Jan. 1, 1924

1,479,466

F. M. GUY ET AL

INTERNAL COMBUSTION ENGINE

Filed May 9, 1919

3 Sheets-Sheet 1

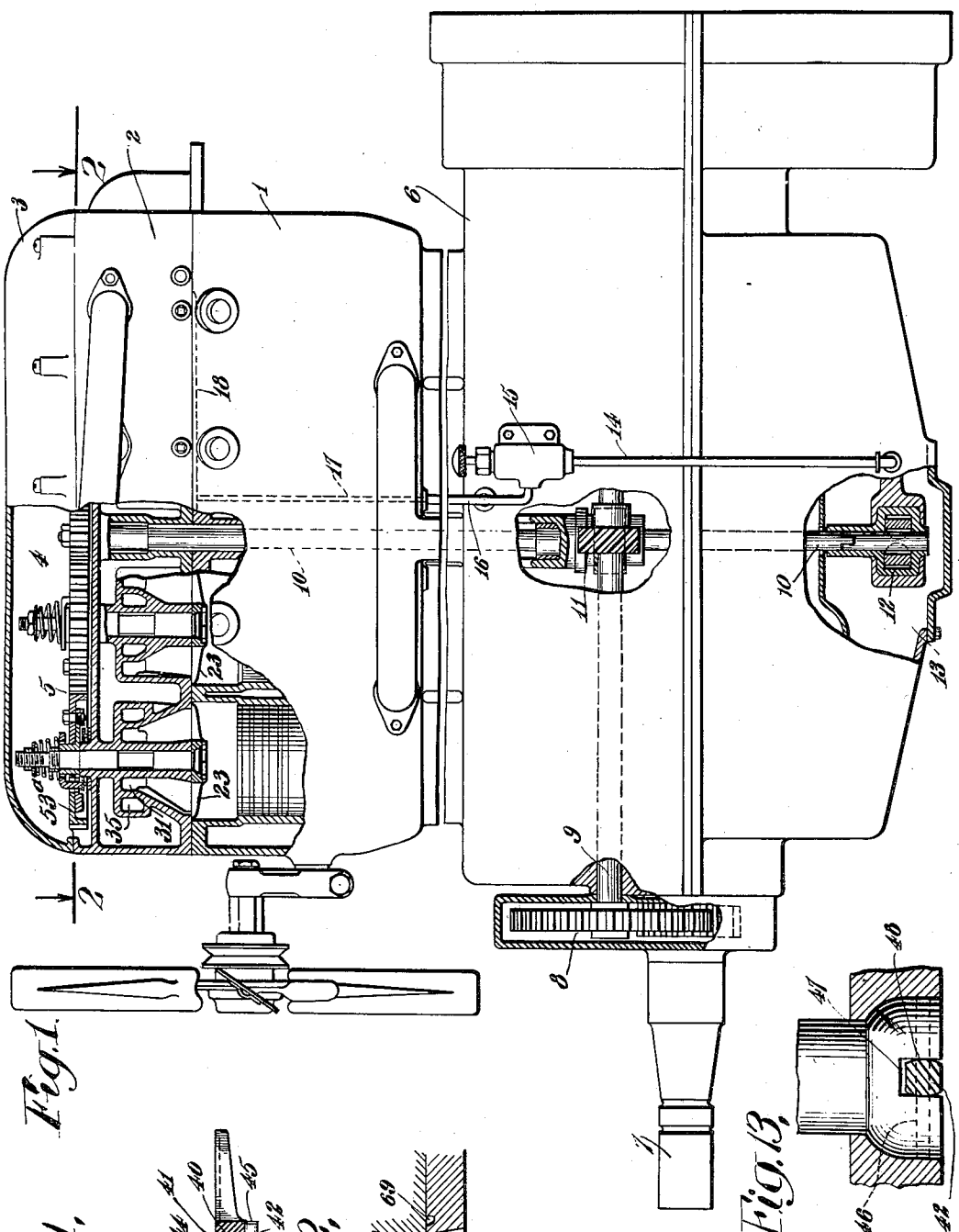


Fig. 1.

Fig. 3.

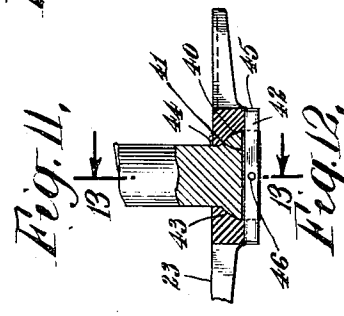


Fig. 11.

Fig. 12.

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INTERNAL COMBUSTION ENGINE

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3 Sheets-Sheet 2

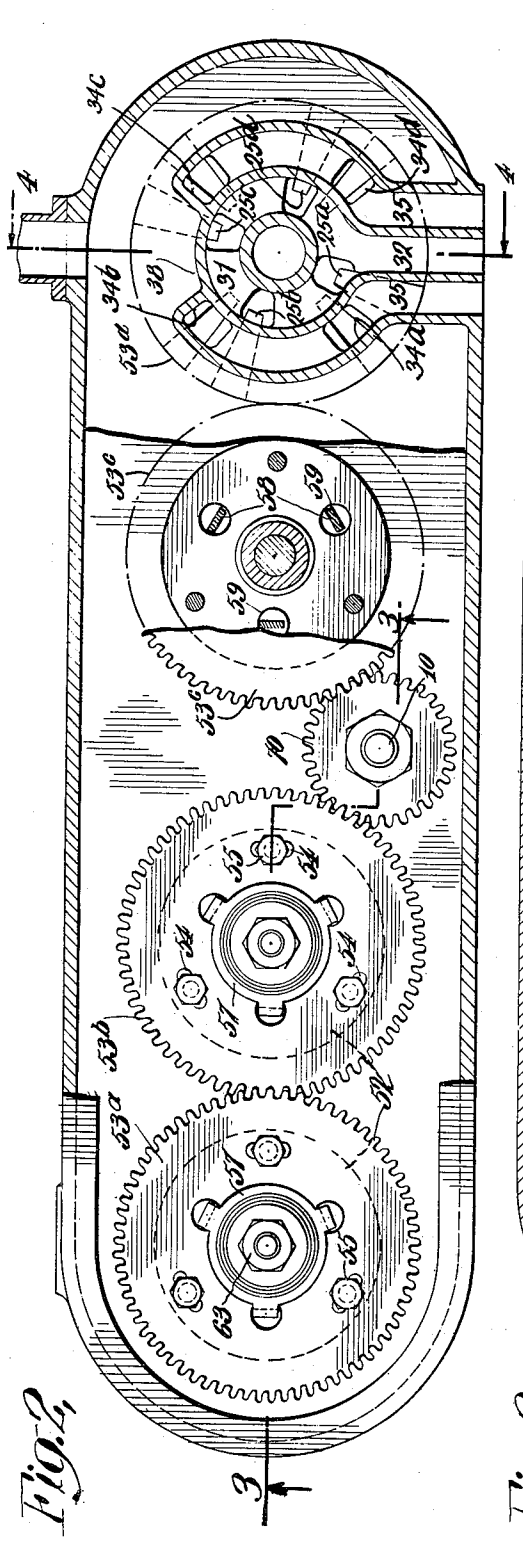


Fig. 2.

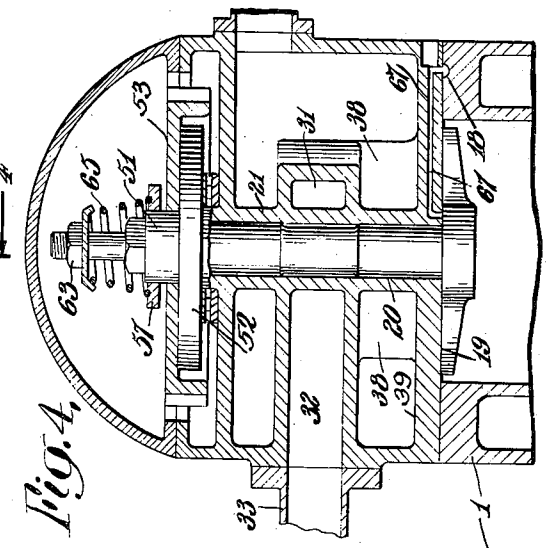


Fig. 4.

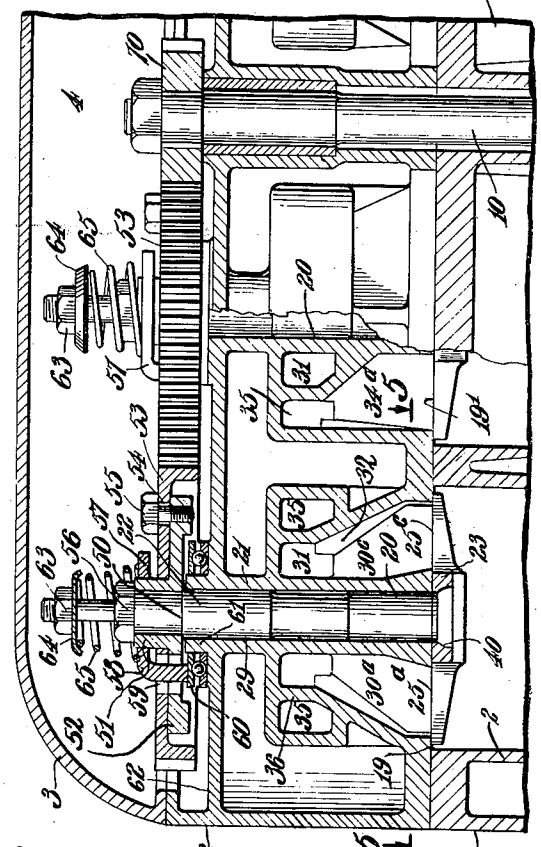


Fig. 3.

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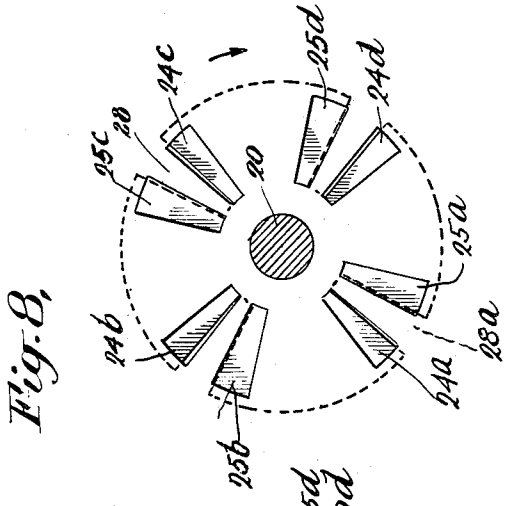
their ATTORNEY

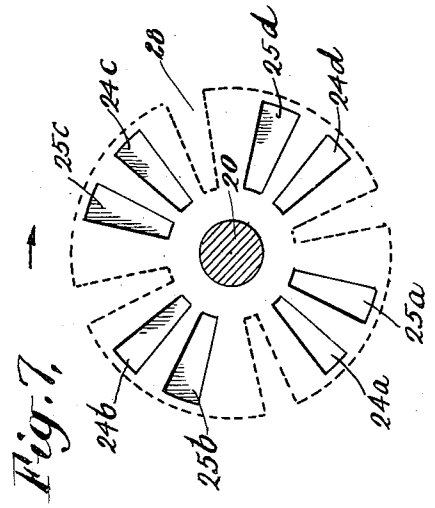
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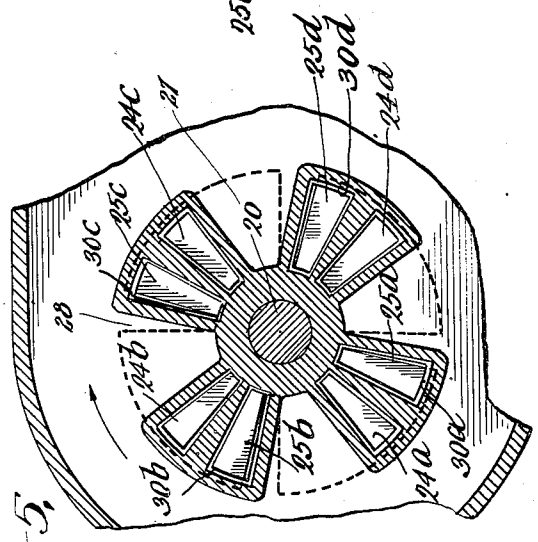
F. M. GUY ET AL

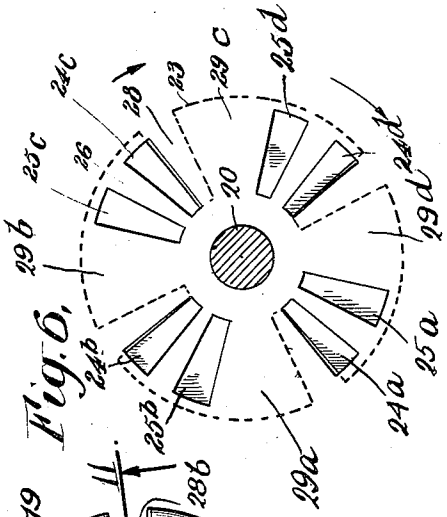
INTERNAL COMBUSTION ENGINE

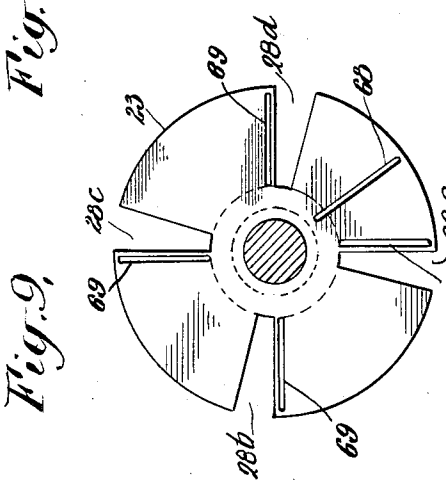
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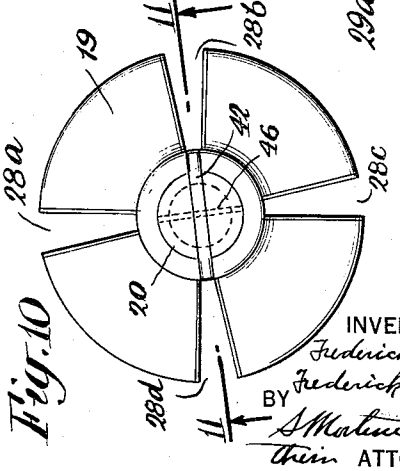












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Patented Jan. 1, 1924. 1,479,466

UNITED STATES PATENT OFFICE.

FREDERICK M. GUY, OF GRAND RAPIDS, MICHIGAN, AND FREDERICK R. SUNDERMAN, OF NEWBURGH, NEW YORK.

INTERNAL-COMBUSTION ENGINE.

Application filed May 9, 1919. Serial No. 295,959.

To all whom it may concern:

Be it known that we, FREDERICK M. GUY, a citizen of the United States, and a resident of Grand Rapids, in the county of Kent and State of Michigan, and FREDERICK R. SUNDERMAN, a citizen of the United States, and a resident of Newburgh, in the county of Orange and State of New York, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

Our invention relates to internal combustion engines, and more particularly to rotary valves for controlling the intake and exhaust ports of the cylinders of such engines, and to other features pertaining thereto.

The advantages of rotary valves over poppet valves for internal combustion engines have been long recognized, but heretofore considerable difficulty has been experienced in keeping the rotary valve disk which is located right in the combustion chamber, from becoming distorted, burnt or otherwise damaged due to the intense heat to which it is subjected. The effect of heat on the valve itself, on the valve spindle, and the difficulty of getting the valve to accurately seat in engagement with the adjacent ported surface of the cylinder head, the rapid carbonization of lubricating oil when attempt is made to lubricate the seat of the valve, the difficulty of readily and accurately adjusting the various rotary valves with respect to each other and the difficulty of avoiding steam pockets in the water cooling spaces in the heads of the cylinders due to relatively small water cooling passages coming in contact with the exhaust passages from the exhaust ports in the cylinder heads, have been such obstacles in the practical utilization of rotary valves for gas engines as to prevent any extended or general use of such valves in replacing poppet valves or in sharing in general use therewith.

The object of our invention, generally stated, is to provide a durable and efficient internal combustion engine of the rotary valve type which, from the standpoint of production, is readily manufactured and assembled, and the valve gearing of which is simple, durable and noiseless in operation.

More specifically stated, the objects of our invention are to overcome the various difficulties above enumerated.

The invention consists in the novel features of construction and combination of parts which are hereinafter shown and described in their preferred form, and the invention is more particularly pointed out in the appended claims.

Further objects and advantages of the invention will more fully appear from the following description taken in connection with the accompanying drawings in which—

Fig. 1 is a side elevation of an engine embodying the preferred form of our invention and having certain parts broken away and certain parts in section;

Fig. 2 is an enlarged view, partly in plan and partly in section, taken on line 2—2 of Fig. 1;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2;

Fig. 4 is a sectional view taken on line 4—4 of Fig. 2;

Fig. 5 is a cross-sectional view taken on line 5—5 of Fig. 3;

Figs. 6, 7 and 8 are somewhat diagrammatic views showing the relative relations of the ports in the valve and valve seat;

Fig. 9 is a top plan view of the valve disk on its spindle;

Fig. 10 is a bottom plan view of the valve disk;

Fig. 11 is a sectional view of the valve taken on line 11—11 of Fig. 10;

Fig. 12 is an enlarged fragmentary view showing details of the ports; and

Fig. 13 is an enlarged sectional view taken on line 13—13 of Fig. 11.

Referring to the drawings (Fig. 1), 1 is the main cylinder casting or body of the engine, which is provided with a detachable cast head 2 containing intake and exhaust passages and water cooling chambers, hereinafter more fully described. This head is provided with a hood or cap plate 3 forming with the top of the head, a chamber 4 for valve gearing 5 hereinafter described.

The engine is provided with a suitable crank case 6 having a main crank shaft 7 to which is geared, through gearing 8, a shaft 9 which in turn drives a vertical shaft

10 through suitable spiral gearing 11. The bottom of the shaft 10 drives a gear oil pump 12 which pumps oil from the sump tank 13 through pipe 14 to a connection 15 from which the oil is distributed to suitable parts of the engine in any well known manner. From the connection 15 there is provided a by-pass oil pipe 16 which extends upward to a vertical passage or bore 17 in the cylinder casting through which the oil is conducted to a horizontal groove or bore 18 in the upper surface of said casting, and from this bore oil is distributed to the various valve seats, as hereinafter described.

In the particular engine shown there are four cylinders, and the heads of each are cast integrally in the form of casting 2. Since the cylinder heads and valve mechanism of all of the cylinders are identical, we will only refer to one cylinder in the description, and will indicate corresponding parts of each cylinder with like reference numerals. The part of the casting constituting each cylinder head has its bottom surface 19 machined off smoothly, and the center of the cylinder head is bored out to form a spindle bore 20, the wall 21 of which will be referred to as the spindle sleeve. In this bore is located a vertical valve spindle 22 (see Figs. 1 and 3) carrying at its lower end the rotary valve 23. The seat 19′ for this valve is formed in the adjacent or lower surface of the cylinder head which in turn is provided with a plurality of intake ports 24*a*, *b*, *c* and *d*, and a plurality of exhaust ports 25*a*, *b*, *c* and *d*, arranged concentrically and symmetrically about the axis of the spindle 22, the exhaust ports and intake ports alternating one with the other. We have shown four of each such ports, or eight in all, but it will be understood that so far as concerns certain features of the invention, any desired number of exhaust and intake ports may be utilized. In the present form of the invention the intake ports each have a 13-degree angular opening, while each of the exhaust ports have a 15-degree angular opening, with the narrow bridging portions 26 of the valve seat between adjacent intake and exhaust ports having an angular embrace of 12 degrees, and the broader bridging portions of the valve seat 27 between adjacent groups or pairs of ports have an angular embrace of 40 degrees. These exhaust and intake ports are adapted to be opened and closed by the rotary valve disk 23, which in turn is provided with four symmetrically arranged ports 28*a*, *b*, *c*, and *d*, each of the same dimensions and each having an angular embrace of 13 degrees. The ports 28, etc., are in communication with the intake ports 24, etc., during the downward or suction stroke of the piston; while during the upward or compression stroke and the next downward or firing stroke of the piston all of the exhaust and intake ports are closed, after which the valve ports come into communication with the exhaust ports 25, etc., during the next upward stroke of the piston, at the end of which stroke the exhaust ports are closed and the intake ports opened, and so on. This action is best shown from the diagrams Figs. 6, 7 and 8, and considering these figures, it may be borne in mind that in the present embodiment of the invention the valve ports are of one degree greater angular embrace than the narrow bridging sections 26 between the exhaust and intake ports, the object of which is to uncover the intake port just before the exhaust port is closed so as to permit the fuel to start its flow in the passages to the intake ports as the crank shaft is going over center, thus obtaining a prompter flow of the fuel to the cylinders which results in a quicker acting and more powerful engine. With this understanding, and referring to Fig. 6, in which the valve disk 23 is shown in dotted lines, the valve ports 28 are shown in the position they assume just prior to the completion of the intake stroke where the intake ports 24, etc., are shown as about to be closed. As the valve rotates in the direction of the arrow shown and past the broad bridging spaces 29*a*, *b*, *c* and *d* of the valve seat, the piston moves through its compression stroke and its firing stroke, the intermediate position of the valve ports 28 while completely closed by the bridging member being shown in Fig. 7. At the commencement of the exhaust stroke the valve ports, 28, etc. will be in the position shown in Fig. 5, where the exhaust ports are shown as just commencing to be uncovered; and the valve ports 28, etc., reach the position of exact register with the said exhaust ports when the piston is half way up on its exhaust stroke, the exhaust ports being almost closed by the time the piston completes its exhaust stroke. At this time—i.e., as the crank shaft is passing over dead-center, the valve ports 28 have moved to and assume the position shown in Fig. 8 where the exhaust ports are almost closed and the intake ports slightly uncovered to obtain the desired quick action and increased power referred to; and during the rest of the intake stroke of the piston the valve ports continue to move more into register with the intake ports until the completion of the stroke, whereupon the intake ports are closed, and so on.

With this understanding of the general principle and actions of the rotary valve in opening and closing the ports, we will now refer to the arrangement and construction of the intake and exhaust passages extending from the valve seat to the manifold.

Referring to Figs. 1, 3, 4 and 5, each of the rather narrow elongated exhaust ports in the valve seat has an exhaust passage extending therefrom upwardly and tapering inwardly toward the spindle sleeve 21, and these passages 30*a*, *b*, *c* and *d* are gradually contracted radially and expanded angularly about the spindle axis so as to preserve a substantially uniform cross sectional area throughout their length, and they all open at their upper ends into a common exhaust passage 31 which substantially surrounds the spindle sleeve 21 and is provided with a lateral exhaust opening 32 communicating at its outer end with the exhaust passage in the manifold 33.

In the preferred arrangement and construction of these exhaust ports as shown, it will be observed that the sleeve 21 constitutes a common wall between the valve spindle and the exhaust passages, thereby providing a very compact construction and obviating any small water cooling spaces between what would otherwise be the inner walls of these exhaust passages and the spindle 21, which would result in "steam pockets." Likewise, the intake ports in the valve seat have individual intake passages 34*a*, *b*, *c* and *d* extending upwardly therefrom along the valve spindle and tapering outwardly therefrom and communicating at their upper ends with a common intake passage 35 which throughout its length surrounds the common exhaust passage and is concentric therewith and separated therefrom only by a partition 36 common to the two. The individual intake passages, like the individual exhaust passages, are contracted radially and expanded angularly about the axis of the spindle as they extend upwardly so as to maintain a substantially uniform cross-sectional area. The individual intake passages up to the point where they incline outwardly to the outside of the common exhaust passage, likewise extend directly to the spindle sleeve 21 so that the relatively cool fuel mixture flowing through this portion of the passages will assist in cooling the valve spindle. Adjacent individual exhaust and intake passages—i. e., those of each pair, as they extend upwardly, are separated only by a common partition as in the case of the common exhaust and intake passages 31 and 35, so that throughout substantially the entire length of the common and individual intake passages the fuel is brought into direct contact with the highly heated walls of the exhaust passages, which has the advantage of very considerably raising the temperature of the fuel mixture before it reaches the combustion chamber. This arrangement and construction of the ports and passages provides a very compact construction with port passages of relatively short length, and permits of the utilization of the exhaust gases in heating the intake mixture, and of the utilization of the intake mixture in correspondingly cooling the heated parts of the structure, and avoids the undesirable "steam pockets." This arrangement also permits the production of relatively large water cooling passages 38 (see Fig. 4) in the intervening spaces between the successive pairs of intake and exhaust passages, and these water spaces extend right up to the valve sleeve 21 both below and above the common exhaust and intake passages 31 and 35, so as to cool the valve sleeve which acts to dissipate the heat from the exhaust passages. The location of the common intake passage 35 surrounding the common exhaust passage 31 and on the same level therewith, not only permits of a compact and convenient construction, but it also permits of the substantial water spaces 38 intervening between the lower wall of the common exhaust passage 31 and the upper surface 39 of the valve seat 19, so as to sufficiently cool the seat and sleeve 21 and avoid the danger of "steam pockets" above the combustion chamber.

We have found it important to support the rotary valve 23 from the valve spindle loosely so as to permit slight universal movement or tilting of the valve with respect to the spindle to permit it to be self-seating so as to facilitate or insure accurate seating of the valve disk on its seat, that would otherwise be prevented by lack of accurate alignment of the spindle or its sleeve, or due to lack of accuracy in forming the surface of the valve at right angles to the spindle or in the machining of the seat or the valve, any of which would prevent accurate rotative engagement of the upper valve surface with its seat.

It is important that the connection of the valve on the spindle should be strong and durable so as to withstand distortion and burning due to the intense heat to which this part of the mechanism is subjected. And to permit this self-seating of the valve while reliably supporting and driving the same, we have provided the following means:

The lower end of the valve spindle (see more particularly Figs. 3 and 11) is provided with a shoulder 40 of substantially spherical contour, from the lower end of which shoulder the valve stem continues down cylindrically and is provided with a transverse slot or groove 41 adapted to receive a driving key 42. The center of the valve disk 23 is also provided with a shoulder 43 adapted to fit the rounded shoulder 40, while the shallow cylindrical bore 44 of the valve disk just above the rounded shoulder 43 and the cylindrical portion of the bore of the valve disk just below the shouldered portion fits the corresponding portions of the spindle of the valve sufficiently loose to permit the slight tilting or

teetering of the valve with respect to the axis of the spindle. The lower portion of the hub of the valve disk is likewise slotted at 45 to permit the passage of said driving key 42, and this key is held in the slots of the spindle and valve disk by means of a small transverse pin 46. The slot in which the key 42 is located is slightly deeper than the key so as to provide a little clearance shown at 47 in Fig. 13, between the upper wall of the slot and the key 42 to permit the valve disk to rock slightly on the rounded shoulder up and down i nthe direction of the key, while the sides 48 of the key are slightly rounded to permit the valve disk to rock on its shoulder up and down transversely of the axis of the key. In other words, the slot and key are so arranged and constructed as to permit the spindle to drive the valve without interfering with the free tilting of the valve on the supporting rounded shoulder. The enlarged lower end of the valve spindle with the rounded shoulder provides a substantial support for the disk, which prevents danger of the valve under the action of the intense heat, from dropping from the disk into the cylinder with the possible resulting damage to the engine; while the rigid spindle 22 extending through the relatively long sleeve 21 gives a substantial driving spindle held securely in alignment. The elongated sleeve 21 not only provides a bearing for the spindle that is obviously more durable than a short bearing sleeve, but the relative long length of the sleeve assists in preventing leakage of the gases between the spindle and its sleeve during the explosion stroke.

We have provided the following means for yieldingly holding the valves in engagement with their seats and for rotating the valves.

Referring more particularly to Fig. 3, it will be noted that the valve spindle is provided with a shoulder 50 upon which rests the lower end of a hub 51 of a flange or disk 52 to which is secured a spindle-driving gear 53. The hub 51 is firmly keyed to the spindle, and the gear is provided with three slots 54 through each of which a tap bolt 55 is passed and threaded into the disk 52. These slots and bolts permit of ready angular adjustment of the gear 53 with respect to the valve spindle to facilitate the seating of the several valves of the engine. The hub of the disk 52 is held down on the shoulder by means of a nut 56. Around the hub 52 is provided a loosely fitting spider 57 having three prongs 58 extending through aligned slots 59 in the disk 52 and gear 53 into engagement with the upper plate of a ball thrust bearing 60 which is centered about the extension 61 of sleeve 21 above the upper surface 62 of the cylinder head. The upper extremity of the valve spindle is threaded and provided with a nut 63 against which rests a washer 64 taking the upward thrust of spring 65 the lower end of which rests against the spider 57. This arrangement and construction of the parts permits the valve disk to be held resiliently against its seat in such manner that the adjustable parts can be readily gotten at and the adjustment made without doing anything more than removing the cap plate 3 and adjusting the nut 63. It will be observed that the use of the spider passing through the slots in the gear 53 and disk 52 obviates the necessity of having the driving gear slidable longitudinally of the spindle, as would be the case if the spring bore directly upon the hub of the gear, as has been heretofore proposed, and which is an undesirable feature. This arrangement also permits of the placing of the thrust bearing on a firm seat against the cylinder head and in a position where it is out of the way of the other parts and will not be disturbed in adjusting or repairing the other valve parts at any time.

One of the principal difficulties with rotary valves located in the combustion chamber of the cylinders has been due to the difficulty of properly lubricating the engaging surfaces of the valve and its seat without causing carbonization of the lubricating oil, which results in roughening the seat, wearing the valve with resulting leakage, and the partial clogging of the ports in the valve seat due to deposits of the carbonized oil. We have heretofore attempted to oil the valve by leading oil to a point in the valve seat in the path of rotation of the valve ports, but we have found that this results in an excess of oil as the ports uncover the oil passage, and this excess of oil is carried against the walls of the ports where it is burned and carbonized. We have also found that if the oil in the port is carried right to the valve spindle, a certain amount of oil is blown along into the valve sleeve and wasted and partly carbonized around the bottom portion of the sleeve due to the heat of explosion of the gases. To obviate these two difficulties, we have provided an oil bore 67 (see more particularly Fig. 4) in the cylinder head communicating at its outer end with the oil groove 18 extending along the cylinder casting and at its inner end opening onto the upper surface of the valve disk at a point spaced both from the valve spindle bore and from the inner ends of the ports.

In order to permit a limited supply of oil to be taken from the hub portion of the valve out along the ported portions, there is provided a single radial groove 68 in the upper face of the valve (see Fig. 9) which comes into communication with the oil passage 67 but once for each rotation of the valve, so as

to receive a slight amount of oil once for each revolution of the valve, and this limited amount of oil is allowed to flow down the groove 68 to lubricate the ported portions of the valve surface and seat. We have found that this arrangement effectively prevents any appreciable oil film or sulplus supply of oil between the valve and its seat which would be carbonized by the intense heat to which it is subjected, with the detrimental results pointed out.

Further provision has been made to prevent the lubricating oil from gathering on the edges of the ports and being carbonized there; and this consists in narrow radial grooves extending along and closely adjacent the trailing edges of the valve ports into which grooves any slight surplusage of oil is wiped by the edges of the ports in the valve seat as these grooves pass beneath them. The grooves thus act as small scavengers and retainers for any slight amount of surplus oil that might otherwise collect on the edges of the ports.

We have also found in practice that due to the intense heat to which the valve disk is subjected, there is considerable tendency to burn and distort the more restricted cross sectional portions of the valve, and that where the ports terminate near the periphery of the valve leaving at each port a peripheral bridging piece of small cross-sectional area, these parts get unduly hot and the intense heat of these parts actually distorts the valve and prevents smooth operation and proper seating of the valve, causing noise, wear and leakage and rendering the valve less efficient and durable. In order to obviate this trouble and at the same time obtain a port of greater area without increasing its angular embrace, we have done away with these bridging portions by slotting the ports completely through the periphery of the valve disk as shown in the drawings. This also assists in preventing accumulation of the oil out under the periphery of the valve disk.

As shown in Fig. 2 the spindle driving gears 53*a* and 53*b* are directly in mesh one with the other, while the spindle gears 53*c* and 53*d* are likewise directly in mesh; and the gears 53*b* and 53*c* are in mesh with driving pinion 70 carried at the upper end of the vertical shaft 10. The utilization of four exhaust ports and four intake ports as shown and described, permits the valves to be rotated at one-eighth of the speed of the crank shaft, and, as will be readily appreciated, any reduction in the valve speed below the crank shaft speed is very desirable, since the valves will operate more quietly and there will be less wear. This reduction in speed calls for an 8:1 ratio of the gearing between the crank shaft and the valve spindle, and this is effected through the 2:1 ratio between the pinion 70 and the spindle gears 53*b* and 53*c*, and a 4:1 reduction between the crank shaft 7 and the shaft 10.

It is desirable to get the shaft 10 as close to the spindles as possible, and to avoid having the shaft on the outside of the main cylinder casting, and we have therefore arranged the shaft 10 in a bore directly in the cylinder casting, and have located it between the second and third cylinders in order to distribute as uniformly as possible any lost motion in the valve gearing.

While we have described our invention in detail in connection with the present preferred embodiment thereof as shown in the drawings, it will be obvious to those skilled in the art, after understanding our invention, that certain features thereof may be utilized without others, and that various modifications and changes in the arrangement and construction of the parts may be made without departing from the spirit and scope of our invention, and that some of these may be utilized in an air-cooled engine, and we aim in the appended claims to cover all such modifications as are within the scope of our invention.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent, is:—

1. In an internal combustion engine the combination of an engine cylinder and piston, a removable valve port casing having intake and exhaust ports, a rotary valve for opening and closing said ports, a spindle extending through said casing for rotating said valve, a gear on said valve and spindle, a thrust bearing on said casing, a spider having arms extending loosely down through said gear and engaging said bearing and a spring interposed between said spider and the end of the spindle tending to keep the valve seated on its valve seat.

2. In an internal combustion engine the combination of an engine cylinder and piston, a removable head for the cylinder having intake and exhaust ports, a rotary valve for opening and closing said ports, a spindle extending through said head for rotating said valve, a gear on said spindle on the outside of the head for rotating the spindle and valve, a thrust ball bearing carried on the outside of said head, a spider having arms extending loosely down through said gear and engaging said bearing, a member removably secured to the outer end of the spindle and a compression spring interposed between said spider and said member tending to keep the valve seated on its valve seat.

3. In an internal combustion engine the combination of an engine cylinder and piston, a removable head for the cylinder having intake and exhaust ports, a rotary valve for opening and closing said ports, a spindle

extending through said head for rotating said valve, a gear on said spindle on the outside of the head for rotating the spindle and valve, a disk secured to the spindle, a screw operating through a slot in the gear for securing the gear in adjusted position to said disk whereby the gear may be fixed in adjusted position with respect to the spindle, a thrust ball bearing carried on the outside of the said head, a spider having arms extending loosely down through said gear and engaging said bearing, a member removably secured to the outer end of the spindle and a compression spring interposed between said spider and said member tending to keep the valve seated on its valve seat.

4. In an internal combustion engine, the combination of an engine cylinder having a valve port casing, a plurality of intake ports and a plurality of exhaust ports in said casing, a rotary valve for opening and closing said ports, and a spindle for rotating the valve and extending outwardly through said casing, said ports extending outwardly in said casing and being arranged about said spindle, the intake ports leading to a common intake passage in said casing and the exhaust ports leading to a common exhaust passage in said casing, one of said passages being arranged about and close to said spindle and spaced from said ports.

5. In an internal combustion engine, the combination of an engine cylinder having a valve port casing, a plurality of intake ports and a plurality of exhaust ports in said casing, a rotary valve for opening and closing said ports, and a spindle for rotating the valve and extending outwardly through said casing, said ports extending outwardly in said casing and being arranged about said spindle, the intake ports leading to a common intake passage in said casing and the exhaust ports leading to a common exhaust passage in said casing, and said cylinder head having water cooling passages adjacent all of said ports.

6. In an internal combustion engine, the combination of an engine cylinder, a plurality of intake ports and a plurality of exhaust ports at one end of the cylinder, a rotary valve for opening and closing said ports, and a spindle for rotating the valve and extending outwardly through the head of the cylinder, said intake ports extending upwardly in the cylinder head with the upward extensions arranged about said spindle and terminating in a common inlet passage.

7. In an internal combustion engine, the combination of an engine cylinder having a valve port casing, a plurality of intake ports and a plurality of exhaust ports in said casing, a rotary valve for opening and closing said ports, and a spindle for rotating the valve and extending outwardly through said casing, said intake ports extending outwardly in the direction of said spindle in said casing with the outward extensions arranged about said spindle and terminating in a common inlet passage.

8. In an internal combustion engine, the combination of an engine cylinder, a plurality of intake ports and a plurality of exhaust ports at one end of the cylinder, a rotary valve for opening and closing said ports, and a spindle for rotating the valve, said intake ports having passages extending therefrom upwardly in the cylinder head and arranged about said spindle and leading to a common intake passage in the cylinder head arranged about and close to the spindle and spaced from said ports.

9. In an internal combustion engine, the combination of an engine cylinder having a valve port casing, a plurality of intake ports and a plurality of exhaust ports in said casing, a rotary valve for opening and closing said ports, and a spindle for rotating the valve, said intake ports extending in the direction of said spindle in said casing, with the outer extensions arranged about said spindle and terminating in a common inlet passage, and a cooling chamber having extensions under said common passage between the same and the lower surface of the valve port casing containing said ports.

10. In an internal combustion engine, the combination of an engine cylinder having a valve port casing, a plurality of intake ports and a plurality of exhaust ports in said casing, a rotary valve for opening and closing said ports, and a spindle for rotating the valve, said intake ports having passages extending in the direction of said spindle in said casing with the outer extensions arranged about said spindle and extending substantially the same length and terminating in a common passage arranged about said spindle in a plane substantially at right angles to the axis thereof.

11. In an internal combustion engine, the combination of an engine cylinder, a head for said cylinder, a plurality of intake ports and a plurality of exhaust ports in said head, a rotary valve having a plurality of ports therein for opening and closing said intake and exhaust ports, and a spindle journaled in said head for supporting and rotating said valve, said intake and exhaust ports being arranged about said spindle, each of the intake ports having passages extending upwardly therefrom to a common intake passage communicating with the upper ends of said individual intake passages, and each of the exhaust ports having passages extending therefrom upwardly to a common passage with which they communicate at their upper ends, and said cylinder head having water cooling channels extending between said common exhaust passage and the lower wall of the cylinder head con-

taining said exhaust ports and between the upwardly extending passages of said exhaust ports.

12. In an internal combustion engine, the combination of an engine cylinder, a head for said cylinder, a plurality of intake ports and a plurality of exhaust ports in said head, a rotary valve having a plurality of ports therein for opening and closing said intake and exhaust ports, and a spindle journaled in said head for supporting and rotating said valve, said intake ports being arranged in the head of the cylinder about said spindle alternately with said exhaust ports which are also arranged in said head about said spindle, each of the intake ports having passages extending upwardly therefrom along the spindle to a common intake passage communicating with the upper ends of said individual intake passages, and each of the exhaust ports having passages extending therefrom upwardly along the spindle to a common passage with which they communicate at their upper ends.

13. In an internal combustion engine, the combination of an engine cylinder, a head for said cylinder, a plurality of intake ports and a plurality of exhaust ports in said head, a rotary valve having a plurality of ports therein for opening and closing said intake and exhaust ports, and a spindle journaled in said head for supporting and rotating said valve, said intake and exhaust ports being arranged about said spindle, each of the intake ports having passages extending upwardly therefrom along the spindle to a common intake passage centrally located in the cylinder head, and each of the exhaust ports having passages extending upwardly therefrom to a common exhaust passage located about the common intake passage.

14. In an internal combustion engine, the combination of an engine cylinder, a head for said cylinder, a plurality of intake ports and a plurality of exhaust ports in said head, a rotary valve having a plurality of ports therein for opening and closing said intake and exhaust ports, and a spindle for supporting and rotating said valve, said exhaust and intake ports being arranged alternately about the spindle, each intake port having upwardly extending passages communicating at their upper ends with a common intake passage arranged about the spindle, and each exhaust port likewise having upwardly extending passages communicating with a common exhaust passage, said upwardly extending inlet and exhaust passages in section extending out from the spindle radially along their greatest dimension and flaring outwardly from the spindle, water channels extending adjacent each upright passage, and beneath the common exhaust passage, and over the lower wall of the cylinder head containing the ports, whereby a maximum cooling passage area is obtained adjacent the exhaust passages and the lower wall of the cylinder head.

15. In an internal combustion engine, the combination of an engine cylinder having a valve port casing, a plurality of intake ports and a plurality of exhaust ports in said casing, a rotary valve having a plurality of ports therein for opening and closing said intake and exhaust ports, and a spindle for rotating said valve, each of the intake ports having passages extending outwardly therefrom to a common intake passage substantially surrounding the spindle, and each of the exhaust ports having passages extending outwardly therefrom to a common exhaust passage also substantially surrounding the spindle, with a common wall separating said intake and exhaust common passages.

16. In an internal combustion engine the combination of a plurality of engine cylinders, having valve port casings thereon, with intake and exhaust ports in said casings, rotary valves for opening and closing said ports, spindles passing through the casings for rotating said valves, and oil conduits in the casings each ending at a point spaced from the corresponding spindle and also spaced from the inner ends of the ports of the corresponding valve, and the cylinder body casting having an oil groove in its upper end adjacent the valve port casings and communicating with the oil ducts in the said casings.

17. In an internal combustion engine the combination of an engine cylinder with intake and exhaust ports and a rotary valve for opening and closing said ports and having ports adapted to register with the said intake and exhaust ports at predetermined times during the rotation of the valve, said valve having radial grooves in its surface that is adjacent the intake and exhaust ports and adjacent the rear edge of the ports in the valve to take up oil from the edges of the intake and exhaust ports.

18. In an internal combustion engine the combination of an engine cylinder with intake and exhaust ports and a rotary valve for opening and closing said ports and having ports adapted to register with the said intake and exhaust ports at predetermined times during the rotation of the valve, the exhaust port at the cylinder being wider than the intake port at the cylinder and the bridging part of the valve seat between adjacent exhaust and intake ports being narrower than the respective ports of said valve.

19. In an internal combustion engine the combination of an engine cylinder with intake and exhaust ports and a rotary valve for opening and closing said ports and hav-

ing ports adapted to register with the said intake and exhaust ports at predetermined times during the rotation of the valve, the ports in the valve being sufficiently wide to open the intake ports in the cylinder before the exhaust ports in the cylinder are fully closed.

20. In an internal combustion engine the combination of an engine cylinder having a plurality of intake and exhaust ports, a rotary valve for opening and closing said ports and having valve ports adapted to register respectively with the said intake and exhaust ports, the exhaust ports in the cylinder being wider than the intake ports in the cylinder and the bridging parts of the valve seat between adjacent exhaust and intake ports being of less width than the respective ports of said valve.

21. In an internal combustion engine the combination of an engine cylinder having a valve port casing, with intake and exhaust ports in said casing, a rotary valve for opening and closing said ports, and a spindle for rotating said valve and extending through said casing, said valve being connected to said spindle by a ball and socket joint located beyond said casing and adapted to have a universal movement with respect to the spindle to insure a more accurate seating of the valve on its valve seat.

22. In an internal combustion engine, the combination of an engine cylinder with intake and exhaust ports, a rotary disc valve for opening and closing said ports, a spindle for rotating said valve, and a bearing for said spindle; said valve being connected to said spindle by a universal joint lying beyond the end of said bearing adjacent said valve to allow a more accurate seating of the valve.

23. In an internal combustion engine the combination of an engine cylinder with intake and exhaust ports, a rotary valve for opening and closing said ports, and a spindle for rotating said valve, said valve being connected to said spindle by a universal joint to insure a more accurate seating of the valve on its valve seat and a member cooperating with apertures in the spindle and valve to cause the valve to rotate with the spindle without preventing the valve from having a universal movement with respect to the spindle.

24. In an internal combustion engine the combination of an engine cylinder having a valve port casing, with intake and exhaust ports therein, a rotary valve for opening and closing said ports, a vertical spindle extending through said casing and having a shoulder at its lower end on which said valve is supported so as to be movable with respect to the spindle to insure seating of the valve and means connecting said spindle and valve to cause the valve to rotate with the spindle while permitting relative tilting of the valve on the spindle.

25. In an internal combustion engine, the combustion of an engine cylinder, a valve port casing, a plurality of intake ports and a plurality of exhaust ports in said casing, a rotary valve having a plurality of ports therein for opening and closing said intake and exhaust ports, and a spindle journalled in said casing for supporting and rotating said valve, said intake ports being arranged in the casing about said spindle alternately with said exhaust ports which are also arranged in said casing about said spindle, each of the intake ports having passages extending upwardly therefrom along the spindle to a common intake passage communicating with the upper ends of said individual intake passages, and each of the exhaust ports having passages extending therefrom upwardly along the spindle to a common passage with which they communicate at their upper ends, said casing having water cooling chambers extending between certain of the upwardly extending passages and to the wall of the valve spindle and between the common passages and the lower surface of the casing in which said ports are formed.

26. In an internal combustion engine, the combination of an engine cylinder, a head for said cylinder, a plurality of intake ports and a plurality of exhaust ports in said head, a rotary valve having a plurality of ports therein for opening and closing said intake and exhaust ports and a spindle journalled in said head for supporting and rotating said valve, said intake ports being arranged in the head of the cylinder about said spindle alternately with said exhaust ports which are also arranged in said head about said spindle, each of the exhaust passages extending upwardly along the valve spindle, a common exhaust passage substantially surrounding said spindle and with which the upper ends of the individual exhaust passages communicate, each of the intake ports likewise having individual passages extending upwardly along the valve spindle each adjacent an exhaust passage, with an intervening wall between the two, a common intake passage substantially surrounding the spindle and being separated from the exhaust passage by a common wall whereby the fuel gasses in the common and individual intake passages are subjected directly to the heat of the walls of the common and individual exhaust passages.

In testimony whereof, we have signed our names to this specification.

FREDERICK M. GUY,
FREDERICK R. SUNDERMAN.