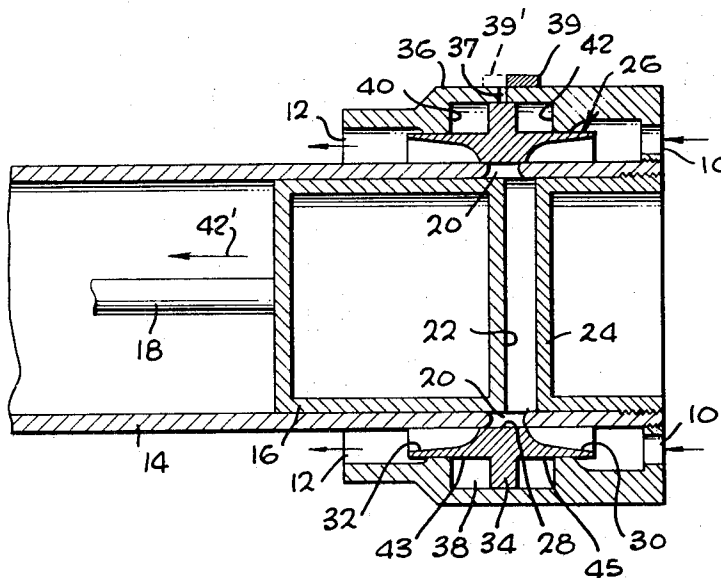


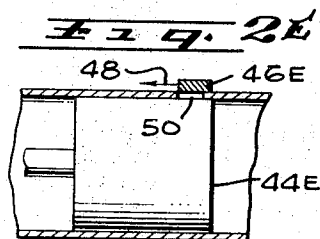
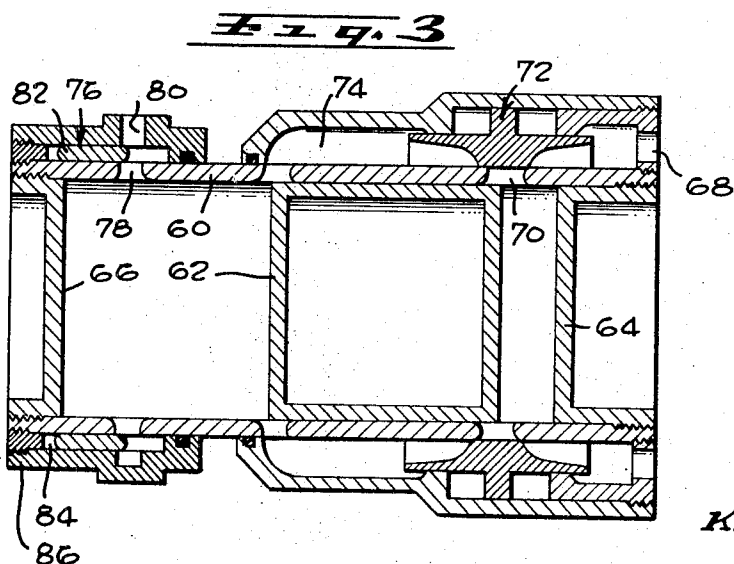
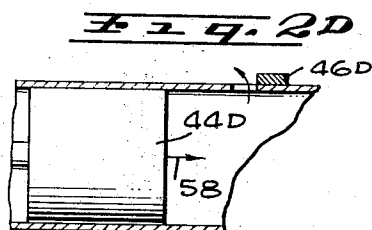
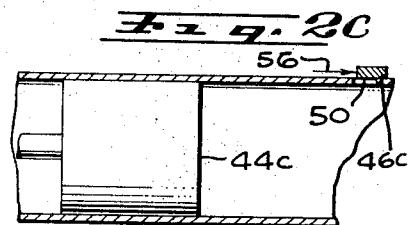
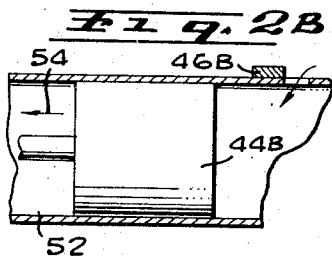
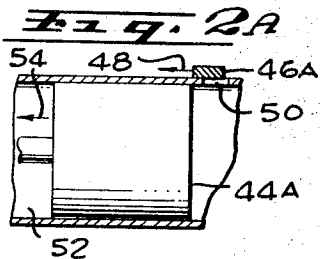
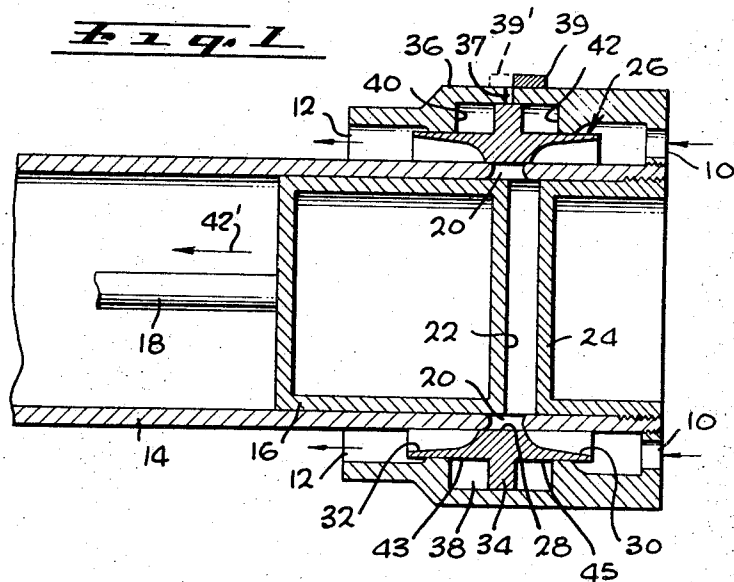
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[54] **PNEUMATICALLY OPERATED VALVE**
4 Claims, 7 Drawing Figs.
[52] **U.S. Cl.**..... **137/107,**
91/300, 91/468, 123/46, 123/90, 123/188,
230/223
[51] **Int. Cl.**..... **F01 5/00**
[50] **Field of Search**..... 123/46A,
74(D), 46, 46(SC), 188(B & C), 92; 91/318, 300, 468;
230/223; 137/625.66, 625.67, 87, 102, 107

ABSTRACT: A valve for controlling the intake and exhaust of an air compressor, internal combustion engine, or the like, comprising a slide member that slides back and forth over an opening in the engine cylinder to open and close the valve. The slide member is not physically attached to any operating mechanism, but bounces back and forth in a bounce chamber, compressing the air in the bounce chamber as it moves toward one end, and allowing the compressed air to propel it toward the other end of the bounce chamber. Gas movements through the valve opening keep the slide member bouncing back and forth.





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PNEUMATICALLY OPERATED VALVE

BACKGROUND OF THE INVENTION

This invention relates to valves and, more particularly, to improvements therein.

Air compressors, internal combustion engines and other machines require valves for regulating intake and exhaust. In many types of engines, the movement of the intake and exhaust valves is regulated by direct connections to camshafts or the like, which are coupled to movements of the engine piston. The mechanical connections between the piston and valves entails the use of mechanisms of a complexity which adds appreciably to the cost and maintenance requirements of the engine, and the additional parts limit engine speed and therefore the horsepower-to-weight ratio. Furthermore, in certain engines, such as free piston types where no mechanical connections to the pistons are employed, synchronization of the intake and exhaust valves with the piston is difficult.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide valves which are operated with a minimum of external mechanical connections.

Another object is to provide a valve for an engine-type mechanism to control intake and/or exhaust, which is operated without mechanical connections to the engine piston and which is synchronized to movements of the engine piston by pressure pulses within the engine cylinder.

Yet another object is to provide synchronized valve assemblies of lower weight than those available heretofore.

The present invention provides a valve with only one moving part comprising a sliding member which moves back and forth across a valve opening. The sliding member is moved by a bounce chamber and by impulses of the fluid, such as a gas, passing through the valve opening which it covers and uncovers. The sliding member moves within the bounce chamber like a piston. When the sliding member approaches one end of the bounce chamber, it compresses air at that end which bounces the member back toward the other end of the bounce chamber. As the sliding member bounces back and forth, it covers and uncovers the valve opening leading to the engine cylinder, through which gas passes. Energy for maintaining the bouncing action of the valve member, and for synchronizing movements of the valve with movements of a piston within the engine cylinder, is provided by gas impulses in the cylinder which pass around the valve's sliding member.

In one embodiment of the invention, the valve is employed in conjunction with an air compressor to regulate intake of air and exhaust of compressed air. The valve includes a ring-shaped slide on the outside of the cylinder which moves back and forth to cover and uncover ports in the cylinder walls. In one extreme position, the slide uncovers the ports and also connects them to an intake, for allowing air to enter the cylinder. In an opposite extreme position, the slide uncovers the ports in the cylinder and also connects them to an exhaust, for exhausting compressed air from the cylinder. Thus, the valve connects the cylinder to either an intake or exhaust area. The slide has an extension portion which lies within a bounce chamber formed in a sleeve extending about the slide, for moving the slide back and forth.

A more complete understanding of the invention can be had by considering the following detailed description and claims when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a valve constructed in accordance with the invention, shown in conjunction with an air compressor;

FIGS. 2A through 2E illustrate the relationship between the positions of the valve and the engine piston of FIG. 1; and

FIG. 3 is a sectional view of a free-piston engine utilizing valves constructed in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates an air compressor for receiving air at intake 10 and exhausting it under pressure at outlet 12. The compressor comprises a cylinder 14 and a piston 16 which moves within the cylinder by means of a connecting rod 18 attached to a motor (not shown). The cylinder 14 has several ports 20 formed therein through which air is admitted into the cylinder and from which air is exhausted. Air admitted through the ports 20 is compressed by the piston 16 between its face 22 and a cylinder head 24. The compressed air moves out of the cylinder through the same ports 20 to the outlet 12.

The valve mechanism of the invention comprises a ring-shaped slide 26 disposed about the compressor cylinder 14, and movable axially along the cylinder for covering and uncovering all of the ports 20 simultaneously. When the slide 26 is in one extreme position closest to the outlet 12, the ports 20 are uncovered, and air can flow through the intake 10, through the ports 20, and into the cylinder 14. When the slide 26 is in an extreme position closest to the intake 10, the ports 20 are uncovered and compressed air can flow from the cylinder 14, through the ports 20 and out of the outlet 12. In an intermediate position, the slide 26 covers the ports 20, and air cannot flow through the ports. Thus, the slide serves as a valve closing means movable over the port to completely cover it and away from the port to at least partially uncover it.

The ring-shaped slide 26 has a valve face portion 28 disposed against the ports 20, an intake channel for directing air from the intake 10 through the ports 20 in one position of the slide, an outlet channel 32 for directing compressed air from the ports 20 to the outlet 12 for another position of the slide, and a bounce piston 34. A sleeve 36 disposed about the cylinder 14 and slide 26 and attached to the cylinder 14 by supports (not shown) forms the inlet 10, outlet 12, and a bounce chamber 38. The bounce chamber 38 has a first end 40 nearest the outlet 12 and a second end 42 nearest the intake 10. As the slide 26 reciprocates in the course of opening and closing the ports 20, the bounce piston 34 moves toward the first and second ends 40 and 42 of the bounce chamber.

The bounce chamber 38 contains air. As the slide 26 moves back and forth, the bounce piston 34 alternately compresses air between it and the ends 40 and 42 of the bounce chamber. The momentum of the slide 26 carries the bounce piston 34 close to the end of the bounce chamber toward which it is moving. Air compressed between the bounce piston and an end of the bounce chamber functions as an elastic means which stops the slide 26 and absorbs the energy, and moves the slide in the opposite direction by the release of the stored energy. The surfaces 43 and 45 formed on the slide serve as sealing surface means to seal the piston 34 to the bounce chamber. A hole 37 in the center of the bounce chamber can be used to control the pressure therein, in those situations where control is desired. A cover 39 can be moved partially or wholly over the hole 37, as to the position shown at 39', to control the size of the opening or to completely cover it.

While the bounce chamber 38 and bounce piston 34 cause the slide 26 to reciprocate, energy is used up in overcoming friction and must be supplied to the system. This energy is supplied by air passing the intake and outlet channels 30 and 32 of the slide. As air rushes past the intake channel 30 into the cylinder, its motion is changed from an axial direction to a radial direction through the ports 20, thereby pushing the slide toward the outlet 12. Similarly, air passing out of the cylinder 14 is altered in direction by an outlet channel 32 and pushes the slide toward the inlet 10. The curved shape of the channels 30 and 32 enables smooth air flow. It should be noted that once the slide is brought up to speed, very little energy is expended in maintaining its motion. The acceleration of the slide from standstill to operating speed can be accomplished with puffs of air or other means. However, the following discussion will deal primarily with the operation of the valve at and near a speed at which it is synchronized with the piston.

The synchronization of the compressor piston 14 with the slide 26 is such that most of the air flow into the cylinder 14

occurs as the slide 26 moves toward the outlet 12, and most of the air flow out of the cylinder occurs as the slide moves toward the inlet 10. As a result, the impulses supplied to the slide 26 tend to maintain its motion. These impulses, and particularly those due to the exhaust of gases, supply the energy required to overcome friction and also serve to synchronize movements of the slide 26 with movements of the piston 16 in the compressor cylinder 14. Synchronization is easily achieved because the slide 26 and bounce chamber 38 are constructed to have a natural frequency of oscillation slightly higher than the speed at which the compressor operates. Friction results in lowering the frequency of the slide to approximately the speed of the compressor, so that synchronization in phase is easily achieved.

Synchronization of the slide 26 and the piston 16 results from the fact that the strength of the impulses to the slide is increased or decreased in a manner that helps to maintain synchronization. As the slide 26 begins to uncover the ports 20 in moving toward the outlet 12, the piston 16 begins to move in the direction of the arrow 42. Air moving past the intake channel 30 of the slide imparts an appreciable impulse to the slide. Generally, in properly synchronized motion, the slide begins to uncover the ports 20 an appreciable time before the piston 16 has begun to move in the direction of the arrow 42'. If the slide 26 is ahead of the cylinder 16, much of the air passes through intake channel 30 while the slide is reversing direction near the outlet 12, and less energy will be supplied to slide 26 to maintain its motion. Therefore, the slide will move more slowly until it is in synchronization. If, on the other hand, the slide 26 is behind the cylinder, more air will flow past inlet 30 as the slide is moving toward the outlet 12 and the slide will receive an even greater impulse than it would in synchronization. Therefore, the slide will tend to move faster until it is in synchronization.

An understanding of the positions and movements of the slide with respect to the main piston of the air compressor can be had by considering the positions of these elements as shown in FIGS. 2A through 2E. In these FIGS., the piston is shown at positions 44A through 44E, and the corresponding positions of the slide are shown at 46A through 46E. In FIG. 2A, the slide 46A is moving in the direction of the arrow 48 and has just begun to uncover the port 50 to allow air to enter the cylinder 52. At the same time, the piston 44A is near the cylinder head and is beginning to move in the direction of the arrow 54.

In FIG. 2B, the slide 46B is in its extreme position toward the outlet while the piston 44B is still moving in the direction of the arrow 54. During the period between attainment of the positions shown in FIGS. 2A and 2B, air is entering the cylinder 52. In FIG. 2C, the slide 46C is moving in the direction of the arrow 56 and has just begun to uncover port 50, while the piston 44C is in its extreme position away from the cylinder head. In FIG. 2D, the slide 46D is in its extreme position nearest the intake while the piston 44D is moving in the direction of the arrow 58 toward the cylinder head. During the period between attainment of the positions shown in FIGS. 2C and 2D, air is exhausted through the port 50 to the outlet. In FIG. 2E, the slide 46E is moving in the direction of the arrow 48 and has begun to uncover the port 50, while the piston 44E is in its extreme position against the cylinder head. This is the position of FIG. 2A, and thereafter the same cycle is repeated.

FIG. 3 is a sectional view of a free piston engine employing the valve system of the invention. This embodiment comprises a cylinder 60 with a free piston 62 which moves between a compressor head 64 and a combustion chamber head 66. The engine includes an inlet 68, inlet ports 70 for admitting an air and fuel mixture from the inlet 68 into the cylinder, and an intake valve 72 of the type shown in FIG. 1 for controlling the intake of the mixture into the inlet ports 70 and the emptying of the mixture through the ports 70 into a transfer manifold 74. The engine also includes an exhaust valve assembly 76 for controlling the flow of exhaust gas out of the cylinder from the area between the free piston 62 and the combustion chamber head 66.

In the operation of the engine, an air and fuel mixture enters the inlet 68 and flows through the inlet ports 70 into the cylinder. This mixture is then transferred from the cylinder area between the piston and the compressor head 64 through a manifold 74 into the area between the piston and the combustion chamber head 66. The gases in the latter area are burned, and the exhaust is expelled through ports 78 to an outlet 80 so that the gases pass serially through the port openings at 78 and the port formed by the outlet 80. As mentioned above, the intake valve assembly 72 is similar to the valve assembly shown in FIG. 1, and it operates in the same manner except that the outlet portion empties into the transfer manifold.

The exhaust valve assembly 76, which is also constructed in accordance with the invention, comprises a slide member 82 which reciprocates in a bounce chamber 84 to open and close the ports 78 in the cylinder. The bounce chamber 84, formed by an exhaust sleeve 86 and the cylinder 60 causes the slide 82 to bounce back and forth and thereby open and close the ports 78, the air in the bounce chamber compressed by the slide member 82 providing this motive force. The slide 82 is simpler than the slide 26 of the valve of FIG. 1, but it merely covers and uncovers ports and does not alternately connect the ports to an intake and exhaust.

The bounce valve assembly shown in the figures can be started in a number of ways, including the use of puffs of air, until they move in synchronism with the cylinders. Once started, the bounce valves of the invention provide valves which work efficiently and reliably. The absence of mechanical connections reduces the number of moving parts of the engine or compressor, thereby reducing costs and maintenance requirements and increasing reliability.

I claim:

1. A valve structure comprising:

port means for allowing the flow of fluid therethrough; valve closing means movable between a first position opening said port means, a second position closing said port means, and a third position opening said port means, said second position located between said first and third positions;

bounce chamber means for oscillating said valve closing means to repeatedly move it between said first and third positions past said second position, including first elastic means for absorbing and releasing energy as said valve closing means moves towards said first position and towards said third position, respectively, and second elastic means for absorbing and releasing energy as said valve closing means moves towards said third position and towards said first position, respectively; and;

said valve closing means movable within said bounce chamber means for compressing said first and second elastic means therein and receiving expansion forces therefrom to reciprocate said valve closing means.

2. A valve structure as defined in claim 1 wherein: said bounce chamber means forms a substantially sealed container and at least one of said elastic means is air.

3. A valve structure comprising:

port means for allowing the flow of fluid therethrough; valve closing means movable between a first position opening said port means, a second position closing said port means, and a third position opening said port means, said second position located between said first and third positions, said valve closing means including a valve face portion movable over said port means, and means extending from edges of said valve face portion which form channels extending in the directions of movement of said valve closing means for receiving impulses when fluid changes direction in flowing through said channels and through said port means;

bounce chamber means for moving said valve closing means between said first, second and third positions, said

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bounce chamber means having elastic means for absorbing and releasing energy, and

said valve closing means including means movable within said bounce chamber means for compressing said elastic means therein and receiving expansion forces therefrom to reciprocate said valve closing means between said first, second and third positions.

4. A valve structure comprising:

port means for allowing the flow of fluid therethrough;

valve closing means including a valve face portion slidable across said port means serially between a first position opening said port means, a second position closing said port means, and a third position opening said port means;

bounce chamber means for moving said valve closing means

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between first, second and third positions, having elastic means for absorbing and releasing energy;

said valve closing means including piston means coupled to said valve face portion and disposed for reciprocation within said bounce chamber means to compress said elastic means and receive expansion forces therefrom to reciprocate said valve closing means between said first, second and third positions; and

said valve closing means including bounce sealing surface means for sealing said piston means to said bounce chamber means as said piston means reciprocates therewithin.

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