# PATENT SPECIFICATION 632,128

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## PROVISIONAL SPECIFICATION.

# Improvements in or relating to Valve Gear for Four-Stroke Internal Combustion Engines.

I, ALFRED BOORER, a British Subject, of 120, Broadwater Street West, Broadwater, Worthing, Sussex, do hereby declare the nature of this invention to be as follows:—

This invention relates to valve gear for four-stroke internal combustion engines of the kind in which rotary valves control the flow of combustible gases into a valve chamber and also control the flow of exhaust gases out of that chamber. The chamber is separated from the engine cylinder by a master valve, preferably of the poppet type.

The chief objection to the use of rotary valves for internal combustion engines is the necessity to run these valves with exceedingly small clearances in order to hermetically seal the combustion chamber during the working stroke.

In prior patent specifications Nos. 566,416 and 566,450 there is described an engine in which the poppet valve is used to seal the combustion chamber during the compression and firing strokes while rotary inlet and exhaust valves are situated above and on either side of this valve and are rotated as half engine speed.

These rotary valves have communication into and out of the throat of the poppet valve.

As these rotary valves are shielded from the combustion space during the compression and firing strokes by the closed poppet valve, the necessity to maintain hermetic sealing is largely removed. Provided a sufficient distance can be arranged to exist between the ports of adjacent cylinders sufficient clearance can be given between the rotary valve and its cylindrical bore to avoid metallic contact.

In these earlier constructions, in order to ensure the most efficient inter-related movements of the three valves, it was thought desirable to incorporate a type of rotary valve which is geared to rotate at high speed. This type of valve is generally known as the offset type (i.e. the opposite ends of each of its throughways are offset axially) and is driven at half engine speed.

Unfortunately, this type of valve takes up twice as much space as one in which the ends of each throughway are diametrically opposite one another and which is geared to run at one-quarter engine speed. Thus, not only is a multi-cylinder engine extended in length, but also the distance between the ports is reduced and leakage between cylinders may result.

The object of this invention is to obtain a short engine having adequate distance between adjacent cylinder ports to avoid leakage during the inlet and exhaust strokes, and at the same time to obtain efficient operation of the valves. In order to carry out this object, it is necessary to treat the inlet and exhaust rotary valves in different ways to comply with the special requirements of each.

In the case of the rotary inlet valve it is essential to obtain rapid initial opening, to maintain this opening, and so arrange the timing that when the poppet valve closes the passage into the cylinder, the valve is still open sufficiently to enable the kinetic energy of the incoming mixture to be exerted in filling the cylinder.

According to the present invention, a valve gear for a four-stroke internal combustion engine of the kind first referred to above is characterised in that the rotating exhaust valve and the casing in which it rotates are provided, for each engine cylinder, with circumferentially arranged ports so that a throughway for the exhaust gases is established in each cylinder twice every rotation of the valve and means are provided for rotating the exhaust valve at one-quarter engine speed, while the inlet valve and the casing in which it is rotated are provided with ports which are so arranged that a throughway is established for the inlet gases for each cylinder once every revolution of the valve and means are provided for rotating that valve at half engine speed. For example, the rotary inlet valve may be hollow and means are provided for maintaining the interior in constant communication with a supply of combustible gases, which valve is provided with a port for each engine cylinder which is arranged, once every revolution, to register with a port in the valve casing communicating with the valve chamber controlled by a master valve.

The means for maintaining the hollow valve in communication with a supply of combustible gases may comprise a ring of ports around the hollow valve and axially displaced with respect to the other ports and arranged for registering with a port in the valve casing communicating with a source of supply.

Thus, all the desirable features mentioned above are obtained by making the rotary inlet valve in the form of a tube, which tube may also constitute the inlet manifold.

To reduce the overall length of this valve, means are provided for maintaining the interior of the valve in constant communication with the supply of air or combustible mixture according to whether the engine is of the compression ignition or spark ignition type.

This means may comprise a series of ports at one or two points in the valve or it may be done by leaving one end of the tube open. Thus, it would be possible to dispense with one of the two ports usually necessary for each cylinder.

The port in the valve casing for the inlet valve communicating with a source of supply may be arranged at the top of the valve casing and may be fed by a down-draught carburettor.

In the case of the rotary exhaust valve, it is not practicable to use the tubular type of valve described above, because as is well known, the exhaust from one cylinder would interfere with the evacuation of adjacent cylinders. It is therefore essential to use the through ported type which is driven at one-quarter engine speed. For example, the valve may comprise a fixed core having diametrically extending passages formed in it, which core is encircled by a rotatable sleeve having ports which may register with the ends of the passages twice every rotation of the sleeve.

As in the construction described in patent specification No. 566,450, means may be provided for operating the master valve so that it opens about 45° before bottom dead centre of the firing stroke and remains open during the whole of the exhaust and induction strokes and finally closes about 45° after the commencement of the compression stroke, whereby it remains open for about 450° of crankshaft angle.

The ports in the rotary valve are somewhat differently arranged from the earlier constructions. The circumferential extent of the ports in the valve and valve casings is such and the valves so driven that the rotary inlet valve opens at the conventional point in the stroke of a four-stroke cycle engine, i.e. about 30° before the commencement of the down stroke and remains open for a sufficient time after the closing of the master valve to enable the kinetic energy possessed by the incoming gases to be fully used. For example, the inlet valve may remain open for about 80° after the closing of the master valve.

As the essential feature required in the exhaust valve is that it should be fully or nearly fully open by the time the master valve starts to open to release the exhaust gases from the working cylinder, speed of rotation is not so necessary as will be explained herein.

The circumferential extent of the ports in the rotary exhaust valve and its casing are so selected and the valve so driven that a throughway is established immediately the rotary inlet valve closes and does not close until the end of the exhaust period, or shortly after that period. There is thus an overlap period of the opening of the inlet and exhaust valves of about 45°.

The above arrangement of valves enables port areas to be employed in the exhaust valve which can be at least equal to those which are obtained by the arrangement in which the ends of the exhaust passages through the valve are axially displaced and in which the valve is driven at half engine speed.

Since the valves are shielded from the combustion chamber during the compression and firing strokes by the master valve, they may rotate without metal-to-metal contact.

The rotary inlet and exhaust valves may be arranged side by side over the valve chamber and the arrangement of ports may be such that the length of the rotary valve can be within the required limits.

It will be seen that during the time that the master valve is closed, i.e. the compression and firing periods, movement is still taking place in the rotary valves. In a normally-timed engine this period is equal to roughly 280 crankshaft degrees. This period is just sufficiently long to enable lag on the inlet closing and lead on the exhaust opening. For example, with the inlet rotating at half engine speed a lag of 80° would leave a port opening of 40° angle at the time when the master valve closes at the end of the inlet period. This will leave 200° in which to open the rotary exhaust port in preparation for the exhaust stroke. As this valve is driven at one-quarter speed, 200 crankshaft degrees will give a port opening of 50° by the time the master valve starts to open to release the exhaust gases. These port angles represent ample areas for the purposes detailed above.

It will be seen from the above that all the special functional characteristics necessary for the efficient operation of this type of combustion engine are incorporated together with the retention of a short engine and also ample distance is provided between individual ports to avoid leakage in the rotary valves.

Dated this 28th day of January, 1948.

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Chartered Patent Agents.

COMPLETE SPECIFICATION.

# Improvements in or relating to Valve Gear for Four-Stroke Internal Combustion Engines.

I, Alfred Boorer, a British Subject, of 120, Broadwater Street West, Broadwater, Worthing, Sussex, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to valve gear for four-stroke internal-combustion engines of the kind in which rotary valves control the flow of air or combustible gas (according to whether the engine is a compression ignition or sparking plug engine) into a separate valve chamber for each cylinder and also control the flow of exhaust gases out of that chamber. Each valve chamber is separated from its engine cylinder by a master valve, preferably of the poppet type.

The chief objection to the use of rotary valves for internal combustion engines is the necessity to run these valves with exceedingly small clearances in order to hermetically seal the combustion chamber during the working stroke.

In prior patent specifications Nos. 566,416 and 566,450, there is described an engine in which the poppet valve is used to seal the combustion chamber during the compression and firing strokes while rotary inlet and exhaust valves are situated above and on either side of this valve and are rotated at half engine speed.

These rotary valves have communication into and out of the throat of the poppet valve.

As these rotary valves are shielded from the combustion space during the compression and firing strokes by the closed poppet valve, the necessity to maintain hermetic sealing is largely removed. Provided a sufficient distance can be arranged to exist between the ports of adjacent cylinders sufficient clearance can be given between the rotary valve and its cylindrical bore to avoid metallic contact.

In these earlier constructions, in order to ensure the most efficient inter-related movements of the three valves, it was thought desirable to incorporate a type of rotary valve which is geared to rotate at high speed. This type of valve is generally known as the offset type (i.e. the two ends of each of its throughways are not diametrically opposite each other but are offset axially with respect to each other and is driven at half engine speed.

Unfortunately, this type of valve takes up twice as much length as one in which the ends of each throughway are diametrically opposite one another and which is geared to run at one-quarter engine speed. Thus, not only is a multi-cylinder engine extended in length but also the distance between the ports is reduced and leakage between cylinders may result.

The object of this invention is to obtain a short multi-cylinder engine having adequate distance between adjacent cylinder ports to avoid leakage during the inlet and exhaust strokes, and at the same time to obtain efficient operation of the valves. In order to carry out this object, it is necessary to treat the inlet and exhaust rotary valves in different ways to comply with the special requirements of each.

In the case of the rotary inlet valve it is essential to obtain rapid initial opening, to maintain this opening, and so arrange the timing that the full kinetic energy of the incoming mixture may be exerted in filling the cylinder right up to the time the master valve closes.

According to the present invention, a valve-gear for a four-stroke internal combustion engine of the kind first referred to above is characterised in that the rotating exhaust valve and the casing in which it rotates are provided, for each cylinder, with ports so arranged that a passage for the exhaust gases is established from each cylinder twice every rotation of the valve and means are provided for rotating the exhaust valve at one-quarter engine speed, while the inlet valve and the casing in which it is rotated are provided with ports which are so arranged that a passage is established for the inlet gases into each cylinder once every revolution of the valve and means are provided for rotating that valve at half engine speed. For example, the rotary inlet valve may be hollow and means are provided for maintaining the interior in constant communication with a supply of air or combustible gas mixture, which valve is provided with a port for each engine cylinder and is driven so that said port, once every revolution of the valve, registers with a port in the valve casing communicating with the valve chamber, communication of which with its cylinder is controlled by the master valve.

Thus, all the desirable features mentioned above are obtained by making the rotary inlet valve in the form of a tube, which tube may also constitute the inlet manifold.

The aforesaid means for maintaining the interior of the inlet valve in constant communication with a supply of air or combustible mixture may comprise a set of circumferentially-arranged ports at each of one or more locations along the valve and/or an open end to the hollow rotary valve, each communicating with an appropriate port in the valve casing connected with the source of air or mixture, as distinct from the usual arrangement in which the valve casing is provided, for each cylinder, both with a port communicating with the supply of combustible mixture and with a port communicating with the cylinder.

That port or those ports in the inlet valve casing communicating with the supply of air or mixture may be arranged at the top of the valve casing and may be fed by a down-draught carburettor or carburettors.

In the case of the rotary exhaust valve, it is not practicable to use the tubular type of valve described above, because the exhaust from one cylinder would interfere with the evacuation of adjacent cylinders. It is therefore essential to use the through-ported type, which is driven at one-quarter engine speed. For example, the exhaust valve may comprise a solid rotatable cylinder member having diametrically-extending passages formed in it, which member is encircled by the valve casing having ports which may register with the ends of the passages twice every rotation of the valve, and means for driving said valve at quarter crank-shaft speed.

As in the construction described in patent specification No. 566,450, means may be provided for operating the master valve so that it opens about 40° before bottom dead centre of the firing stroke and remains open during the whole of the exhaust and induction strokes and finally closes about 40° after bottom dead centre at the commencement of the compression stroke, whereby it remains open for about 440° of crankshaft angle.

The ports in the rotary valves of the present invention are somewhat differently arranged from those in the earlier constructions referred to. The circumferential extents of the ports in the valves and valve casings are such and the valves so driven that the rotary inlet valve opens at the conventional point in the stroke of a four-stroke cycle engine, i.e. about 30° before the commencement of the down stroke and remains open for a sufficient time after the closing of the master valve to enable the kinetic energy possessed by the incoming gases to be fully used up to the closing of the master valve. For example, the inlet valve may remain open for about 60° after the closing of the master valve.

Means may be provided for operating the master valve, inlet valve and exhaust valve so that the master valve opens at the conventional time for the opening of an exhaust valve, i.e. 40° before bottom dead centre of the firing stroke, and so remains open during the exhaust and induction stroke and closes at the conventional time for the closing of the inlet valve, say 40° after the bottom dead centre of the inlet stroke, and so that the inlet valve opens at the conventional time about 30° before top dead centre of the exhaust stroke and commences to close after the closing of the master valve, and so that the exhaust valve is fully open before the opening of the master valve and closes at a conventional time after top dead centre of the exhaust stroke. Thus, the master valve may commence to open about 40° before bottom dead centre of the firing stroke and is closed about 40° after bottom dead centre of the inlet stroke. The inlet valve may be closed about 60° after the closing of the master valve and the exhaust valve may commence to open about 40° before the end of the compression stroke. The conventional time for the closing of the exhaust valve is about 20° after top dead centre of the exhaust stroke and the conventional time for opening the inlet valve is about 30° before top dead centre of the exhaust stroke.

The following is a description of an engine according to this invention and of the timing of its valve, reference being made to the accompanying drawings, in which :—

Figure 1 is a section along the axis of the cylinder through one end of the cylinder and the valve gear;

Figure 2 is a section on the line 2—2 of Figure 1; the valve ports being shown for simplicity in axial alignment, but being in practice angularly displaced according to the firing order of the cylinders.

Figure 3 is a diagrammatic cross-section through the inlet valve which shows the port opening when the master valve is closed at the end of the inlet period;

Figure 4 is a diagrammatic cross-section through the exhaust valve showing the port opening when the master valve opens at the commencement of the exhaust period ;

Figure 5 is a rectilineal valve diagram showing the times of opening and closing of the inlet, exhaust and master valves ; and

Figure 6 is a polar valve diagram showing the effective times of opening and closing of the inlet and exhaust ports.

As will be seen from Figure 1, there is arranged above the cylinder 10 a cylinder head 11 formed with a combustion chamber 12 having a valve seat 13 controlled by a master poppet valve 14. The valve chamber 15 on the opposite side of the poppet valve to the combustion chamber is provided with an inlet port 16 and an outlet port 17 ; the inlet port communicates with a cylindrical casing 18 while the outlet port communicates with a cylindrical exhaust valve casing 19. Mounted within the cylindrical inlet valve casing is a hollow tubular inlet valve member 20 which, as will be seen from Figure 2, is provided with an inlet port 21 for each cylinder and a centrally located circumferential set of ports 22 which communicate with a passage 23 leading to a source of supply of combustible mixture. In Figure 1 this passage is shown as communicating with the side of the cylinder head, but it may be arranged to communicate with the top of the cylinder head and be fed with a down draught carburettor. In Figure 2, the ends of the tubular inlet valve member are shown closed, but as an alternative or in addition to the circumferentially-arranged series of ports 22, one end of the valve casing may be open and may communicate with a carburettor.

Referring again to Figure 1, the exhaust port 17 is controlled by a rotatable cylindrical valve member 24 provided with a straight throughway 25 for each cylinder, each of which communicates with a short exhaust passage 26 in the side of the cylinder head and an exhaust manifold may be bolted at the top of the cylinder head over the exhaust passages. Means, not shown, are provided for rotating the hollow inlet valve member 20 at held engine speed, and for rotating the cylindrical exhaust valve member 24 at quarter engine speed. The poppet valve is operated through a cam 27 driven at half engine speed which engages conventional rocker gear 28.

The shafts of the inlet and exhaust valve members 20 and 24 are geared together by toothed wheels (not shown) so that the exhaust valve is rotated at half the speed of the inlet valve. The inlet valve shaft is driven at half the crank shaft speed by suitable gearing. The exhaust valve member is thus rotated at quarter crank shaft speed.

As will be seen from Figure 2, intercommunication between adjacent exhaust ports along the rotating valve is prevented by the substantial distance apart of the ports and the same applies to the inlet ports, and thus an appreciable clearance can be allowed between the rotating valve members and the valve casing without the necessity of metal-to-metal contact around the whole circumference of the valve ; thus frictional resistance is reduced to a minimum and it is also unnecessary to provide any particular sealing means.

Referring now to Figure 5 and 6, it will be noted that the master valve opens about 40° before bottom dead centre for the exhaust stroke, which timing is about the normal timing for opening of an exhaust valve, and closes about 40° after bottom dead centre at the commencement of the compression stroke. The inlet valve commences to open at 30° before top dead centre and is closed 60° after the closing of the poppet valve ; thus it is fully open at the time when the poppet valve closes at 40° after bottom dead centre, which is a normal closing time for an inlet valve. The exhaust valve commences opening about 40° before top dead centre of the compression stroke, but is ineffective since at that time the poppet valve is closed, but by the time the poppet valve is open the exhaust valve will be fully open ; this valve closes about 20° after top dead centre, which is the normal time for the closing of such a valve.

Referring now to Figures 3 and 4, it will be seen that the circumferential extent of the ports 21 in the hollow inlet valve 20 and the port 16 leading into the valve chamber are so selected that the effective port opening when the master poppet valve closes, at the end of the inlet period, is about 30°, whereas the effective port opening for the exhaust valve is about 45° when the master valve opens at the commencement of the exhaust period.

It should be appreciated that as the essential feature required in the exhaust valve is that it should be fully or nearly fully open by the time the master valve starts to open to release the exhaust gases from the working cylinder, a rapid speed of rotation of the exhaust valve is not so necessary as will be explained herein.

The circumferential extent of the ports in the rotary exhaust valve and its casing are so selected and the valve so driven that a throughway is established soon after the rotary inlet valve closes and does not close until top dead centre, i.e. the end of the exhaust period, or shortly after that period. There may thus be an overlap period between the opening of the inlet and the closing of the exhaust valves of about 50°.

The above arrangement of valves enables port areas to be employed in the exhaust valve, which can be at least equal to those which are obtained by the arrangement in which the ends of the exhaust passages through the valve are axially displaced i.e. the two ends of each passage are not diametrically opposite one another, and in which the valve is driven at half engine speed.

Since the valves are shielded from the combustion chamber during the compression and firing strokes by the master valve, they may rotate without metal-to-metal contact around the whole of their circumferences.

The rotary inlet and exhaust valves are arranged side by side over the valve chamber, and since in both valves offset ports for each cylinder are avoided, the arrangement of ports may be such that the length of the rotary valve can be less than if offset ports were employed.

It will be seen that during the time that the master valve is closed, i.e. the compression and firing periods, movement is still taking place in the rotary valves. In a normally-timed engine this period is equal to roughly 280 crankshaft degrees. This period is just sufficiently long to enable lag on the inlet closing and lead on the exhaust opening. For example, with the inlet rotating at half engine speed, a lag of 60° would leave a port opening of 30° angle at the time when the master valve closes at the end of the inlet period, as indicated above. There is now a leg of 40° between closing of the inlet valve and opening of the exhaust valve which will leave 180° in which to open the rotary exhaust port in preparation for the exhaust stroke. As this valve is driven at one-quarter speed, 180 crankshaft degrees will give a port opening of 45° by the time the master valve starts to open to release the exhaust gases, also as indicated above. These port angles represent ample areas for the purposes detailed above.

It will be appreciated from the above that large port openings and long periods of opening may be obtained with the retention of an engine of short axial length and also ample distance is provided between individual ports to avoid leakage in the rotary valves.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A valve gear for a four-stroke internal-combustion engine of the kind referred to, wherein the rotating exhaust valve and the casing in which it rotates are provided, for each engine cylinder, with ports so arranged that a passage for the exhaust gases is established from each cylinder twice every rotation of the exhaust valve and means are provided for rotating the exhaust valve at one-quarter engine speed, while the inlet valve and the casing in which it is rotated are provided with ports which are so arranged that a passage is established for the inlet gases into each cylinder once every revolution of the inlet valve and means are provided for rotating that valve at half engine speed.

2. A valve gear according to Claim 1, wherein the rotary inlet valve is hollow and means are provided for maintaining the interior thereof in constant communication with a supply of air or combustible gas according to whether the engine is a compression ignition or sparking plug engine, which valve is provided with a port for each engine cylinder and is driven so that each port registers once every revolution of the valve with a port in the valve casing communicating with its respective valve chamber, communication of which with its respective cylinder is controlled by the master valve.

3. A valve gear according to Claim 2, wherein the means for maintaining the hollow interior of the valve in communication with the source of air or combustible mixture comprises a series of circumferentially arranged ports at each of one or more locations along the valve, and/or an open end to the hollow rotary valve, communicating with appropriate ports in the valve casing connected with the source of air or mixture.

4. A valve gear according to Claim 3, wherein the port or ports in the inlet valve casing are arranged at the side or top of the casing and in the latter case are fed by a down draught carburettor or carburettors.

5. A valve gear according to any of the preceding claims, wherein the exhaust valve comprises a solid rotatable cylindrical member having diametrically-extending passages formed in it, which member is encircled by the valve casing having ports which register with the ends of the passages twice every rotation of the member, and means for driving said member at quarter crank-shaft speed.

6. A valve gear according to any of the preceding claims, wherein means are provided for operating the master valve, inlet valve and exhaust valve, so that the master valve opens at the conventional time for the opening of an exhaust valve before bottom dead centre of the firing stroke and remains open during the exhaust and induction strokes and closes at the conventional time for the closing of an inlet valve after bottom dead centre of the inlet stroke, and so that the inlet valve opens at the conventional time before top dead centre of the inlet stroke and commences to close after the closing of the master valve, and so that the exhaust valve is fully open before the opening of the master valve and closes at the conventional time after top dead centre of the exhaust stroke.

7. A valve gear according to Claim 6, wherein the master valve commences to open about 40° of crank rotation before bottom dead centre of the firing stroke and is closed about 40° after bottom dead centre of the inlet stroke.

8. A valve gear according to Claim 6 or Claim 7, wherein the inlet valve is closed about 60° of crank rotation after the closing of the master valve.

9. A valve gear according to any of Claims 6 to 8, wherein the exhaust valve commences to open about 40° of crank rotation before the end of the compression stroke.

10. A valve gear according to any of Claims 6 to 9, wherein the exhaust valve may be closed about 20° after top dead centre of the exhaust stroke and the inlet valve may commence to open about 30° before top dead centre of the exhaust stroke.

11. A valve gear for a four-stroke internal combustion engine substantially as described with reference to the accompanying drawings.

Dated this 2nd day of November, 1948.

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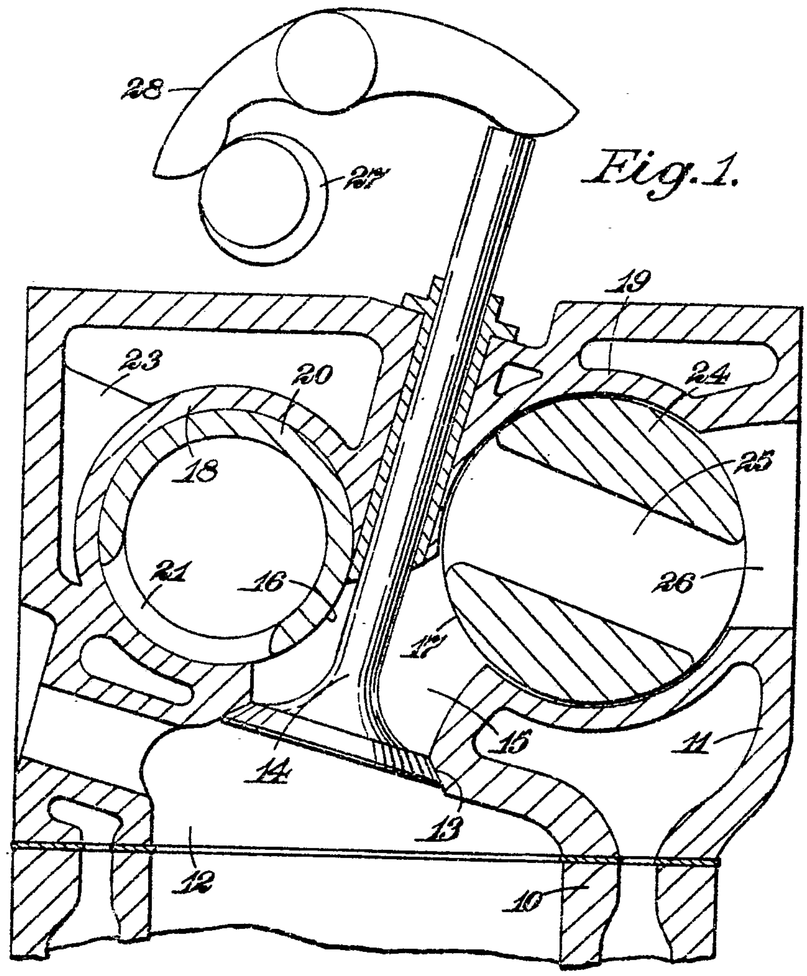

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Fig.1.
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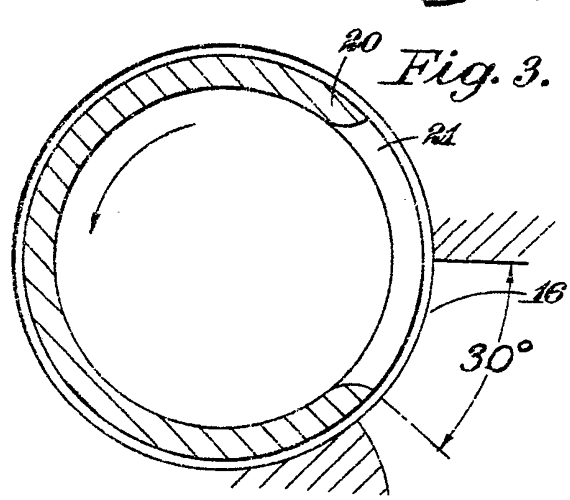

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Fig. 3.
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...g. 1.

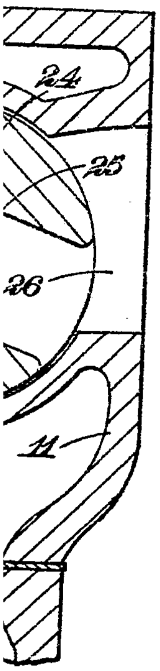


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Fig. 4.

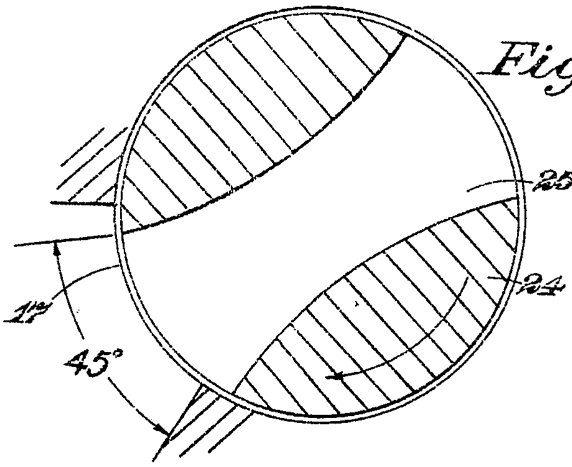
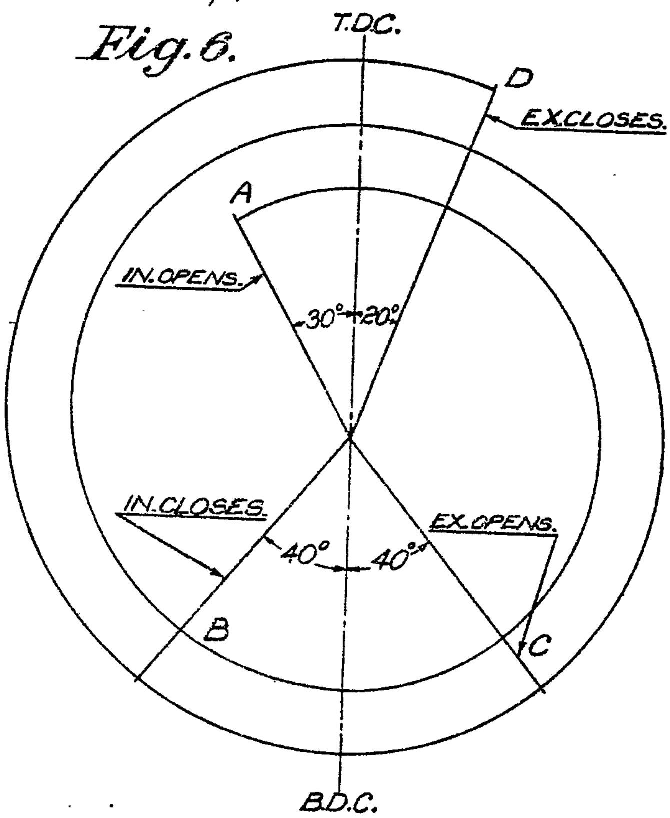



Fig. 6.



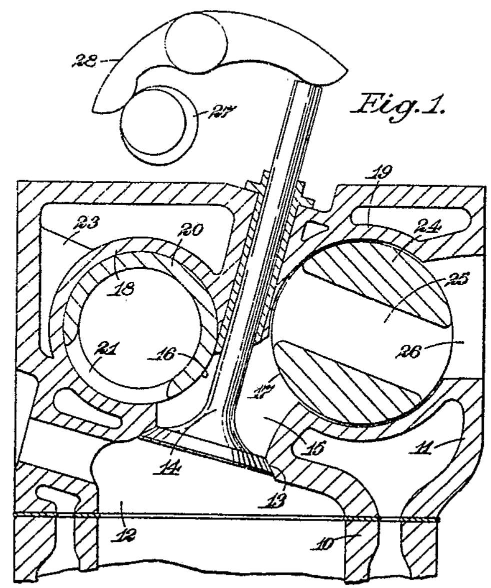



Fig. 1.

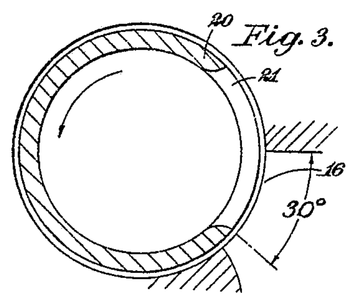



Fig. 3.

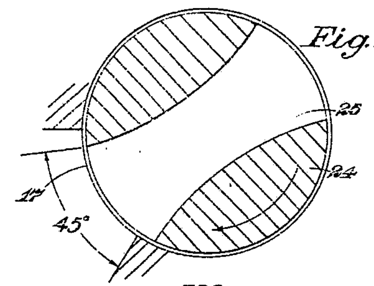



Fig. 4.

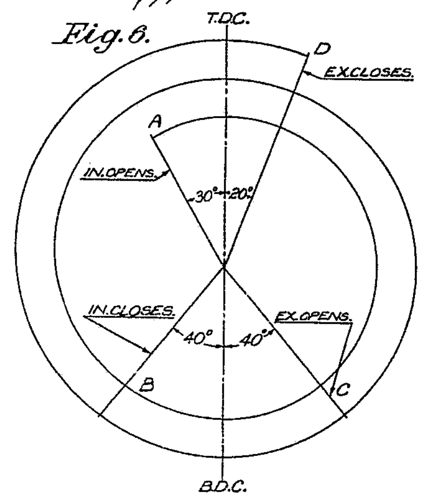



Fig. 6.

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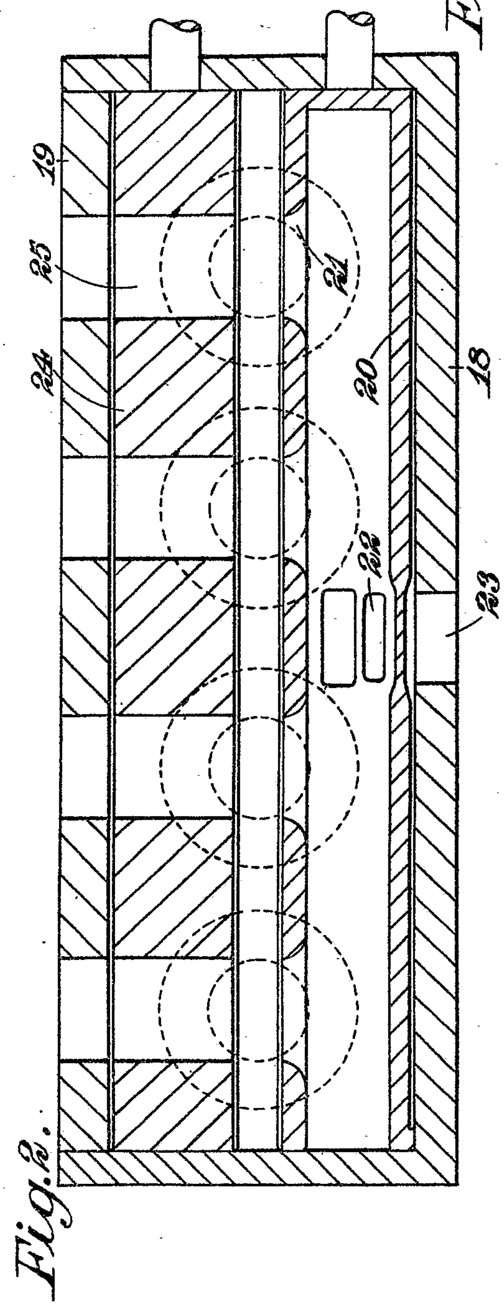
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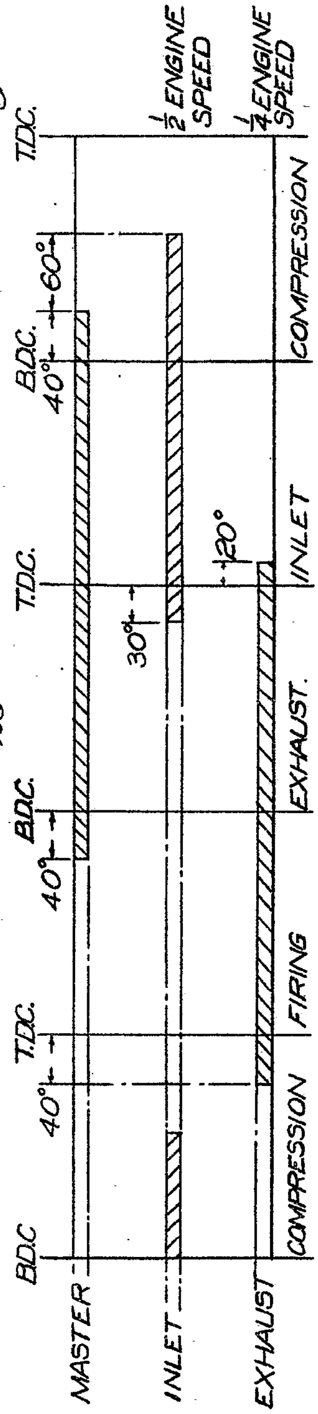
Fig.2.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COMPRESSION
INLET
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FIRING
COMPRESSION
MASTER
INLET
EXHAUST

Fig.5.