

April 24, 1945.

W. G. GERNANDT

2,374,191

ENGINE

Filed May 2, 1942

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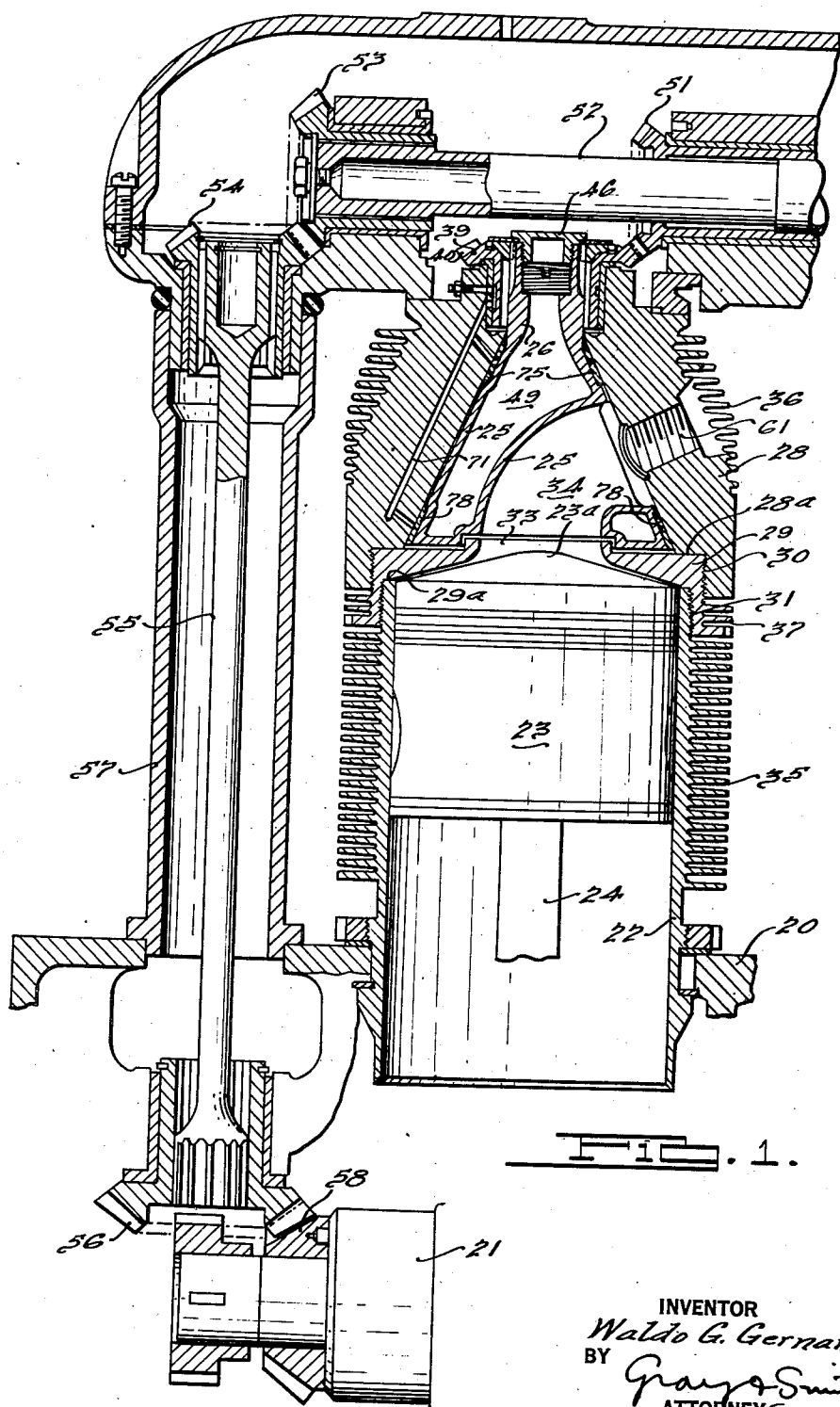


FIG. 1.

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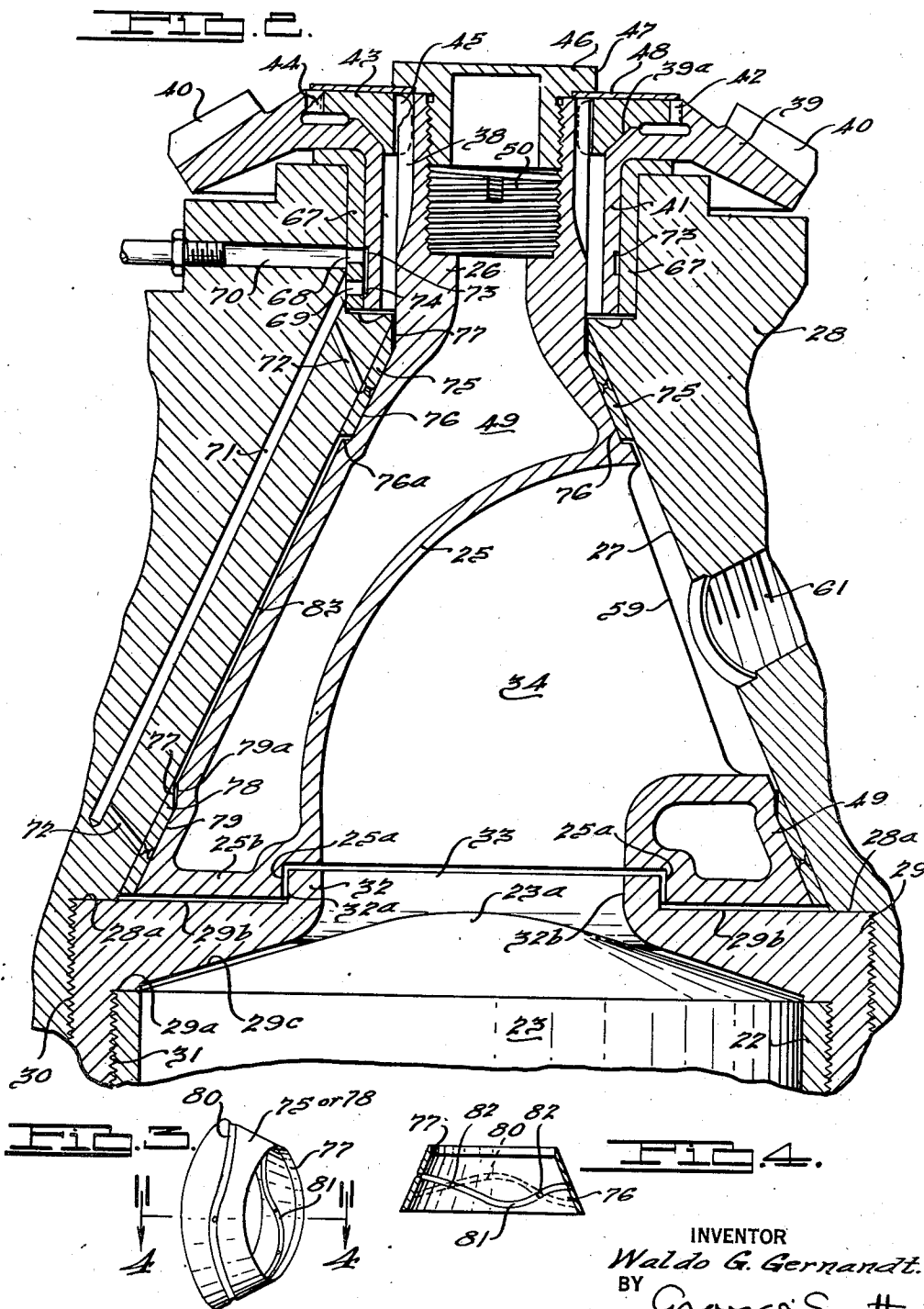
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4 Sheets-Sheet 2



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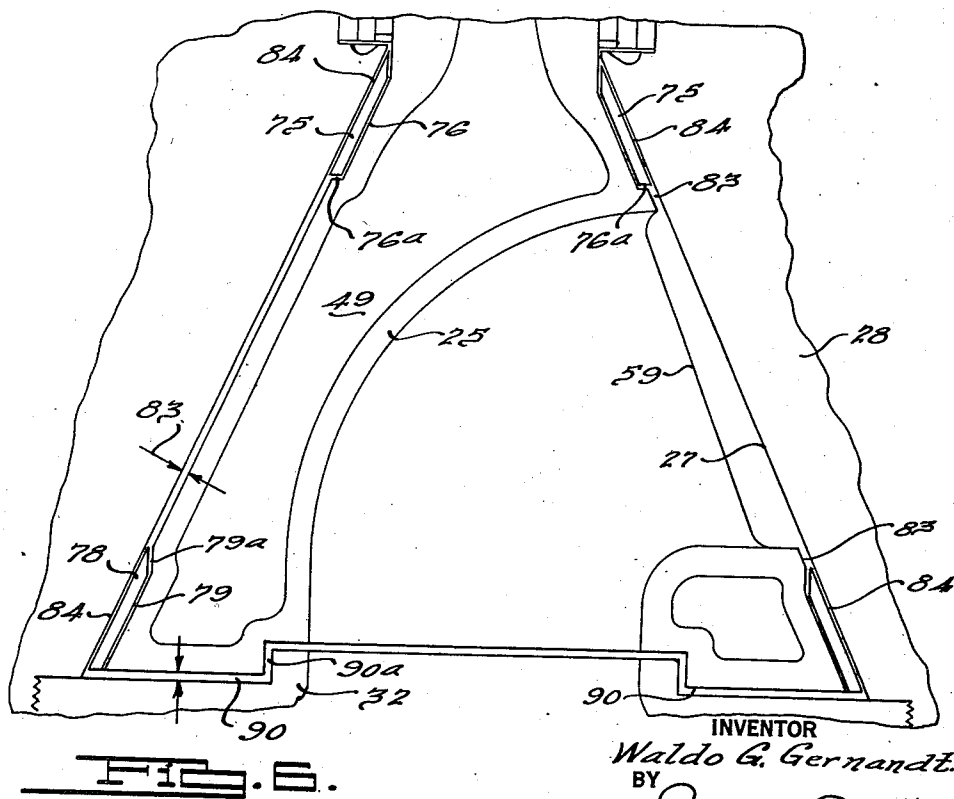
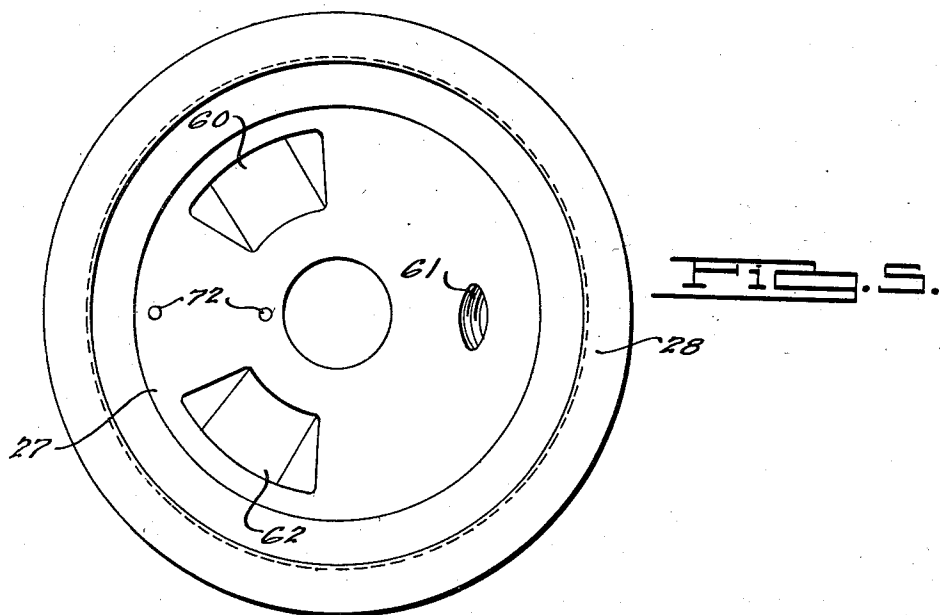
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4 Sheets-Sheet 3



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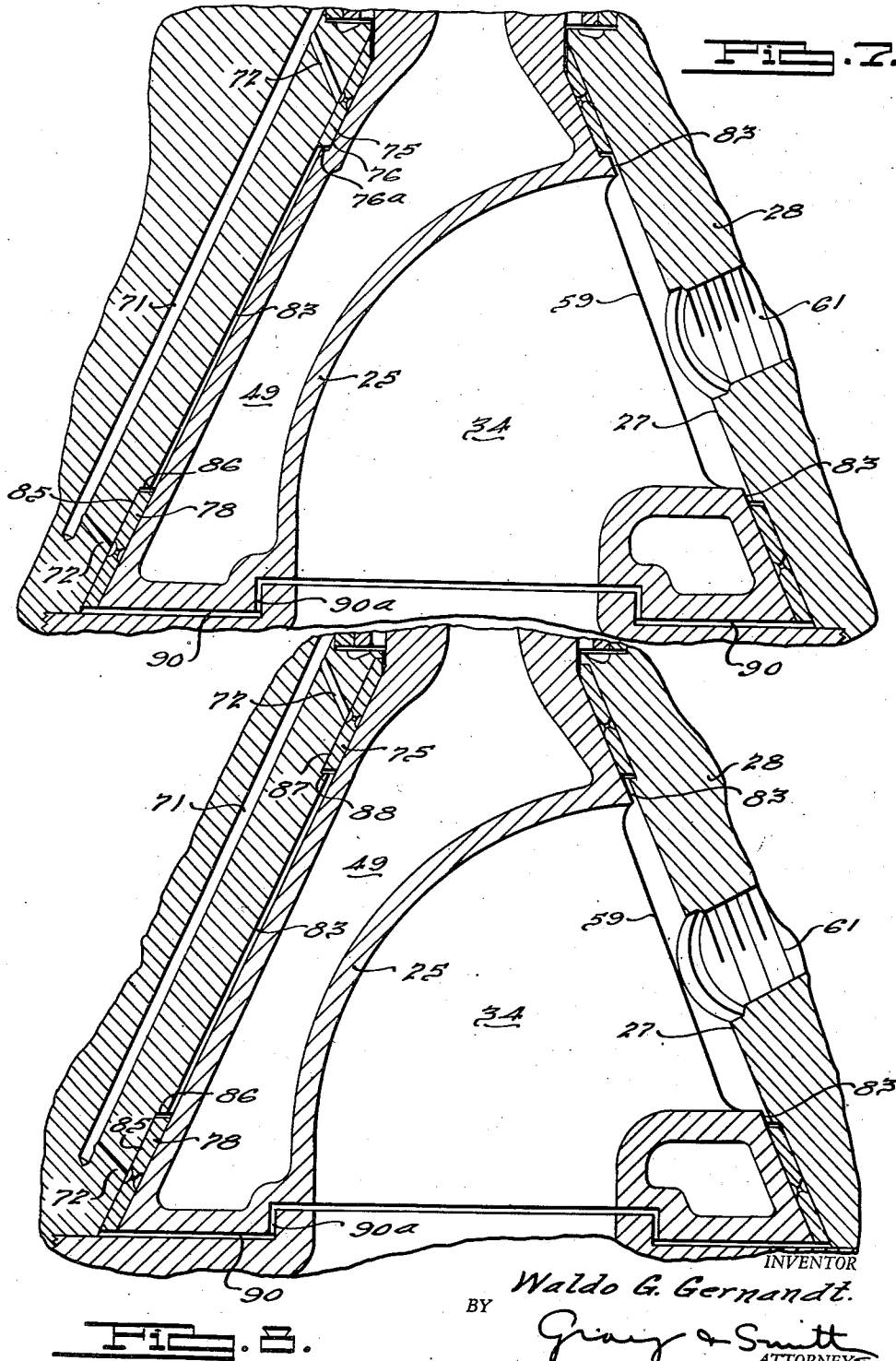
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2,374,191

ENGINE

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4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

2,374,191

ENGINE

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Application May 2, 1942, Serial No. 441,474

34 Claims. (Cl. 123—190)

This invention relates to internal combustion engines and particularly to engines of the type having a rotatable valve in the head thereof.

The present invention has particular application to an internal combustion engine of the kind in which the rotatable valve in the head, preferably although not necessarily of the kind which rotates continuously in one direction, is formed with substantially all or at least the major portion of the combustion chamber and is generally conical or frusto-conical in shape.

In the preferred embodiment of the invention the combustion chamber in the valve has an opening or port in the side of the valve adapted to communicate with an intake or exhaust passage, or both as the case may be, and also an opening at the inner end or bottom of the valve leading to the cylinder. With the exception of the ports in the side and bottom of the rotor which afford communication between the combustion chamber, cylinder and intake or exhaust passage or passages, the combustion chamber is otherwise entirely enclosed or housed within the valve member or rotor. The combustible charge within the combustion chamber is fired preferably by spark ignition although in its broader aspects the invention is not considered to be so limited.

Engines of the foregoing type present the possibility of considerable advantages, long recognized, as compared with conventional engines of the poppet valve type, such as simplification of construction, reduction in weight, and higher speed operation with consequent increase in power output. Many problems have heretofore been encountered in the production of a satisfactory engine of this type, such as in respect to adequate lubrication of the valve or rotor under sustained operation, satisfactory control and limitation of oil consumption, elimination of power losses due to excessive friction between moving parts, and the provision of efficient and durable bearings for the rotatable valve or rotor.

The foregoing problems have been rendered difficult of solution because of variations in pressures or forces acting upon the valve during the engine cycle. One major difficulty has arisen by reason of the effect of the explosion force or pressure in driving the cone-type valve member not only outwardly but also laterally, thereby causing a severe wedging action or thrust of the valve against its seat and tending to seriously impair the oil film between the surfaces of the valve and its bearing seat in the cylinder head, resulting in seizing and scoring of the valve member. Unsuccessful attempts have been made to avoid these

disadvantages or difficulties, in order to attain efficient and sustained high speed performance, such as is required for aircraft engines, by resorting to elaborate bearing arrangements and by experimentation with various materials and combinations of materials for the bearing surfaces of the valve within the cylinder head. I have found that the power output of the engine is materially affected by the effectiveness of the seal of the intake and exhaust ports in the cylinder head during the compression and power strokes of the piston, particularly the latter and especially at the time of explosion. Leakage of gases between the surfaces of the valve and head and around these ports will markedly reduce the power output of the engine. Heretofore, where it was attempted to avoid this by fitting the valve quite snugly within its bearing cavity in the head, other difficulties of a serious nature were immediately encountered, such as the impairment of the oil film and consequent seizure of the valve or scoring thereof.

An important object of the invention is to provide an improved internal combustion engine of the foregoing type in which considerable and preferably most of the bearing load is distributed over or concentrated at two predetermined areas of the frusto-conical rotor, namely, at different areas at the outer and inner ends of the frusto-conical portion of the valve member or rotor, and in these areas in which this bearing load is taken there are provided bearing rings interposed between the rotor and the cylinder head.

Still a further object of the invention is to provide an improved internal combustion engine of the foregoing type in which most of the bearing load, or at least a substantial portion thereof, at the time of explosion is concentrated in predetermined areas adjacent the outer and inner ends of the frusto-conical valve member, and in these areas there are provided floating annular bearing members or bushings interposed between the valve or rotor and the cylinder head.

A further object of the invention is to control more effectively the position of the rotor within the cylinder head and thereby avoid scoring and seizing of the valve, to increase the power output by reducing leakage of gases around the intake and exhaust ports, and to improve the lubrication of the valve while reducing oil consumption.

Still another object of the invention is to simplify the bearing for the valve or rotor within the cylinder head, eliminating complicated thrust bearing arrangements, complicated adjustment devices therefor, reducing weight, saving space,

increasing the performance life of the engine, and permitting the use of less expensive metals in the fabrication of the rotor valve and the cylinder head.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Fig. 1 is a fragmentary sectional elevation illustrating a portion of a multi-cylinder engine embodying the present invention.

Fig. 2 is an enlarged fragmentary sectional elevation illustrating particularly the associated cylinder head and rotary valve or combustion chamber structure shown in Fig. 1.

Fig. 3 is a perspective view of one of the floating bearing members.

Fig. 4 is a section taken substantially through lines 4-4 of Fig. 3 looking in the direction of the arrows.

Fig. 5 is a bottom plan view of a portion of the cylinder head illustrating particularly the bearing cavity for the rotor or rotary valve.

Fig. 6 is a generally diagrammatic view illustrating particularly the manner in which the valve or rotor is mounted within the cylinder head and the preferred clearances at the sides and bottom of the valve.

Figs. 7 and 8 are sectional views in part similar to Fig. 2 but illustrating additional embodiments.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

In the drawings there are illustrated, by way of example, several embodiments of the invention as applied to an internal combustion engine of the spark ignition type designed particularly for the power plant of an aircraft. The invention may obviously be embodied in engines for other purposes, such as automotive, marine and industrial engines. For most uses the engine is of the multi-cylinder type, although any number of cylinder units may be employed in any given engine. In the present embodiment, for the purposes of simplicity, a single cylinder unit of the engine is illustrated, it being understood that the remaining cylinders of the engine are identical to the structure herein shown and described.

Referring to Fig. 1, the present engine comprises a suitable crankcase 20 within which is mounted a crankshaft 21 supported in bearings according to conventional practice. A cylinder 22 is secured rigidly to the crankcase and has its lower or inner end projecting thereinto. Mounted to reciprocate within the cylinder is a piston 23 adapted to be connected in the usual manner by a connecting rod 24 to the crankshaft 21.

In the present engine the combustion chamber of the cylinder is formed principally within a rotor or rotary member 25, this member comprising a frusto-conical body arranged immediately above the piston when at the top of its stroke and also having a cylindrical stem 26 projecting from the outer end of the rotor body. The rotor 25 fits within a correspondingly shaped substantially frusto-conical cavity 27 in an upper cylinder head

member 28. The cylinder head of the engine may be said to comprise two portions or members secured together and to the upper end of the cylinder 22. In addition to the outer member 28 the cylinder head comprises an intermediate member 29 which may herein be termed the rotor mask or shield and forming the pressure control member for the rotor and head and also the throat opening from the cylinder into the combustion chamber.

The upper or outer end of the cylinder is formed with external threads which are engaged by internal threads on the cylindrical skirt portion of the head member 28 as indicated at 31. The member 29 in turn is provided with external threads which are engaged by internal threads on the cylindrical skirt portion of the outer cylinder head member 28, as indicated at 30. From this construction it will be seen that the cylinder head or mask member 29 may be screwed down tightly over the outer end of the cylinder 22 until the annular shoulder 29a of the member 29 substantially abuts against or engages the upper or outer edge of the cylinder, as shown in Figs. 1 and 2. Also it will be seen that the outer cylinder head member 28 is screwed down tightly over the member 29 until the bottom shoulder 28a of the head 28 substantially engages or abuts against the upper flat ledge or face 29b of the mask member 29 or fire plate 29.

The rotor mask or shield 29 terminates centrally in a projecting annular flange 32 which forms the throat opening 33 into the combustion chamber 34 of the rotor member or rotary valve 25. This rotor is formed at its bottom with an annular recessed portion 25a, the annular surfaces of which are flat and smooth and correspond in shape to the adjacent exposed surfaces of the throat flange 32, there being normally a predetermined clearance between the juxtaposed surfaces of the rotor 25 and the plate 29, as hereinafter described. The lower or inner end 25b of the rotor, which is annular in shape and which terminates in a smooth flat surface, fits into and is confined within the annular recess formed between the outer face 32a of the throat flange 32 and the inner tapered wall of the rotor cavity or chamber 27 in the cylinder head.

The piston 23 is preferably formed at its outer end with a tapered portion 23a, as illustrated in Fig. 1, which projects into the throat opening 33, thereby reducing the size of the combustion space and preferably confining the combustion chamber substantially to the space within the rotor 25. The piston at the top of its stroke, as shown in Fig. 1, preferably has only a minimum operating clearance with the bottom correspondingly tapered wall 29c of the mask or fire plate 29. The upwardly inclined wall 29c of the mask or fire plate 29 merges into the annular inner wall or surface 32b of the flange 32 forming the throat opening, the surfaces 29c and 32b being joined by a smooth curved surface as shown in the drawings. In will thus be seen that the throat flange 32 provides a restricted passage between the cylinder and the combustion space 34.

The present engine is illustrated as being air cooled and, accordingly, the cylinder 22 is provided with projecting fins 35. Cooling fins 36 and 37 are also provided on the cylinder head members 28 and 29, respectively. It will be understood that the present invention is not limited to an air cooled engine as it will be apparent that any effective cooling system may be utilized.

The rotor 25 is driven through the medium of

the stem 26 which is positively connected to a driving gear in such manner as to permit slight relative axial and radial movement between the driving gear and the rotor. The stem 26 of the rotor is provided with external longitudinal splines 38 and is also provided with internal threads within the cylindrical bore thereof. The rotor is driven by a gear 39 having suitable gear teeth 40, this gear being formed with a depending cylindrical hub or sleeve 41 having a clearance over the stem 26. The gear 41 also has internal tooth-like splines 42. A coupling member 43 fits within the annular space formed between the teeth 42 of the driving gear 39, this coupling member having exterior teeth or splines 44 fitting into the spaces between the splines 42 of the driving gear and also having internal splines 45 fitting within the spaces formed by the splines 38 of the stem 26. The coupling member 43 has an annular tapered surface engageable with a correspondingly shaped tapered surface 39a of the gear 39. 46 is a clamping nut having external threads engageable with the threads of the valve stem 26 and having an outwardly projecting hex formed flange 47. Interposed between this flange and the end of the stem 26 is a spring washer 48 having a central aperture through which the clamping nut projects, the washer being of a sufficient diameter to engage the upper face of the gear 39, as shown in Fig. 2.

The rotor body 25 is cored entirely around the combustion chamber 34 to provide a cavity 49 which is closed at the upper end of the valve by means of a screw plug 50 screwed tightly into the threaded portion of the valve stem 26 below the clamping nut 46. Any suitable heat transfer or conducting medium, such as metallic sodium, is introduced into the cavity 49 through the hollow stem 26, and sealed therein by the screw plug 50.

Referring to Fig. 1, the gear 39, which is attached to the projecting stem of the rotor 25, is driven through the medium of a gear 51 attached to a top horizontal shaft 52. This shaft is of the desired length to permit simultaneous driving of the rotors of a plurality of cylinders arranged in line. Attached to the end of the shaft 52 is a gear 53 which is driven by a gear 54 secured to the upper end of a tower shaft 55. This shaft is suitably housed at 57 and has secured to the lower end thereof a gear 56 which is driven through the medium of a gear 58 attached to the crankshaft 21.

It will be seen that in the particular embodiment herein illustrated the rotor or valve 25 has a single port 59 in its side communicating with the combustion chamber 34 adapted to register in succession with an intake port 60, a spark plug at location 61, and an exhaust port 62. In this embodiment, therefore, the valve or rotor 25 is driven at one-half engine or crankshaft speed. The driving mechanism, above described and shown in the drawings, is illustrative of a suitable mechanism by which one or a plurality of rotary valves for a corresponding plurality of cylinders may be driven from the crankshaft.

The spark plug location 61 is in the form of a tapped hole for the reception of a spark plug of any suitable type. The intake and exhaust ports or passages 60 and 62, formed in the cylinder head 28, open into the frusto-conical cavity 27 of the cylinder head and at these points the passages 60 and 62 are shaped in the manner illustrated in Fig. 5.

The present engine preferably utilizes a fuel

injection system instead of a carburetor, although it will be understood that the invention is not so limited. Fuel is preferably supplied to the air stream directed through the inlet passage 60 into the combustion chamber when the port 59 in the rotor 25 registers with the port or passage 60. Fuel may be injected through the medium of any suitable fuel injector (not shown) so that the rotor will be supplied with the proper combustible mixture at the time of ignition, namely when the port 59 registers with the spark plug at location 61. It will be understood that suitable lubricating means is provided for the rotor 25 and also for the operating parts of the engine so as to maintain an oil film between all surfaces requiring lubrication. Such lubricating means in part may be similar to that shown and described in the patent to Isley, 2,305,874, December 22, 1942.

The frusto-conical cavity 27 in the cylinder head 28 terminates at its upper end in a cylindrical counterbore within which is press fitted a sleeve or bushing 67. The sleeve or hub portion 41 of gear 39 rotates within the bushing 67. The bushing 67 at one side thereof is provided with vertically spaced radially extending holes or ports 68 and 69. The upper hole or port 68 registers with and is constantly in communication with a transverse drilled hole 70 in the upper end of the cylinder head. Lubricating oil is supplied under constant pressure to the passage or conduit 70 through the medium of any suitable oil pump system. The lower hole or port 69 registers with and is constantly in communication with the upper end of a drilled hole 71. Leading from the passage 71 to the tapered wall of the cavity 27 and hence to the space between the adjacent walls of the rotor 25 and the cavity or recess 27 are relatively narrow or small ducts or passages 72. The sleeve 41 of the gear 39 is provided with an annular groove or channel 73 (see Fig. 2) which registers and is in constant communication with the port 68 and hence with the oil inlet conduit 70. At one point in the annular groove or channel 73 there is provided a communicating groove or notch 74 which extends downwardly from the channel 73. This groove or notch 74 is adapted to register at each revolution of the gear 39 and hence at each revolution of the rotor 25 with the port 69 leading into the communicating oil passage 71. Thus, it will be seen that at each revolution of the driving gear 39 and of the rotor 25 the oil inlet passage 70 will be placed in direct communication with the oil distributing passage 71 through the medium of the oil ports 68 and 69 and oil passage 74 which bridges the space between these ports. In this manner the oil delivered to the valve for lubricating it is metered and as a consequence more efficient control of the oil consumption is achieved.

Interposed between the upper end of the tapered wall of the valve or rotor 25 and the correspondingly tapered wall of the cylinder head cavity 27 is a rotatable thrust bearing ring 75 formed of a suitable material such as bronze or lead bronze alloy. The rotor is formed with an annularly extending recess 76 to receive the frusto-conical ring 75 which is a free floating bearing between the rotor and cylinder head. In the present embodiment of the invention the upper edge of the bearing ring 75 is machined on the inner surface thereof to provide a cylindrical portion 77 adapted to fit smoothly against the outer cylindrical surface of the stem 26. Thus, the inner surface of the ring 75 bears smoothly

against the bottom tapered or inclined surface of the recess 76 in the valve and the upper edge of the ring is tapered so as to bear at its outer surface against the converging wall of the cavity 27 and at its inner surface against the cylindrical stem 26, as clearly seen in Fig. 2. The recess 76 is formed so that normally there is a space or clearance between the lower edge of the bearing ring and the lower edge of the recess at 76a. The width of the bearing ring 75 and recess is preferably such that their lower edges are located a suitable distance above the upper edges of the ports 60 and 62 and similarly above the port 59.

Interposed between the lower end of the tapered wall of the valve or rotor 25 and the tapered wall of the cylinder head cavity 27 is a second rotatable thrust bearing ring 78 formed of material similar to that of the upper ring 75. The lower ring 78 may have substantially the same construction as the upper ring 75, as shown in Figs. 3 and 4, and in like manner is housed within a similarly shaped annularly extending recess 79 in the outer surface of the valve or rotor 25. The width of the recess 79 is somewhat greater than the bearing ring 78 so as to produce normally a clearance 79a between the adjacent upper tapered edge 77 of the ring and the correspondingly tapered upper edge of the recess. The width of the bearing ring 78 and recess 79 is such that their upper edges are located a suitable distance below the lower edges of the ports 59, 60 and 62, the lower edge of the ring 78 terminating flush with the bottom of the valve. The clearances 76a and 79a are important in permitting slight relative axial movement of the valve and rings during operation.

Since the rings 75 and 78 are free from positive connection with the rotor and cylinder head and, therefore, substantially float therebetween, it will be seen that these rings will have rotational movement imparted to them during rotation of the rotor. Normally the rings 75 and 78 will turn at half the speed of the rotor, thus materially reducing frictional losses and providing a very efficient and long lived bearing for the rotor. The rotor, therefore, will rotate relatively to the rings which in turn will rotate relatively to the head, and these parts also will be permitted relative movement in a direction parallel to wall 27.

Each of the bearing rings 75 and 78 is provided on its outer and inner surfaces with serpentine or generally zigzag oil grooves 80 and 81, respectively. The undulations of the grooves are arranged reversely to each other. Where the paths of the inner and outer oil grooves 81 and 80 cross each other, as shown in Fig. 4, the two grooves are connected by holes 82 drilled through the wall of the bearing. An adequate and metered supply of oil is directed to the bearing rings 75 and 78 during operation of the engine through the medium of two of the oil passages 72 leading from the oil distributing passage or conduit 71. Lubricating oil thus will be delivered at timed intervals and in predetermined amounts to the outer surfaces of the bearing rings 75 and 78 and, hence, to the outer oil grooves 80 therein. Oil will be collected in the serpentine grooves 80, which extend entirely around the bearing rings, and will provide adequate lubrication for the entire outer surfaces of the bearing rings. Some of this oil will be forced through the holes 82 into the inner serpentine oil grooves 81 and thus will lubricate adequately the inner surfaces of the bearing rings.

An important feature of the present invention

resides in the fact that the bearing loads between the rotor or valve 25 and the head 28 are taken substantially entirely at the locality of the bearing rings 75 and 78. To accomplish this purpose the areas between the bearing rings are relieved to such an extent as to provide a greater clearance between the valve and cylinder head walls than the clearance at the locality of the rings. The various clearances between the valve, bearing rings and associated cylinder head parts have been exaggerated in the drawings in order to illustrate these features more clearly. This applies especially to Figs. 6 to 8 inclusive which are intended to be largely diagrammatical.

In the embodiment of Fig. 6 the bearing rings 75 and 78 are, as above described, located in annular recesses 76 and 79 formed in the outer wall of the valve 25. All surfaces of the outer wall of the valve 25 are relieved a corresponding amount between the bearing rings 75 and 78, as indicated at 83, so as to space these surfaces away from the adjacent surfaces of the cylinder head 28 sufficiently to relieve them of any material bearing loads. In the preferred construction there is what is ordinarily considered an operating or running clearance between the bearing rings and the adjacent surfaces of the cylinder head 28 and also between the inner faces of the bearing rings and the bottom surfaces of the recesses 76 and 79. These running or operating clearances are indicated in Fig. 6 at 84 whereas the clearances between the bearing rings are increased materially as indicated at 83. The clearances at 83 may be in the neighborhood of one and one-half or two thousandths of an inch greater than the operating clearances at 84. From this construction it will be readily seen that the principal bearing loads are taken at the bearing rings, all other surfaces of the valve between these rings being relieved of load.

In the embodiment of Fig. 7 the upper bearing ring 75 is mounted within the annular recess 76 in the valve as described in the previous embodiment. However, in this instance the lower bearing ring 78 is mounted within an annular recess 85 formed in the cylinder head 28. These bearing rings have the same operating clearances with the valve and cylinder head as described in connection with Fig. 6, and the increased clearance 83 at all surfaces between the bearing rings is the same as in the embodiment of Fig. 6. The lower bearing ring 78 is also free to move in an axial direction relatively to the surface of the recess 85 and also relatively to the valve 25, this being permitted by virtue of the clearance 86 between the upper edge of the bearing ring and the upper edge of the recess 85.

In the embodiment of Fig. 8 both bearing rings 75 and 78 are mounted in recesses formed in the cylinder head 28 instead of within recesses formed in the valve according to the embodiment of Fig. 6. As illustrated in Fig. 8, the upper bearing ring 75 is mounted within an annular recess 87 in the cylinder head 28, a clearance 88 being provided between the lower edge of the bearing ring and the recess 87. The lower bearing ring 78 in the embodiment of Fig. 8 is mounted in the same manner as described in connection with the embodiment of Fig. 7. The operating clearances at the locality of the bearing rings are the same in all embodiments and the increased clearance at 83 in the areas between the bearing rings is also preferably the same in all embodiments.

The bottom of the rotor 25 is substantially at all times free from bearing or frictional contact

with the mask plate 29. The rotor is normally held away from the mask or flame plate 29 by the spring ring 48. At the time of the explosion there is some resultant force tending to shift the rotor toward the side of the cavity 27 opposite the spark plug location 61 and also to shift the rotor outwardly in an axial direction. These forces are all transmitted to the cylinder head through the bearing rings 75 and 78 which relieve the remainder of the valve wall between these bearings of any material bearing loads. Moreover, since the rings girdle the valve above and below the ports 59, 60 and 62, they will effectively seal these ports against leakage of gases from the combustion chamber. At the time of maximum outward pressure on the valve the clearance between the bottom of the valve and the mask plate 29 will preferably be approximately fifteen thousandths of an inch, as indicated at 90 and 90a in Fig. 7. The construction and amount of relief are such that throughout the cycle of operation a clearance is maintained between all adjacent surfaces of the valve and the mask plate so that at no time does the valve ride upon or against any surface of the mask plate.

The use of the floating bearing rings 75 and 78 and the provision of increased clearance in the areas at 83 eliminate the necessity of oiling the surfaces between the rings and thereby reduce greatly the oil loss due to burning off of oil when surfaces of the cylinder head are exposed to the combustion chamber at port 59. It is only necessary to conduct oil as at 72 to the bearing rings and in effect the areas at 83 can be left free of any oil film. Thus, great savings in oil consumption as well as appreciable increase in the life of the valve due to elimination of friction are possible. The use of the floating bearing rings 75 and 78 has the further advantage of permitting substantial savings in the cost of metals used for manufacturing the head and the valve 25. By virtue of this construction it is possible to use cast iron in the head instead of aluminum as heretofore and also to use inexpensive steel in the manufacture of the cone 25.

I claim:

1. In an internal combustion engine having a cylinder head, a rotatable cone type valve therein, and a plurality of spaced floating frusto-conical bearing rings interposed between adjacent tapering walls of the valve and head, each ring extending into a recess in one of said walls.

2. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped cavity in said head, and a free floating bearing ring interposed between the wall of said valve and the wall of the cavity adjacent the wider end of the valve, said ring extending into a recess in one of said walls.

3. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a bearing ring interposed between said valve and the wall of the recess adjacent the wider end of the valve, said ring being located in a recessed portion of the valve, and free to rotate relative thereto.

4. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a bearing ring interposed between said valve and the wall of the recess adjacent the wider end of the valve, said ring be-

ing free of said valve and wall and extending into a recess in one thereof.

5. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a bearing ring interposed between said valve and the wall of the recess adjacent the wider end of the valve, said ring being located in a recessed portion of the valve and being free of said valve and wall.

6. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of free floating bearing rings interposed between the wall of said valve and the wall of the recess adjacent the narrower and wider ends of the valve, each ring extending into a recessed portion of one of said walls.

7. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of bearing rings interposed between said valve and the wall of the recess adjacent the narrower and wider ends of the valve, said rings being located in recessed portions of the valve and free to rotate relative thereto.

8. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of bearing rings interposed between the wall of said valve and the wall of the recess adjacent the narrower and wider ends of the valve and each being free of said valve and wall, each ring extending into a generally similarly shaped recessed portion of one of said walls.

9. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of bearing rings interposed between the outer wall of the valve and the wall of the recess adjacent the narrower and wider ends of the valve, said rings being located in recessed portions of one or the other of said walls and being free of said walls.

10. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of free floating bearing rings interposed between said valve and the wall of the recess adjacent the narrower and wider ends of the valve, said valve and recess wall having sufficient clearance in the area between said rings to cause most of the bearing load to be applied at the locality of said rings.

11. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of bearing rings interposed between said valve and the wall of the recess adjacent the narrower and wider ends of the valve, said rings being located in recessed portions of the valve and free to rotate relative thereto, said valve and recess wall having sufficient clearance in the area between said rings to cause most of the bearing load to be applied at the locality of said rings.

12. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of bearing rings interposed between said valve and the wall of the recess adjacent the narrower and wider ends

of the valve and each being free of said valve and wall, said rings being free to move axially of the valve.

13. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a pair of bearing rings interposed between the outer wall of the valve and the wall of the recess adjacent the narrower and wider ends of the valve, said rings being located in recessed portions of one or the other of said walls and being free of said walls, said rings being free to move axially of the valve and constructed to receive most of the bearing loads during operation.

14. An internal combustion engine comprising a cylinder head, a cylinder having a reciprocable piston therein, a rotatable frusto-conical valve in said head having a chamber forming a substantial portion of the combustion space, said valve having a port in the base thereof connecting said cylinder and chamber and a port in the tapered side wall thereof leading to said chamber, and a pair of floating bearing rings interposed between the valve and head at opposite sides of said last named port and constructed to receive most of the bearing loads during operation.

15. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a bearing ring interposed between said valve and the wall of the recess adjacent one end of the valve, said ring being located in a recessed portion of the head and free to rotate relative thereto.

16. An internal combustion engine comprising a cylinder having a reciprocable piston therein, a rotatable frusto-conical valve associated with the cylinder and including therein a substantial portion of the combustion space, a fixed body having a frusto-conical bearing cavity for said valve, a pair of floating frusto-conical bearing rings interposed between said valve and the wall of said cavity, a portion of the wall of said cavity being relieved between said rings, one of said rings being freely mounted in a recessed portion of said cavity and the other of said rings being freely mounted in a recessed portion of said valve.

17. An internal combustion engine comprising a cylinder having a reciprocable piston therein, a rotatable frusto-conical valve associated with the cylinder and including therein a substantial portion of the combustion space, a fixed body having a frusto-conical bearing cavity for said valve, and a pair of frusto-conical bearing rings interposed between the outer wall of the valve and the adjacent wall of said cavity, each ring being freely mounted in a recessed portion of one of said walls, and one of said walls between said rings having a relieved area whereby said bearing rings are adapted to receive the major portion of the bearing load during operation.

18. In an internal combustion engine having a cylinder, a rotatable valve associated with the cylinder and having a combustion chamber therein, a fixed body having a cavity to receive the valve, the valve and cavity having corresponding converging walls, two spaced floating bearing rings interposed between the adjacent walls of the valve and cavity, conduit means for supplying lubricating oil through the wall of said cavity solely at points opposite said rings.

19. In an internal combustion engine having a cylinder, a rotatable valve associated with the cylinder and having a combustion chamber

therein, a fixed body having a cavity to receive the valve, the valve and cavity having corresponding converging walls, two spaced floating bearing rings interposed between the adjacent walls of the valve and cavity, conduit means for supplying lubricating oil through the wall of said cavity solely at points opposite said rings, the areas of the adjacent walls of the valve and cavity between said rings being free of direct lubrication.

20. In an internal combustion engine having a cylinder, a rotatable valve associated with the cylinder and having a combustion chamber therein, a fixed body having a cavity to receive the valve, the valve and cavity having corresponding converging walls, two spaced floating bearing rings interposed between the adjacent walls of the valve and cavity, conduit means for supplying lubricating oil through the wall of said cavity solely at points opposite said rings, the areas of the adjacent walls of the valve and cavity between said rings being spaced and free of direct lubrication.

21. In an internal combustion engine having a cylinder, a rotatable valve associated with the cylinder and having a combustion chamber therein, a fixed body having a cavity to receive the valve, the valve and cavity having corresponding converging walls, two spaced floating bearing rings interposed between the adjacent walls of the valve and cavity, conduit means for supplying lubricating oil through the wall of said cavity solely at points opposite said rings, said bearing rings having means for conveying oil from one surface to the other thereof.

22. In an internal combustion engine having a cylinder head, a rotatable cone type valve therein, a pair of floating bearing rings interposed between adjacent tapering walls of the valve and head and spaced apart in the direction of the axis of rotation of the valve, and conduit means for supplying lubricating oil directly to said bearing rings and through the walls of the rings.

23. In an internal combustion engine having a cylinder and a reciprocable piston therein, a rotatable generally frusto-conical valve associated with the cylinder and including therein a substantial portion of the combustion space, a fixed body having a generally frusto-conical cavity for said valve, a bearing ring interposed between adjacent tapering walls of the valve and head and free of said walls, and means for supplying lubricating oil to said ring and through the wall thereof.

24. In an internal combustion engine having a cylinder and a reciprocable piston therein, a rotatable generally frusto-conical valve associated with the cylinder and including therein a substantial portion of the combustion space, a fixed body having a generally frusto-conical cavity for said valve, and a bearing ring interposed between adjacent tapering walls of the valve and head and free of said walls, said ring having passage means therethrough for lubricating oil.

25. In an internal combustion engine having a cylinder and a reciprocable piston therein, a rotatable generally frusto-conical valve associated with the cylinder and including therein a substantial portion of the combustion space, a fixed body having a generally frusto-conical cavity for said valve, and a bearing ring interposed between adjacent tapering walls of the valve and head and free of said walls, said ring having an

oil groove in a wall thereof and a passage through the wall leading into said groove.

26. In an internal combustion engine having a cylinder and a reciprocable piston therein, a rotatable generally frusto-conical valve associated with the cylinder and including therein a substantial portion of the combustion space, a fixed body having a generally frusto-conical cavity for said valve, and a bearing ring interposed between adjacent tapering walls of the valve and head and free of said walls, said ring having zig-zag oil grooves in opposite surfaces thereof and an oil passage connecting said grooves.

27. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a bearing ring interposed between said valve and the wall of the recess adjacent the narrower end of the valve, said ring being located in a recessed portion of the valve and free to rotate relative thereto.

28. An internal combustion engine comprising a cylinder head, a rotatable frusto-conical valve mounted within a generally similarly shaped recess in said head, and a bearing ring interposed between said valve and the wall of the recess adjacent the narrower end of the valve, said ring being located in a recessed portion of the valve and being free of said valve and wall.

29. In an internal combustion engine having a cylinder head and a rotatable valve therein having a tapering wall associated with a tapering wall in the head, a floating bearing ring interposed between said walls and extending into a recess in one thereof.

30. In an internal combustion engine having a cylinder head and a rotatable cone type valve therein, a floating bearing ring interposed between a portion only of the adjacent tapering walls of the valve and head and extending into a recess in one of said walls, the depth of said recess being substantially equal to the wall thickness of the ring.

31. In an internal combustion engine having a cylinder head and a rotatable valve therein having a tapering wall associated with a tapering wall in the head, a floating bearing ring interposed between said walls and extending into a recess in the valve wall.

32. In an internal combustion engine, a cylinder head, a rotatable cone type valve therein, a floating generally frusto-conical bearing ring interposed between adjacent tapering walls of the valve and head, said ring having a width less than the height of the said tapering wall of the valve and located in a recessed portion of one of said walls.

33. In an internal combustion engine, a cylinder head, a rotatable valve therein, said head and valve having cooperating tapering walls, a rotatable bearing ring freely interposed between adjacent walls of the valve and head and located in a recessed portion of one thereof.

34. An internal combustion engine comprising a cylinder head, a rotatable valve, said valve and head having cooperating tapering walls, and a bearing ring located in a recess in one wall adjacent one end of the valve and being free of said valve and head.

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