft, a plurality of explosive chambers encircling said shaft and spaced therefrom, a pair of piston cylinders open to said explosive chamber at opposite ends thereof, pistons mounted in said cylinders, a driving connection between said pistons and said shaft, a gas passageway disposed within the circle of said explosive chambers and positioned between the ring of chambers and said shaft, radially extending valves for controlling the gas flow between the passageway and the explosive chambers, said valves being provided with actuating stems, and extending radially toward the shaft, and valve actuating means disposed between the shaft and the valve stems, adapted to bear on the stems to actuate the same but otherwise free of the stems whereby any one of the valves may be readily dismantled without affecting the action of said means on the remaining valves.

29. In an internal combustion engine, the combination of a cylindrical casting including in effect three concentrically disposed shells, means for dividing the space between the outer and the intermediate shells into a plurality of explosive chambers, the space between the intermediate and the inner shell constituting a gas passageway, the intermediate shell provided with a port for placing one of the chambers in fluid communication with the passageway, a radially extending valve for controlling said port, the outer shell opposite said valve provided with an opening affording access to the valve and means for normally closing said opening.

30. In an internal combustion engine, the combination of a cylindrical casting including in effect three concentrically disposed shells, means for dividing the space between the outer and the intermediate shells into a plurality of explosive chambers, the space between the intermediate and the inner shell constituting a gas passageway, the intermediate shell provided with a port for placing one of the chambers in fluid communication with the passageway, a radially extending valve for controlling said port, the outer shell opposite said valve provided

with an opening affording access to the valve, means for normally closing said opening, and means for controlling said valve housed within the inner shell.

5 31. In an internal combustion engine, the combination of a cylindrical casting including in effect three concentrically disposed shells, means for dividing the space between the outer and the intermediate shells into a
10 plurality of explosive chambers, the space between the intermediate and the inner shell constituting a gas passageway, the intermediate shell provided with a port for placing one of the chambers in fluid communication with the passageway, a radially
15 extending valve for controlling said port, the outer shell opposite said valve provided with an opening affording access to the valve, means for normally closing said opening,
20 and an outlet pipe from the passageway extending therefrom radially through the outer shell.

32. In an internal combustion engine of the balanced piston type, the combination
25 of a plurality of explosive and expansion chambers disposed concentrically about an axis of reference and spaced therefrom, said chambers each including a pair of alined piston cylinders and a common explosive
30 chamber therebetween and with the inner wall of the explosive chambers spaced from the axis a distance greater than the corresponding distance of the inner wall of the piston cylinders thereby to form an annular
35 space between the piston cylinders, means providing two annular passageways within said space, one of said passageways con-

stituting means for supplying fuel to the several explosive chambers and the other passageway constituting a means for conducting the spent gas from said explosive
40 chambers.

33. In an internal combustion engine of the balanced piston type, the combination of a plurality of explosive and expansion
45 chambers disposed concentrically about an axis of reference and spaced therefrom, said chambers each including a pair of alined piston cylinders and a common explosive chamber therebetween and with the inner
50 wall of the explosive chambers spaced from the axis a distance greater than the corresponding distance of the inner wall of the piston cylinders thereby to form an annular space between the piston cylinders, means
55 providing two annular passageways within said space, one of said passageways constituting means for supplying fuel to the several explosive chambers and the other passageway constituting a means for conducting the spent gas from said explosive
60 chambers, valves for controlling the flow between said explosive chambers and said passageways, and valve control mechanism disposed in the space between the axis and the annular gas and fuel conducting passageways and operatively connected to said
65 valves to cause the same to function in their proper sequence.

In testimony whereof we affix our signatures.

ALBERTO LLEÓ.
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