C. Y. KNIGHT.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JUNE 4, 1906.

1,090,991. Patented Mar. 24, 1914.

Fig. 1.

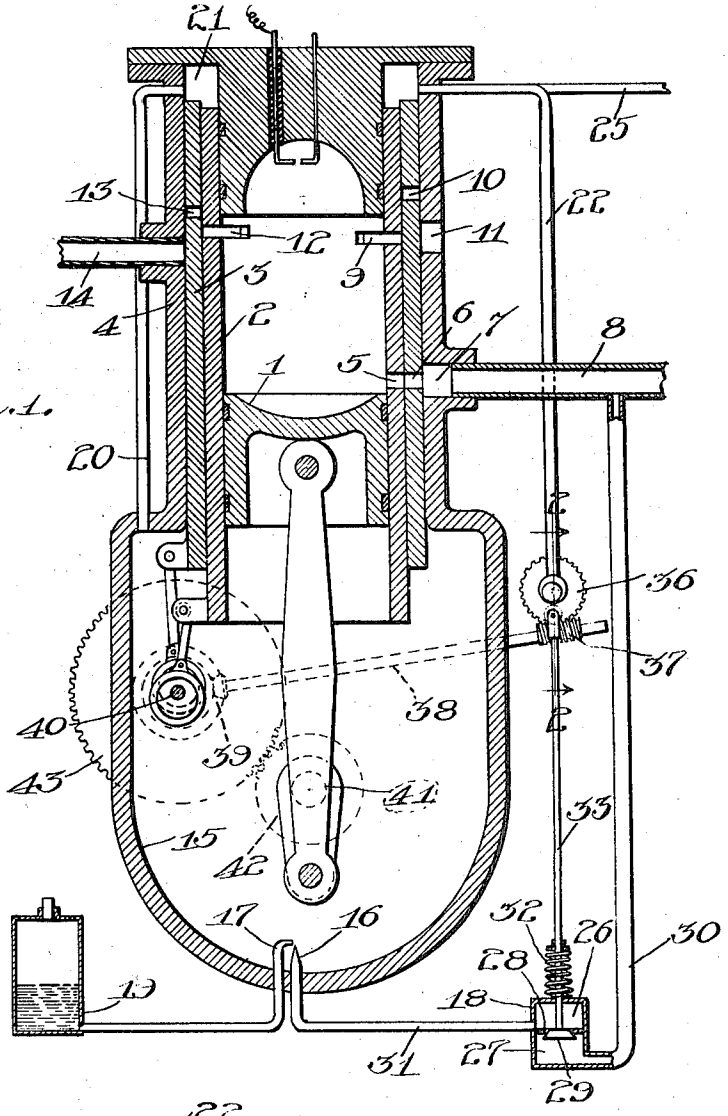
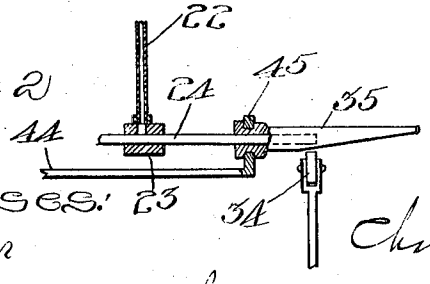


Fig 2



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

1,090,991. Specification of Letters Patent. Patented Mar. 24, 1914.

Application filed June 4, 1906. Serial No. 320,048.

To all whom it may concern:

Be it known that I, CHARLES Y. KNIGHT, a citizen of the United States, formerly residing at Oak Park, in the county of Cook and State of Illinois, and now residing at Coventry, England, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a full, clear, and exact specification.

This invention will be set forth in the subjoined description and accompanying drawings, and more particularly pointed out in the claims appended to said specification.

In the said drawings Figure 1 is a diagrammatic illustration of an explosion engine provided with a lubricator embodying this invention. And Fig. 2 is a detail view of a part of the mechanism for regulating the supply of lubricant.

My invention relates to an explosive engine of unusual form and to means for lubricating it. In this particular type of engine, the valving is accomplished by the combined action of the piston 1, and two relatively reciprocating sleeves 2, 3, arranged within the main cylinder 4, and provided with ports 5, 6, respectively, constituting a terminal exhaust, which at the proper time communicate with an exhaust port 7 in the cylinder 4, and this in turn may of course be connected with an exhaust pipe 8, as usual. These sleeves 2, 3, may also be provided with suitable intake ports 9, 10, which come into register with each other and with an intake 11 in the cylinder 4 at the proper time, auxiliary exhaust ports 12, 13, 14, being provided when the engine is used as a four-cycle engine.

In the exemplification set forth herein the sleeve valves are telescoped with each other in a fixed cylinder and over a piston and fixed head and are actuated by eccentrics which revolve once to two revolutions of the main crank shaft, the eccentric controlling one sleeve valve leading that actuating the other by any number of degrees (in this case 45°) suitable for causing the ports therein to move in and out of register and in and out of lapped relation with each other and the fixed head as required for the four-cycle stroke.

Beginning with the explosion stroke, the inner sleeve valve is approximately at the end of its outer travel when the working piston is at the top dead center. At or about the time the working piston starts downward, the inner sleeve also starts downward. When the piston has reached within the desired distance from the end of the power stroke, it uncovers the lower exhaust port in the sleeve which is then in register with the lower exhaust port in the cylinder, at which time the sleeve valves will have been brought by their eccentrics to such position that the ports therein will also register with the exhaust ports in the cylinder at the top, permitting the burned gases to escape at both top and bottom of the cylinder as the piston returns upon the scavenging stroke. The exhaust passages in this form are closed through the changing of position with relation to each other of the two sleeves, the upper lip of the port in the outer sleeve lapping with the lower lip of the port in the inner sleeve to seal the combustion chamber against the return of spent gases from the exhaust port in the cylinder. As the piston descends upon its suction stroke, the sleeve-valves are further displaced with relation to each other by the eccentrics, which causes the intake ports to open, hitherto closed through the lapping of the lips of ports in one sleeve-valve with the lips of ports in the other. When the suction stroke is completed, the sleeve-valves move upward over the fixed head and the sealing of the explosion chamber is accomplished through the lapping of the intake and exhaust ports in the outer end of the inner sleeve with the fixed head.

The base of the engine is in the form of an inclosed crank case 15, as is usual with many forms of explosion engines, and in the crank case, at the most advantageous position for discharging upon the parts to be lubricated, is arranged an atomizer, or any other suitable spraying device, consisting of an air nozzle 16 and an oil nozzle 17 connected, respectively, with a valve housing 18 and a tank or source of lubricant 19, so that when pressure is admitted to the nozzle 16 the lubricant will be thrown in a mist or spray over the parts within the crank case, rising also into engagement with the piston, the inner walls of the cylinder, and the wearing surfaces of the sleeves 2, 3. This pressure within the nozzle 16 may be drawn from any suitable source, but pref-

erably from the exhaust pipe of the engine, as will be presently explained, and from whatever source it be taken, it will create more or less pressure within the crank case, and this is taken advantage of for raising the lubricant to the upper end of the cylinder, where it is discharged through any suitable passage or connection 20, into a space 21 which is left between the head of the cylinder and the upper ends of the sleeves, and in which space more or less suction is created by the reciprocating movement of the sleeves, which also tends to lift the lubricant. This brings the lubricant into contact with the sleeves at their upper ends, and insures their lubrication at a much higher elevation than could be accomplished by lubricating from the lower ends alone, and it also affords a source from which to draw this fog or mist of lubricant for oiling the bearings of the machine at distant points. As an example, the space or chamber 21 is shown as connected by a pipe 22 to a bearing 23, in which the shaft 24 of the valve-operating cam, to be presently described, is journaled, but other pipes or connections, such as pipe 25, may also be led from the chamber 21 to other parts of the machine, the lubricant being carried to its destination through these pipes or tubes by the pressure created in the chamber 21 by the combined action of the sleeves and the atomizer, which is also assisted or augmented by the fanning motion of the piston.

In order that the supply of lubricant discharged by the atomizer may be regulated to suit the requirements, any appropriate means may be provided for intermittently, and at longer or shorter periods as may be required, interrupting communication between the nozzle 16 and the exhaust pipe 8, or other source of the fluid under pressure. For this purpose, the valve housing 18 is divided into two compartments 26, 27, by a valve seat 28 and valve 29, the compartment 27 being connected by a pipe 30 to exhaust pipe 8, and compartment 26 by a pipe 31 to nozzle 16. The valve 29 is held closed by a spring 32 on a valve-stem 33, whose upper end has an anti-friction roller 34, arranged to be engaged by a cam 35, which has the form that would result from cutting away on a taper or angle one side of a cylinder. This cam is rotated by the cam-shaft 24, having a worm wheel 36 engaging a worm 37, connected in any suitable way with the operating mechanism of the engine, as, for example, by a shaft 38 having bevel-gear connection 39 with a shaft 40, which drives the sleeve-operating eccentrics 40^a, 40^b and derives motion from crank shaft 41 through the intermediary of suitable gears 42, 43, so that at each revolution of the cam 35 the valve 29 will be opened a greater or less length of time, according to the position of the anti-friction roller 34 with respect to the length of the cam, the cam 35 being adjustable longitudinally for varying its position with respect to the roller. The cam may be thus adjusted by any suitable means. For example, it may be splined on its shaft 24, or otherwise connected thereto so as to be capable of sliding thereon, while compelled to rotate therewith, and to it may be attached an adjusting rod 44 by means of a collar 45 let into a peripheral groove in one end of the cam.

What I claim is:

1. In an apparatus of the character described the combination of an internal combustion engine having ports and embodying a main cylinder or casing, a crank case on which said cylinder is mounted and into which it opens, two telescoped sleeve valves for controlling the ports of the engine sliding axially within said main cylinder, a working piston reciprocating in the inner one of said sleeve valves, a head fixed to the main cylinder and projecting into the inner sleeve valve whereby a chamber is created at the ends of said sleeve valves removed from the crank case, the outer one of the sleeve valves being in working relation to the main cylinder, and means operatively connected with the piston for reciprocating said sleeve valves in said chamber whereby suction and compression is created therein alternately as the piston alternately creates suction and compression in the crank case, and means for supplying the crank case with lubricant whereby such lubricant will be caused to contact with the end faces of the sleeve valves and to be distributed between such valves lengthwise thereof.

2. In an apparatus of the character described the combination with an internal combustion engine having intake and exhaust ports and embodying a crank case, a main cylinder opening into the crank case and having its outer end closed, a head fixed against movement relatively to the said main cylinder and projecting thereinto and spaced from the walls thereof, two telescoped sleeve valves for controlling said ports telescoped with said head and open at both ends and communicating with the crank case at one end and with the space between said head and main cylinder at the other end, a working piston reciprocating in the inner one of said sleeve valves relatively thereto, the outer one of said sleeve valves being arranged in operative relation to the inner of said sleeve valves for controlling the parts aforesaid, and means operatively connecting the piston with the sleeve valves for reciprocating them, of means for supplying lubricant to the crank case whereby the alternate rarefaction and compression of the air in the space between said head and main

cylinder and in the crank case will cause lubricant to flow between and lengthwise of the sleeve valves.

3. In an apparatus of the character described the combination with an internal combustion engine having intake and exhaust ports and embodying a crank case, a main cylinder closed at its outer end and opening into the crank case at its inner end, two telescoped reciprocating sleeve valves telescoped in said main cylinder and relatively movable for controlling the said ports, a working piston reciprocating in the inner one of said sleeve valves relatively thereto, the outer one of said sleeve valves being arranged in working fit with the face of the main cylinder, and means operatively connecting the sleeve valves with the piston for reciprocating them, of means for supplying lubricant to the crank case whereby such lubricant will be supplied to the ends of the sleeve valves and distributed lengthwise between them as they reciprocate.

4. In a lubricator, the combination of an atomizer, means for supplying the same with lubricant, means whereby the atomizer may be supplied with fluid under pressure, a valve for regulating the pressure supplied to the atomizer, a cam for opening said valve, and means for rotating said cam.

5. In a lubricator, the combination with an atomizer, means for supplying the same with lubricant, means for supplying the atomizer with fluid under pressure, a valve for regulating the pressure supplied to the atomizer, a cam for opening the valve, having an active face varying in extent longitudinally of its axis, means for rotating the cam, and means for adjusting it lengthwise of its axis.

6. In a lubricator, the combination with an engine having an exhaust passage, an atomizer, means connecting the atomizer with a source of lubricant, and means connecting the atomizer with said exhaust passage.

7. In a lubricator, the combination with an engine having an exhaust passage, of an atomizer connected with said passage, means for controlling the connection between the atomizer and said passage, and means for supplying the atomizer with lubricant.

8. In a lubricator, the combination with an engine, of an atomizer, means for supplying the atomizer with lubricant, means for supplying the atomizer with fluid under pressure, and means for controlling the latter supply, operatively connected with the engine, whereby the supply will be in proportion to the speed of the engine.

9. In a lubricator, the combination with an engine, of an atomizer, means for supplying the atomizer with lubricant, means for supplying the atomizer with fluid under pressure, a valve for controlling the latter said supply, means for opening the valve intermittently, and means connecting the last said means with the engine whereby the discharge of the atomizer will be in proportion to the speed of the engine.

10. In a lubricator, the combination of an engine having an exhaust passage, an atomizer arranged to discharge upon the parts to be lubricated, and means connecting the atomizer with the exhaust passage whereby the discharge from the atomizer will be in proportion to the speed of the engine.

11. In a lubricator, the combination of an atomizer, means for supplying the same with lubricant, means for supplying the atomizer with fluid under pressure, a valve for controlling the supply of fluid under pressure, means for operating the valve, and means for varying the movement of the valve for regulating the said supply of fluid under pressure.

12. The combination with the parts of an apparatus to be oiled of an oiling device separated from said parts by an intervening space, and means for operating said oiling device in timed relation to the movement of the parts to be oiled to throw a definite and predetermined amount of oil in the form of a jet intermittently upon said parts at predetermined times.

13. The combination with an open ended cylinder and a piston working therein, of an oiling device acting intermittently to throw a jet of oil into the open end of the cylinder, and means for operating the oiling device in timed relation to the movement of the piston.

14. In an apparatus of the character described, the combination with an internal combustion engine having intake and exhaust ports and embodying a crank case, a main cylinder closed at its outer end and opening into the crank case at its inner end, a head fixed to the said cylinder and projecting thereinto and spaced from the walls thereof, two telescoped reciprocating sleeve valves telescoped with said head in said main cylinder and relatively movable for controlling the said ports, a working piston reciprocating in the inner one of said sleeve valves, the outer one of said sleeve valves being arranged in working fit with the face of the main cylinder, both of said sleeve valves being open at their inner ends to the crank case, and means operatively connecting the sleeve valves with the piston for reciprocating them, of means for supplying the crank case with lubricant whereby the valves are supplied with such lubricant, the same being distributed between said valves as they reciprocate.

15. In an apparatus of the character described the combination with an internal combustion engine having intake and exhaust ports and embodying a main cylinder, a head projecting into said cylinder and

spaced from the walls thereof and fixed against movement with relation thereto, a working piston opposed to said head and reciprocating with relation thereto, two telescoped sleeve valves surrounding said head and piston in the space between the head and cylinder, the outer one of said sleeve valves being arranged in operative relation to the inner of said sleeve valves for controlling the ports aforesaid, and means operatively connecting the sleeve valves with the piston for reciprocating them in said space, of means for supplying the crank case with lubricant.

16. In an apparatus of the character described the combination with an internal combustion engine embodying a main cylinder having intake and exhaust ports, a crank case into which the main cylinder opens, a fixed head closing the other end of the main cylinder and projecting thereinto and spaced from the walls thereof, a working piston reciprocating in said cylinder with relation to said head, a sleeve valve telescoped with the head and forming the barrel for the piston and in which barrel the piston reciprocates, a second sleeve valve telescoped over the first said sleeve valve and arranged in working relation to the first sleeve valve for controlling the said ports therein, said sleeve valves being as long as the stroke of the piston and opening at their inner ends into the crank case, and means operatively connecting the sleeve valves with the piston for reciprocating them in the space between the head and the cylinder and at times in opposite directions, of means for supplying lubricant to the space between said head and sleeve valves at the outer ends of the latter whereby said lubricant is caused to work between the contiguous faces of the sleeve valves.

17. In an apparatus of the character described the combination of the base or crank case of an internal combustion engine, a fixed cylinder open at its lower end and mounted on said crank case and having intake and exhaust ports, two telescoped sleeve valves open at both ends and telescoped with said cylinder and relatively movable for controlling said ports, a piston working in the inner one of said sleeve valves toward and from said crank case whereby a fanning action of the air is created in the crank case resulting in inward and outward draft between said sleeve valves, means connecting the piston with said sleeve valves for reciprocating them in opposite directions, and means for supplying lubricant into the crank case adjacent to the contiguous faces of the sleeve valves.

18. In an apparatus of the character described the combination of the base or crank case of an internal combustion engine, a fixed cylinder open at its lower or inner end into said crank case and having intake and exhaust ports, a head fixed in the opposite end of the cylinder and projecting thereinto and spaced from the walls thereof, two sleeve valves telescoped one within the other for controlling the ports aforesaid and fitting over said head in the space between the same and the fixed cylinder, a working piston reciprocating in the inner one of said sleeve valves with relation to said head, both of said sleeve valves being as long as the working stroke of the piston and projecting into the crank case, means connecting the sleeve valves with the piston for reciprocating them, and means for supplying the crank case adjacent to the contiguous faces of the sleeve valves with lubricant during the reciprocating action of the piston.

19. In an apparatus of the character described, the combination with an internal combustion engine having intake and exhaust ports and embodying a crank case, a main cylinder closed at its outer end and opening into the crank case at its inner end, two telescoped reciprocating sleeve valves telescoped in said cylinder and movable relatively for controlling the said ports, a working piston reciprocating in the inner one of said sleeve valves relatively thereto, the outer one of said sleeve valves being arranged in working fit with the face of the main cylinder, means operatively connecting the sleeve valve with the piston for reciprocating them, a head fixed with relation to the main cylinder and fixed against movement with said sleeve valves and piston and projecting into and filling the cross section of the inner one of said sleeve valves, said main cylinder head and sleeve valves forming a chamber into which the sleeve valves reciprocate, and a connection between said chamber and the crank case, of means in the crank case for depositing a lubricant in said connection.

20. In an apparatus of the character described, the combination of a main cylinder of an internal combustion engine, having intake and exhaust ports, a head fixed in said cylinder and projecting thereinto and spaced from the walls thereof, two telescoped reciprocatory sleeve valves telescoped with said head in said cylinder and in the space between the latter and the head, said sleeve valves having ports adapted to come into register as the valves reciprocate, (the inner one of said sleeve valves coöperating with said head for closing the ports in said inner sleeve and the outer one of said sleeve valves coöperating with the inner sleeve for controlling the ports in the said outer sleeve), a working piston reciprocating in the inner one of said sleeve valves with relation thereto and with relation to said head, means for firing a charge in the inner one of said sleeve valves between said piston and head, and

means operatively connecting said sleeve valves with said piston for reciprocating them with relation to the piston and to one another.

21. In an internal combustion engine the combination of a fixed cylinder having intake and exhaust ports, a working piston surrounded by said cylinder and reciprocating therein, two concentric annular port controlling elements encompassing the axis of the piston within said cylinder and being relatively movable, and means connecting said elements with its piston for moving them a distance less then its piston stroke for the purpose of controlling the ports in said annular ported elements by their relative movement.

22. In an internal combustion engine, the combination with a working reciprocating piston, of a crank shaft connected thereto, a fixed cylinder co-axial with the piston having intake and exhaust ports, two concentric cylindrical elements, one of which surrounds the other, said cylinders being relatively movable and encompassing said piston and the space in which the piston reciprocates, said elements having means for the admission of a charge of fluid to said space and the exhaust of gases therefrom, means for firing a charge within said space, and means operatively connecting said cylindrical elements with the crank shaft for reciprocating them relatively to each other and to the piston and to the fixed cylinder for opening and closing said exhaust and intake ports and the explosion chamber.

23. In an internal combustion engine the combination of a working reciprocating piston, a crank shaft connected thereto, a fixed cylinder coaxial with the piston and having intake and exhaust ports, two concentric cylindrical elements one of which surrounds the other and one of which is fixed against movement and the other of which is movable axially with relation to the first, said elements being coaxial with said fixed cylinder and surrounded thereby, the movable one of said elements encompassing the piston and a space in which the piston reciprocates and having means for the admission of a charge of fluid to said space and the exhaust of gases therefrom, the said movable one of said elements having coöperative relation with the other for preventing the escape of fluid from said space during the compression and firing strokes of the piston, means for firing a charge in said space between and against the piston and the fixed one of said elements, means connecting the movable one of said elements with the piston for moving it over the said fixed element to close the said space against the escape of fluid therefrom during the said compression and firing strokes of the piston, and then imparting further movement to it relatively to said fixed element for opening said space during the next two strokes of the piston, and port controlling means located around said movable element and movable relatively thereto with ports registering in the fixed cylinder and being also operatively connected with the piston whereby a relative movement is created for cutting off communication between said space and exhaust port during the second one of the two last said strokes of the piston.

24. An internal combustion engine comprising in combination a cylinder having inlet and exhaust ports, a head over which said cylinder moves, adapted to cover and uncover said ports, a piston in said cylinder, means operatively connected with said piston for moving said cylinder with relation to said head, and a sleeve concentric with said cylinder, also connected with the piston and movable relatively to said cylinder and a fixed cylinder surrounding said sleeve and having ports communicating with ports in said sleeve and movable cylinder, the relative movement of which controls the ports thereof.

25. In a four-cycle internal combustion engine the combination of a fixed cylinder having fixed intake and exhaust ports, a reciprocating piston coaxial with said cylinder, a crank shaft connected to the piston, means for respectively controlling said intake and exhaust ports during two strokes of the cycle and preventing fluid egress from the explosion space of the engine during the other two strokes, embodying a reciprocating cylindrical element coaxial with said fixed cylinder and piston and surrounded by the former and surrounding the latter and also surrounding the explosion space of the engine and having means for the admission of the fluid charge thereto and the exhaust of the gases therefrom, a reciprocating port-controlling sleeve external to the explosion space and engaging the inner face of the fixed cylinder, a head telescoped with said reciprocating cylindrical element, means operatively connecting the piston with the said reciprocating cylindrical element and sleeve for moving the same relatively to intercept communication between the explosion space and the said fixed ports alternately during one revolution of the crank shaft and to close the explosion space against the escape of fluid therefrom during both piston strokes of the next revolution of the crank shaft, and means for firing a charge in the explosion space.

26. In an internal combustion engine the combination of a fixed cylinder having a port, a reciprocating cylinder surrounded by said fixed cylinder and surrounding the explosion space of the engine and having means for fluid admission to and exhaust from the explosion space, port-controlling

means fixed against movement and engaging said reciprocating cylinder for controlling fluid escape therefrom, a working piston reciprocating in said reciprocating cylinder with relation thereto, means operatively connecting the reciprocating cylinder with the piston for reciprocating the reciprocating cylinder and placing its ports out of lapped relation with said fixed port-controlling means during two successive piston strokes for fluid admission to and exhaust from the explosion space and in lapped relation with said port-controlling means during the two succeeding strokes of the piston, and a slidable port-controlling element disposed between the said fixed and movable cylinders, coöperating with the cylinder for controlling the port therein and having operative connection with the piston, and means for firing a charge in the reciprocating cylinder during the second one of the first two said piston strokes.

27. In an internal combustion engine the combination of a fixed cylinder provided with exhaust and inlet ports, a head fixed to said cylinder and projecting thereinto, and being spaced from the walls thereof, a second cylinder slidable within the first said cylinder and telescoping with said head, a piston working within the second said cylinder, a crank to which said piston is connected, a sleeve surrounding the second said cylinder, and means operatively connecting the second said cylinder and sleeve with said crank for reciprocating them relatively at lesser frequency than the piston and opening and closing the said ports.

28. In an internal combustion engine the combination of a cylinder having a port, a piston, a second cylinder telescoped with the first said cylinder and arranged concentrically with said piston for at times controlling said port, a head in the first said cylinder and with which head the second said cylinder is telescoped and moves with reference thereto, packing rings interposed between said head and second cylinder, means for igniting a charge between the head and the piston, a crank connected with the piston, means operatively related to the piston for moving the second said cylinder simultaneously with the piston for at times controlling said port, and a port controlling element movable by the crank relatively to said second cylinder and cooperating with the reciprocating cylinder also for controlling the said port.

29. In an internal combustion engine the combination of a fixed cylinder having intake and exhaust ports, a reciprocating cylinder surrounded by said fixed cylinder and surrounding the explosion space of the engine and having ports in its sides for admitting fluid to and exhausting fluid from the explosion space, internal port-controlling means fixed against movement and engaging said reciprocating cylinder, a working piston reciprocating coaxially with relation to said reciprocating cylinder and surrounded thereby, means operatively connecting the reciprocating cylinder with the piston for reciprocating the reciprocating cylinder with the said ports thereof in lapped relation with said port-controlling means during two successive piston strokes and out of lapped relation therewith during the two succeeding strokes of the piston, and means for firing a charge in the explosion space during the second one of the first two said piston strokes, and an annular port-controlling element movable relatively to and coaxial with the said reciprocating cylinder and connected with the piston whereby the reciprocating cylinder and annular port-controlling element are moved relatively for controlling the ports thereof.

30. In an internal combustion engine the combination of a fixed cylinder having intake and exhaust ports, a reciprocating cylinder surrounded by said fixed cylinder and surrounding the explosion space of the engine and having means for fluid admission to and exhaust from the explosion space including an exhaust port movable therewith, port-controlling means internal to said reciprocating cylinder and engaging therewith for controlling said exhaust port thereof, a working piston reciprocating coaxially with relation to said reciprocating cylinder and surrounded thereby, means operatively connecting the reciprocating cylinder with the piston for reciprocating the reciprocating cylinder with the said exhaust port thereof in lapped relation with said port-controlling means during two successive piston strokes and out of lapped relation therewith during the two succeeding strokes of the piston, means for controlling the admission of fluid to the explosion space from said intake port of the fixed cylinder embodying a reciprocating sleeve, and means for firing a charge in the explosion space during the second one of the first two said piston strokes.

31. A four-cycle internal combustion engine having in combination a fixed cylinder provided with a closed end fixed with relation thereto, said cylinder having a port, means for opening communication from the explosion chamber to said port embodying two relatively movable cylindrical elements, a piston arranged concentrically with said elements and opposed to the closed end of said fixed cylinder, means for firing a charge in the space between said fixed end of the cylinder and said piston, and means for moving the said port-controlling elements to cut off communication between the said space and the said port

during one of the inward piston strokes and to establish communication between said port and space during the next inward piston stroke of the same cycle.

32. In an internal combustion engine, the combination of a fixed cylinder having intake and exhaust ports, a reciprocating cylinder surrounded by said fixed cylinder and surrounding the explosion space of the engine and having means for fluid admission to and exhaust from the explosion space including an exhaust port movable therewith into and out of communication with the exhaust port of the fixed cylinder, a head internal to said reciprocating cylinder and engaging therewith, a working piston reciprocating coaxially with relation to said reciprocating cylinder, means connecting the reciprocating cylinder with the piston for reciprocating the reciprocating cylinder with said exhaust port thereof in lapped relation to said head during two successive piston strokes and out of lapped relation therewith during the two succeeding strokes of the piston, a port-controlling annular valve external to the explosion space and internal to said fixed cylinder and engaging the inner face thereof and movable relatively to the said reciprocating cylinder for intercepting communication between the explosion space and said intake and exhaust ports of the fixed cylinder alternately during the second two said piston strokes, and means for firing a charge in the explosion space during one of the first two said piston strokes.

33. In an internal combustion engine the combination of a fixed cylinder having intake and exhaust ports, a crank shaft, a reciprocating piston connected therewith, a reciprocating cylinder surrounded by the fixed cylinder and surrounding the explosion space of the engine and containing and guiding the piston and in which the piston reciprocates relatively thereto, a head telescoped with said reciprocating cylinder and fixed against movement therewith and with the piston, means for exploding a charge in said reciprocating cylinder between and against said head and piston, the wall of said reciprocating cylinder being apertured for induction of the charge and discharge of the exhaust and the apertured area thereof being adapted to move over and away from said head, means connecting the piston with said reciprocating cylinder for reciprocating the reciprocating cylinder with the said apertured area thereof in lapped relation to said head during two successive piston strokes, and a sleeve external to said reciprocating cylinder and reciprocable relatively thereto and contemporaneously with the movement of the piston and for controlling fluid admission to the explosion space when said apertured area is out of lapped relation with the said head during one stroke of the piston, and controlling communication between the fixed exhaust port and explosion space during another stroke of the piston, and controlling communication between the fixed exhaust port and explosion space during another stroke of the piston.

34. In an internal combustion engine the combination of a fixed cylinder surrounding the explosion space of the engine and having fixed intake and exhaust ports, a piston, a crank shaft connected thereto, means for firing a charge in said explosion space and means for respectively controlling fluid egress from the explosion space and communication between the explosion space and said fixed ports embodying two cylindrical telescoped elements, one of which encompasses the explosion space and reciprocates contemporaneously with the piston and with relation to the other of said elements which latter element is fixed against movement, one of said elements having its wall apertured throughout a portion of its area for fluid admission to and exhaust from the explosion space and both of said elements being concentric with said fixed cylinder, a packing interposed between the contiguous faces of said elements and secured to one of them for covering the said apertured area of the other one during one inward stroke of the piston and the succeeding outward stroke, said packing being substantially equal in width to the travel of said reciprocating element during the two said strokes of the piston, means connecting the piston with the said reciprocating element for moving it until said apertured area and packing are in overlapped relation substantially throughout the revolution of the crank shaft including said two piston strokes and out of such relation substantially throughout the immediately preceding revolution of the crank shaft, the said means for controlling communication between the explosion space and fixed parts also including a reciprocating port-controlling sleeve surrounding said reciprocating element and connected with the piston for movement with relation to said reciprocating element and for alternately cutting the said intake and exhaust ports off from communication with the explosion space during the second said revolution of the crank-shaft.

35. In an internal combustion engine the combination of a piston, a crank-shaft connected thereto, a fixed cylinder having fixed intake and exhaust ports, a head arranged in said cylinder, reciprocating port-controlling means embodying two cylindrical telescoped elements coaxial with the piston and telescoped with said heads and surrounded by said fixed cylinder, said reciprocating port-controlling means having ports coöperating with each other to open and close communication between the explosion space

and said fixed ports alternately during one revolution of the crank shaft, said cylindrical elements coöperating interiorly with the said head, and means for firing a charge in the explosion space during the latter said revolution.

36. In an internal combustion engine, the combination of a fixed cylinder having fixed intake and exhaust ports, means for controlling fluid ingress to and egress from the explosion space embodying a cylindrical head fixed against movement with relation to the said fixed cylinder, and projecting thereinto and spaced from the walls thereof, and a reciprocating cylinder surrounded by said fixed cylinder and surrounding the explosion space of the engine and having means for fluid induction to and exhaust from the explosion space, said reciprocating cylinder being telescoped over said head whereby the explosion space is opened and closed as the reciprocating cylinder moves, a port controlling sleeve around said reciprocating cylinder engaging with the inner face of the fixed cylinder and coöperating with the reciprocating cylinder for controlling the inlet and exhaust from said fixed ports, a working piston reciprocating in said reciprocating cylinder with relation thereto, a crank-shaft connected to said piston, means operatively connected with the piston for moving the reciprocating cylinder and said port controlling sleeve with relation to the head and fixed cylinder in concert with the movement of the piston for opening communication between the explosion space and the said fixed intake port during an outward piston stroke, then lapping said means for fluid induction and exhaust of the reciprocating cylinder over the said head to close the explosion space during the two succeeding piston strokes, and finally opening communication between the explosion space and said fixed exhaust port during the piston stroke immediately following said two succeeding strokes, and means for exploding a charge between said head and piston.

37. In an internal combustion engine, the combination with a fixed cylinder having intake and exhaust ports, a cylindrical head projecting into said cylinder and space from the walls thereof and forming an annular explosion space therewith, two concentric relatively moving cylindrical port-controlling elements telescoped in said cylinder and over said head, said port-controlling elements inclosing the explosion space of the engine, both of said elements having intake and exhaust ports adapted to communicate during the relative movement of said elements for controlling the intake of fluid and the exhaust of gases from the explosion space, a working piston reciprocating axially with relation to said elements and surrounded thereby, speed reducing means positively connecting the piston with said elements for reciprocating them with relation to each other and with relation to the head and cylinder, and means for firing a charge in said explosion space.

38. In an internal combustion engine, the combination of two ported cylindrical sleeve valves surrounding a reciprocating working piston with intervening actuating mechanism connecting said valves with said piston for imparting to said sleeve valves a motion of lesser frequency than that of the piston for opening and closing said ports in the manner required for sealing the explosion chamber during approximately one full revolution of the crank shaft and alternately opening and closing the exhaust and intake ports during the succeeding revolution thereof.

39. In an internal combustion engine, the combination of two ported cylindrical sleeve valves surrounding a reciprocating working piston and a main cylinder inclosing said valves and having one end opening into a crank case and the other end closed by a head fixed against movement relatively to said main cylinder and projecting thereinto, actuating mechanism for the valves and for the said piston whereby the mechanism for the valve imparts a motion of lesser frequency than that of the working piston.

40. In an internal combustion engine, the combination of two ported sleeve valves surrounded by a fixed cylinder or casing, an inwardly projecting head fixed against movement and opposite to a working piston which reciprocates in the inner one of said sleeve valves, together with a mechanism connecting said sleeve valves with said piston, imparting to the former a movement of less frequency than that of said piston, causing the ports in the inner of said valves to be uncovered by said inwardly projecting head during two full successive strokes of the piston, and covered during the two subsequent successive strokes.

41. In an apparatus of the character described, the combination of a main cylinder of an internal combustion engine, having intake and exhaust ports, a head fixed in said cylinder and projecting thereinto and spaced from the walls thereof, two telescoped reciprocatory sleeve valves telescoped with said head in said cylinder and in the space between the latter and the said head, said sleeve valves having ports adapted to go into register as the valves reciprocate, the inner one of said sleeve valves coöperating with said head for sealing the explosion chamber during the compression and firing strokes of the engine, and the outer of said sleeve valves coöperating with said inner sleeve for opening and closing the exhaust from said cylinder during one stroke and closing the intake to said cylinder during

the next stroke, and a working piston reciprocating in the inner one of the said sleeve valves with relation thereto, and with relation to said head, means for firing the charge in the inner one of said sleeve valves between said piston and said head, and means operatively connecting said sleeve valves with said piston for moving them with relation to said piston at a lesser frequency than the same and to one another.

42. In an internal combustion engine, the combination with a fixed cylinder having intake and exhaust ports, a working piston surrounded by said cylinder and reciprocating therein, two concentric annular port controlling elements encompassing the piston within the said cylinder and being relatively movable, for controlling the ports, and means connecting the said elements with the piston for moving them a distance less and at a lesser frequency than the piston stroke.

43. In an internal combustion engine, the combination with a fixed cylinder of sleeve valves movable therein and relatively to one another, a piston operable in the inner one of said sleeve valves, a head closing the combustion engine of said cylinder, and projecting thereinto, and means for operating said sleeve valves from said piston, whereby the inner one of said valves coöperates with said head for sealing the explosion chamber during the compression and firing strokes of the engine, and the outer valve controls the distribution of gases as required by four stroke cycle engine.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, on this 31st day of May A. D. 1906.

CHARLES Y. KNIGHT.

Witnesses:

FRANCIS A. HOPKINS,

CHARLES H. SEEM.