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PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in or relating to Rotary Internal Combustion Engines.

We, VINCENT ROTARY ENGINES LIMITED, a British Company, of 7, Buckingham Gate, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to rotary internal combustion engines.

The invention provides a rotary internal combustion engine comprising a ported structure and an assemblage of parts providing a set of combustion spaces, the ported structure and assemblage of parts being relatively rotatable so that the ports in the ported structure communicate successively with the combustion spaces of the assemblage of parts there being pairs of sealing faces encircling, and spaced apart along, the axis of said relative rotation of the ported structure and assemblage of parts on either side of the combustion spaces, one sealing face of each pair being on the ported structure and the other sealing face being on the assemblage of parts, means being provided for introducing sealing liquid between the sealing faces of each pair, and suction scavenging means being provided for withdrawing sealing liquid from the spaces between the opposed faces of the ported structure and assemblage of parts which lead from the sealing faces to the combustion spaces.

Preferably said suction scavenging means are activated by shear drag set up in a film of sealing liquid between relatively rotating closely spaced surfaces.

Each said pair of sealing faces may comprise a sealing ring in a groove in one of the relatively rotating parts and engaging a face on the other part.

In the case where said pair of sealing faces comprise a sealing ring in a groove in one of the parts which ring engages a face on the other part that face of each ring which may be subjected to a pressure corresponding to the pressure in the combustion spaces is of a greater area than the face on the opposite side of the ring which is exposed to the pressure of the sealing liquid whereby the ring tends to move in a direction to bring the sealing faces together.

Each sealing ring may be mounted in a circumferential groove in that part which contains the combustion spaces and means may be provided for introducing sealing liquid between a face of the ring and an opposed face on the ported structure and which ring is so formed and mounted in the groove as to provide a passageway extending along the bottom wall of the groove and along a side wall of the groove, one end of which passageway terminates at the opposed faces of the relatively rotating parts on that side of the locality where fluid is introduced between said opposed faces which is nearer the combustion spaces and the other end of the passageway communicates with a throughway terminating at the opposed faces of the relatively rotating parts on the opposite side of the aforesaid locality to that where said passage terminates whereby the oil shear drag between the surfaces of the relatively rotating parts adjacent the end of the throughway has a suction scavenging action causing the sealing liquid to flow in a direction away from the combustion spaces aided by centrifugal motion.

Relatively rotating stepped faces may be provided on parts of the ported structure and assemblage of parts containing the combustion spaces so as to lie between the sealing rings and combustion spaces.

In any of the above arrangements additional sealing means may be provided in the

[*Price*

form of blades disposed between adjacent combustion spaces and mounted on one of the relatively rotating parts so as to be movable towards the other part and means for maintaining a minimum distance between said blades and the other part whereby the flow of gases from one combustion space to another is substantially prevented.

In the case where blades are mounted on one of said relatively rotating parts said blades may be mounted in slots in a part of the rotatable structure and are provided at opposite ends with followers which engage surfaces on the ported structure adjacent said sealing rings and wherein the followers on the trailing side of the combustion spaces have associated therewith suction scavenging means whereby oil tending to pile up on the leading faces of the trailing followers is prevented from flowing into the combustion spaces.

Preferably the faces of the followers arranged on the trailing side of the combustion spaces and which engage the surfaces are provided with grooves extending from the leading to the trailing ends of the followers so as to assist in the scavenging effect produced by oil shear drag between the relatively moving faces of the followers and said surface. Each said surface may be substantially in line with one of the sides of one of the grooves in which the sealing ring is located so that the suction produced by the oil shear drag between the ring and a face of the ported structure assists in the withdrawal of oil from said surface through appropriate drillings.

The following is a description of one form of rotary internal combustion engine according to the invention reference being made to the accompanying drawings in which:—

Figure 1 is a part end elevation and part cross sectional view of the engine;

Figure 2 is a view looking from the top of Figure 1 part of which view is in section;

Figure 3 is a sectional view on the line 3—3 of Figure 1, inverted and omitting the engine cylinder and pistons;

Figure 4 is a sectional view on a different scale to Figure 1 on the line 4—4 of Figure 1 looking in the direction of the arrows; and

Figure 5 is a section on the line 5—5 of Figure 3 with the ported structure removed.

Referring now to Figures 1 and 2, the rotary internal combustion engine comprises, three main parts a rotatable crank shaft 10, a rotatable cylinder assemblage 11, and a stationary ported structure 12 having a part which encircles the cylinder assemblage.

The cylinder assemblage is made up of a number of parts including an annular cylinder block 13 the opposite sides of which are formed with circumferential cooling fins 14 concentric with the engine crankshaft 10. The cylinder block is provided with three radially extending cylindrical bores 15 in which pistons 16 are reciprocal. Connecting rods 17 connect gudgeon pins 18 in the pistons to a single crank pin 19 of the crankshaft 10. Annular members 20 are secured to opposite sides of the cylinder block 13 and project radially outwards from the cylinder block so as to form an encircling channel for the purpose described later. Each of the annular members 20 is provided with an axially extending rim portion 21 which encircles a marginal portion of the cylinder block 13. Also each of the annular members 20 is disposed within a circumferential groove in the inner side face of an annular part 22 of the cylinder assemblage. On the right hand side of the engine is a hub part 22*a*, and on the left hand side is a hub part 22*b*.

The inner periphery of the part 22*b* on the left hand side of the engine encircles and is rotatably supported on a bush 23 on a hollow shaft 24 of the stationary ported structure 12 and the inner periphery of the shaft portion 24 is provided with a bush 25 which supports the left hand end of the crankshaft 10.

The hub 22*a* on the right hand side of the cylinder block 13 is provided with a bush 26 which supports the right hand end of the crankshaft 10 and the hub is also provided with an extended hollow shaft 27 a part of the outer circumference of which is supported in bearings 28 housed in a part 29 of the ported structure 12.

The shaft 27 forms a power take-off of the engine and is formed with gear teeth 30 on its outer circumference which meshes with a gear wheel 31 on a further shaft (not shown) which drives both an oil pump to which reference is made later, and also drives a distributor of a conventional type, the two latter parts being housed in a housing attached to the stationary structure.

The ported structure 12 is provided with an inwardly extending circumferential portion 32 which is located in the aforesaid channel between the outwardly extending portions of the annular members 20 and extending laterally from this portion 32 on either side thereof are circumferential walls 33 which overlie and project beyond the annular parts 22 and are spaced from the outer circumferential faces of those parts 22 to provide oil collection galleries 34 referred to later. The ported structure is also provided with cup shaped side walls 35, the rims of which are formed with spigot sockets 36 in which the aforesaid circumferential walls 33 are located and secured.

Sealing means indicated generally at 37 are provided between the inner side face of each annular member 20 and a side face of the inwardly extending circumferential portion 32 of the ported structure. The axially extending rim portions 21 of the annular members 20 each project into a circumferential recess in the inwardly extending circumferential portion 32 of the ported structure, which recess is located between the aforesaid sealing means and the cylinder block 13. The inner end of each of the axially extending rim portions 21 has faces 38, 39 with a step 40 between them and the opposed face of the recess of the part 32 is likewise stepped at 38, 39, 40 so as to lie in close proximity to the stepped face of the rotating rim 21 thus there is formed between the parts 21 and 32 a narrow tortuous annular space.

Openings 8 and 8*a* are formed respectively in the cup shaped part 35 of the ported structure and in the annular members 20 and annular parts 22. Air from outside the engine can reach the aforesaid circumferential fins 14 on the cylinder block 13 through the openings 8 and is assisted by a number of air impeller blades 41 formed on an annular member 42 which is attached to the hub part 22*b* on the left hand side of Figure 2. The blades 41 are provided with parts 41*a* which deflect air through the openings 8*a* so as to cool this ported structure aided by a cowling (not shown).

The rotatable cylinder assemblage 11 is arranged to rotate the crankshaft 10 in the opposite direction to that in which the cylinder assemblage itself rotates; this is effected by means of an epicyclic gear train arranged between those parts. The sun wheel 43 of the epicyclic train has a splined bore which receives one end of a splined shaft 43*a*, the other end of which shaft is received in a splined bore in the crankshaft 10. The sun wheel engages pinions (not illustrated) rotatable on shafts parallel with the axis of rotation of the crankshaft and carried by the hub portion 24 of the ported structure. The pinions also engage an internal gear 44 formed around the internal periphery of the hub 22*b* on the left hand side of the engine and to the left of the bush 23. The splined shaft 43*a* is provided with an extension which is arranged to drive a governot referred to later.

A number of spaced cooling fins 45 (Figure 1) extend radially outwards from the outer surface of the circumferential wall 32.

A number of sockets 46 extend through holes in the portion 32 of the ported structure and accommodate sparking plugs 47 so that cylinders come opposite them during rotation of the cylinder assemblage. Conventional sparking plugs may be used or alternatively glow plugs may be used. Other holes in the circumferential walls receive liners 48 and 49 so as to constitute inlet and exhaust passages respectively and the former communicate with carburettors and the latter with the exhaust systems.

The inlet passages 48 are provided with extensions 48*a* at their outer ends in which are located blades 50 (Figure 2) which are ldjustable across the passage by means indicated at 51 so as to vary the effective area of the inlet passages whereby the velocity of the gases may be maintained substantially constant for varying engine speeds. By suitably shaping the inlet passages 48 where they enter the bore of the ported structure it is also possible to vary the point in the engine cycle when an inlet passage comes into register with an engine cylinder.

A governor (not illustrated) located in the chamber 50*a* and driven by the aforesaid splined shaft 43*a* may be provided which governor is arranged to alter the position of the blades 50 in accordance with changes of speed of rotation of the crankshaft whereby the mean velocity of gases passing through the inlet port, when a combustion chamber is in register with an inlet port may be maintained substantially constant.

It will be appreciated that an effective seal requires to be provided by the aforesaid sealing means 37 between the rotating cylinder assemblage 11 and ported structure 12 so as to prevent the escape of products of combustion to the ambient atmosphere. For this purpose sealing liquid is introduced between opposed faces of the sealing means 37 and the face 56 of the part 32 of the ported structure in the manner referred to later. This raises the further problem of preventing such sealing liquid being drawn into the engine cylinders through the aforesaid tortuous annular space between the stepped faces 38, 39, 40 and an important aspect of the invention is the provision of means for scavenging the sealing liquid from the aforesaid annular spaces.

Such scavenging means are arranged to provide a suction effect and are now described together with the means for introducing the sealing liquid between the parts 32, 37.

The introduction of the sealing liquid and the suction scavenging means is now described with reference to Figure 3.

The aforesaid sealing means comprises a sealing ring 37 which may be split around its circumference and is located in a circumferential groove 52 in a side face of each of the annular members 20, which groove has side walls 53, 54 and bottom wall 55. Each ring 37 is pressed towards a side face 56 of the inwardly extending portion 32 of the ported structure by spring urged plungers 57 disposed in bores 58 through the wall 55 of the groove 52 (see the left hand side of Figure 3). A space 59 is left between the bottom 55 of the groove and the adjacent face of the ring 37. As can be seen in Figure 5 the bores 58 which accommodate the plungers 57 are disposed to either side of the engine cylinders so that the part of the sealing ring which extends between the plungers is urged towards the face 56 of the part 32. Sealing liquid from the sealing faces may enter the gap 59 between the sealing ring and the bottom of the groove 55, and this liquid is prevented from flowing circumferentially around the gap by the plungers which are dimensioned so as to extend across the whole width of the groove. Sealing liquid is introduced between the opposite face of each ring and the opposed face 56 of the part 32 of the ported structure, through passages 60 in each ring which communicate with a circumferential groove 61 in the ring which in its turn communicates with a number of passages 62 in the annular member 20. These passages terminate in axially extending recesses 63 in the outer peripheral face of the annular member 20. The annular member 20 is provided with radial passages 64 which communicate with the axial recesses 63 through a stop valve 65 which opens against the action of a light spring under centrifugal force. The radial passages 64 receive oil constituting the aforesaid sealing liquid that is thrown out of the crankshaft bearings (not shown) and collects around the periphery of the bore through the cylinder block 13 at *64a*. The oil reaches the crankshaft bearings through drillings 66 in the crankshaft 10 which are supplied with oil by the aforesaid oil pump.

With this arrangement the supply of oil to the passage 60 in the ring 37 is under considerable pressure due to the centrifugal effect on the oil in passing through the passage 64 in the rotating annular member 20, whereby an effective oil feed is provided between two opposed faces of the sealing ring 37 and of the part 32 of the ported structure.

Pressure will build up in the space 59 due to oil therein which is subjected to the pressure in the engine cylinders during the explosion strokes which pressure is used to assist the action of the spring 57 on the adjacent side of the ring 37. The opposite side of the ring is cut back at 9 so that its area is less, and this will ensure the oil film being at a greater pressure than the combustion gas pressure in order that the oil film may not be blown away by the pressure of the combustion gases.

It will be appreciated that there will be a tendency for the oil between the opposed faces of the ring 37 and part 32 to flow through the aforesaid tortuous stepped annular space bounded by the faces 38, 39, 40 towards the engine cylinders particularly when the pressure within the cylinder is low and as indicated above an important feature of the invention is the provision of suction scavenging means to prevent this. The scavenging means comprises a number of orifices 65 (see the left hand side of Figure 3) in that face of the annular member 20 which is disposed opposite the side face of the inwardly extending part 32 of the ported structure each of which orifices is at the end of a passage 66 in that part of the annular member 20 and which terminates in a radial passage 67 which in its turn terminates at the aforesaid space 59 between the ring 37 and the bottom wall 55 of the groove 52. The face of the annular member 20 which contains the orifice 65 is provided with a groove 68 (see Figure 5) which terminates in one of a number of cut away portions 69 in the face of the annular member 20 which is disposed opposite the inwardly extending part 32 of the ported structure.

In addition to the annular member 20 of the cylinder assemblage being provided with radial passages 67 in communication with the passages 66 there are provided other radial passages 70 (see Figure 5) which at one end communicate with a part of the space 59 between the sealing ring 36 and the bottom wall 55 of the groove 52 which is sealed off from combustion gases by the plungers 57 and at the other end they communicate with the space 34 shown in Figure 3.

It will be appreciated with this arrangement that a shear drag is set up in the oil film between the stationary surface 56 (Figure 3) of the side wall of the inwardly projecting part 32 of the ported structure and the opposed rotating face of the part of the annular member 20 which is provided with the orifices 65 thus producing a suction in the passages 66, 67 and space 59, thus providing a controlled discharge rate approximately proportional to engine speed for any oil which may have collected between the side of the ring 37 and the side wall 53 of the circumferential groove in which it is located and between that wall and an opposed face of the part 32 thus preventing the oil from flowing through the tortuous annular passage flanked by the stepped faces 38, 39, 40. Any oil sucked away in this manner eventually passes through the passages 67 and from the grooves 68 into the cut away portions 69 of the annular member 20 and thence into the space 34 between the part 33 of the ported structure and the annular part 22 and finally through a port 71 communicating with an oil sump (not shown) and thence with the inlet side of the oil pump.

It is found that with this arrangement the suction scavenging effect produced by the shear drag on the oil between the stationary face 56 of the ported structure and the opposed rotating face of the annular member 20 is sufficient and counterbalances or exceeds the suction prevailing in said annular space flanked by the stepped faces 39, 39, 40 both during the suction stroke of the engine and also during over-running of the engine with small throttle openings. Excessive escape of oil under pressure from between the face 53 of the annular member 20 and the ring 37 during the high pressure periods of the explosion strokes of the engine through the space between the stationary face 56 and the closely spaced rotating face of the annular member 20 is resisted because the face 56 and opposing face of the annular member 20 provide a constricted passage in which oil drag is high and this opposes flow of oil through the passage.

It is also desirable to prevent escape of gases from the engine cylinders except when the cylinders are in register with inlet and exhaust ports and for this purpose sealing blades 72 (see Figures 3, 4 and 5) are mounted in slots 73 on each side of each cylinder 15 and so as to be movable in directions substantially parallel to the axis of the engine cylinders 15. The outer end of each blade 72 engages a follower 74 in a slot in that part 21 of the annular member 20 in which is formed the aforesaid circumferential groove for accommodating the sealing ring 37. In Figure 3 the follower 74 being in a plane below that of the section appears withdrawn partly from the slot. The outer end of the slot with respect to the crankshaft is disposed opposite a track constituting the surface 75 on the inwardly projecting part 32 of the ported structure so that with the rotation of the cylinder assemblage the follower travels around that surface. When the followers 74 are brought into engagement with the tracks 75 under the action of spring means (not shown) and the action of centrifugal force the edges of the blades 72 opposite the ported structure are spaced therefrom by a few thousandths of an inch in accordance with the radial thickness of the followers 74 so as to prevent wear yet at the same time prevent a substantial escape of gas from the cylinder.

As previously indicated the opposed faces of the annular member 20 and of the inwardly projecting part 32 of the ported structure are stepped at 38, 39, 40. As best seen in Figure 4 the faces of the follower which project from the slots in the annular member 20 are likewise stepped and are given the same reference numerals 38, 39, 40. This stepped face of each follower is pressed against the stepped face 39 to the part 32 of the ported structure by a compression spring 76 disposed in a hole in the follower and at one end abutting the bottom of the hole and at the other end abutting against the annular member 20. As described later lubricating oil is permitted to enter the gap between the follower and the face 39 but is prevented from flowing past the stepped faces into the gap between the follower and the face 40. Thus the face of the follower opposite the face 40 of the ported structure is cut back a little so that when the follower is urged towards the face 39 of the ported structure a slight gap remains between it and the face 40.

Assuming the cylinder assemblage and annular member 20 are rotating anti-clockwise it will be noted from Figure 5 that certain of the radial passages 70 will be disposed in advance of and close to leading followers 74 and certain of the passages 67 will be disposed on the trailing sides of those followers whereas others of the passages 67 will be disposed in advance of and close to trailing followers and others of the passages 70 will be disposed on the trailing side of those followers.

Each of the trailing followers is provided on that face thereof which moves around the track 75 of the inwardly projecting part 32 of the ported structure with grooves indicated at 77 in Figure 4 also both the trailing sides and leading sides of all followers are provided with inclined slots 78 as seen in Figure 5 which at one end are opposite the steps 40 on the followers and which slots communicate with the ends of passages 79 in a part of the annular member 20 and which terminate in the sides of the slot in which the followers are located, the other ends of the passages terminate in that part of the annular member 20 which is disposed opposite the track 75.

Thus should any oil accumulate at the steps 40 on the ported structure it will be collected by slots 78 on the followers whence it passes down the passages 79 under the action of centrifugal force and is deposited on the track 75 whence it may pass to either a passage 70 or 67.

In order to limit the volume of oil on the part of the track between leading and trailing followers provision is made to reduce the quantity of oil on the track between the leading and trailing followers of each cylinder. Any excess oil thereon will build up at the leading edge of the trailing follower. In Figure 4 the leading face of the leading follower 74 is indicated by the dotted cross lines and it will be seen that the lower edge of the leading face is disposed adjacent the space between the inner face of the ring 37 and the overlying face 53 of the annular member 20 and the centrifugal motion and the suction is being applied to that space via passages 59, 67, 66 and 65.

Any oil building up on the edge of the leading face of the trailing follower requires to be transferred to an area on the trailing side of the follower. This is in part effected by the shear drag of the oil between the faces of the follower and the faces of the track on the ported structure over which the follower moves. This effect is enhanced by the grooves 77 formed in the follower and this shear drag constitutes a further suction scavenge means. The oil accumulating on the trailing side of the follower then centrifuges out through the radial passage 70 on the trailing side of that follower to the annular space 34.

Various of the annular parts referred to above may be required to be manufactured to a slightly eccentric shape so that on reaching normal hot running conditions those parts expand to a substantially annular configuration.

WHAT WE CLAIM IS:—

1. A rotary internal combustion engine comprising a ported structure and an assemblage of parts providing a set of combustion spaces, the ported structure and assemblage of parts being relatively rotatable so that the ports in the ported structure communicate successively with the combustion spaces of the assemblage of parts there being pairs of sealing faces encircling, and spaced apart along, the axis of said relative rotation of the ported structure and assemblage of parts on either side of the combustion spaces, one sealing face of each pair being on the ported structure and the other sealing face being on the assemblage of parts, means being provided for introducing sealing liquid between the sealing faces of each pair, and suction scavenging means being provided for withdrawing sealing liquid from the spaces between the opposed faces of the ported structure and assemblage of parts which lead from the sealing faces to the combustion spaces.

2. A rotary internal combustion engine according to claim 1 wherein said suction scavenging means are activated by shear drag set up in a film of the sealing liquid between relatively rotating closely spaced faces.

3. A rotary internal combustion engine according to either of the preceding claims wherein each said pair of sealing faces comprises a sealing ring in a groove in one of the relatively rotating parts and engaging a face on the other part.

4. A rotary internal combustion engine according to claim 3 wherein each sealing ring is mounted in a circumferential groove in that part which contains the combustion spaces and means are provided for introducing sealing liquid between a face of the ring and an opposed face on the ported structure and which ring is so formed and mounted in the groove as to provide a passageway extending along the bottom wall of the groove and along a side wall of the groove, one end of which passageway terminates at the opposed faces of the relatively rotating parts on that side of the locality where fluid is introduced between said opposed faces which is nearer the combustion spaces, and the other end of the passage way communicates with a throughway terminating at the opposed faces of the relatively rotating parts on the opposite side of the aforesaid locality to that where said passage terminates whereby the oil shear drag between the surfaces of the relatively rotating parts adjacent the end of the throughway has a suction scavenging action causing the sealing liquid to flow in a direction away from the combustion spaces, aided by centrifugal motion.

5. A rotary internal combustion engine according to claim 4 wherein that face of each ring which may be subjected to a pressure corresponding to the pressure in the combustion spaces is of greater area than the face on the opposite side of the ring which is exposed to the pressure of the sealing liquid whereby the ring tends to move in a direction to bring the sealing faces together and the film of sealing liquid is maintained at a pressure in excess of the pressure ruling in the combustion space.

6. A rotary internal combustion engine according to claim 4 or claim 5 wherein relatively rotating stepped faces are provided on parts of the ported structure and assemblage of parts containing the combustion spaces so as to lie between the sealing rings and combustion spaces.

7. A rotary internal combustion engine according to any of the preceding claims wherein additional sealing means are provided in the form of blades disposed between adjacent combustion spaces and mounted on one of the relatively rotating parts so as to be movable towards the other part and means for maintaining a minimum clearance between said blades and the other part whereby the flow of gases from one combustion space to another is substantially prevented.

8. A rotary internal combustion engine according to claim 7 wherein said blades are mounted in slots in a part of the rotatable structure and are provided at opposite ends with followers which engage surfaces on the ported structure adjacent said sealing rings and wherein the followers on the trailing side of the combustion spaces have associated therewith suction scavenging means whereby oil tending to pile up on the leading faces of the trailing followers is prevented from flowing into the combustion spaces.

9. A rotary internal combustion engine according to claim 8 wherein the faces of the followers arranged on the trailing side of a combustion space and which engage the surfaces are provided with grooves extending from the leading to the trailing ends of the followers so as to assist in the scavenging effect produced by oil shear drag between the relatively moving faces of the followers and said surface.

10. A rotary internal combustion engine according to claim 4 together with either of claims 8 or 9 wherein each said surface is substantially in line with one of the sides of one of the grooves in which a sealing ring is located so that the suction produced by the oil shear drag between the ring and a face of the ported structure assists in the withdrawal of oil from said surface.

11. A reciprocating piston rotary internal combustion engine substantially as herein described with reference to and as shown in the accompanying drawings.

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Agents for the Applicants.

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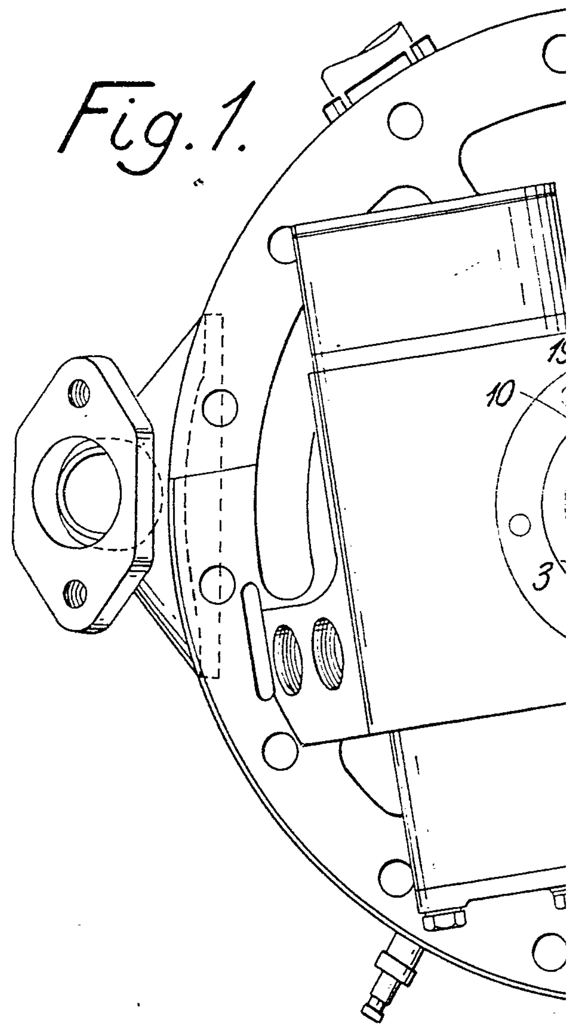
Fig.1.



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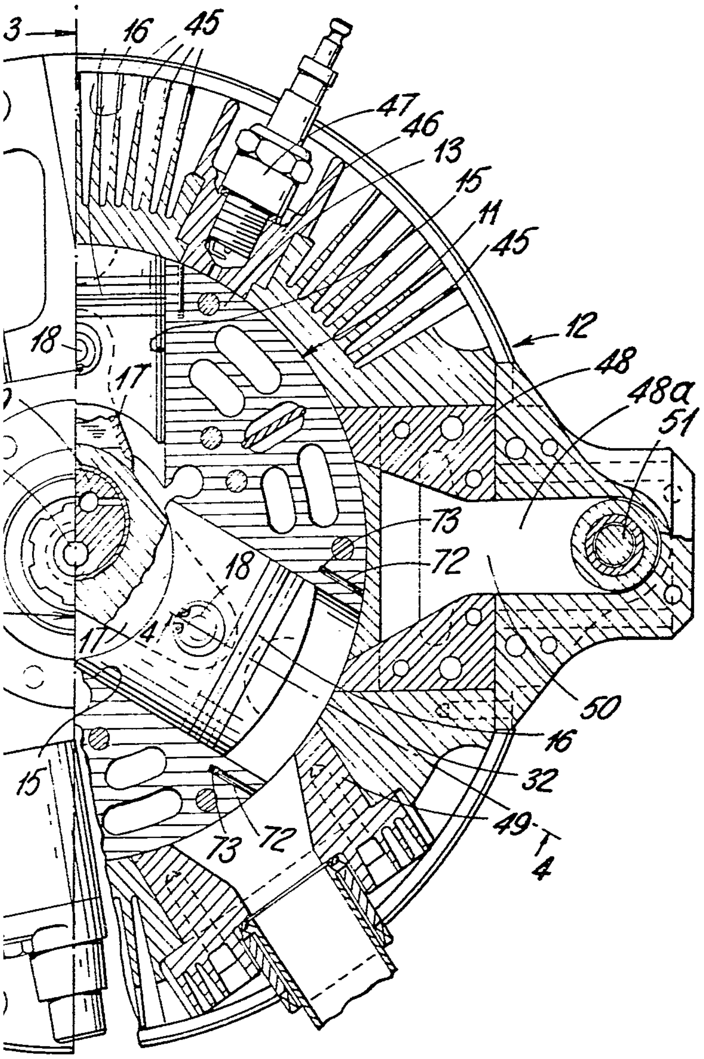

Fig. 1.

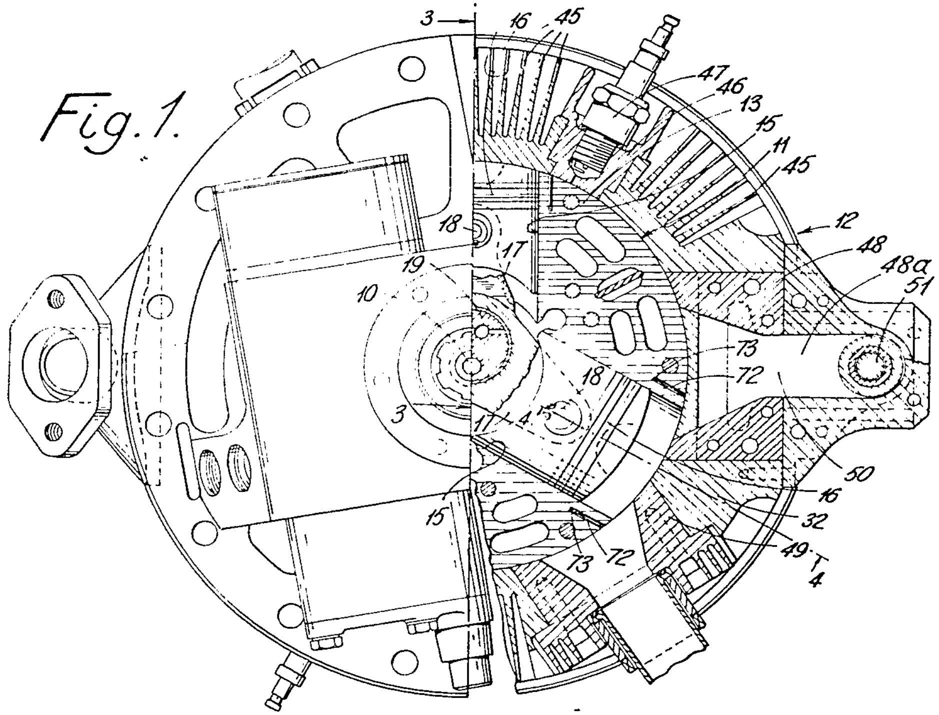
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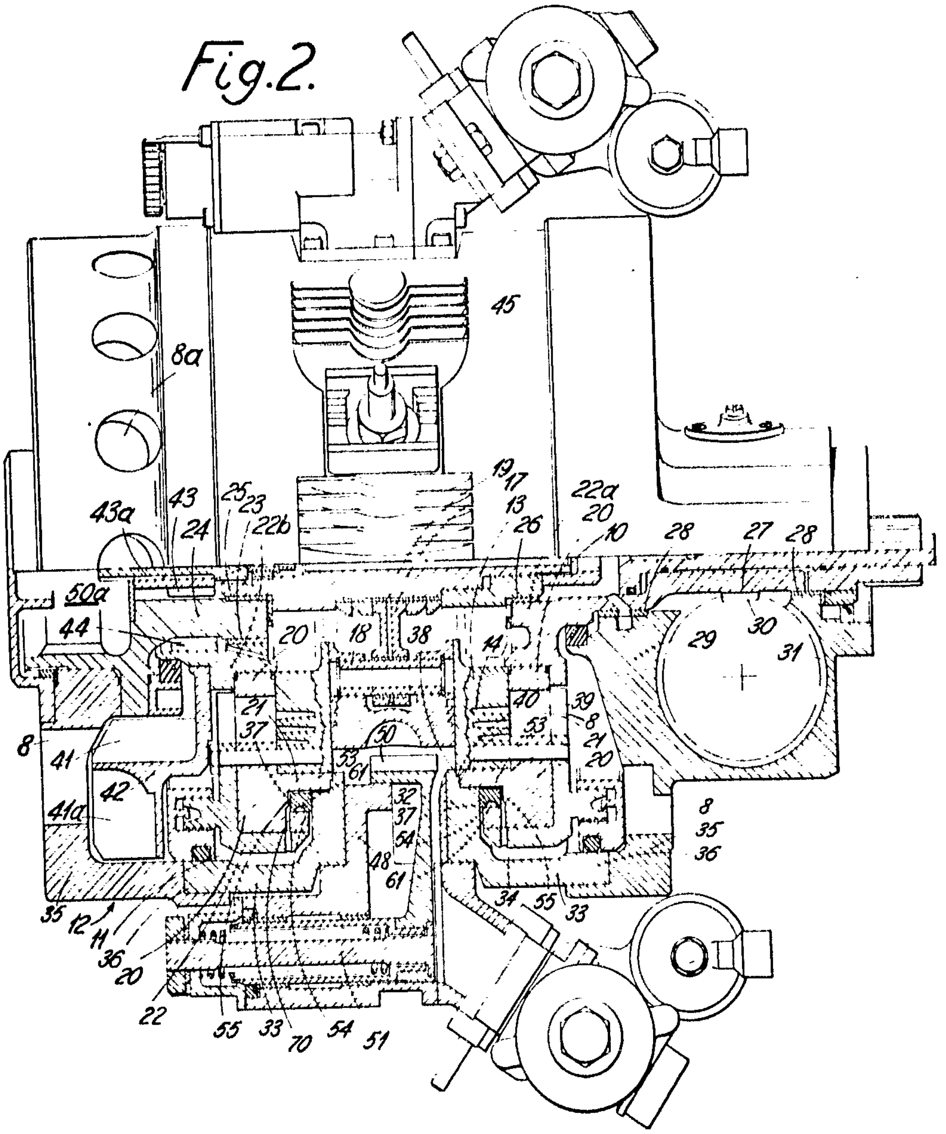
Fig.2.



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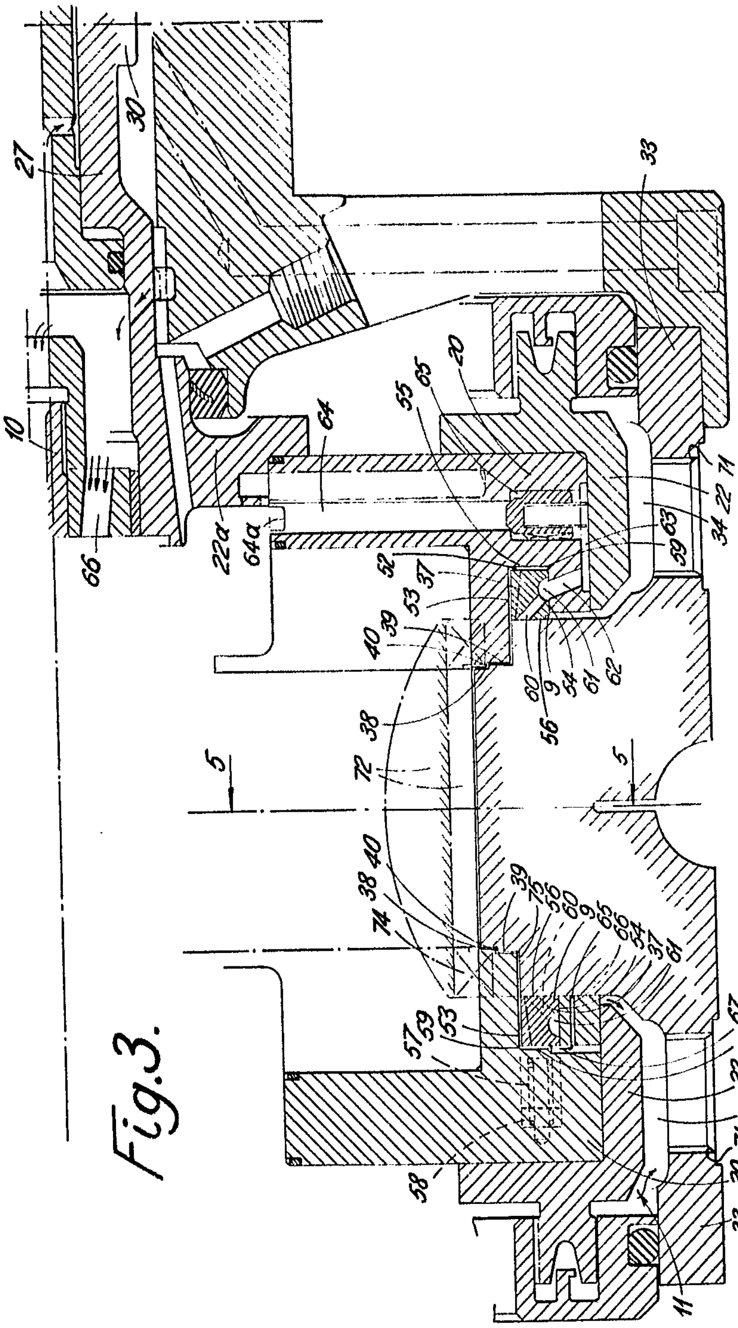

Fig.3.

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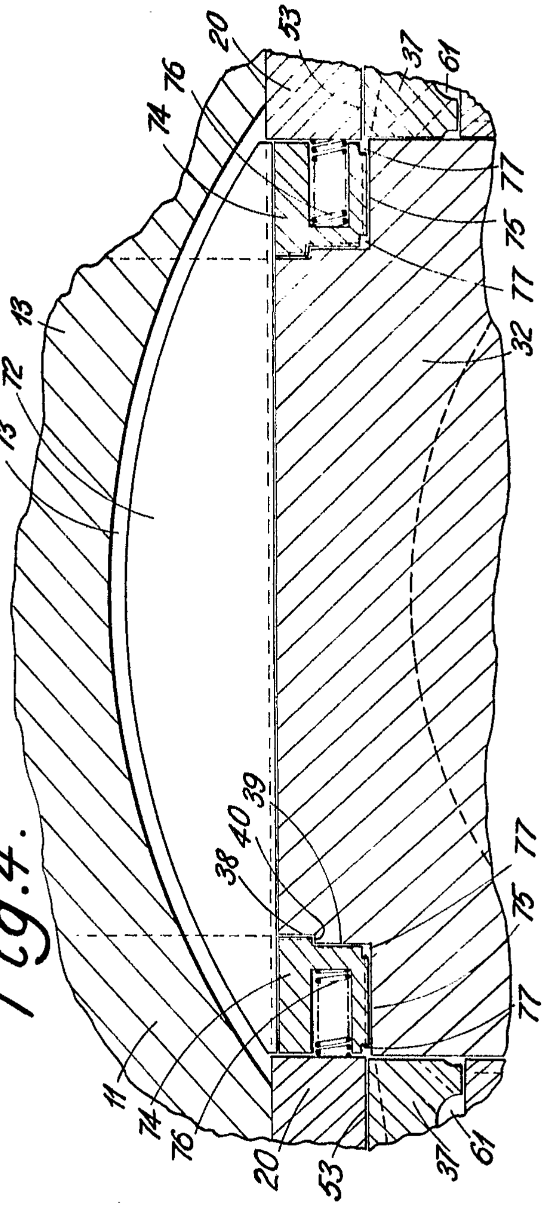

Fig.4.

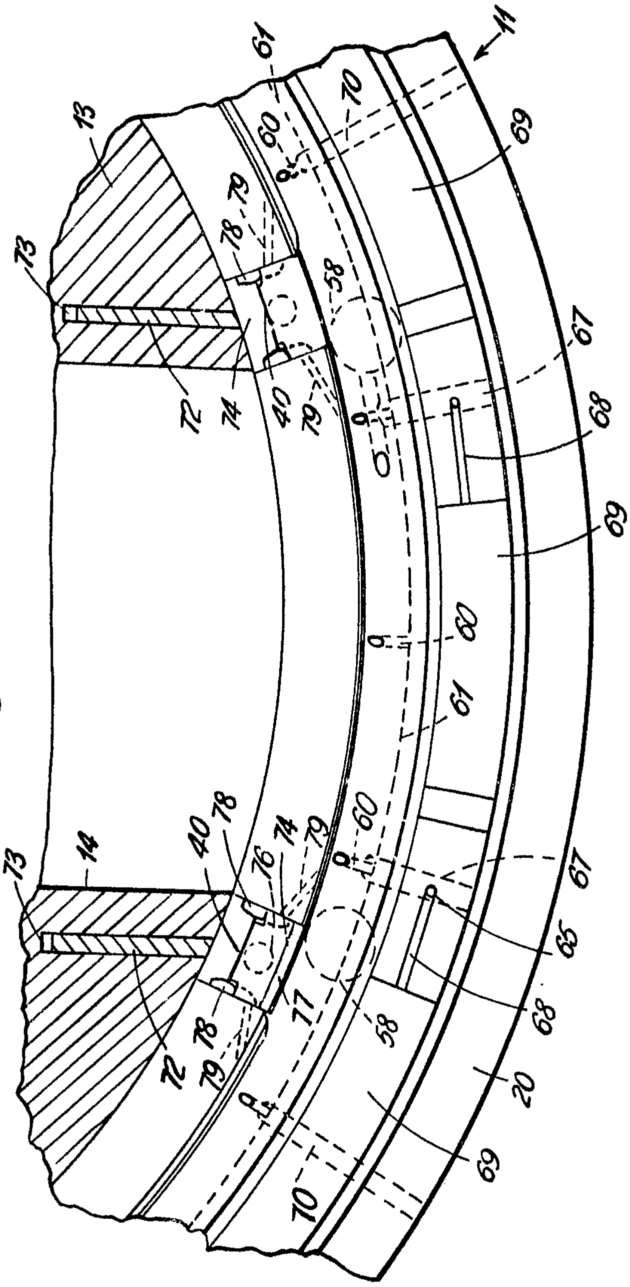

Fig. 5.