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(58) Field of Search
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INT CL[7] **F01B, F02B**
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(54) Abstract Title
Reciprocating-piston i.c. engine with cam mechanism instead of crankshaft

(57) An internal combustion engine comprising at least one cylinder mechanism; a rotary output drive which is rotationally driven by the cylinder mechanism; the cylinder mechanism comprising: a housing 2 in which is formed a cylinder 4; a piston 6 which co-operates with the cylinder 4 during a combustion cycle to generate the rotary movement of the rotary output drive; a movement control mechanism comprising a cam 36 and a cam follower 10 which controls the relative movement of the piston in relation to the cylinder 4 during the combustion cycle; characterised in that the cam surrounds the piston 6 and cylinder 4.

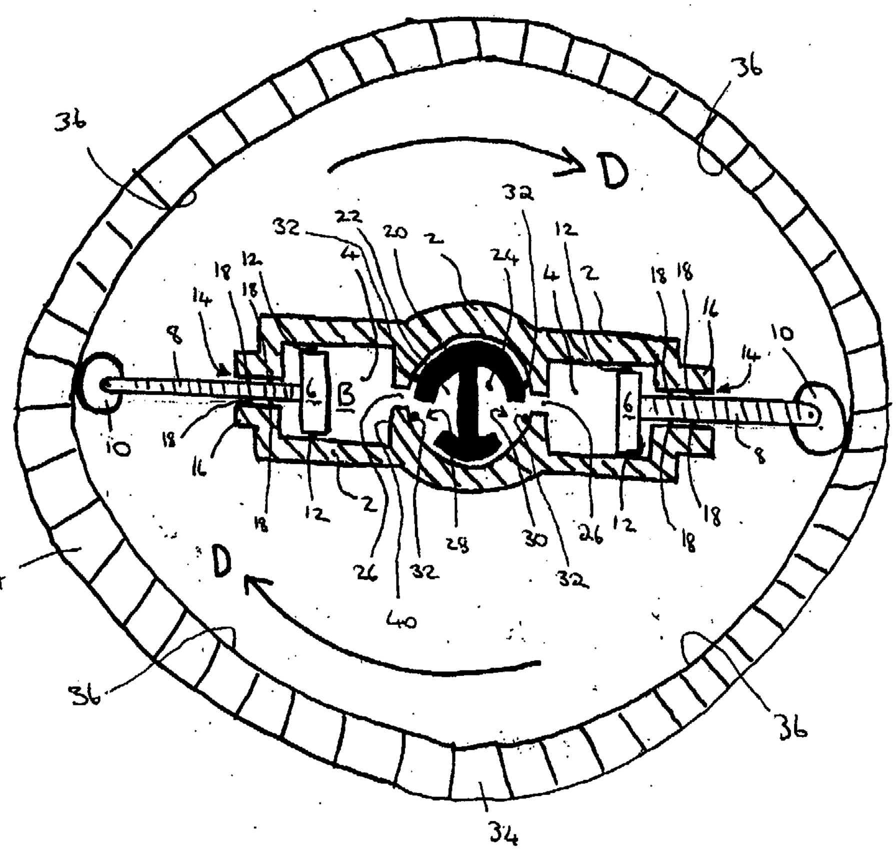

Fig. 1

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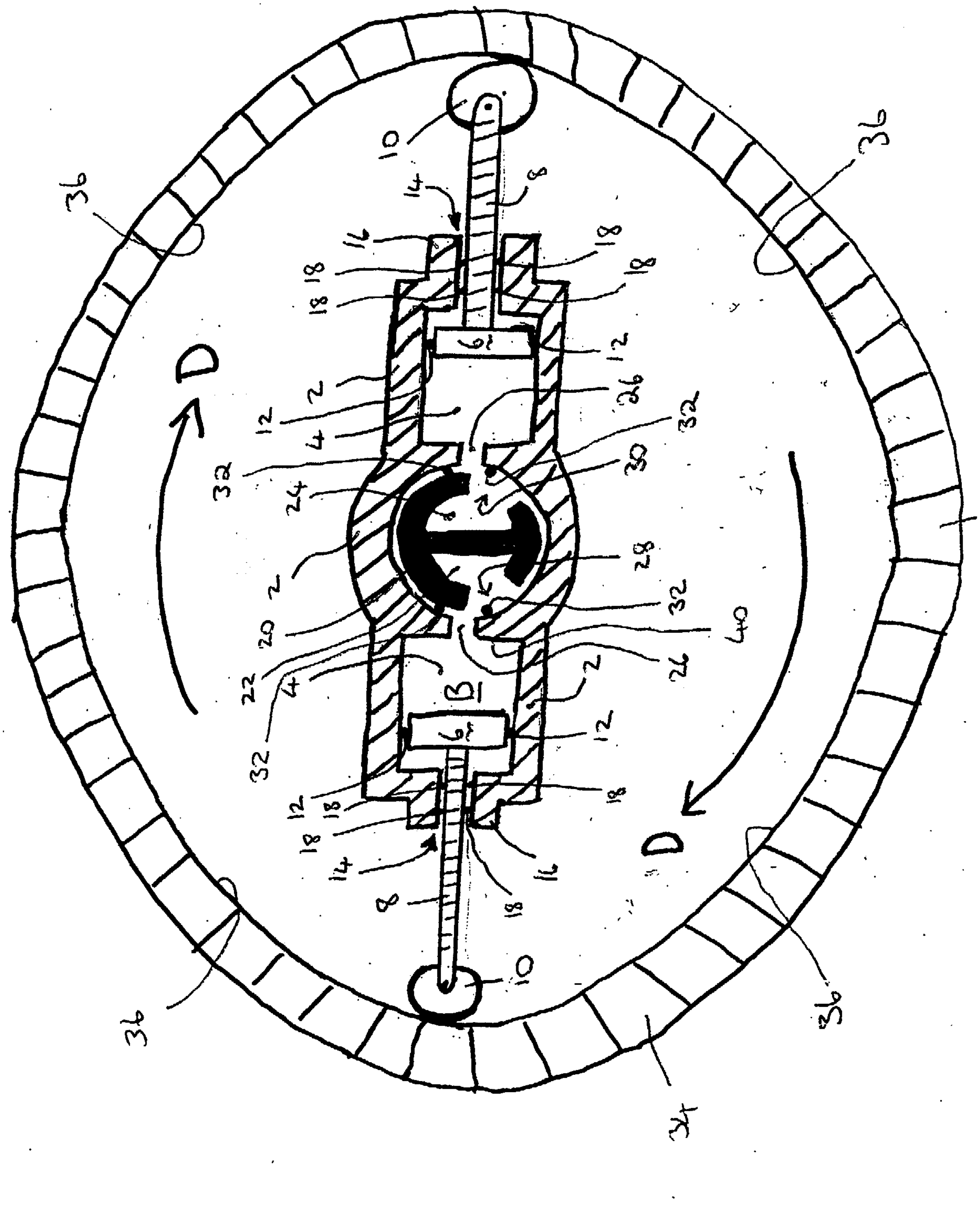
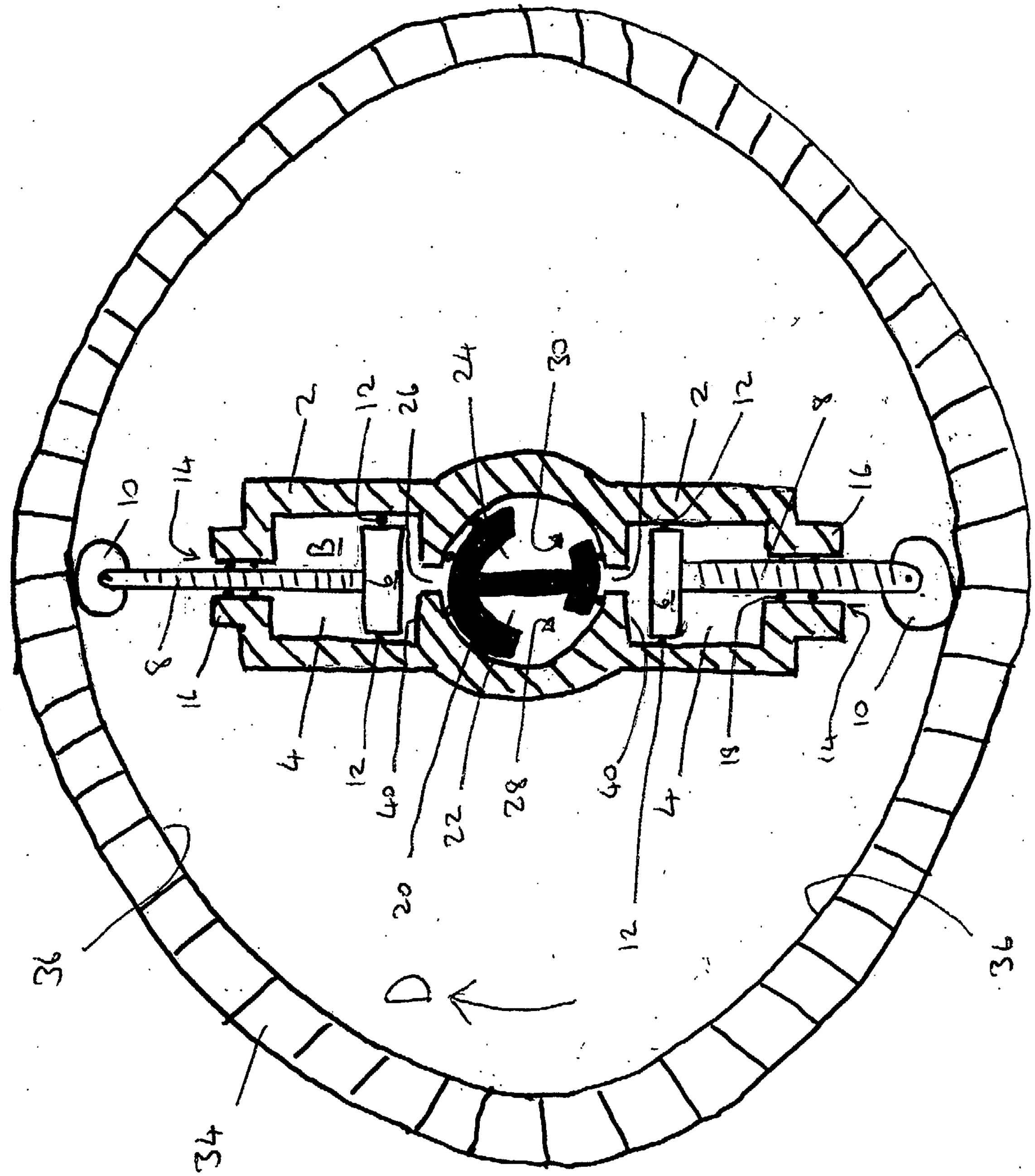


Fig. 1

Fig. 2



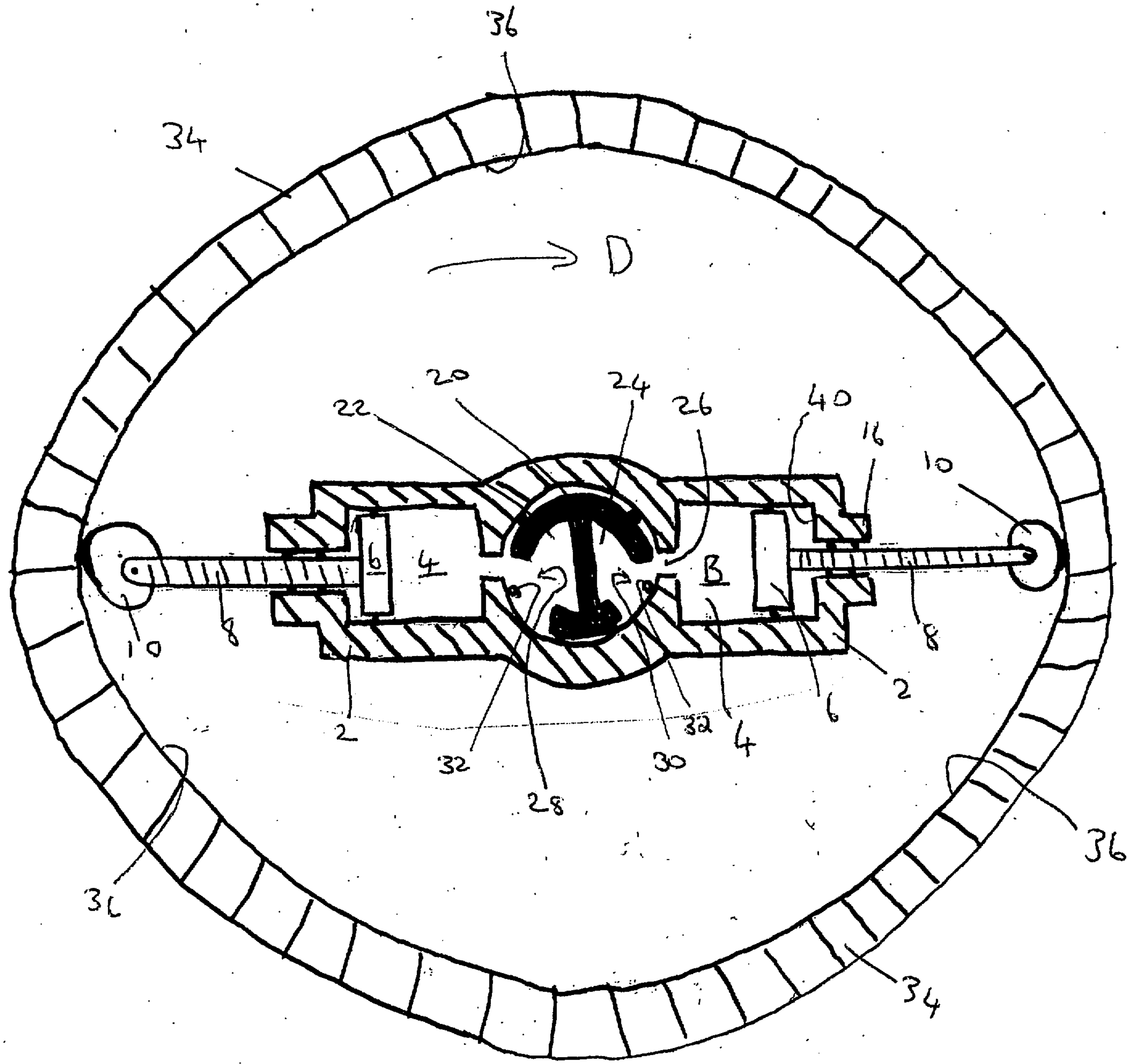


Fig. 3

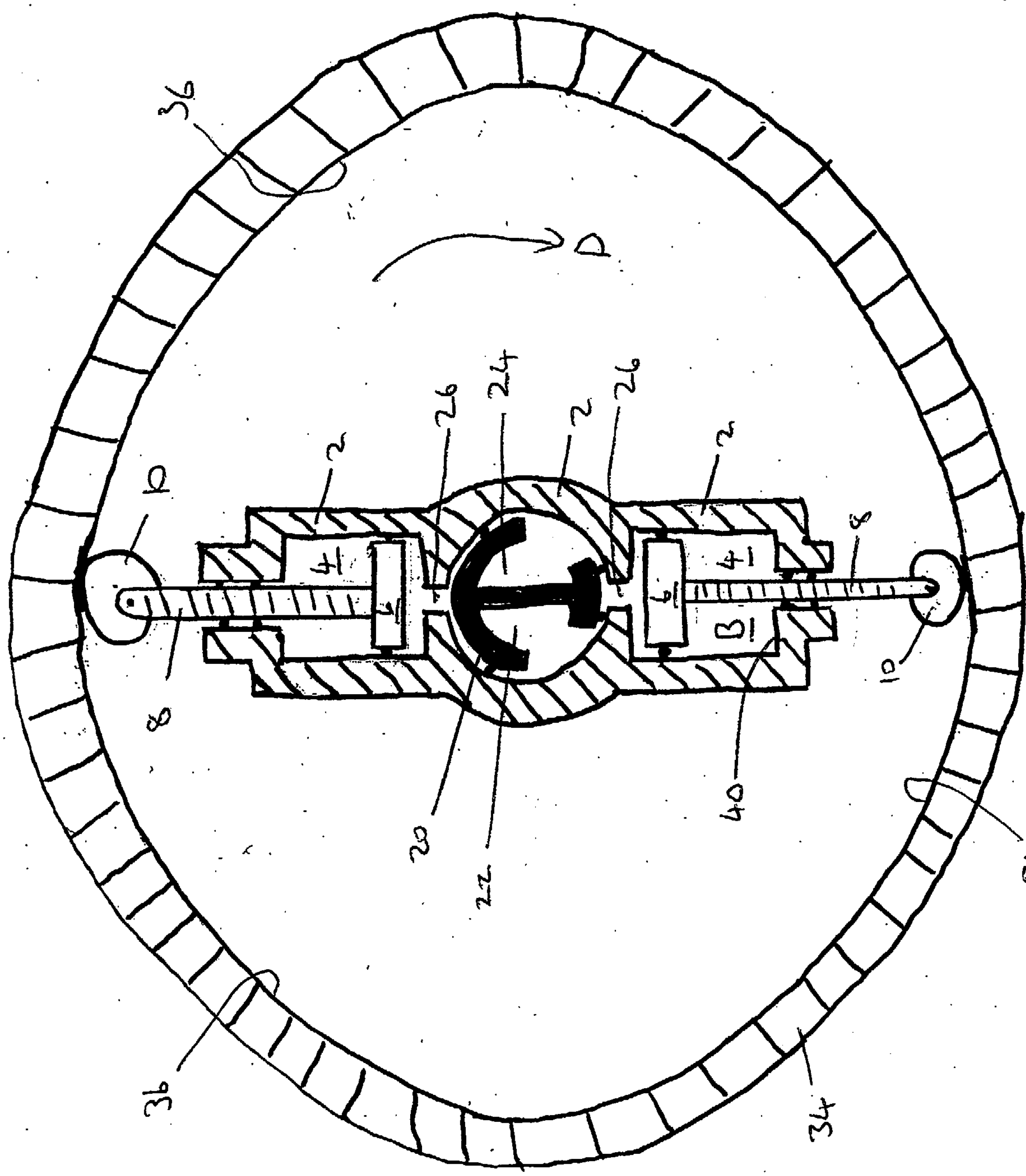


Fig. 4

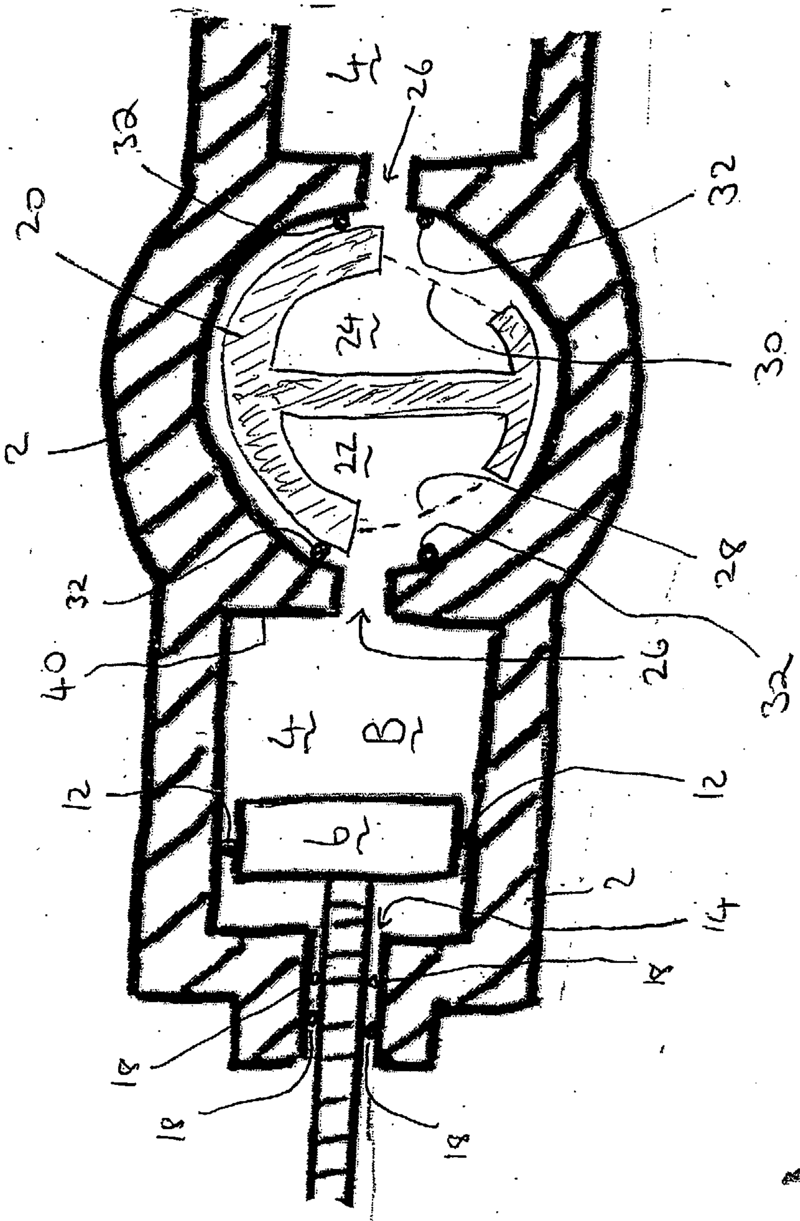


Fig.5

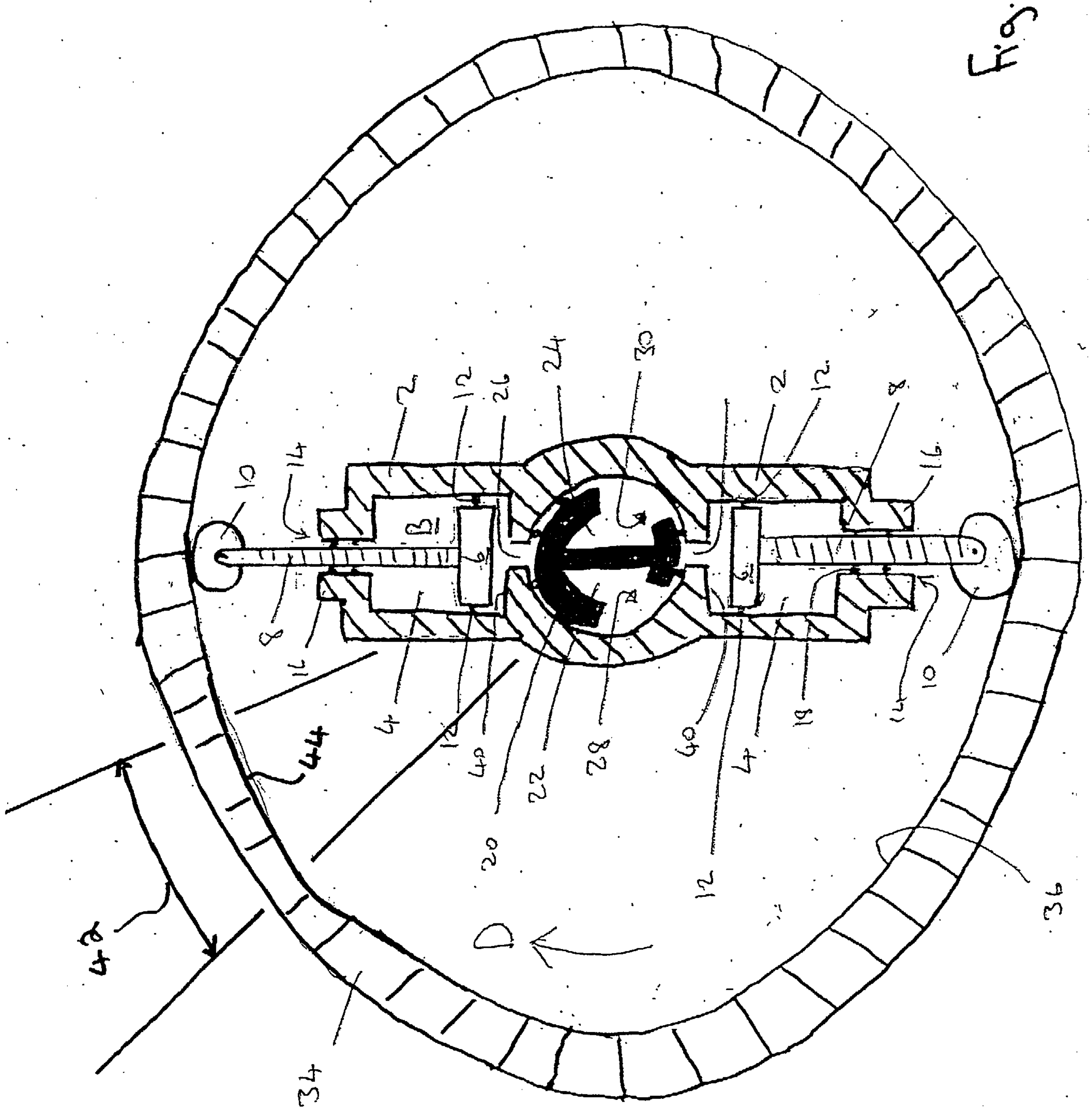


Fig. 6

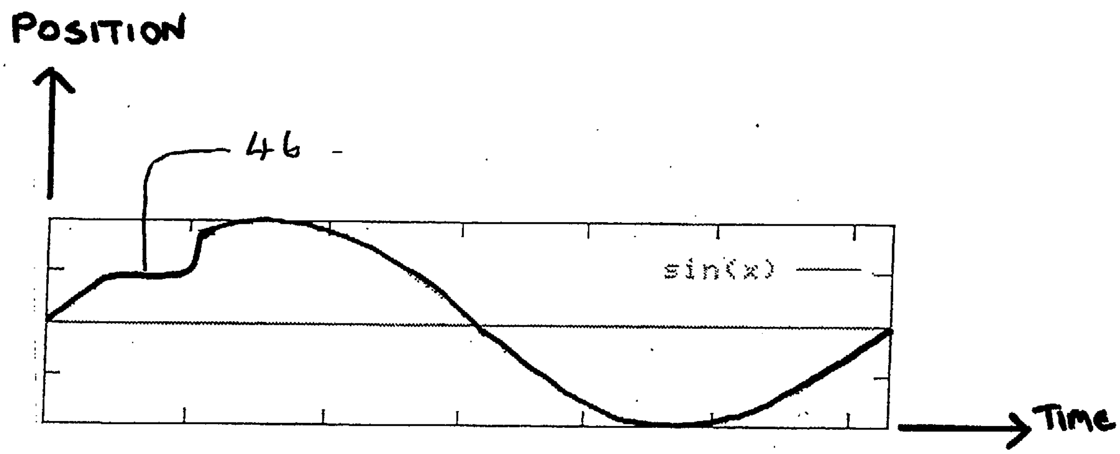


Fig. 7.

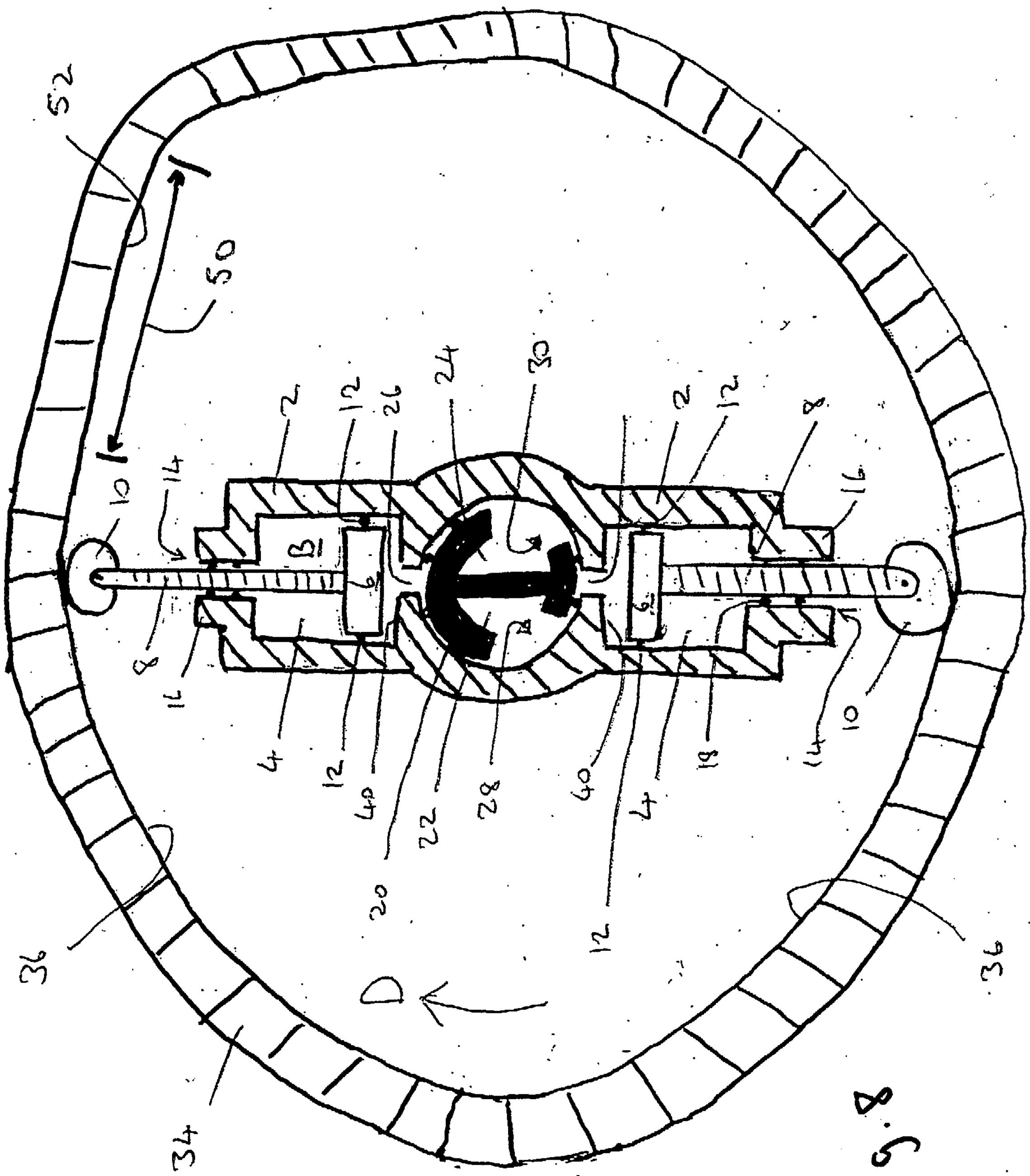


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Fig. 8

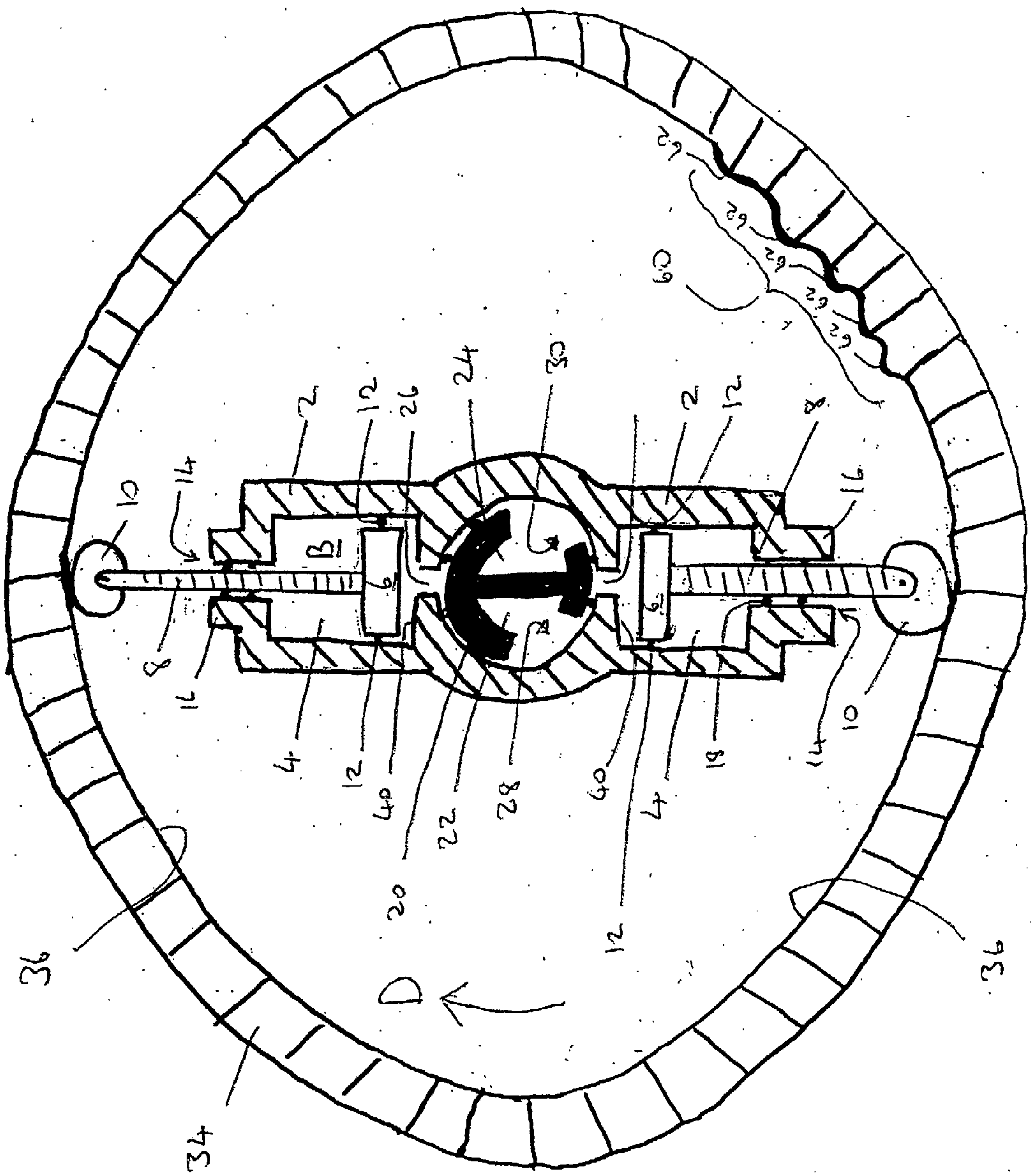

Fig. 9

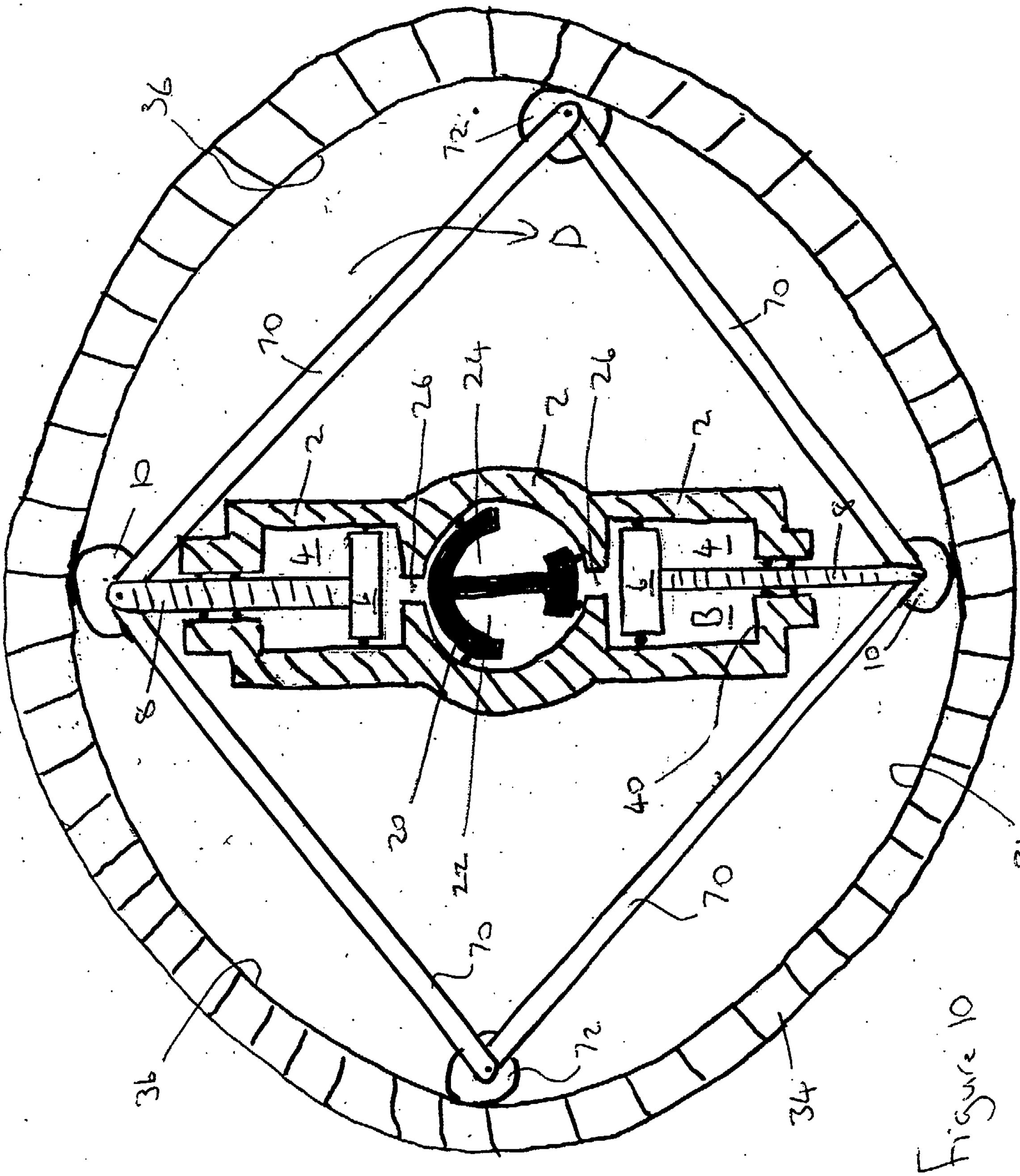

Figure 10

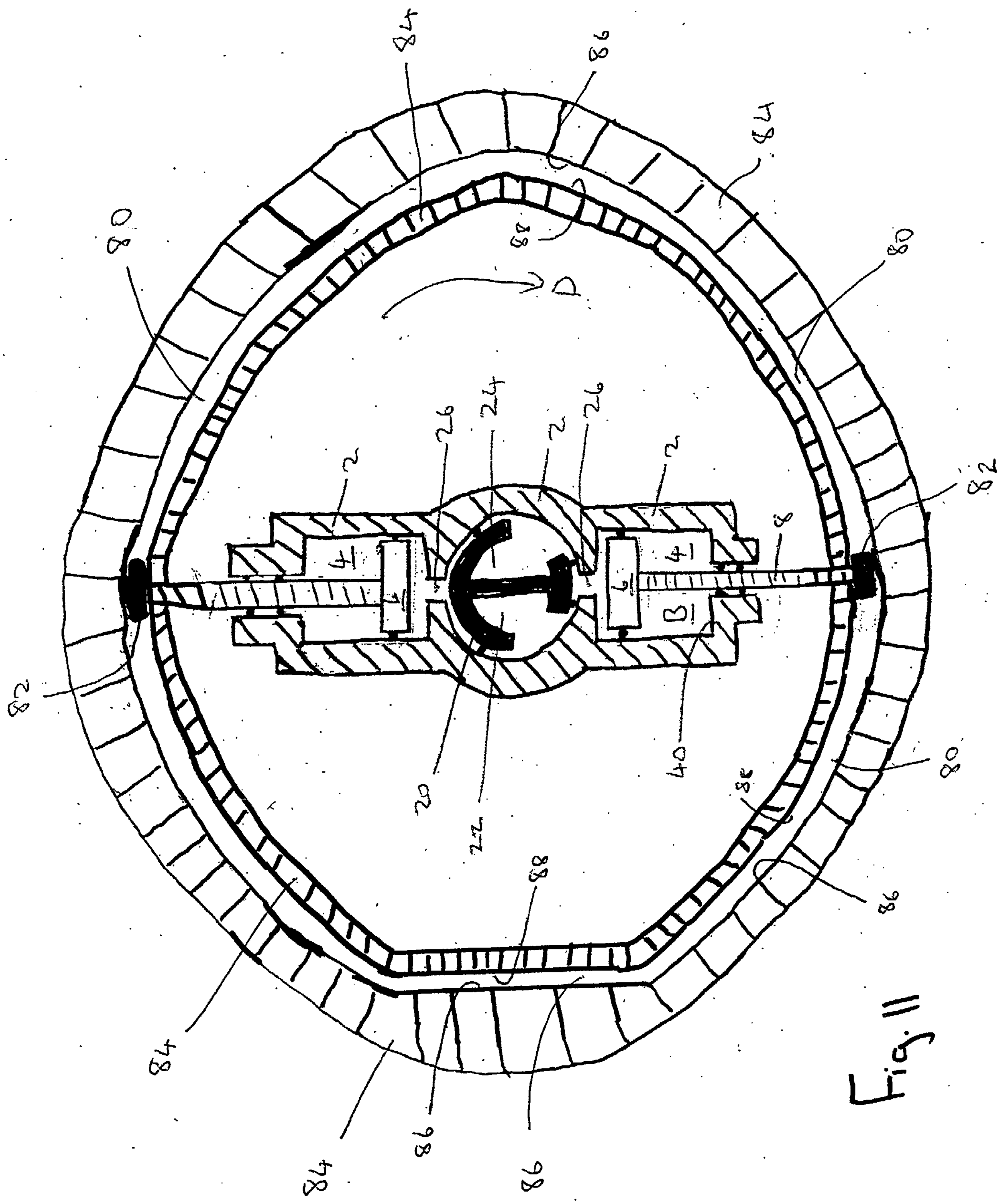
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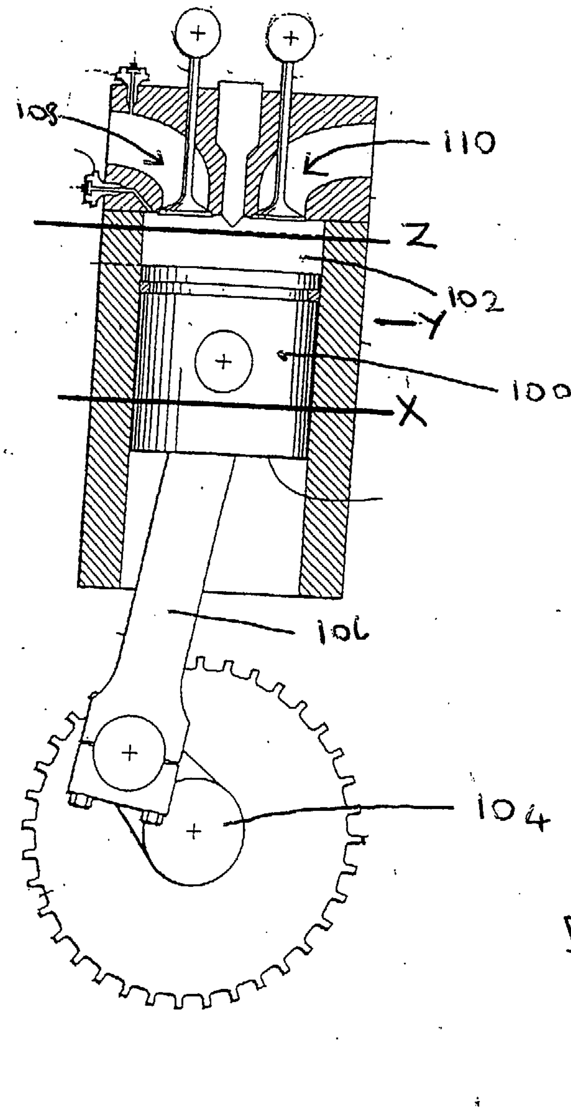
Fig. 11



PRIOR ART

Fig. 12

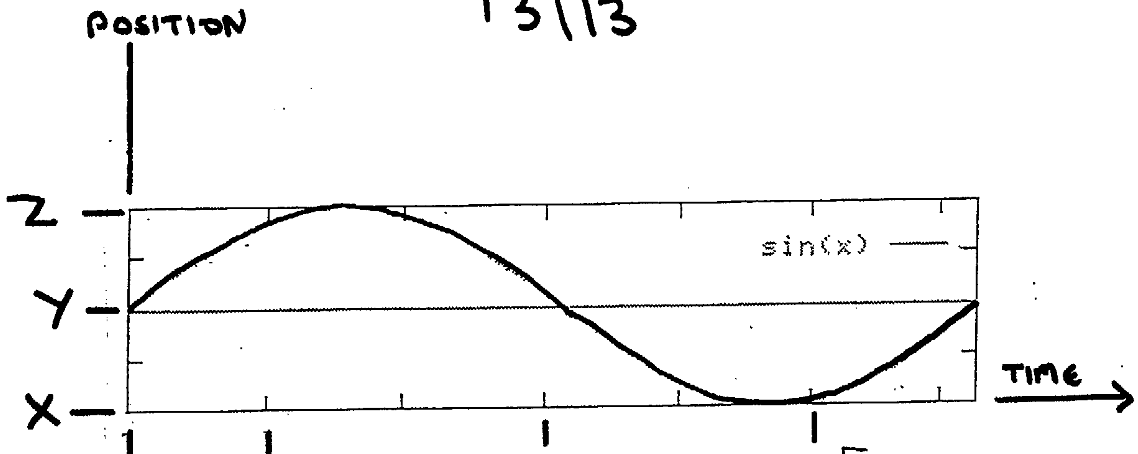


Fig 13A

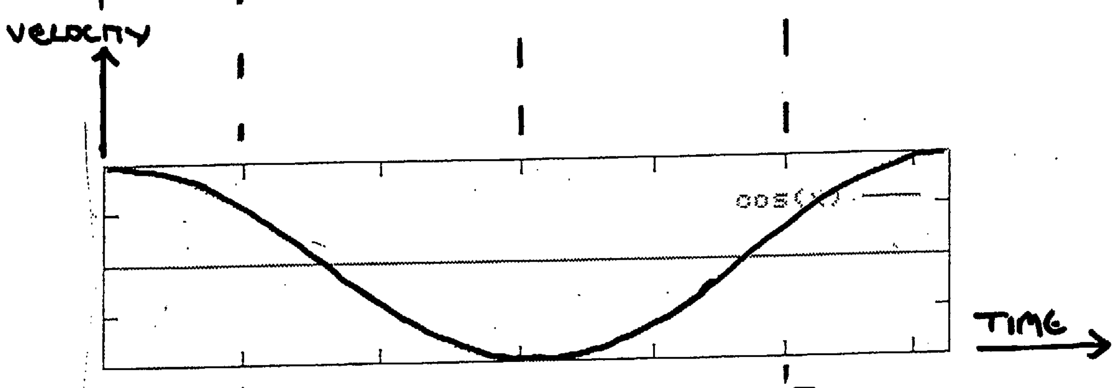


Fig. 13B

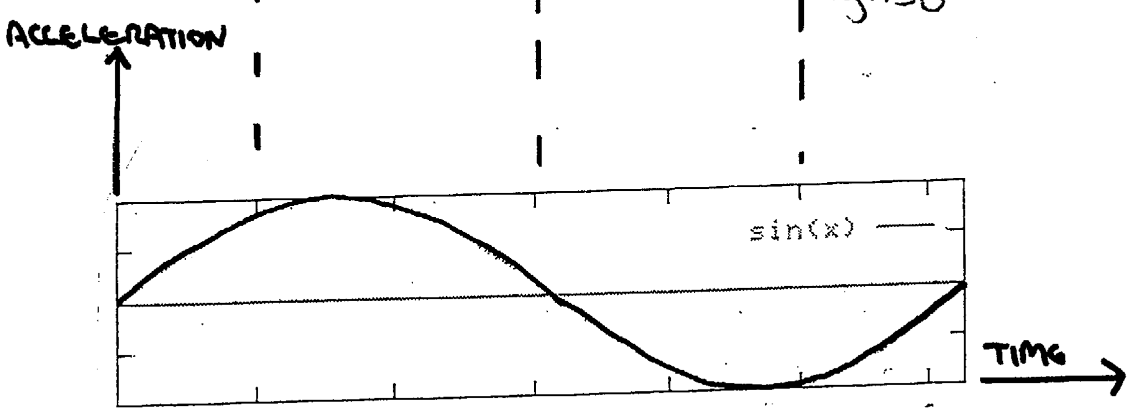


Fig. 13C

Internal Combustion Engine

The present invention relates to an internal combustion engine and in particular, to an internal combustion engine which has a piston located within a cylinder and which is reciprocatingly driven within the cylinder during a combustion cycle.

Internal combustion engines which comprise pistons reciprocatingly driven within cylinders during a combustion cycle are well known. There are two standard types of design, a four stroke engine and a two stroke engine. As these two types of engine are well known in the art, no further reference will be made in relation to how they work. However, both types of engine comprise a crank which converts the linear reciprocating movement of the piston within the cylinder into a rotary movement of the crankshaft. The crank acts as a movement control mechanism which co-ordinates the movement of the piston in relation to the cylinder during the combustion cycle of the engine. If the rate of rotation of the crankshaft is constant, the movement with time, velocity and acceleration of the piston within the cylinder is a simple sinusoid. This can be restrictive.

GB1115147 discloses an engine whereby the crank shaft has been replaced by a cam shaft and which is used to convert the reciprocating movement of the piston to a rotary movement of the cam shaft. During the combustion cycle, it is arranged that the piston remains stationary for part of the cycle even though the cam shaft continues to rotate. This allows the movement with time, velocity and acceleration of the piston within the cylinder to deviate from a simple sinusoidal motion even if the rate of rotation of the cam shaft is constant. However, the construction disclosed in GB115147 is such that the variation in the sinusoidal movement of the piston is very limited.

According to the first aspect of the present invention, there is provided an internal combustion engine comprising at least one cylinder mechanism;

a rotary output drive which is rotationally driven by the cylinder mechanism;

the cylinder mechanism comprising:

a housing in which is formed a cylinder;

a piston which co-operates with the cylinder during a combustion cycle to generate the rotary movement of the rotary output drive;

a movement control mechanism comprising a cam and a cam follower which controls the relative movement of the piston in relation to the cylinder during the combustion cycle;

characterised in that the cam surrounds the piston and cylinder.

By constructing the engine in this manner, it produces a long cam surface along which the cam follower can slide. This allows the designer significant more maneuverability when designing the engine to provide the idea shape of cam throughout the whole of the combustion cycle due to the large length of the cam over which the cam follower has to follow.

The cylinder and piston can rotate about an axis of rotation during the combustion cycle. If so, the axis of rotation of the cylinder and piston can be perpendicular to the longitudinal axis of the cylinder.

The cylinder could comprise at least one aperture through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder. Ideally, there is only aperture through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder.

According to the second aspect of the present invention, there is provided an internal combustion engine comprising at least one cylinder mechanism;

a rotary output drive which is rotationally driven by the cylinder mechanism;

the cylinder mechanism comprising:

a housing in which is formed a cylinder;

a piston which co-operates with the cylinder during a combustion cycle to generate the rotary movement of the rotary output drive;

a movement control mechanism which controls the relative movement of the piston in relation to the cylinder during the combustion cycle;

characterised in that the cylinder and piston rotate about an axis of rotation during the combustion cycle.

By constructing an engine with rotating cylinders and pistons, it creates centrifugal forces on the parts of the engine which can be used to assist in the running and/or controlling of the engine.

The axis of rotation of the cylinder and piston can be perpendicular to the longitudinal axis of the cylinder.

The movement control mechanism can comprise a cam and a cam follower which controls the relative movement of the piston in relation to the cylinder during the combustion cycle wherein the cam surrounds the piston and cylinder. When a cam and cam follower are used, the centrifugal force can be used to keep the cam follower engaged with the cam.

The cylinder can comprise at least one aperture through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder. Ideally, there is only aperture through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder.

According to the third aspect of the present invention, there is provided an internal combustion engine comprising at least one cylinder mechanism;

a rotary output drive which is rotationally driven by the cylinder mechanism;

the cylinder mechanism comprising:

a housing in which is formed a cylinder;

a piston which co-operates with the cylinder during a combustion cycle to generate the rotary movement of the rotary output drive;

a movement control mechanism which controls the relative movement of the piston in relation to the cylinder during the combustion cycle;

characterised in that the cylinder comprises at least one aperture through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder.

This provides a structure whereby the same apertures are used for injecting the fuel mixture into the cylinder and removing the exhaust gases from the cylinder.

Ideally, there is only aperture through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder. Such a construction provides for a simple design requiring only aperture and hence one valve assembly to seal the aperture.

The piston and cylinder can rotate about an axis of rotation during the combustion cycle. The axis of rotation of the cylinder and piston can be perpendicular to the longitudinal axis of the cylinder.

The movement control mechanism can comprise mechanism comprising a cam and a cam follower which controls the relative movement of the piston in relation to the cylinder during the combustion cycle wherein the cam surrounds the piston and cylinder.

The shape of the cam can be such to produce a movement of the piston in relation to the cylinder which is a complex sinusoidal movement when the rate of rotation of the rotary output drive is constant. This enables the combustion cycle to be optimised for efficiency.

The velocity or acceleration of the piston in relation to the cylinder can vary in a complex sinusoidal manner when the rate of rotation of the output drive is constant.

During a single combustion cycle, a part of the reciprocating movement cycle of the piston can be complex sinusoid movement wherein the remainder of is simple sinusoid movement.

The engine can comprises a fuel mixture supply and exhaust removal unit which rotates in relation to the cylinder housing and comprises apertures through which the fuel mixture can pass through to the cylinder and exhaust gases can pass through to be removed from the cylinder, the cylinder comprising at least one aperture through which the fuel mixture can pass through into the cylinder and exhaust gases can pass through to exit the cylinder, wherein the fuel mixture is added to the cylinder from the fuel mixture supply and exhaust removal unit and the exhaust gas is removed from the cylinder to the fuel mixture supply and exhaust removal unit when the corresponding apertures are aligned during the rotation of the fuel mixture supply and exhaust removal unit in relation to the cylinder housing.

Six embodiments of the invention will now be described with reference to the accompanying drawings of which:-

Figure 1 shows a sketch of a vertical cross section of the engine with the cylinders and pistons located at a first position of the combustion cycle;

Figure 2 shows a sketch of a vertical cross section of the engine with the cylinders and pistons located at a second position of the combustion cycle;

Figure 3 shows a sketch of a vertical cross section of the engine with the cylinders and pistons located at a third position of the combustion cycle;

Figure 4 shows a sketch of a vertical cross section of the engine with the cylinders and pistons located at a fourth position of the combustion cycle;

Figure 5 shows a sketch of a close up of the central core and left cylinder shown in Figure 1;

Figure 6 shows a sketch of a vertical cross section of the engine with the cylinders and pistons surrounded by the cam surface according to the second embodiment of the invention;

Figure 7 shows a graph of the movement of the piston in the second emebodiment in relation to the cylinder over time;

Figure 8 shows a sketch of a vertical cross section of the engine with the cylinders and pistons surrounded by the cam surface according to the third embodiment of the invention;

Figure 9 shows a sketch of a vertical cross section of the engine with the cylinders and pistons surrounded by the cam surface according to the fourth embodiment of the invention;

Figure 10 shows a sketch of a vertical cross section of the engine with the cylinders and pistons surrounded by the cam surface according to the fifth embodiment of the invention;

Figure 11 shows a sketch of a vertical cross section of the engine with the cylinders and pistons surrounded by the cam surface according to the sixth embodiment of the invention;

Figure 12 hows a sketch of a vertical cross section of a standard four stroke; and

Figure 13 shows a graph of the movement of the piston of a standard four stroke engine in relation to the cylinder over time.

Figure 12 shows the prior art. Referring to figure 12 , a four stroke engine comprises a piston 100 located within a cylinder 102. The piston 100 attaches to a crank shaft 104 via rod 106 which is pivotally attached to the base of the piston 100. Fuel is inserted into the cylinder 102 through a first valve 108 mounted in the top of the cylinder 102 and exhaust fumes are removed through a second valve 110 also mounted in the top of the cylinder in well known manner. The reciprocating piston 100 rotatingly drives the crank shaft 104. The movement of the piston 100 relative to the cylinder 102 is controlled by the crank shaft 104. The position of the piston 100 within the cylinder 102 is dependent on the angular position of the crank shaft 104. The piston 100 travels reciprocatingly along the cylinder 102 between the two positions indicated by the letters X and Z. The mid point between these two positions is indicated by the letter Y. Figure 13A shows the position of the piston 100 in the cylinder in relation to the central point Y over time when the crank shaft 104 rotates at a constant rate of rotation. The distance is positive when the piston 100 is above the position Y towards the valves and the distance is negative if the piston 100 is below the position Y towards the crank shaft 104. As can be seen the movement of the piston 100 over time produces a smooth sinusoidal movement shown graphically as a smooth sinusoidal curve. Similarly the velocity shown Figure 13B and acceleration shown in Figure 13C of the piston 100 within the cylinder 102 change with time in a smooth sinusoidal manner as shown by the smooth sinusoidal curves. The construction of such an engine is that, due to crank, if the rate of rotation of the crank is constant, the movement position over time, the velocity and acceleration vary in a smooth sinusoidal manner. Such a smooth sinusoid is referred to as a "simple sinusoid" throughout this specification.

The first embodiment of the present invention will now be described with reference to figures 1 to 4.

The engine comprises a cylinder housing 2 which forms two cylinders 4. Located within each cylinder 4 is a piston 6 which is able to linearly slide within the cylinder 4. Piston rings 12 surround each of the pistons 6 and engage with the wall of the cylinder 4 to provide a seal between the piston 6 and the wall of the cylinder.

Attached to the rear of each piston 6 is an elongate rod 8. Attached to the other end of the elongate rod 8 is a wheel 10. The elongate rod 8 passes through an aperture 14 formed at the outer end 16 of the cylinder housing 2 at the base of the cylinder 4. Bearings 18 are mounted within the wall of the cylinder housing 2 within the sides of the aperture 14 which engage with the elongate rod 8 to enable the elongate rod 8 to slide linearly within the aperture 14 (see Figure 5). The elongate rod 8 is prevented from moving in relation to the cylinder housing 2 in any direction except in a linear sliding motion along its longitudinal axis.

The cylinder housing 2 is rotationally mounted on a central core section 20 which is fixed in position through which the fuel mixture is fed into the two cylinders 4 and through which the exhaust fumes are removed from the two cylinders 4 (see Figure 5). The central core section 20 comprises two chambers 22, 24, the first chamber 22 through which the fuel mixture passes prior to entering into the cylinders 4, and the second chamber 24 through which the exhaust gases leave the cylinders 4 to be directed away from the engine. Formed in the lower side of the first chamber 22 is an aperture 28 (shown as a dashed line in Figure 5) which enables the fuel mixture to enter into the cylinders 4. Formed in the lower side of the second chamber 24 is an aperture 30 (shown as a dashed line in Figure 5) through which the exhaust gases can be removed from the cylinders 4.

Formed in the top end of each of the cylinder 4 is an aperture 26 which enables either the fuel mixture to enter into each of the cylinders 4 or through which the exhaust gases can be removed from the cylinders 4. The central core section is fixed.

The outer surface of the central core section 20 is cylindrical to enable the cylinder housing 2 to rotate about it. Bearings (not shown) are also be used to reduce friction. Seals 32 are provided on the cylinder housing 2 between the central core section 20 and the cylinder housing 2 so that the cylinders 4 are sealed when the aperture 26 are not aligned with either of the two apertures 28, 30 in the central core section 20.

The cylinder housing and the central core section of located within a fixed outer casing 34 which is prevented from movement. Formed on the inner the wall of the casing is a cam surface 36 which surrounds the cylinder housing 2 through 360 degrees. The wheel 10 mounted on the end of the elongate rod 8engages with the cam surface 36. The cam surface 36 is not circular such that the distance between the axis of rotation of the cylinder housing 2 and the cam surface 36 at various points along the cam surface varies through the 360 degrees. The shape of the cam surface 36 in the first embodiment is that of an ellipse such that the two parts of the surface which face each other horizontally as shown in figure 1 are further apart and the two parts of the surface which face each other vertically are closer together. As the cylinder housing 2 rotates, each of the wheels 10 mounted on the end of elongate rods 8 roll over the cam surface 36 which results in the position of the piston 6 within the cylinder 4 moving. The shape of the cam surface in conjunction with the wheel which acts as a cam follower controls the relative movement of the piston within the cylinder.

In the first embodiment, no mechanical means are provided by which it is ensured that the wheels 10 engage with the cam surface 36. However, when the engine is operational, the cylinder housing 2 rotates which in turn causes the pistons 6 to similarly rotate. The centrifugal force would cause the pistons 6 to naturally slide outwardly causing the wheels 10 to engage with the cam surface 36. As such, the centrifugal force provides the biasing force which urges the wheel 10 is into engagement with the cam surface 36.

The operation of the engine will now be described with reference to Figures 1 to 4. The description of how the engine works will be only with reference to the cylinder indicated by the letter B. However, it will be under stood that the operation of the second cylinder is the same as that of the first, only with the combustion cycle 180 degrees out of phase with the first. The combustion cycle is that of a four stroke engine. The cycle is shown in sequence in Figures 1 to 4 respectively. As the engine operates the cylinder housing 2 rotates clockwise as shown in the figures indicated by Arrow D (Figures 1 to 4 when viewed in numerical sequence show the cylinder housing rotating in a clockwise direction).

Located within the first chamber 22 is a fuel mixture which is pressurised. Details of the type of fuel mixture are not relevant to the invention and therefore not describe in any detail. The most common type of fuel mixture is air and vapourised petrol though a person skilled in the art would realise that a range of fuel mixtures could be used in such a construction.

When the cylinder housing 2 is either approaching or is located in the position as shown in figure 1, the aperture 26 formed in the side wall of the first chamber 22 of the central core 22, is aligned with the aperture 26 formed in the top of the cylinder 4. The pressurised fuel mixture is able to enter into the part of the cylinder 4 located between the end of the piston 6 and the top 40 of the cylinder 4. As the cylinder housing 2 rotates, when the cylinder housing 2 is either approaching or is located in the position as shown in figure 1, whilst the two apertures 26, 28 are aligned, the piston 6 is moving outwardly due to the cam surface 36. This is due to the part of the cam surface 36 where the wheel 10 on the elongate rod 8 is in contact with the cam surface 36, being located at an increasing distance from the central axis of rotation of the cylinder housing 2. This draws the fuel mixture into the cylinder 4 and ensures that the piston is located towards the bottom end so that the maximum volume of space exists between the piston 6 and the top 40 of the cylinder 4 which is filled with the fuel mixture.

As a cylinder housing 2 continues to rotate, the aperture 26 in the top 40 of the cylinder 4 moves past the aperture 28 to the fuel mixture chamber 22 and passes the seal 32 such that the cylinder 22 becomes sealed. Similarly, the aperture 28 of the chamber 22 becomes sealed due to other seals (not shown).

As the cylinder housing 2 continues to rotate, the point where the wheel 10 mounted on the end of elongate rod 8 engages with the cam surface 36 commences to move radially inwards in relation to axis of rotation of the cylinder housing 2 causing the rod 8 to be pushed into the cylinder which results in the piston 6 travelling towards the head 40 of the cylinder 4 compressing the fuel mixture which has now been sealed within the end of the cylinder by the seals 32. The piston rings 12 prevents the fuel mixture from passing the piston 6 into the outer part of the cylinder 4 in well known manner. When the wheel 10 is at the point where the cam surface is radially at its minimum inner most position (as shown in Figure 2), and therefore the fuel mixture is under maximum compression, a spark from a sparkplug (not shown) ignites the fuel mixture causing it to burn.

The sparkplug is mounted on the side of each cylinder. The end of the plug which ignites the fuel projects into the cylinder in well known manner. The cylinder housing is earthed and this is used to provide the ground connection for the plug. A slip ring not shown) or other similar device which is live makes connection with the spark plug at the appropriate time in the combustion cycle to complete the circuit and generate the spark. As this is well know in the art, no further description will be provided.

As it burns, it generates an expansive force in well known manner causing the piston 6 to be pushed outwardly from the axis of rotation. This exerts a force by the wheel 10 mounted on the elongate rod 8 onto the cam surface 36. As it exerts the force on part of the cam surface 36 which part, at the beginning of this process, is at the radially inner most part of the cam surface (see Figure 2), it pushes against it and commences to slide along the cam surface 36 due to the fact that the cam surface moves radially outwardly away from the axis of rotation of the cylinder housing 2 further around the cam surface 36. Therefore, the force generated by the fuel mixture burning causes the piston 6 to move outwardly which results in the wheel 10 on the elongate rod 8 to push against and slide along the cam surface 36 to a point located furthest radially from the axis of rotation due to the force being applied to the piston (as shown in Figure 3). This results in the cylinder housing rotating during this process.

As a cylinder housing continues to rotate, the aperture formed 26 in the top 40 of the cylinder 4 aligns itself with the aperture 30 formed in the central core section 20 into the exhaust chamber (this commences to happen when the cylinder housing is in the position sown Figure and continues as it moves towards the position but not at the position shown in Figure 4). As the central cylinder housing 2 continues to rotate, the wheel rides along the cam surface 36 which at the point of the cam surface 36 where it engages with the cam surface 36, is moving radially inwardly, causing the wheel 10 to be pushed back into the cylinder 4 and hence push the piston 6 to the top of the piston forcing the exhaust gas through the aperture 26 in the top 40 of the cylinder 4 through the aperture 30 of the exhaust chamber 24 and hence into the exhaust chamber. The exhaust fumes then are directed away from the engine.

The cycle the repeats itself. The wheel 10 remains in contact with the cam surface 36 throughout the 360 degree rotation. Throughout every 360 rotation of the cylinder housing, the piston slides twice up and down the cylinder, the engine acting as a four stroke engine. The process is assisted by the angular momentum within the rotating cylinder housing and piston which urges the cylinder housing to continue to rotate even when no force is being generated by the burning of the fuel mixture.

As the cam surface is a smooth elliptical surface, if the rate of rotation of the cylinder housing is constant, the movement, velocity and acceleration of the piston within the cylinder is a simple sinusoidal movement.

A second embodiment of the invention will now be described with reference to Figure 6. The second embodiment of the invention is similar to that of the first embodiment. Where the same features occur in the second embodiment which would present in the first embodiment, the same reference numerals are used to denote the same feature.

The second embodiment as the same as the first embodiment except for the shape of the cam surface 36 in the angular region indicated by the reference number 42. In this angular region, the shape of the cam surface 44 is circular about the axis of rotation of the cylinder housing 2. Therefore, as the wheel 10 travels over the part 44 of the cam surface 36, as it is perfectly circular, the elongate rod 8 is neither pushed into or extends from the cylinder housing 2 and therefore as the cylinder housing rotates whilst the wheel is engaged with this part 44 of the cam surface 36, the piston 6 remains stationary within the cylinder 4 relative to the cylinder 4. Once the wheel has passed this part 44 of the cam surface 36, it then commences to continue along the non radial part of the cam surface pushing the elongate rod into the cylinder housing.

Figure 7 shows a graph of the movement of the piston 6 in relation to the cylinder over time. As your not, the majority of the cycle of the movement of the piston 6 is tiny sidle. However during the region 42 when the wheel 10 rolls over the part 44 of the cam surface 36, the piston is stationary and as such, the graph is flat indicating no movement (shown at 46). Similarly, and this point, as piston is stationary within the cylinder, the velocity and the acceleration are both zero. These are referred to as a complex sinusoidal curves ie a non smooth sinusoidal curve.

A third embodiment of the invention will now be described with reference to Figure 8. The third embodiment of the invention is similar to that of the first embodiment. Where the same features occur in the third embodiment which would present in the first embodiment, the same reference numerals are used to denote the same feature.

The third embodiment as the same as the first embodiment except for the shape of the cam surface 36 in the angular region indicated by the reference number 50. In this angular region, the shape of the cam surface 52 is curved differently to that of the ellipse. The angle of curvature is reduced. Therefore, as the wheel 10 travels over the part 50 of the cam surface 52, angle at which the elongate rod 8 is against the cam surface 52 is greater and therefore has a greater pushing effect on the cam. This produces a complex sinusoidal curve in relation to the movement, velocity and acceleration of the piston 6 ie a non smooth sinusoidal curve.

Once the wheel has passed this part 50 of the cam surface 36, it then commences to continue along the elliptical part of the cam surface 36.

A fourth embodiment of the invention will now be described with reference to Figure 9. The fourth embodiment of the invention is similar to that of the first embodiment. Where the same features occur in the fourth embodiment which would present in the first embodiment, the same reference numerals are used to denote the same feature.

The fourth embodiment as the same as the first embodiment except for the shape of the cam surface 36 in the angular region indicated by the reference number 60. In this angular region, the shape of the cam surface comprises a series of humps 62. This produces a complex sinusoidal curve in relation to the movement, velocity and acceleration of the piston 6 ie a non smooth sinusoidal curve.

Once the wheel has passed this part 60 of the cam surface 36, it then commences to continue along the elliptical part of the cam surface 36.

A fifth embodiment of the invention will now be described with reference to Figure 10. The fifth embodiment of the invention is similar to that of the first embodiment. Where the same features occur in the fifth embodiment which would present in the first embodiment, the same reference numerals are used to denote the same feature.

The fifth embodiment of the invention is the same as the first embodiment of the invention except for the fact that four interconnecting rods 70 and to guide wheels 72 have been added. One end of each of the interconnecting rods 70 attaches to the axis of rotation of the wheels 10 mounted on the ends of the elongate rods 8. The interconnecting rods 70 converts about the axis of rotation. The other end of the interconnecting rods 70 connect pivotally to the guide wheels 72. The axis of pivot of the interconnecting rods 70 is that of the axis of rotation of the guide wheels 72. As the cylinder housing rotates, the guide wheels roll along the cam surface 36. The interconnecting rods 70 form a parallelgram which changes from a diamond to a square shape as the cylinder housing 2 rotates. The interconnecting rods 70 and guide wheels ensure that the wheels 10 mounted on the ends of the elongate rods 8 connected to the pistons 6 remain engaged with the cam surface 36 at all times and hence avoid the need to rely on centrafugal force. It will be appreciated by a person skilled in the art that in such a design, the cylinder housing 2 can remain stationary and the cam surface 36 rotates about the cylinder housing as the interconnecting rods 70 ensure that the wheels 10 engaged with the cam surface at all times. If the cylinder housing is stationary, the standard design of valve system used in existing types of engine is used to inject the fuel mixture and remove the exhaust gas.

A sixth embodiment of the invention will now be described with reference to Figure 11. The sixth embodiment of the invention is similar to that of the first embodiment. Where the same features occur in the sixth embodiment which would present in the first embodiment, the same reference numerals are used to denote the same feature.

The sixth embodiment as a same as that of the first embodiment except for the fact that the cam surface 36 has been replaced by a groove 80 formed in an outer housing 84 which runs around the cylinder housing 2 as shown in figure 11. A slider 82 is pivotally attached to the end of each of the elongate rods 8 connected to the pistons 6. The slider 82 is located within the groove 80. As the cylinder housing rotates, the slider 82 slides along the groove 82. The slider 82 is prevented from leaving the groove 80 and this ensures that the movement of the piston is controlled by the position of the slider within the groove. This enables the cylinder housing 2 to remain stationary whilst the outer casing 84 rotates. If the cylinder housing is stationary, the standard design of valve system used in existing types of engine is used to inject the fuel mixture and remove the exhaust gas. Furthermore it allows the movement of the pistons 6 can be controlled by the shape of the groove 80 and as such allows the movement of the piston within the cylinder to be that of a complex sinusoid. It will be understood that the groove acts as a double sided cam effectively having two cam surfaces, 86, 88 which control the movement of the slider 82. As shown in figure 11, the shape of the majority of the groove is elliptical. However, a portion 86 of the groove 80 is straight. Whilst the slider is located within this portion of groove, the piston reverses direction for a small period of time within the cycle before commencing its normal sinusoidal movement due to the shape of the groove.

CLAIMS

1 An internal combustion engine comprising at least one cylinder mechanism; a rotary output drive which is rotationally driven by the cylinder mechanism; the cylinder mechanism comprising:

a housing 2 in which is formed a cylinder 4;

a piston 6 which co-operates with the cylinder 4 during a combustion cycle to generate the rotary movement of the rotary output drive;

a movement control mechanism comprising a cam 36 and a cam follower 10 which controls the relative movement of the piston in relation to the cylinder 4 during the combustion cycle;

characterised in that the cam surrounds the piston 6 and cylinder 4.

2 An internal combustion engine as claimed in claim 1 wherein the cylinder 4 and piston 6 rotate about an axis of rotation during the combustion cycle.

3 An internal combustion engine as claimed in claim 2 wherein the axis of rotation of the cylinder 4 and piston 6 is perpendicular to the longitudinal axis of the cylinder 4.

4 An internal combustion engine as claimed in claim 1, 2 or 3 wherein the cylinder 4 comprises at least one aperture 26 through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder 4.

5 An internal combustion engine comprising at least one cylinder mechanism;

a rotary output drive which is rotationally driven by the cylinder mechanism;

the cylinder mechanism comprising:

a housing 2 in which is formed a cylinder 4;

a piston 6 which co-operates with the cylinder 4 during a combustion cycle to generate the rotary movement of the rotary output drive;

a movement control mechanism which controls the relative movement of the piston in relation to the cylinder during the combustion cycle;

characterised in that the cylinder 4 and piston 6 rotate about an axis of rotation during the combustion cycle.

6 An internal combustion engine as claimed in claim 2 wherein the axis of rotation of the cylinder 4 and piston 6 is perpendicular to the longitudinal axis of the cylinder 4

7 An internal combustion engine as claimed in claims 4 or 5 wherein the movement control mechanism comprises a cam and a cam follower which controls the relative movement of the piston in relation to the cylinder during the combustion cycle wherein the cam surrounds the piston 6 and cylinder 4.

8 An internal combustion engine as claimed in claims 5, 6 or 7 wherein the cylinder 4 comprises at least one aperture 26 through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder 26.

9 An internal combustion engine comprising at least one cylinder mechanism;

a rotary output drive which is rotationally driven by the cylinder mechanism;

the cylinder mechanism comprising:

a housing 2 in which is formed a cylinder 4;

a piston 6 which co-operates with the cylinder 4 during a combustion cycle to generate the rotary movement of the rotary output drive;

a movement control mechanism which controls the relative movement of the piston in relation to the cylinder during the combustion cycle;

characterised in that the cylinder comprises at least one aperture through which the fuel mixture is injected into the cylinder and the exhaust gases are removed from the cylinder.

10 An internal combustion engine as claimed in claim 9 wherein the piston 6 and cylinder 4 rotates about an axis of rotation during the combustion cycle.

11 An internal combustion engine as claimed in claim 10 wherein the axis of rotation of the cylinder 4 and piston 6 is perpendicular to the longitudinal axis of the cylinder 4

12 An internal combustion engine as claimed in claims 9, 10 or 11 wherein the movement control mechanism comprises a cam and a cam follower which controls the relative movement of the piston in relation to the cylinder during the combustion cycle wherein the cam 36 surrounds the piston 6 and cylinder 4.

13 An internal combustion engine as claimed in any one of the previous claims wherein the shape of the cam 36 is such to produce a movement of the piston 6 in relation to the cylinder 4 which is a complex sinusoidal movement when the rate of rotation of the rotary output drive is constant.

14 An internal combustion engine as claimed in any one of the previous claims wherein the velocity or acceleration of the piston 6 in relation to the cylinder varies in a complex sinusoidal manner when the rate of rotation of the output drive is constant.

15 An internal combustion engine as claimed in any one of the previous claims wherein during a single combustion cycle, a part of the reciprocating movement cycle of the piston 6 is complex sinusoid movement wherein the remainder of is simple sinusoid movement.

16 An internal combustion engine as claimed in any one of the previous claims wherein the engine comprises a fuel mixture supply and exhaust removal unit 20 which rotates in relation to the cylinder housing 2 and comprises apertures 28, 30 through which the fuel mixture can pass through to the cylinder 4 and exhaust gases can pass through to be removed from the cylinder 4, the cylinder comprising at least one aperture 26 through which the fuel mixture can pass through into the cylinder 4 and exhaust gases can pass through to exit the cylinder 4, wherein the fuel mixture is added to the cylinder from the fuel mixture supply and exhaust removal unit and the exhaust gas is removed from the cylinder 4 to the fuel mixture supply and exhaust removal unit when the corresponding apertures 26; 28,30 are aligned during the

rotation of the fuel mixture supply and exhaust removal unit 20 in relation to the cylinder housing.

Application No:	GB 0227703.6	**Examiner:**	John Twin
Claims searched:	1 to 4	**Date of search:**	22 May 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1-4	GB 2020739 A	(Barbagallo) - see eg figs. 1,3
X	1	GB 1565669	(Combustion R & T)
X	1-4	GB 1250229	(Hottelet)
X	1-4	GB 1112409	(Mercer)
X	1-4	GB 523765	(Kulkki & Kulkki)
X	1-4	GB 187227	(de Wasmundt)
X	1-4	GB 115873	(Egerton)
X	1	WO 01/77494 A1	(Stokes)
X	1	US 4334506	(Albert)
X	1-4	US 1646695	(Hubbard)

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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{V}:

F1B

Worldwide search of patent documents classified in the following areas of the IPC^{7}:

F01B; F02B

The following online and other databases have been used in the preparation of this search report:

online: EPODOC, JAPIO, WPI