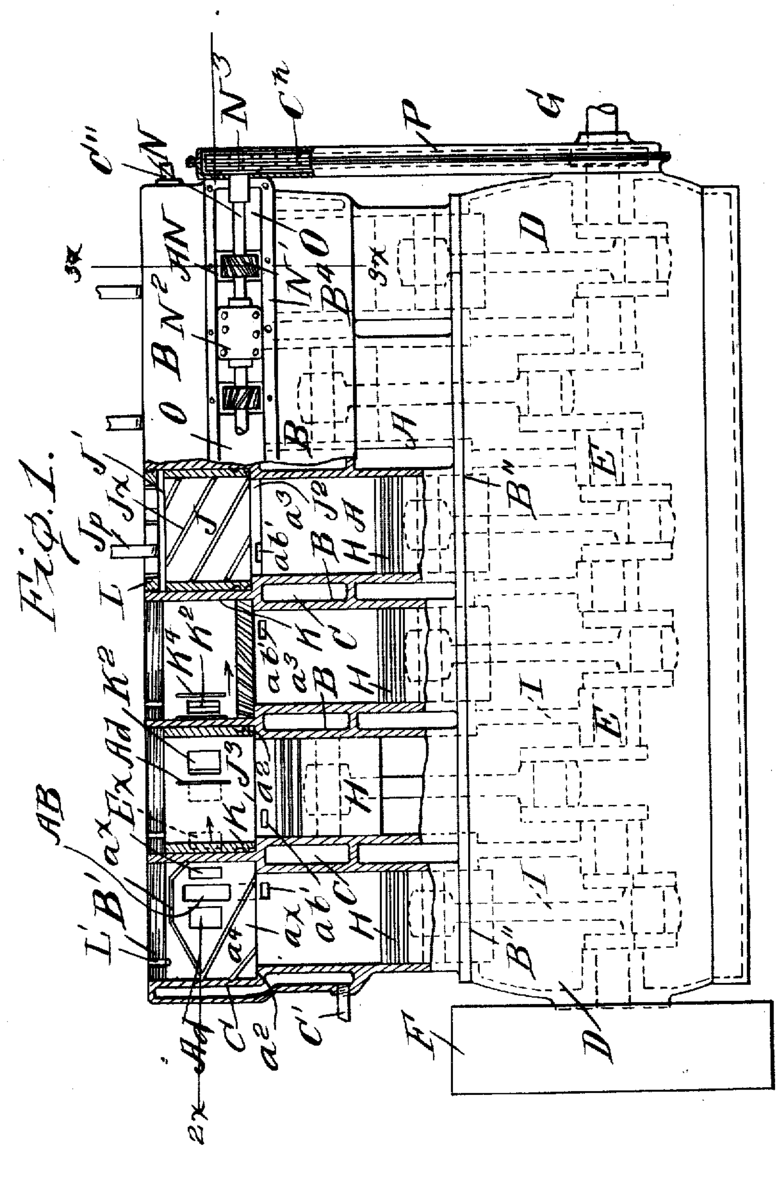
E. H. BELDEN.
INTERNAL COMBUSTION ENGINE.
APPLICATION FILED NOV. 9, 1911.

1,017,075.

Patented Feb. 13, 1912.
4 SHEETS—SHEET 1.



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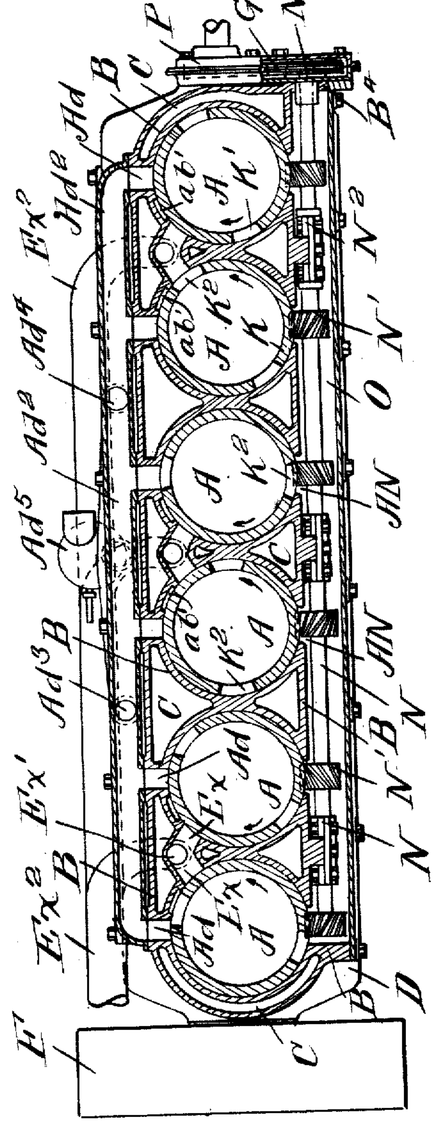
4 SHEETS—SHEET 2.

Fig. 2.



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4 SHEETS—SHEET 3.

Fig. 3.

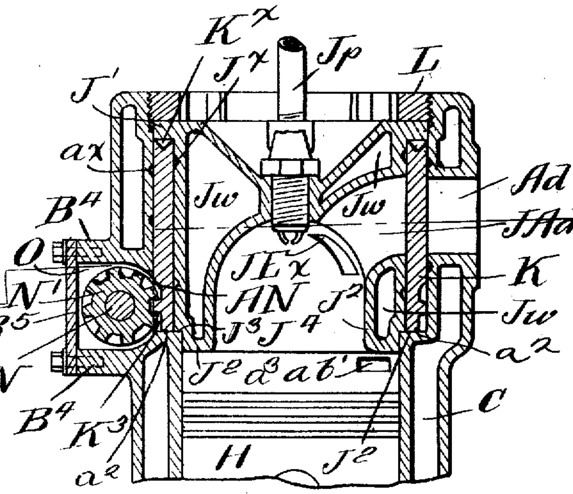
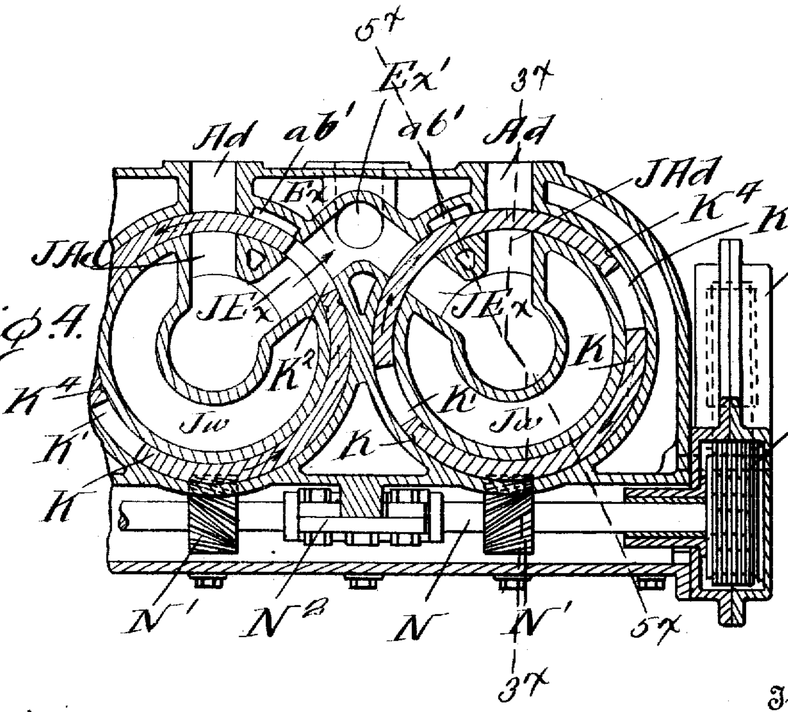


Fig. 4.



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4 SHEETS—SHEET 4.

Fig. 5.

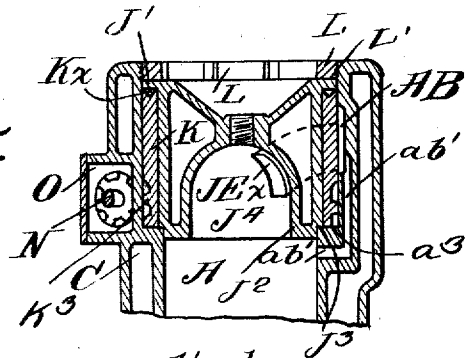


Fig. 6.

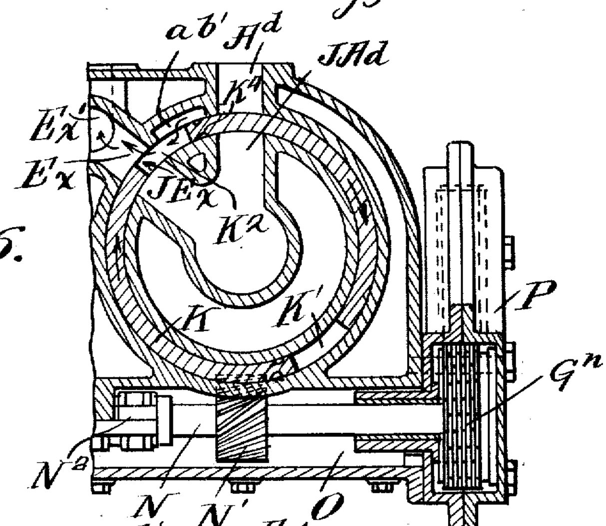
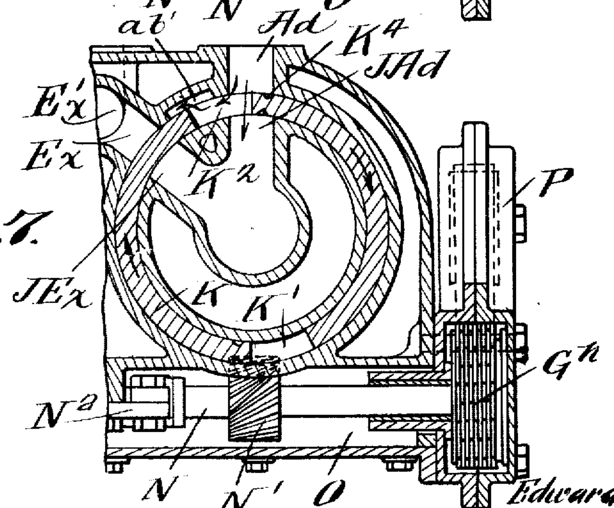


Fig. 7.



Witnesses

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UNITED STATES PATENT OFFICE.

EDWARD H. BELDEN, OF PITTSBURGH, PENNSYLVANIA.

INTERNAL-COMBUSTION ENGINE.

1,017,075. Specification of Letters Patent. Patented Feb. 13, 1912.

Application filed November 9, 1911. Serial No. 659,442.

To all whom it may concern:

Be it known that I, EDWARD H. BELDEN, a citizen of the United States, and a resident of Pittsburgh, county of Allegheny, and State of Pennsylvania, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

My invention relates to internal combustion engines and has particular reference to improvements in the valves and valve gearing of internal combustion engines of the four-cycle type.

The objects of my invention are to simplify the construction and to lessen the cost of such engines; to eliminate the vibration and the noise incident to their operation; to balance the valves thereof; and to increase the power, efficiency and durability thereof.

My further purpose is to do away with the short-lived and noisy reciprocating valves and valve gearing now in common use and to substitute therefor a minimum number of large substantial parts that cannot easily be broken, to balance the valves and otherwise arrange and construct them to offer the least possible resistance to the operation of the engine.

A special object of my invention is to provide an engine of the class named with a non-vibratory, constantly lubricated and substantially balanced admission and exhaust valve and to maintain it at a low temperature protected from the hot gases of the cylinder.

Still other objects of the invention are to provide an internal combustion engine equipped with a balanced valve and having a cylinder which contains both the cylinder head and the necessary port-controlling means and from which both the head and the piston may be removed without disturbing the cylinder or said port controlling means or gearing, and from which the valve may be removed without disturbing the cylinder or the valve gearing; and to provide an engine having valves and valve seats which shall be freely accessible upon removal of the cylinder head.

Another object of my invention is to provide a four-cycle engine conforming to the foregoing outline and which may be made and assembled, dismembered and reassembled by ordinary mechanics and in less time than other four-cycle engines.

A further object is to provide balanced rotary valves and valve gearing of such form and arrangement that the several cylinders of a multiple engine may be economically formed in one block or casting.

Still further objects of my invention will appear hereinafter.

My invention resides in an internal combustion engine which, in its simplest form, has a single-piece ported cylinder, a single-piece cylinder head, a single-piece valve which is incased by the cylinder and the head and is substantially balanced therebetween, a single valve operating member and a single actuating and timing device which connects the valve operating member with the crank shaft.

The simple structure here outlined is somewhat amplified in the higher developments of my invention but even in its multiple cylinder forms I prefer to use only one valve operating member and one driving device.

The invention will be readily understood upon reference to the accompanying drawings, which form part of this specification and in which I have depicted a preferred embodiment of my invention in a six cylinder combustion engine.

In the drawings, Figure 1 is a side elevation of my novel engine, four of the cylinders being shown in vertical longitudinal section;—Fig. 2 is a horizontal section, substantially on the line 2^x—2^x of Fig. 1, all of the cylinder heads being removed;—Fig. 3 is an enlarged vertical section on the line 3^x—3^x of Figs. 1 and 4;—Fig. 4 is a similarly enlarged horizontal section on the line 4^x—4^x of Fig. 3;—Fig. 5 is a vertical section on the line 5^x—5^x of Fig. 4; Fig. 6 is a sectional view similar to Fig. 4 showing the valve simultaneously open to the exhaust port and to the balancing cavity in the cylinder; and Fig. 7 shows the valve simultaneously open to the admission port and the balancing cavity in the cylinder.

I have here illustrated my invention as embodied in a water cooled multiple cylinder engine of a vertical type particularly adapted for use in automobiles. Its cylinders A, six in number, are arranged side by side in a single casting B. Various means may be employed for cooling the cylinder and valve seats. For example the casting B may contain a water space or jacket C which is common to all the cylinders. The water space extends from the top B′ of the casting to a point near the lower ends of the cylinders. The bottom B″ of the cylinder casting is secured upon the top of the base D. The base contains the crank shaft E shown in dotted lines in Fig. 1. On one end of the shaft E is a fly wheel F. The other end of the crank shaft carries a sprocket wheel G, (see dotted lines Fig. 1) the use of which will be explained hereinafter. Each cylinder A contains a piston H, joined to the crank shaft E by a connecting rod I, shown in dotted lines in Fig. 1. The cylinders open through both the top and the bottom of the casting B. They have separate heads J. The head J of each cylinder is preferably wholly contained within the upper or outer end of the cylinder. I make these ends of the cylinders large enough to receive the pistons so that the latter may be inserted and removed through the tops of the cylinders after the cylinder casting B has been fastened to the base D. The heads are larger than the pistons and each head rests upon an annular shoulder a^2, which distinguishes the piston containing portion a^3 of the cylinder from its head containing portion a^4. Both cylinder portions a^3 and a^4 are cylindrical. They are preferably concentric. The portion a^4 is large enough to contain not only the head but also the valve K, about to be described. Each head has an annular flange J′ that fits the upper part of the cylindrical bore a^4. The lower end J^2 of each head J snugly fits the piston bore a^3 of the cylinder and the annular shoulder J^3 of the head rests upon the cylinder shoulder a^2 as before explained. The upper end of the bore a^4 of each cylinder is threaded to receive a locking ring L, which is screwed firmly upon the flanged top of the head, completing an oil and pressure tight joint between the head and the cylinder at that point. If desired a key L′ or a set screw may be added to lock the head against rotation. Such device however is not essential to the fastening of the head in the cylinder. The shoulder a^2 of the cylinder and the shoulder J^3 of the head are ground together and when the head is thus secured the shoulders form an oil and pressure tight joint between the lower end of the head and the cylinder. It will be observed that the concentricity of the cylinder and the head is insured by the close fitting of the upper end and the lower end of the head within the larger and the smaller bores a^4 and a^3 of the cylinder. The intermediate portion of each head J, between the flange J′ and the shoulder J^3, is cylindrical and concentric with the containing bore a^4. While this portion, as herein shown, is larger than the piston bore a^3, it is somewhat smaller than the bore a^4 and an annular cavity K′ having parallel cylindrical walls is therefore formed between the cylinder and the head. The top of the cavity K′ is formed by the underside of the head flange J′. The bottom of the annular cavity is formed by the cylinder shoulder a^2 on which the head rests. All of the walls of the cavity are finely ground and serve as seats for the valve K before referred to. The valves K are simple one-piece sleeves or rings that exactly fit their respective cavities K′. They are interchangeable. The inner and outer surfaces of each valve K are finely ground and are cylindrical and parallel. The top and bottom edges are also finely ground or finished and are parallel and perpendicular to the cylindrical surfaces. In practice, the cross sectional dimensions of the valve K are approximately two thousandths of an inch smaller than the corresponding dimensions of the cavity K′, leaving space for thin films of oil between all the opposed surfaces of the valve, cylinder and head. Obviously the space is increased at the groove K^x and between the gear teeth on the valve. Each valve K contains at least one opening or port K^2, the same being of sufficient size to quickly admit and to quickly free the gases and being positioned about midway of the height of the valve. As shown in the drawings I prefer to provide each valve with two diametrically opposite ports K^2, so that one revolution of the valve shall serve for eight successive strokes, two complete power operations, of the piston, as hereinafter explained. Each cylinder is provided with an admission port and passage A^d and an exhaust port and passage E^x, these being formed in the casting B. The ports A^d and E^x open into respective valve cavities K′ in position to register with the ports K^2 in the valve K. The width of the space between the inlet and exhaust ports approximately equals the width of the port K^2 in the valve K. These dimensions may be considerably varied without departing from the invention but I prefer to maintain the described proportions and relation for the particular reason that after the valve has opened to permit the heated gases to exhaust, those portions of the valve which are heated by the exhaust gases are almost immediately cooled by the inrush of cool combustible mixture at the port A^d. The time between the exhaust and the admission of mixture is proportionate to the distance that the valve has to travel between the ports E^x and A^d. In a multiple cylinder engine I prefer to pair the cylinders and connect the exhaust passages E^x of each pair as shown in Figs. 2 and 4. From the points of juncture the exhaust passages extend downward and open through the lower part of the casting B.

$E^{x\prime}$ represents the vertical extension of the united exhaust ports of two cylinders.

E^{x2} represents the exhaust manifold of the engine.

As indicated in Fig. 2, I prefer that the admission passages A^d of the several cylinders shall be independent and shall open through the outer face of the casting above the exhaust manifold. The passages A^d are connected by an admission manifold A^{d2} having two connections A^{d3} and A^{d4} with a suitable carbureter A^{d5}.

As best shown in Figs. 3 and 4, each head J contains a central cavity J^4 hemispherical at the top and opening through the bottom of the head. This cavity which obviously communicates with the piston containing portion a^3 of the cylinder constitutes the compression and combustion chamber of the engine. A central hole is provided in the top of the head and in this hole is the device M for igniting the gases, preferably an electric spark plug. Two passages J—A^d and J—A^x are formed in the head. These open through the valve seat surface of the head, at points directly and respectively opposite the ports A^d and E^x in the valve seat surface of the cylinder, hence these passages or ports of the head are in position to register with the ports K^2 in the valve K.

Referring now to Figs. 4 to 7 inclusive it will be seen that the cylinder wall which forms part of the annular valve cavity contains a recess or cavity AB. This is positioned between the ports A^d and E^x and may extend above and below said ports. Enough of the cylinder wall remains to afford proper lap for the valve around said ports A^d and E^x. The cavity AB opens against the outer periphery of the valve K and its area is preferably slightly less than the combined area of the ports A^d and E^x. The recess or cavity AB is placed in communication with the piston space a^3 in the cylinder by means of a duct ab', leading therefrom to a point in the cylinder wall below the head J. The practical effect of this arrangement of the valve and the balancing cavity AB is that the revoluble valve is so nearly balanced in its cavity that it is but lightly seated across the cylinder ports A^d and E^x, even at moments of maximum pressure within the cylinder. In consequence, the valve is not permitted to cling upon any of its seats and it is not difficult to turn or rotate it in its cavity. And at the same time it will be noted that at moments of vacuum within the cylinder, as when the piston is descending and the admission port A^d and the valve port K^2 are in register, the area of the balancing port AB exceeds the area of the exhaust port in the cylinder, with the result that there is an overbalancing outward pressure on the valve which tightly holds it over the exhaust port E^x and thus prevents the indraft of gases from the exhaust passage E^x.

The port K^2 in the valve K and the balancing cavity AB act in a peculiarly advantageous manner, as follows:—It will be noted from Fig. 6 that when the port K^2 in the valve is about leaving the exhaust port E^x, it opens into or communicates with the balancing cavity AB, by bridging the wall between the same and port E^x. In consequence part of the gases from the cylinder are discharged through the balancing duct ab' and cavity AB. Obviously the exhaust port may be somewhat smaller than if this were not the case for by this arrangement the exhaust is protracted. Similarly the port K^2 in the valve, when it leaves the exhaust port E^x, next opens into the admission port A^d and simultaneously puts the port A^d into communication with the balancing cavity AB. As a result the admission is relatively enlarged and furthermore the combustible mixture which flows into the cylinder through the cavity AB and duct ab' instantly cools the same and the margins of the port K^2 in the valve. It is advantageous also that the cavity AB is each time filled with fresh gas, which being ignited with the remainder of the charge in the cylinder insures a substantially equal pressure upon the inner and outer sides of so much of the valve as lies over the cavity AB. If desired additional balancing cavities may be provided in the cylinder wall on the opposite side of one or both ports A^d and E^x, but I find the single port adequate for the purposes expressed.

The valve operating mechanism is most clearly shown in Figs. 1, 2, 3 and 4. Each member K is a combined valve and gear wheel; that is, the lower outer edge of each valve K is provided with gear teeth K^3 constituting an integral gear wheel whereby the valve may be rotated in its valve chamber or cavity. The valve operating member is arranged on the side of the engine opposite the side which contains the several admission and exhaust ports and the cavity AB. This valve operating member comprises a single shaft N having as many integral gear wheel portions N′ as there are valves. Each cylinder is provided with an opening AN, at a point opposite the gear teeth on the valve and considerably below the level of the ports K^2 in the valve. This opening admits the operating gear N′ into mesh with the gear teeth upon the valve. Obviously all of the openings AN are arranged in a horizontal line. The shaft N is held in suitable bearings N^2 provided on the side of the cylinder casting B as shown in Figs. 2 and 4. The gear teeth on the valves and on the shaft N are preferably 45° spiral teeth. Such gears operate readily in either direction and are noiseless. At its end, the shaft N is provided with a sprocket wheel N^3 and this is connected with the sprocket wheel G on the crank shaft by a suitable sprocket chain G^n. The sprockets G and N^3, and the sprocket belt G^n constitute the driver for the valve operating member or shaft N. The rotation of the crank shaft is thereby communicated to the several valves, and the latter are rotated constantly during the operation of the crank shaft. The sprockets G and N^3 and the gears N′ and K^3 are so proportioned that the valves are caused to turn one-half of a revolution during each two revolutions of the crank shaft; *i. e.* one complete revolution in the time consumed by eight piston strokes. It will be clear that the rotative speed of the valves is relatively low and that nothing short of the breakage of one of these heavy substantial parts can interfere with the proper action of the valve. The valve operating shaft and gears are contained by a horizontal duct O formed in the side of the cylinder casting. B^4, B^4 are the edges of the duct O. These edges are integral with the cylinder casting B. The opening between them is closed by a horizontal plate B^5 tightly bolted thereto and making the duct oil tight. The duct O and the several valve cavities K′ are in communication through the openings AN. The sprockets G and N^3 and sprocket belt G^n are inclosed by a casing P, the upper end of which communicates with the duct O and the lower end of which communicates with the interior of the engine base D. An oil pump (not shown) forces oil into the duct O. The oil is distributed therefrom to the several valves by the gear teeth on the valves K and shaft N; *i. e.* by the gear wheels N′ and K^3. In the case of each valve, its rotation causes the oil to spread upon the outer surface of the valve, whence it will work above and below the valve and spread upon the inner surface thereof. As before explained the differences of diameter, between the valve, the cylinder and the head, are so slight that only minute films of oil may occupy the spaces. These are in fact capillary spaces and while the oil will freely work into and occupy the spaces, due to the rotation of the valve within the inclosing walls, the oil cannot easily be discharged from the spaces by either internal or external pressure. The films of oil constitute fluid packings for the joints. This fact makes it possible to adequately lubricate the valves and inclosing walls without danger of gas leakage from or to the cylinders at moments of compression, combustion and vacuum therein. It is clear also that it is practically impossible for any surface of the valve to engage any opposed surface upon the head or cylinder except through the medium of this minute film of oil which envelops the valve. In consequence the valve and valve seats will operate indefinitely without perceptible wear. Shallow vertical collecting grooves K^4 may be formed in the valves K at the "following" side of the respective ports K^2, as shown in Figs. 1 and 4 and to expedite the distribution of oil within the valve chambers or cavities, I preferably provide the walls thereof with shallow oil grooves. The grooves A^x in the cylinder walls are so inclined that they tend to elevate the oil from the gear openings AN, whereas the grooves J^x in the surfaces of the heads may tend to force the oil downward. As shown in Fig. 3 the upper edge of each valve K is preferably provided with an annular oil groove K^x for an accumulation of oil, to better distribute the oil upon the inner surface of the valve. Very little of the oil thus supplied to the valve is wiped off at the ports, the greater part returning to the trough through the openings AN. It will thus be seen that the valves, the valve cavities and the valve gears constitute an oil circulating system which insures the positive lubrication of these parts at all times. The tight joint before alluded to, between the lower end of the head J and the cylinder prevents leakage of valve oil into the cylinder.

As before explained the water space C within the cylinder casting extends to the top of the cylinders and cooling water is therefore supplied to all of the upper parts of the cylinders except those portions or areas which are occupied by the admission and exhaust passages A^d, E^x, and the gear openings AN. The cooling of the outer walls of the valve cavities and the outer portions of the valves is thus insured. Each head J contains a water space J^w. The water is supplied and discharged through pipes J^p, two of which are provided for each head. The top of the head contains a depression to admit, and to afford easy access to, the firing plug M. The space J^w occupies nearly the whole of the head, only thin walls remaining; the exceptions being the spaces occupied by the ports JA^d and JE^x. As before described, the head is deeper than the valve K, extending both above and below the same. The water space is likewise deep, its bottom being preferably below the level of the valve K and the water rising therein to a level above the top edge of the valve. In other words, the cooling surface of the valve wall of the head is practically co-extensive with the valve and the maintenance of the valve at a low temperature is positively insured. It is not material whether these walls which inclose or envelop the valve are cooled by water or by air, or by some other medium; the important point is that the valves and the inclosing walls are so formed and related that they are quite separate from the hotter portions of the cylinder and head and are fully exposed to the cooling medium.

The operation of the engine is according to the well known four cycle principle and will be clearly understood from the foregoing detailed description of the operation of its several related parts.

As various modifications of my invention will readily suggest themselves to one who is skilled in the art I do not confine or limit the invention to the specific constructions herein shown and described.

The valve construction in itself and the combination of parts, including the shaft N. for actuating the valves, comprise the subject matters, respectively, of my co-pending applications, Serial Nos. 659,204 and 667,764, and are not specifically claimed herein.

Having thus described my invention I claim as new and desire to secure by Letters Patent:—

1. In an internal combustion engine, a cylinder and a piston therein, in combination with a cylinder head fixed in the end of said cylinder, the inner and outer ends of said head being tightly jointed to said cylinder, the intermediate portion of said head being of less diameter than the adjacent portion of the cylinder and concentric therewith an annular valve cavity being thereby formed between said ends of the head, one side of said head and cylinder containing admission and exhaust ports which open into said cavity, an annular valve of slightly greater diameter than the head and of slightly less diameter than said adjacent portion of the cylinder and occupying said cavity, said valve containing a port positioned to register with aforesaid ports, said cylinder containing a balancing cavity opening into said valve cavity between the ports in the cylinder and in communication with the piston space in the cylinder and valve operating gearing deriving motion from said piston.

2. In an internal combustion engine, a cylinder and a piston therein, in combination with a cylinder head fixed in the end of said cylinder, the inner and outer ends of said head being tightly jointed to said cylinder, the intermediate portion of said head being of less diameter than the adjacent portion of the cylinder and concentric therewith an annular valve cavity being thereby formed between said ends of the head, one side of said head and cylinder containing admission and exhaust ports which open into said cavity, an annular valve of slightly greater diameter than the head and of slightly less diameter than said adjacent portion of the cylinder and occupying said cavity, said valve containing two diametrically opposite ports positioned to register with aforesaid ports, the distance between the ports in the cylinder approximately equaling the width of each port in the valve, said cylinder containing a balancing cavity opening into said valve cavity between its ports, a gear formed on the end of said valve, an operator meshing therewith and deriving rotation from said piston, and means for constantly supplying oil to said gears and cavity.

3. In an internal combustion engine, a cylinder and a piston therein, in combination with a cylinder head, the cylinder having admission and exhaust ports in one side, an annular valve positioned within the cylinder, concentric therewith and adapted to close said ports, said valve having an opening adapted to register with aforesaid ports, said cylinder containing a balancing cavity in one side adjacent to its ports and of greater area than either thereof, said cavity opening against said valve and communicating with the piston space in the cylinder, means for supplying oil to said valve, and means for operating said valve in time with the movements of said piston.

4. In an internal combustion engine, a suitably cooled cylinder and a piston therein, in combination with a suitably cooled cylinder head fixed in the end of said cylinder, said head being of less diameter than the adjacent portion of the cylinder and concentric therewith, an annular valve cavity being formed thereby, said head and cylinder containing admission and exhaust ports which open into said cavity, an annular valve occupying said cavity and cooled by the cylinder and head, said valve containing a port positioned to register with aforesaid ports, said cylinder containing a balancing cavity opening through the outer wall of said valve cavity between the ports in the cylinder and in communication with the piston space in the cylinder and valve operating gearing deriving motion from said piston.

5. In an internal combustion engine, a cylinder and a piston therein, in combination with a cylinder head fixed in the end of said cylinder, said head being of less diameter than the adjacent portion of the cylinder and concentric therewith an annular valve cavity being thereby formed between the cylinder and head, one side of said cylinder containing admission and exhaust ports which open into said cavity, a port controlling sleeve valve occupying said cavity, means in said side of the cylinder coacting with the outer periphery of the valve and substantially balancing said valve in said cavity, and valve operating gearing acting on the valve and deriving motion from said piston.

6. In an internal combustion engine, a cylinder in combination with a piston therein, a head within the end of the cylinder, means securing said head against movement in said cylinder, said cylinder and head having corresponding admission and ex-

haust ports, an annular valve disposed concentrically with and between the head and cylinder, said cylinder containing a balancing port which opens against the outer periphery of said valve adjacent the ports in the cylinder, and gearing through the medium of which the piston operates said valve to open and close said ports in time with the piston movements.

7. In an internal combustion engine, a cylinder and a piston therein, in combination, with a cylinder head fixed in said cylinder and having inner and outer ends which make oil and pressure tight joints with the cylinder, the cylinder and head containing between said joints an annular valve cavity and having admission and exhaust passages and ports, an annular valve of greater diameter than the inner part of said cavity and of less diameter than the outer part of said cavity and having a port to register with the ports in the head and cylinder, such differences of diameter providing capillary spaces between the cylinder, valve and head, a balancing cavity being provided in said cylinder adjacent to the admission and exhaust ports therein, means for supplying oil to said valve, and means circumferentially distant from said ports and balancing cavity for rotating said valve to open and close said ports in proper time with the movements of said piston.

8. In an internal combustion engine a cylinder having a piston containing portion and a head containing portion, in combination with a head having its inner end in circumferential and endwise engagement with the walls of said piston containing portion and having its outer end circumferentially engaged with the walls of said head containing portion of the cylinder, means securing the head against movement in the cylinder and effecting tight joints between said ends of the head, and the cylinder, ports in said cylinder and the intermediate portion of the head, an annular valve cavity being provided between the head and cylinder and between said joints, said cylinder containing a balancing cavity adjacent to its ports and opening into said valve cavity, an annular ported valve fitting said valve cavity, an opening in the side of the cylinder and valve cavity and a valve operator positioned in said opening.

9. In an internal combustion engine, a cylinder having a cylindrical piston containing portion and a head containing portion, in combination with a head having an intermediate valve seating portion of less diameter than the head containing portion of said cylinder, said head having its inner end and its outer end engaged with the walls of said piston containing portion and said head containing portion respectively, means fastening said head against movement in the cylinder and effecting tight joints between the cylinder walls and said ends of the head, an annular valve cavity which is closed at its ends being formed by and between said cylinder and said head and situated wholly between the outer end of the cylinder and the inner end of the head, admission and exhaust ports provided in the cylinder and the head and opening into said cavity, a balancing cavity in the cylinder and opening into said cavity, an annular valve occupying substantially the whole of said valve cavity and provided with a port to register with said admission and exhaust ports and means engaged with a periphery of said valve and adapted to rotatively move said valve in said cavity, substantially as described.

10. In an internal combustion engine, a cylinder in combination with a head the ends of which make oil tight joints with the cylinder, an annular valve space or cavity being provided between the cylinder and the head and between said joints, a valve revolubly movable in said cavity, said valve having a port and said cylinder and said head being both provided with admission and exhaust ports which communicate with said cavity, said cylinder containing a balancing cavity between its ports operating to ease the valve across said inlet and exhaust ports during moments of pressure in the cylinder and to press the valve against the ported portion of the cylinder during moments of partial vacuum within the cylinder, and means for operating said valve.

11. In an internal combustion engine, a cylinder having a piston-containing portion or bore and a valve-and-head-containing portion or bore distinguished by a valve-and-head-seating shoulder, in combination with an annular sleeve valve containing a port, fitting said valve-and-head bore of the cylinder and seated on said shoulder of the cylinder, a head fitting within the valve and having its inner end seated upon said shoulder at the end of said valve, means securing the head against movement in the cylinder and effecting tight joints between the head and cylinder at the ends of the head, said cylinder having a balancing port which opens against the outer periphery of said valve, a suitable valve actuator and a driver therefor.

12. In a four-cycle internal combustion engine, a single cylinder block or casting containing a plurality of cylinder bores in combination with cylinder heads, one within each said bore, an annular sleeve valve between each head and cylinder bore and enveloped thereby, said heads, valves and cylinders having suitable registering ports, each said cylinder having a balancing port which opens against the outer periphery of the valve, a valve actuating member for si-

multaneously rotating said valves thereby causing the periodic registry of said ports, and means for driving said member.

13. In a four-cycle internal combustion engine, a single cylinder block or casting containing a plurality of cylinder bores in combination with cylinder heads, one within each said bore, an annular sleeve valve between each head and cylinder bore, said heads and cylinders being tightly jointed above and below respective valves, said heads, valves and cylinders having suitable registering ports, each said cylinder having a balancing cavity opening against the outer periphery of its valve, a single valve actuating member for simultaneously rotating said valves thereby causing the periodic registry of said ports and a single duct containing said member and supplying oil to all said valves.

14. In an internal combustion engine, a single block containing a plurality of suitably cooled cylinder bores, in combination with a single piece suitably cooled head in each said bore, a single piece annular sleeve valve concentric with and interposed between each head and its bore, each said head being jointed to the cylinder bore above and below its respective valve, said cylinders, valves and heads each having a complement of ports, a balancing cavity in each cylinder bore between the ports therein, an opening in the side of each cylinder bore, a single valve operating member acting upon all said valves through said openings, a single oil duct containing said member and communicating with all said openings, a piston in each bore and a driving device for said member, operated by the movement of said pistons.

In testimony whereof, I have hereunto set my hand, this 8th day of November, 1911, in the presence of two subscribing witnesses.

EDWARD H. BELDEN.

Witnesses:
N. CURTIS LAMMOND,
CHARLES GILBERT HAWLEY.