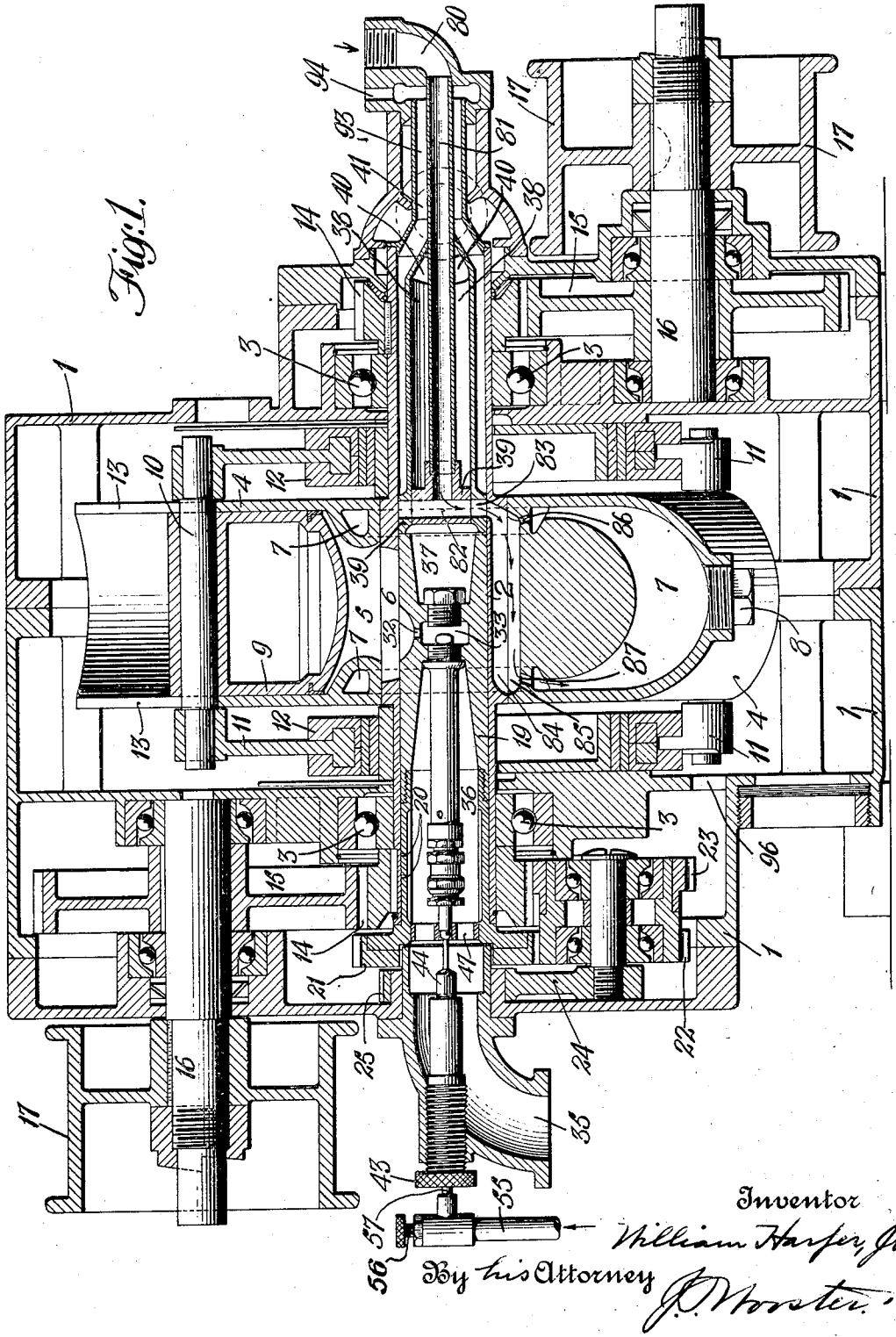
July 30, 1929. W. HARPER, JR 1,722,258

COMBUSTION ENGINE

Filed July 18, 1921 6 Sheets-Sheet 1

Fig. 1.



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July 30, 1929. W. HARPER, JR 1,722,258

COMBUSTION ENGINE

Filed July 18, 1921 6 Sheets-Sheet 2

Fig. 2.

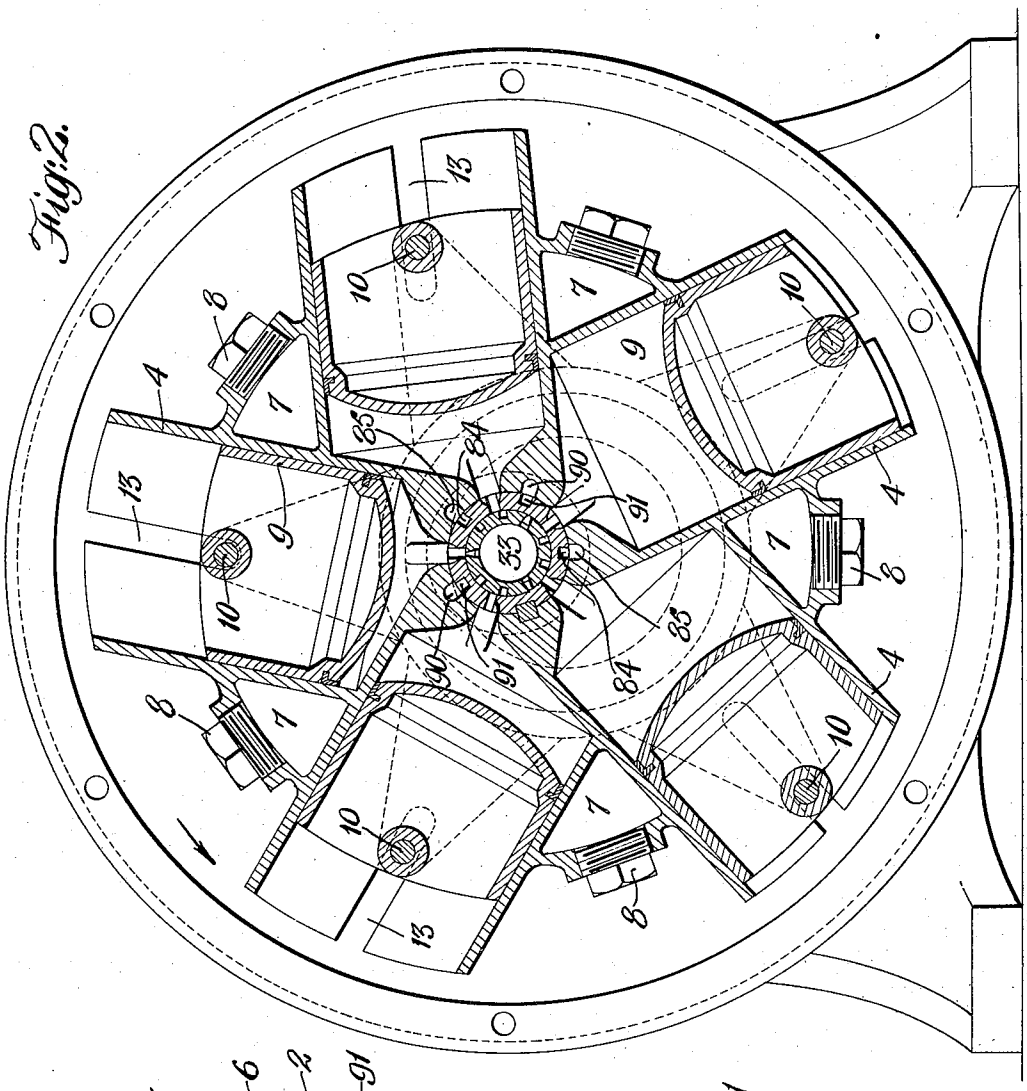


Fig. 3.

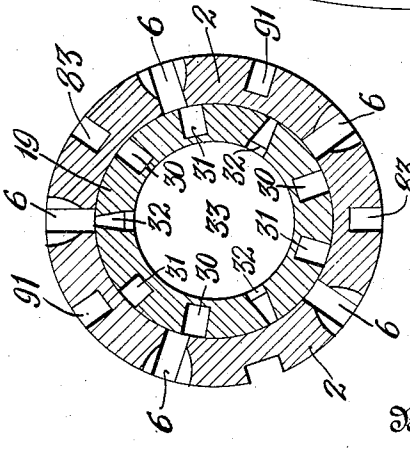
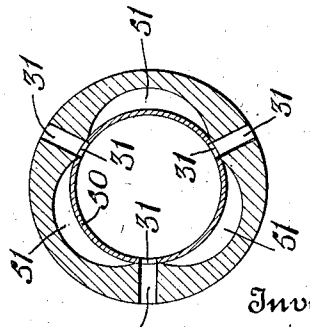


Fig. 4.



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July 30, 1929. W. HARPER, JR 1,722,258

COMBUSTION ENGINE

Filed July 18, 1921 6 Sheets-Sheet 3

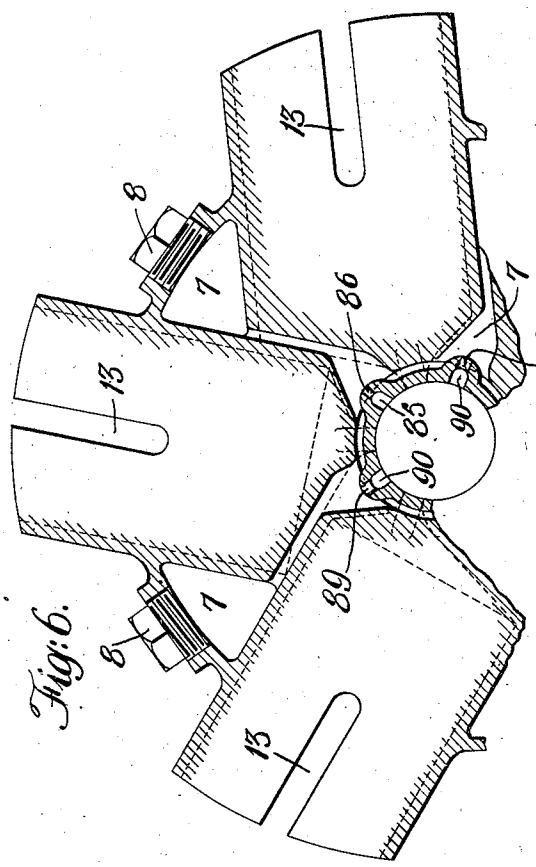


Fig: 6.

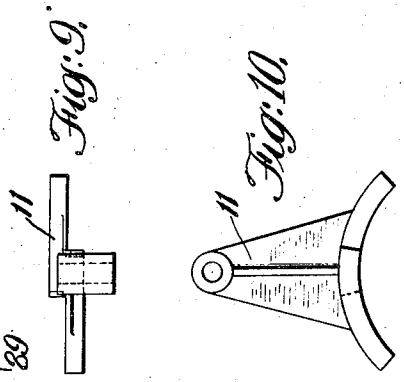


Fig: 9.

Fig: 10.

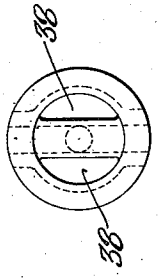


Fig: 8.

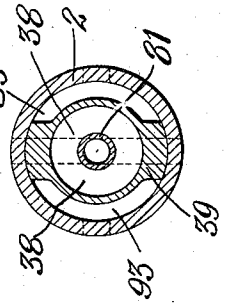


Fig: 7.

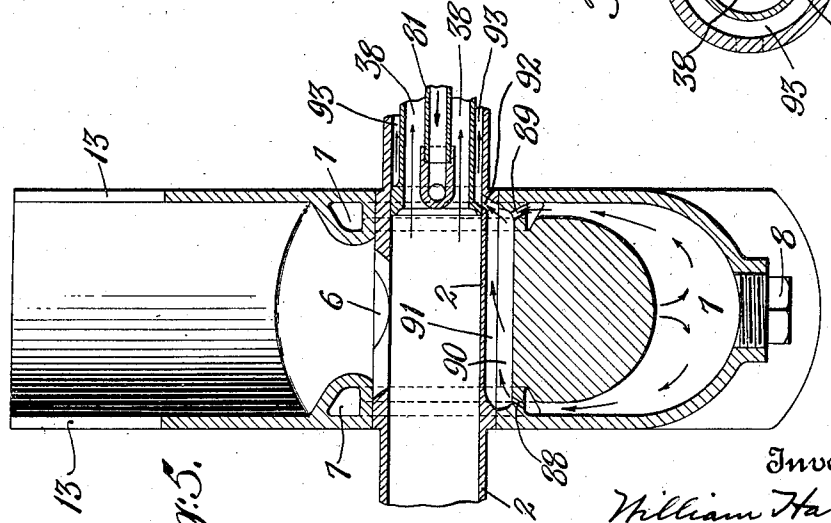


Fig: 5.

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July 30, 1929. W. HARPER, JR 1,722,258

COMBUSTION ENGINE

Filed July 18, 1921 6 Sheets-Sheet 4

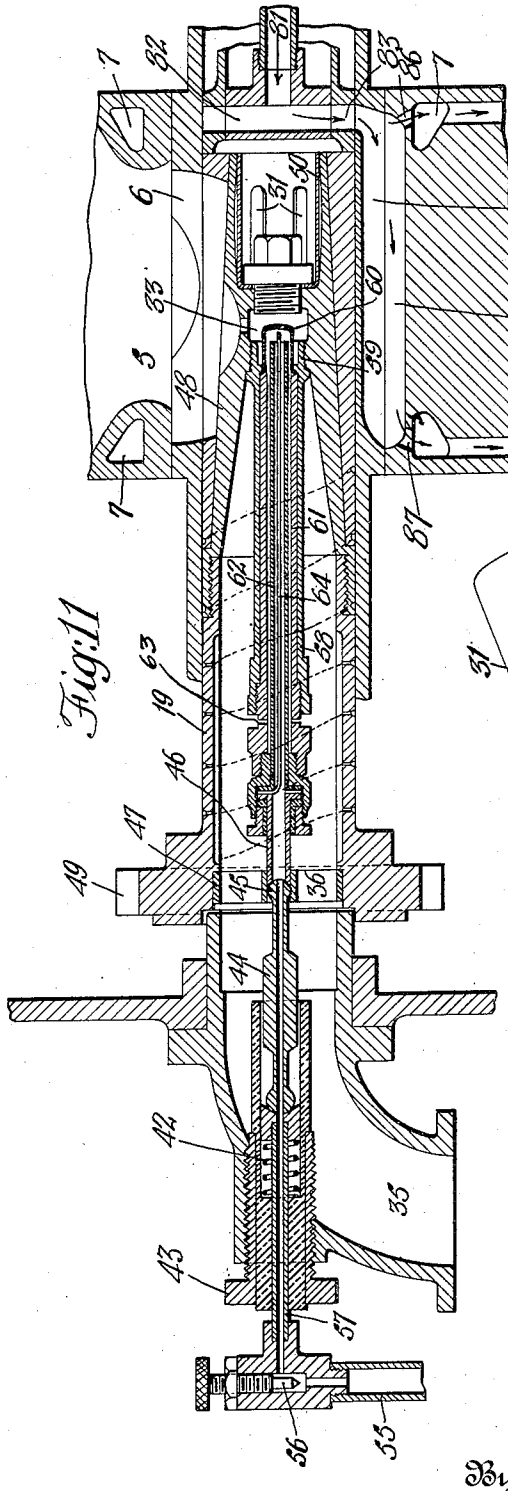


Fig:11

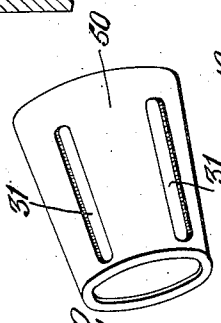


Fig:12

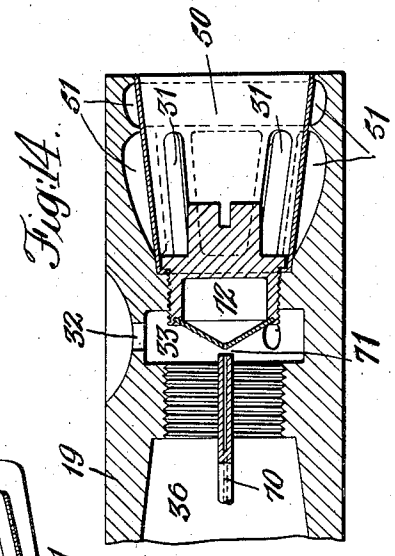


Fig:14.

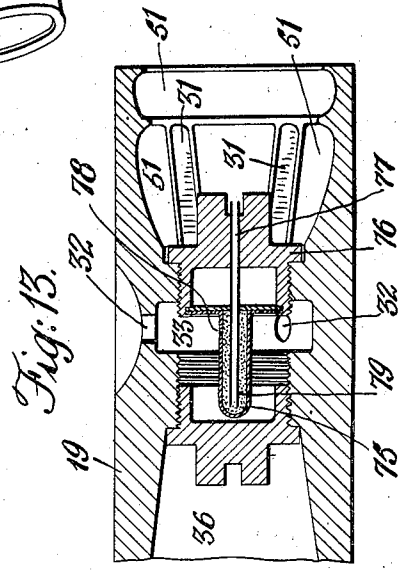


Fig:13.

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July 30, 1929. W. HARPER, JR 1,722,258

COMBUSTION ENGINE

Filed July 18, 1921 6 Sheets-Sheet 5

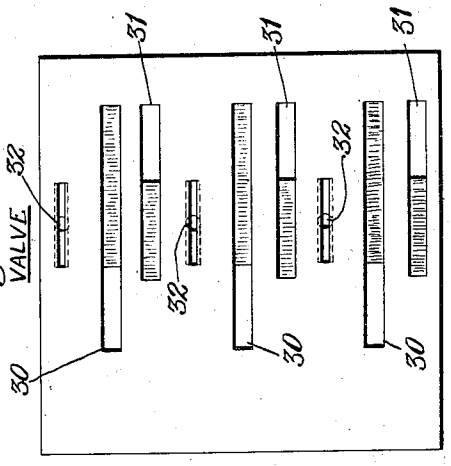


Fig:17.
VALVE

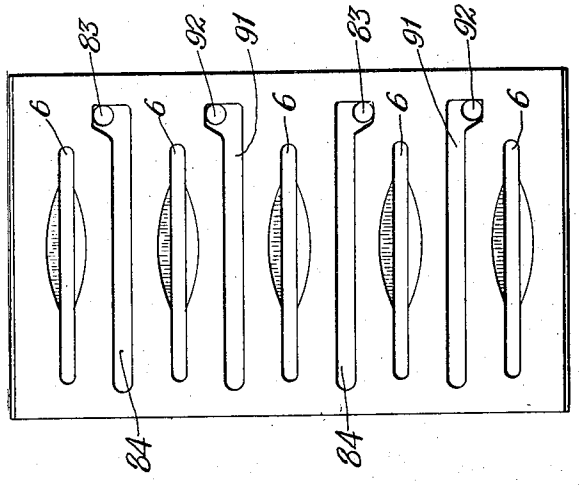


Fig:16.
SHAFT DEVELOPMENT

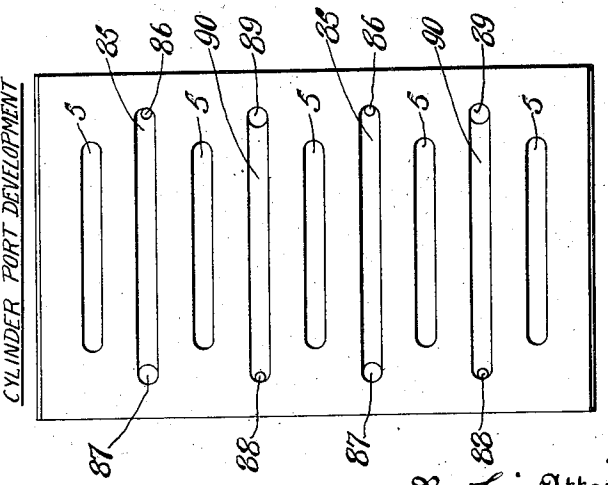


Fig:15.
CYLINDER PORT DEVELOPMENT

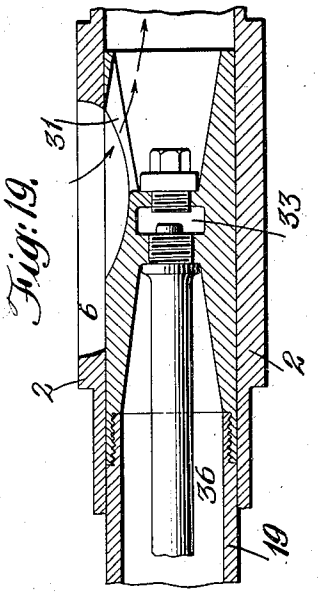


Fig:19.

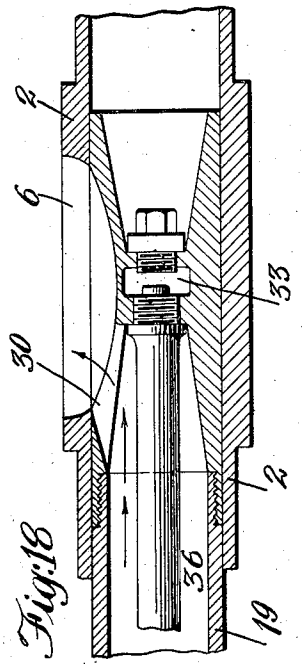


Fig:18.

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July 30, 1929. W. HARPER, JR 1,722,258

COMBUSTION ENGINE

Filed July 18, 1921 6 Sheets-Sheet 6

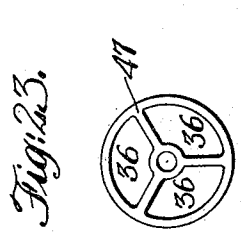


Fig:23.

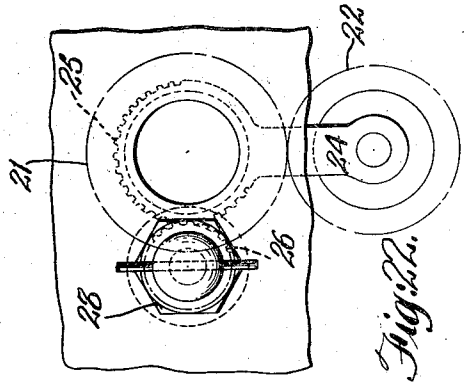


Fig:22.

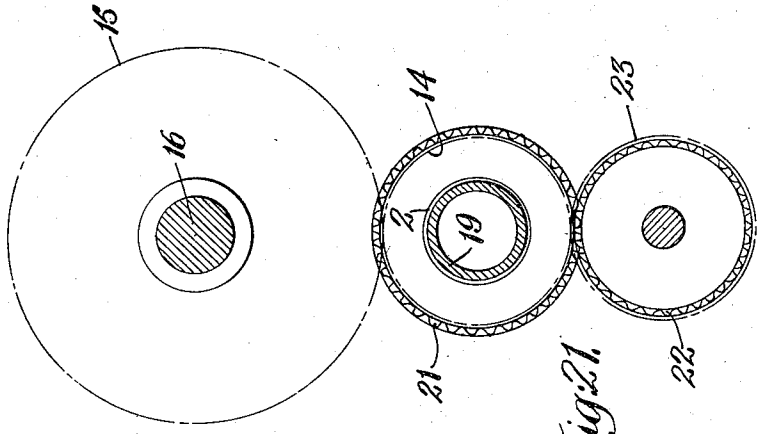


Fig:21.

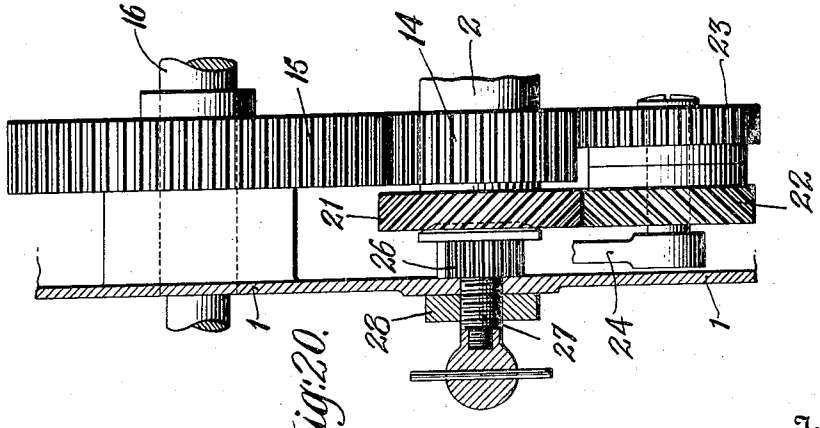


Fig:20.

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Patented July 30, 1929. 1,722,258

UNITED STATES PATENT OFFICE.

WILLIAM HARPER, JR., OF NEW BLOOMFIELD, PENNSYLVANIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN GAS TURBINE CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

COMBUSTION ENGINE.

Application filed July 18, 1921. Serial No. 485,499.

This invention relates to improvements in combustion engines of the rotary reciprocating type, and has for its objects to provide improvements in the cylinder arrangement whereby instead of using radially disposed cylinders the cylinders will be inclined to the radius of rotation thereby permitting a greater displacement without increase of diameter; also to provide improved valve mechanism, particularly the exhaust valve mechanism which has to take care of the greater amount of heat developed by the increased displacement; and an improved means for circulating the cooling water required by the increase of displacement. A further object of the invention relates to an improved contact and cross firing ignition means whereby electrical ignition may be eliminated even for starting.

As herein shown, the invention is applied to an engine of the type wherein the shaft is hollow and carries a tubular differentially driven inlet and exhaust valve provided with cross firing ports whereby the flame from one cylinder is employed to ignite a succeeding cylinder, operating in conjunction with the contact ignition device which functions not only in starting the engine, but in case ignition by cross fire should fail for any reason.

Further improvements relate to the details of the various parts including a jacket exhaust valve especially designed for an engine of this type wherein a large amount of heat is generated in a small space and has to be disposed of without objectionably affecting the valve mechanism or surrounding parts, and also in the various details of ignition means, gas control, etc., all as will be more fully understood in connection with the description of the accompanying drawings, wherein

Figure 1 is a longitudinal section,

Figure 2 is a transverse section,

Figure 3 is a section through the shaft, and the valve firing ports,

Figure 4 is a section of the jacketed exhaust valve,

Figure 5 is a detail showing the water and gas outlets,

Figure 6 is a detail of the water circulation,

Figures 7 and 8 are details through the water and gas outlets shown in Figure 5,

Figures 9 and 10 are details of the yoke pieces,

Figure 11 is a section of the shaft and valve on an enlarged scale,

Figure 12 is a detail of a tapered valve,

Figures 13 and 14 are valve and ignition details,

Figure 15 is a cylinder port development,

Figure 16 is a shaft port development,

Figure 17 is a valve port development,

Figures 18 and 19 are valve details,

Figures 20, 21, 22, are details of the valve driving means, and

Figure 23 is an inlet end view of the valve.

1 is a hollowed frame casing carrying the main shaft 2, mounted in bearings 3 and keyed to the shaft to rotate therewith are open ended cylinders 4, having the several heads adjacent the shaft and provided with cylinder ports 5 opening to ports 6 in the shaft. As shown in Figure 2, the cylinders are offset so that the side of one comes partly under the end of the adjoining one, so that the axes of the cylinders are on chords of the circle of rotation instead of on radii as heretofore proposed. The angle of off-set is preferably about that shown, in an engine of 2½ inch bore and 1¼ inch stroke, this angle being calculated so that at the main running speed of the engine, the off-set is such that the centrifugal forces due to the rotation will always keep the pistons rubbing slightly against the forward side of the cylinder, in order to prevent piston slap. In the construction herein disclosed the pistons are connected by means of studs or wristpins, which move in slots cut in the cylinders, to yokes which travel on a ring eccentric to the shaft and this angle of cylinder off-set is such as to bring the yoke or link in a radius about parallel with the cylinder axis at the maximum combustion pressure. With such relation, the cylinder axis is approximately tangent to a circle having a radius of one half the stroke, under which conditions I have found that the piston has a minimum tendency to slap. Also the resultant explosive force is directly through the cylinder head in a line about tangent to this circle, giving a torque effect approximating that of a gas turbine.

On the compression side, that is with a piston working to compress the charge, or to expel the burned gas, there is no piston slap because the centrifugal forces tending to hold

the piston against the forward side will be much greater than the pull of the yoke tending to pull the piston oppositely against the inner or following cylinder side, but owing to the angulation of these two forces there will be a slight resultant thrust on the rear or following cylinder wall.

If compared with radial cylinders of equal displacement disposed as closely as possible to each other, this invention requires a considerably less diameter, or enables about a fifty (50) percent gain in displacement to be obtained with the same diameter of cylinder rotor element.

Around the cylinders and between the cylinders and shaft are water spaces 7 closed by closure plugs 8, 9 are the pistons, 10 the wrist pin, 11 are yokes having ends off-set to over-lap as shown in Figures 9 and 10 so as to give ample bearing space and traveling on eccentric rings 12 fixed to the frame 1. 13 are slots in the cylinders through which the wrist pins 10 operate. 14 are power transmission gears fixed at opposite ends of the shaft 2 and meshing with gears 15 on shafts 16 carrying pulleys or other driving means 17, so that power can be taken off of either or both ends of the engine. Either of these shafts can be used as a cranking shaft to start the engine.

19 is a tubular valve element having oil holes 20 carrying a gear 21 driven by gears 22, 23, from gear 14 on one end, the gears 22, 23, being mounted on an arm 24 carrying a segmental gear 25 meshing with the segmental gear 26 on stud shaft 27 having lock nut 28 (see Figures 20, 21, 22) so as to shift the arm 24 angularly of the shaft to vary the valve timing. By loosening nut 28, the valve is angularly shifted and then held by nut 28. The proportions of the gear drive are such that the valve is driven one sixth slower than the speed of rotation of the shaft and cylinders in a five cylinder engine. This ratio varies with the number of cylinders, being one eighth slower for a seven cylinder engine and can be figured out for the number of cylinders. The advantage of this is that in a five cylinder engine, for example, the rotary valve will function with three ports for both inlet and exhaust, and will likewise only require three firing ports which simplifies the construction of valve and also enables the necessary lap to be obtained.

The valve details are shown in Figures 1, 3, 4, 11–19, wherein 30 are the inlet ports, shown developed in Figure 17, and 31 are the exhaust ports also shown developed in Figure 17, while 32 are the cross firing ports leading from chamber 33, shown in cross section in Figure 3. To prevent quenching of the cross firing flame, the cross firing ports 32 are longitudinally enlarged as shown in dotted lines in Figures 3, 4, 17, with the narrowest part of the passage on the outside below the surface, the cross fire port 32 consisting of longitudinal slot as seen in Figure 1, made in the periphery of the valve with the bottom enlarged as shown, made by a flat spade drill inserted in the slot, which construction is found not to have a quenching effect on the flame. 35 is a charge inlet leading to the inlet space 36 within the valve, and 37 is the exhaust space in the valve leading to the exhaust spaces 38 past T-piece 39 to the exhaust outlets 40, and to exhaust manifold 41. T-piece 39 (see Figs. 1, 5 and 7) is, as the name indicates, a T-shaped member fixed to pipe 81 and journalled within the rotary shaft.

The valve is either a cylindrical valve as shown in Figures 18, 19, or a special form of taper valve as shown in Figure 11, wherein a spring 42 adjusted by nut 43 exercises pressure through an interposed tubular rod 44 ending in a ball thrust bearing 45 against a tube 46 carried by the ring 47 on the valve body 19, tending to push the valve to the right in Figure 11, it being tapered as shown at 48. The gear 49 on the valve body corresponding to the gear 21 in Figure 20 is of the skew type meshing with similar skew gear 22, so that the axial thrust of the gear opposes the thrust of the spring 42. When the engine is cold these two forces will about be balanced, so that the tapered valve will be thrust very lightly, if at all, into the tapered seat in shaft 2. When the valve heats up and expands with tendency to bind in the taper, the power required to drive it increases it to such extent as to cause the skew gears to push the valve backwards against spring 42 until the friction due to expansion is relieved, thereby permitting the valve to always drive easily and at the same time permitting the spring 42 to hold it on its seat, irrespective of temperature. To permit this the gear 14 is somewhat wider than gear 23 and gears 22, 23 can slide slightly on the shaft carried by arm 24.

A further feature of the invention consists in the provision of an exhaust valve as shown in Figure 14, with a lining 50 with the metal cut away between the parts to form dead air spaces 51, having the effect of heat insulation so that a less amount of heat is absorbed by the valve body at this portion of the valve than would be absorbed by solid metal, thus tending to reduce expansion.

The ignition mechanism consists generally of a contact or catalytic device located in the firing chamber and connected with a small auxiliary source of combustible gas so that combustible gas in small quantities is always drawn through the contact device toward the engine cylinder during the suction stroke tending to cause the contact device to incandesce and thereby causing the ignition from the firing chamber 33 at the proper time, the device being so constructed that there is always a stream of fresh gas being drawn

through the igniter. The igniter consists of a quartz tube carrying finely divided platinum which will automatically heat up in a current of hydrocarbon gas, the platinum being enclosed in a capsule which projects into the firing chamber. 55 is the gas supply for the igniter controlled by valve 56 thence going to tube 57 and through tube 44 into tube 46 which is connected by couplings, as shown, to the igniter casing 58 threaded into the body of the inlet valve as shown at 59. 60 is the capsule which becomes incandescent and is positioned in chamber 33 and carried by igniter body 58. Within the body 58 and spaced from the tubular lining 61 thereof is a quartz tube 62 through which the gas passes and containing at its forward end spongy platinum. The igniter body has a hole 63 opening into the inlet space 36 whereby the suction stroke produces sufficient gas flow through the quartz tube into the capsule and thence out through hole 63 so that the capsule becomes incandescent and will fire the gas in chamber 33 whenever the proper compression is reached, which is at the time when a cross fire should occur if the engine is already running or when a cylinder should be fired in starting. Ordinarily the heat of compression due to cranking the engine a few times will dry out the igniter so that it will start automatically, but in case it should not, a small electric heating wire as 64 can be run through to be heated by a current to dry the capsule until it will incandesce and then be cut off.

The hole in the quartz tube is sufficiently small so that the velocity of the suction gas is greater than the back fire flame speed thus preventing the gas from being burned in the tube and it only burns at the tip. A gauze wire screen in the quartz tube would also prevent back fire. The fresh gas is superheated from the exhaust of gas previously burned in the tube, causing the capsule to become very hot. The quartz tube projects into the capsule as shown, bringing the end of the tube to the tip of the capsule so that the primary combustion of the gas is directly in contact with the interior of the capsule. The contact platinum within the capsule may be in the form of a fine coil of wire or in spongy platinum sufficiently divided so as to permit the gas to pass through as may be desired. One convenient way is to apply finely divided platinum to quartz fibre which will hold the former suspended. If the gas velocity is greater than the flame travel, the travel of gas decreases owing to the increase of space within the end of the capsule as compared with the diameter of the quartz tube. The capsule being exposed to the compression conditions of the engine, retains compression heat. The timing can be varied by throttling the gas at valve 56, which valve will also control the temperature of the platinum.

Another form of ignition is shown in Figure 14, wherein rod 70 constitutes a terminal of a high tension electric ignition system with the gap 71, 72 being a chamber in which gas is compressed at each compression stroke and then expelled, the spark jumping across and igniting the blast of gas from the compression chamber 72. The rod is tubular as shown so that the blast of gas from chamber 72 impinges thereon.

In Figure 13 a modified contact igniter is shown in which platinum capsule 75 is carried by plug 76 in the exhaust chamber, the plug 76 also carrying a tube 77 so that gas is always moving through port 78 in the capsule and out through tube 77, thus causing the active material 79 to heat up and thus heat the capsule. In the Fig. 11 form of contact ignition device sponge, or finely divided platinum, or platinum mixed with oxides of thorium, cerium, etc., may be used, as such oxides tend to attract oxygen from the air.

The water cooling is centrifugal, the cooling water entering a pipe 80 passing through pipe 81 and T piece 39 to passage 82 thence to water inlet ports 83 in the shaft 2 and along slots 84 cooperating with slots 85 in cylinder casting and thence passing through holes 86, 87 to water spaces 7, the holes 86 being slightly smaller than 87 so that the water will evenly divide (see Figures 1, 15). The hot water returns from the cylinders through holes 88, 89, into cylinder passages 90, (see Figure 5) meeting outlet passages 91 in the shaft, (see Figures 3, 16) thence through shaft ports 92, (see Figure 5), to exhaust water space 93 surrounding the gas exhaust passage 38 and thence to water outlet 94. The cooled water coming in at the center and being heavier naturally moves outwardly while the hot water being lighter naturally moves inwardly and thus a continuous circulation is maintained and the engine kept cool.

The cross firing occurs through ports 32 and chamber 33 when one cylinder is at about 120° of its explosion stroke and the second following cylinder is about at the top of its compression stroke, as it will be found by calculation that with the valve running one sixth slower than the cylinders the three firing ports 32, 120° apart, properly function to fire a rotary five cylinder four cycle engine such as herein described.

The provisions for oiling are largely by centrifugal force as this type of engine lends itself especially thereto, the casing being provided with an oil reservoir at the bottom from which the revolving cylinders pick up oil and oil the pistons, yokes, wrist pins, etc., while the valve is oiled through holes 20, and the gears, bearings, etc., by splash from the oil reservoir through port 96.

While the general combination of radial cylinders with differentially driven valve has heretofore been proposed, so far as I am

aware, I am the first to off-set the cylinders in this type of engine so that one partly overlies the other in order to gain volume and power, and more specifically to off-set such cylinders at such angle that centrifugal force opposes the piston slap due to the yoke and eccentric connection. By this means, the improved engine herein described more closely approaches in operation, an ideal form of gas turbine, because the explosive forces in this engine directly tend to produce rotation without producing excessive bearing strains on wrist pins, yokes, eccentrics, etc. Five cylinders is sufficient to give good equality of torque, although a greater or less number of cylinders can be used. Another feature which I regard as important and novel resides in the valve structure whereby expansion difficulties due to the large volume of heat being handled in relatively small spaces are taken care of automatically, and the combination of cross firing and contact ignition operating to produce a powerful yet relatively simple engine, independent of ordinary electrical ignition. A still further feature of novelty and advantage resides in the jacketing of the exhaust valve, either cylindrical or tapered, for the purpose of preventing excessive absorption of heat adjacent the shaft ports.

It is further necessary in a rotary internal combustion motor whose mechanism rotates in a bath of oil to take the exhaust gases away at its center of rotation as the lubricant is thereby centrifugally separated and retained in the case.

A further improvement is that with cylinders off-set as disclosed; the cylinder head moves away from the expanding gas similarly to an impulse turbine and the pistons are stationary relatively to the gas.

Various modifications and improvements may be made in the specific details and arrangements herein described without departing from the scope of the appended claims.

This application is a continuation in part of my application S. N. 427,475 filed December 1, 1920, for Rotary reciprocating combustion engine.

What I claim is:

1. A combustion engine having a cylinder, a piston therein, driving connections for the piston, a tapered valve for said cylinder having a passage for hot gas, a tapered valve seat having a cylinder port for co-operation with said valve passage, means holding the valve on its seat, means producing relative rotation between said valve and its seat, said last mentioned means including automatic means responsive to increase of driving torque to longitudinally shift the valve against said holding means without substantially changing its timing.

2. A combustion engine comprising a cylinder and piston therein, driving connections for the piston, a tapered valve having a passage for hot gas, a tapered valve seat having a cylinder port, means holding the valve on its seat, means for rotating the valve, automatic means to longitudinally shift the valve against said holding means on increase in its driving torque, and means to adjust the timing of said valve during rotation.

3. In a combustion engine comprising a cylinder, a piston therein, driving connections for said piston, a tapered valve controlling the removal of hot gases from said cylinder, means for rotating said valve in timed relation to said piston, means for adjusting the timing of said valve during rotation, a tapered seat for said valve, yieldable means for holding the valve on its seat, said rotating means including automatic means responsive to increase in driving torque of said valve for longitudinally shifting the same against the action of said yieldable means.

4. In a combuston engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered rotary valve concentric with the cylinder movement, a tapered valve seat having cylinder ports, means holding the valve on its seat, means for driving said valve in timed relation to the cylinders, said last mentioned means including means for longitudinally shifting the valve against said holding means on increase in its driving torque.

5. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered rotary valve concentric with the cylinder movement for controlling the cylinders, a tapered valve seat having cylinder ports, means holding the valve on its seat, means for driving said valve in timed relation to the cylinders, said driving means including means responsive to increase of driving torque to longitudinally shift the valve against said holding means, and means for adjusting the timing of said valve during rotation.

6. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons, a tapered valve concentric with cylinder movement for controlling the cylinders, a tapered valve seat having cylinder ports, means holding the valve on its seat, means for driving said valve in timed relation to the cylinders, and means for adjusting the timing of said valve while the engine is running.

7. A multiple cylinder combustion engine having diverging cylinders, a tapered valve between the cylinders having transversely

arranged cross firing passages, a seat for said valve, means for holding the valve on its seat, and means for longitudinally shifting the valve on increase of its driving torque.

8. A multiple cylinder combustion engine of the four-cycle type having an odd number of cylinders, cross-firing passages extending between alternate cylinders and connecting said cylinders in a substantially endless series, a driven tapered valve containing said passages, a valve seat, means yieldably holding said valve on its seat, and means longitudinally shifting said valve on increase in its driving torque.

9. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a driven tapered valve concentric with the cylinder movement, having transverse passages for firing a succeeding from a working cylinder, a tapered valve seat having cylinder ports, means holding the valve on its seat, and means responsive to increase of driving torque to longitudinally shift the valve against said holding means.

10. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having transverse internally connected cross firing passages through its tapered portion, a tapered valve seat having cylinder ports, yieldable means for holding the valve on its seat, and means for driving said valve in timed relation to said cylinders.

11. In a combustion engine, a rotor including diverging rotatable cylinders each provided with a gas port and combustion space at the inner end and tangent to a circle concentric with cylinder movement and of a radius approximately one-half the length of stroke to substantially overcome piston slap, a valve between said cylinders concentric with their movement and having internal transverse passages for firing a non-adjacent succeeding cylinder from a working cylinder, pistons in said cylinders, driving connections for the pistons, means for driving the valve in timed relation to the pistons, and means for adjusting the timing of said valve during rotation.

12. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, pistons in said cylinders, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having internally connected transverse cross firing passages through its tapered portion, and a tapered valve seat having cylinder ports.

13. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having transverse internally connected cross firing passages through its tapered portion, a tapered valve seat having cylinder ports, yieldable means for holding the valve on its seat, means for driving said valve in timed relation to said cylinders, and means for adjusting the timing of said valve during rotation.

14. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having transverse internal cross firing passages through its tapered portion, and a tapered valve seat having cylinder ports.

15. In a combustion engine, a rotor including cylinders having a gas port and combustion space adjacent the same end of each cylinder, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having transverse internal cross firing passages through its tapered portion, a tapered valve seat having cylinder ports, and means for driving said valve in timed relation to the cylinders.

16. In a combustion engine, a rotor including cylinders each having a gas port and combustion space at the same end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve having transverse cross firing passages internally connected and enlarged at their connection through the tapered portion of the valve, a tapered valve seat having cylinder ports, and yieldable means for holding the valve on its seat.

17. In a combustion engine, a rotor including cylinders each having a gas port and combustion space at the same end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve having transverse cross firing passages internally connected and enlarged at their connection through the tapered portion of the valve, a tapered valve seat having cylinder ports, a yieldable means for holding the valve on its seat, and an ignition device within the enlarged and connected ports of said passages.

18. In a combustion engine, a rotor including cylinders each having a gas port and combustion space adjacent the same end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder

movement having transverse internal cross firing passages through its tapered portion enlarged to bend the flame passing from a working to a succeeding cylinder without any sharp bends and a tapered valve seat having cylinder ports.

19. In a combustion engine, rotatable cylinders provided with a gas port and combustion space at their adjacent ends, pistons in said cylinders, driving connections for the pistons, a driven tapered valve between said cylinders and concentric with their movement having cross firing passages transversely through the tapered portion for firing a succeeding from a working cylinder, a tapered valve seat having cylinder ports, means for holding said valve on its seat, and automatic means to longitudinally shift said valve against said holding means on increase of its driving torque.

20. In a combustion engine, rotatable cylinders each provided with a gas port and combustion space at the inner end and tangent to a circle concentric with the cylinders and of a radius approximately one-half the stroke length to substantially overcome piston slap, pistons in said cylinders, driving connections for the pistons, a valve between said cylinders concentric with their movement and having transverse passages for firing a non-adjacent succeeding cylinder from a working cylinder, and means for rotating said valve in timed relation to the cylinders.

21. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a driven tapered valve concentric with the cylinder movement having cross firing passages transversely of its tapered portion, a tapered seat for said valve having cylinder ports, means holding the valve on its seat, and means responsive to increase in the driving torque for longitudinally shifting the valve against said holding means.

22. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a valve concentric with the cylinder movement having exhaust and cross firing passages transversely arranged through its tapered portion, means around at least a portion of said passages to lessen heat absorption by the valve, a valve seat having cylinder ports, and means for supplying fuel to said cylinders.

23. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a driven tapered valve concentric with the cylinder movement having a plurality of sets of supply, exhaust and transverse cross firing passages, a tapered seat for said valve having cylinder ports, means holding the valve on its seat, and means responsive to increase of driving torque to longitudinally shift the valve against said holding means.

24. In a combustion engine having a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement, having internally connected cross firing ports arranged around its tapered portion, a tapered seat for the valve having cylinder ports, means for driving said valve in timed relation to the pistons at a slower rate, and means for yieldably holding the valve in its seat.

25. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a driven tapered valve concentric with the cylinder movement having a plurality of sets of supply and cross firing ports arranged around its tapered portion, and provided with passages through the valve connecting said ports, a seat for the valve, means holding the valve on its seat and means responsive to increase of driving torque to longitudinally shift the valve against said holding means.

26. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having exhaust and internally connected cross-firing passages opening through its periphery, a valve seat having cylinder ports, and ignition means located within and common to said cross-firing passages.

27. In a combustion engine, a rotor including diverging cylinders, each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having a plurality of sets of supply, exhaust and internally connected cross-firing passages opening through its tapered portion, a tapered seat for the valve having cylinder ports therein, yieldable means holding the valve on its seat, means for supplying oil between the valve and its seat during rotation, means responsive to increase of driving torque to longitudinally shift the valve against said holding means, and means for adjusting the timing of the valve during rotation.

28. In a combustion engine, a rotor including cylinders each having a gas port and combustion space at the same end, a piston in each

cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement having transverse internally connected cross firing passages through its tapered portion, a tapered valve seat having cylinder ports, and yieldable means holding the valve on its seat.

29. In a combustion engine, a rotor including cylinders having a gas port and combustion space at their adjacent ends, a piston in each cylinder, means for reciprocating the pistons, a tapered valve between said cylinders and concentric with their movement for controlling said cylinders, a tapered valve seat having cylinder ports, means for holding said valve on its seat, means for rotating said valve in timed relation to said cylinders, a skew gear secured to the valve, a skew driving gear engaging said first gear and arranged to longitudinally shift the valve against said holding means on increase of driving torque, and means for driving the second gear to rotate the valve relatively to said cylinders.

30. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, a tapered valve concentric with the cylinder movement for controlling the admission of gas to the cylinders, a tapered valve seat having cylinder ports, means for holding said valve on its seat, means for rotating said valve in timed relation to the cylinders comprising a skew gear on said valve, a gear carried by said cylinders, intermediate gears connecting said valve and cylinder gears and including a skew gear engaging said valve gear, said skew gears cooperating to longitudinally shift said valve against said holding means on increase of driving torque, movable means carrying said intermediate gears, and means for moving said intermediate gears about said cylinder and valve gears while in mesh and during rotation to change the angular relationship between said valve and cylinders.

31. A combustion engine comprising rotatable cylinders, a tapered valve concentric with the cylinder movement and controlling said cylinders, a fluid passage through the valve, a skew gear fixed on the valve, a skew gear driving said valve gear, said last mentioned skew gear being so mounted and said gears both being so disposed as to automatically shift said valve and its gear longitudinally on increase of driving torque, and means for supplying driving fluid for the engine and exhausting the same.

32. In a combustion engine, a rotor including diverging cylinders each having a gas port and combustion space at the inner end, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a rotary tapered valve concentric with the cylinder movement for controlling the admission of gas to the cylinders, means for driving said valve in timed relation to the cylinders, means for adjusting the timing of said valve, a tube between said valve and its driving means provided with an interior recess, a hole leading from said recess to the periphery of said tube, and a helical groove thereon leading from said hole to the outer tapered surface of the valve for lubricating the same, and means for controlling the exhaust from said cylinders.

33. A diverging multiple cylinder combustion engine, having a centrally disposed tapered valve seat having gas ports leading to the several cylinders, and a tapered rotatable valve carried in said seat and having internal cross firing passages arranged to connect non-adjacent cylinders for cross firing one from the other, and yielding means for holding the valve seated.

34. In a combustion engine, a rotor including cylinders each having a gas port and combustion space adjacent the center, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement containing means in its tapered portion to permit of successively firing a succeeding cylinder from a working cylinder, a tapered valve seat in the rotor, means for driving the valve in timed relation to the pistons, means for yieldably holding the valve seated, said driving means including automatic means responsive to increase in driving torque of said valve for longitudinally shifting the same against said seating means.

35. In a combustion engine, a rotor including cylinders having a gas port and combustion space adjacent the center, a piston in each cylinder, means for reciprocating the pistons during cylinder rotation, a tapered valve concentric with the cylinder movement containing means in its tapered portion to permit of successively firing a succeeding cylinder from a working cylinder, a tapered valve seat in the rotor, means for driving the valve in timed relation to the pistons, means for holding the valve seated, and means for adjusting the timing of the valve during rotation.

Signed at New Bloomfield, in the county of Perry and State of Pennsylvania, this 12th day of July, A. D. 1921.

WILLIAM HARPER, JR.