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(54) **A PISTON OF A FUEL INJECTION PUMP AND A FUEL INJECTION PUMP**

KOLBEN FÜR EINE BRENNSTOFFEINSPRITZPUMPE UND BRENNSTOFFEINSPRITZPUMPE

PISTON DE POMPE D'INJECTION DE CARBURANT ET POMPE D'INJECTION DE CARBURANT

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Description

[0001] The present invention relates to a piston of a fuel injection pump of a piston engine. The present invention also relates to a fuel injection pump.

[0002] Injection pumps are used in piston engines for periodically injecting pressurized fuel into the injector nozzle and further via the injector nozzle into the cylinder. One injection pump of a piston engine comprises a cylinder element, the pressure chamber of which contains a reciprocating piston, the movement of which causes a pressure increase of the fuel. The cylinder element usually contains at least one inlet channel, through which fuel is introduced into the pressurized chamber from an inlet chamber located externally thereof. The piston includes two control edges, the first of which defines the starting time of the fuel injection and the second the ending time. As the first control edge on the side of the piston moving towards the top dead centre in the pressure chamber covers the opening of the inlet channel, the fuel pressure in the pressure chamber increases and pressurized fuel flows from the pressure chamber to the feed channel leading to the injector nozzle. As the second control edge on the side of the piston reaches the opening of the inlet channel and uncovers the inlet channel, the pressure of the pressure chamber is released via the inlet channel into the inlet chamber and the fuel flow into the injector nozzle ends. The second control edge is helical, whereby the ending time of the fuel injection can be changed by rotating the piston about its longitudinal axis.

[0003] US-A- 3 930 482 discloses a piston for a fuel injection pump for use in internal combustion engines and its method of manufacture. The piston is reciprocated and rotated within a cylinder having a fuel supply opening. The piston has an upper control edge determining initiation of fuel injection and a lower control edge determining termination of fuel injection as the edges move past the fuel supply opening. The piston is manufactured to provide a notch in its upper end surface which, at the intersection of the notch with the circumferential surface of the piston, forms at least two upper control sections serving at least as a part of the upper control edge. The two control edge sections have relatively different inclinations with respect to the upper end surface of the piston which effects the fuel injection.

[0004] The aim of the present invention is to provide a solution for improving the operation of the fuel injection pump.

[0005] According to the invention, this is achieved as described in claims 1 and 2.

[0006] A piston of a fuel injection pump according to the invention comprises a first inclined control edge defining the starting time of the fuel injection at a certain engine load, and a second inclined control edge defining the fuel injection ending time at a certain engine load. In the invention, the distance between points of the first and second control edges corresponding to the same load in

the axial direction of the piston changes linearly or essentially linearly at a range corresponding to the engine idle speed and the full load. The first control edge is shaped so that at a range corresponding to a load of about 60-85% the starting time of the fuel injection is advanced in comparison to that of a lower load. The first control edge is shaped so that at a range corresponding to a load of about 85-100% the starting time of the fuel injection is retarded in comparison to that of the load range of 60-85%.

[0007] Considerable advantages are achieved by means of the invention.

[0008] The first inclined control edge of the piston can be formed so that the starting time of the injection changes as desired as the engine load changes. The starting time of the injection can be optimized as desired for improving, for example, efficiency of the engine or its load acceptance or for reducing emissions at a certain load range.

[0009] The control edges of the piston are formed so that the distance between the first control edge and the second control edge in the axial direction of the piston changes linearly or essentially linearly at a range corresponding to the idle speed and full power of the engine. Thus, the effective stroke and the output curve of the injection pump change linearly or essentially linearly at a load range between idle and full load. Thus the output curve of injection pump contains no discontinuities detrimental to the operation of the engine.

[0010] The first control edge of the piston can be formed, for example, so that at a medium engine load of about 60-80% the fuel injection starting time is earlier than at lower loads. With a higher load of about 85-100% the starting time of the fuel injection is retarded in comparison to medium load so that combustion pressure in the cylinder does not become excessive. With an overload, i.e. at a load of over 100%, the ignition is further retarded in comparison to full load for keeping the combustion pressure at an acceptable level.

[0011] In the following, the invention is disclosed in more detail by means of an example according to the appended drawings.

Figure 1 is a partial cross-section of one injection pump according to the invention.

Figure 2 is a side elevation of a fuel injection pump of figure 1.

[0012] The fuel injection pump 1 according to figure 1 is used for pressurizing fuel and injecting it at a desired moment into the cylinder of a piston engine. The injection pump 1 comprises a cylinder element 2 into which a cylindrical pressure chamber 3 is formed. The pressure chamber 3 contains a movable, elongated piston 4 shown un-sectioned in figures 1 and 2. As the engine runs, the piston 4 reciprocates in the pressure chamber 3 in its axial direction, i.e. the direction of the longitudinal axis

13 of the piston. The reciprocation of the piston 4 causes a pressurization of fuel in the pressure chamber 3. The reciprocation of the piston 4 is produced by means of a cam 16 of a rotating camshaft 15, the piston 4 being operatively connected to the cam. The piston 4 is pressed against the cam 16 with a spring (not shown).

[0013] The cylinder element 2 has one or more outlet channels 5 opening into the pressure chamber 3, through which outlet channels pressurized fuel is directed into the high-pressure side of the fuel system, e.g. the injector nozzle 20 of the cylinder. The feed channel 29 leading from the outlet channel 5 to the injector nozzle 5 is provided with a main flow valve 21 opening when the pressure in the pressure chamber 3 exceeds a certain limit value and closes when the pressure in the pressure chamber 3 decreases to below this limit value. The main flow valve 21 is a check valve, i.e. it allows flow from the pressure chamber 3 to the injector nozzle 20, but prevents flow from the injector nozzle 20 towards the pressure chamber 3. Additionally, the injection pump 1 comprises a return channel 30 provided with a constant pressure valve 28, the first end of the return channel being connected to the inlet channel 29 between the main flow valve 21 and the injector nozzle 20. The second end of the return channel 30 is connected to the feed channel 29 between the outlet channel 5 and the main flow valve 21. The constant pressure valve 28 opens when the pressure in the first end of the return channel 30 exceeds a certain limit value and closes when the pressure decreases to below this limit value. The constant pressure valve 28 is also of check valve type, i.e. it allows flow through the return channel 30 from the first end to the second end, but prevents flow in the opposite direction. As the injection of injection pump 20 ends, the pressure in the feed channel 29 is kept at the desired limit value by means of the constant pressure valve 28.

[0014] A sleeve-like body part 6 is arranged around the cylinder element 2. An annular inlet chamber 7 is arranged between the body part 6 and the cylinder element 2, the inlet chamber being connected via fuel channel 22 to a fuel source, such as fuel tank 23. The fuel channel 22 is provided with a pump 24 for pumping fuel from the fuel source into the inlet chamber 7. The inlet chamber 7 is connected to the pressure chamber 3 via one or more inlet channels 8.

[0015] Return channel 26 leads from the inlet chamber 7 back to the fuel source. The return channel 26 is provided with a pressure regulation valve 27 for adjusting the pressure of the fuel flowing in the return channel 26 to the desired maximum value. Additionally, the inlet channel 22 contains a throttle 31 and the return channel 26 contains a throttle 31' for throttling the fuel flow in channel 22, 26.

[0016] The piston 4 comprises an end surface 9 defining one side of the pressure chamber 3. A first inclined control edge 10 is located adjacent the end surface 9 at the side of the piston 4, defining the starting time of the fuel injection of the injection pump 1. A second inclined

control edge 11 is also located at the side of the piston 4 for defining the ending time of the fuel injection of the injection pump 1. The second control edge 11 is below the first control edge 10. The first control edge 10 and the second control edge 11 are inclined in relation to the plane in the direction of the radius of the piston 4. A longitudinal groove 19 extending in the direction of the longitudinal axis 13 of the piston is arranged at the side of the piston 4.

[0017] The injection pump 1 further comprises an actuator 14 for rotating the piston about its longitudinal axis 13 and thus adjusting the starting time of the fuel injection and the duration of the injection. The actuator 14 comprises, for example, a toothed wheel arranged around the piston rod and a toothed rack cooperating therewith, a longitudinal movement of the rack rotating the piston 4 about its longitudinal axis 13.

[0018] The operation of the injection pump 1 is described in more detail in the following. As the engine runs, the camshaft 15 and the cam 16 rotate about the longitudinal axis 18 of the camshaft. When the piston 4 is in its bottom dead centre, fuel flows from the inlet chamber 7 via the inlet channel 8 into the pressure chamber 3. The piston 4 starts to move upwards, i.e. towards the top dead centre, from the bottom dead centre in the pressure chamber 3. The first control edge 10 of the upwards moving piston 4 covers the mouth of the inlet channel 8 opening into the pressure chamber 3, whereby the fuel flow from the inlet chamber 7 via the inlet channel 8 into the pressure chamber 3 ends. Subsequent to this, the upwards moving piston 4 pressurizes the fuel in the pressure chamber 3 and fuel flows through the outlet channel 5 and the main flow valve 21 away from the pressure chamber 3, when the fuel pressure in the pressure chamber 3 exceeds the opening pressure of the main flow valve 21. The fuel flow into the outlet channel 5 continues until the second control edge 11 of the piston 4 reaches the opening of the inlet channel 8 and uncovers the opening. Thereby the pressure of the fuel in the pressure chamber 3 is released via the longitudinal groove 19 on the side of the piston 4 and the inlet channel 8 into the inlet chamber 7. The piston 4 reaches its top dead centre and subsequently starts to move downwards in the pressure chamber 3, whereby the second control edge 11 again covers the mouth of the inlet channel 8. Near the bottom dead centre the first control edge 10 reaches the opening of the inlet channel 8 and uncovers the opening, whereby fuel flows via the inlet channel 8 into the pressure chamber 3. Subsequent to this, the piston 4 reaches its bottom dead centre and stays there for a while, whereby fuel flows into the pressure chamber 3 via the inlet channel 8.

[0019] As the piston 4 is rotated about its longitudinal axis 13, the location of the first control edge 10 changes in relation to the opening of the inlet channel 8 into the pressure chamber 3. Depending on the direction of rotation the first control edge 10 reaches the opening of the inlet channel 8 earlier or later as the piston 4 moves to-

wards its top dead centre in the pressure chamber 3. Thus, the fuel injection into the outlet channel 5 correspondingly starts earlier or later. Thus, the starting time of the fuel injection can be retarded or advanced. The location of the second control edge 11 correspondingly changes in relation to the mouth 3 of the inlet channel 8 opening into the pressure chamber 3 when the piston 4 is rotated about its longitudinal axis 13. Thus, the second control edge 11 of the piston moving towards its top dead centre reaches the opening of the inlet channel 8 earlier or later, whereby fuel injection into the outlet channel 5 correspondingly ends earlier or later. Thus, the ending time of the fuel injection can be retarded or advanced. The duration of the fuel injection of the injection pump 1 and thus the amount of fuel injected into the cylinder can be changed by rotating the piston 4 about its longitudinal axis 13.

[0020] In figure 2, the letter A refers to the load points of the first control edge 10 and the second control edge 11 corresponding to the idle speed of the engine. As the engine runs on idle speed, the piston 4 is rotated into a position in which the points of the control edges 10, 11 corresponding to the letter A coincide with the opening of the inlet channel 8 in direction of the axis 13 of the piston. The letter D correspondingly refers to the load points of control edges 10, 11 corresponding to full load of the engine (100%). As the engine runs on full load, the piston 4 is rotated to a position in which the points of the control edges 10, 11 corresponding to the letter D coincide with the opening of the inlet channel 8 in direction of the axis 13 of the piston. The first control edge 10 and the second control edge 11 of the piston 4 are formed so that the axial distance, i.e. distance in the direction of the longitudinal axis 13 of the piston, between points corresponding to the same load changes linearly or essentially linearly at the range corresponding to the engine idle speed A and the full load D. Thus, the effective stroke of the piston 4 changes linearly or essentially linearly at an output range between idle and full load. The output curve of the injection pump 1 is also linear or essentially linear in the range between the engine idle speed and the full speed. The first control edge 10 and the second control edge 11 can be formed as described above also in the load range corresponding to engine overload, i.e. a load of over 100%.

[0021] The starting time of the fuel injection of the injection pump 1 changes as defined by the shape of the first control edge 10 to either advance or retard (inclined portions) or stays the same (straight portions) as the piston 4 is rotated about its longitudinal axis 13 in the range between idle A and full load D. The second control edge 11 is shaped so that its form at a point corresponding to similar load changes in the same way as the form of the first control edge 10. Additionally, the distance in the direction of the longitudinal axis 13 of the piston between the points of the first control edge 10 and the second control edge 11 corresponding to the same load changes linearly or essentially linearly in the load range between

idle A and full load D. Thus, the effective stroke of the piston 4 and the output curve of the injection pump 1 change linearly or essentially linearly at a load range between idle and full load.

[0022] The first control edge 10 of the piston 4 in figure 2 is shaped so that in the range corresponding to a load of 60-85% (range B-C) the starting time of the fuel injection of the injection pump 1 is advanced in comparison to the range corresponding to idle and 60% load (range A-B). The starting time of the fuel injection is most advanced at a point corresponding to a load of about 80%. Correspondingly, at a range corresponding to a load of 85-100% (range C-D) the starting time of the fuel injection is retarded in comparison to the range corresponding to a load of 60-85% (range B-C).

[0023] The pistons shown in figure 2 can be used in piston engines used in, for example, power plants, whereby the cylinder pressure can be kept near its maximum value, thereby achieving the best efficiency of the engine at the usual operating range thereof.

[0024] The invention also has embodiments differing from what is described above. The injection pump 1 can comprise separate channels located in different levels in the direction of the axis of the piston for directing fuel from the inlet chamber 7 into the pressure chamber 3 and for releasing the pressure of the pressure chamber 3 into the inlet chamber 7 at the end of the injection.

30 Claims

1. A piston (4) of a fuel injection pump (1) of a piston engine, comprising a first inclined control edge (10) located at the side of the piston (4) for determining the starting time of the fuel injection of the injection pump (1) at a certain engine load, and a second inclined control edge (11) located at the side of the piston (4) for determining the ending time of the fuel injection of the injection pump (1) at a certain engine load, wherein the distance between the points of the first control edge (10) and the second control edge (11) corresponding to the same load in the axial direction (13) of the piston (4) changes linearly or essentially linearly at a range corresponding to the engine idle speed and the full load, whereby the first control edge (10) is shaped so that at a range (B-C) corresponding to a load of about 60-85% the starting time of the fuel injection is advanced in comparison to that of a lower load, **characterized in that** the first control edge (10) is shaped so that at a range (C-D) corresponding to a load of about 85-100% the starting time of the fuel injection is retarded in comparison to that of the load range of 60-85% (B-C).
2. A fuel injection pump (1) of a piston engine, comprising

- cylinder element (2) having a pressure cham-

ber (3) provided with an outlet channel (5) for removing pressurized fuel from the pressure chamber (3), and
at least one inlet channel (8) leading into the pressure chamber (3) for directing fuel into the pressure chamber (3),

characterized in that a piston according to claim 1 is provided in the pressure chamber (3).

3. An injection pump (1) according to claim 2, **characterized by** means (14) for rotating the piston (4) about its longitudinal axis (13) for changing the start and end times of the fuel injection.

Patentansprüche

1. Kolben (4) für eine Brennstoffeinspritzpumpe (1) eines Kolbenmotors, umfassend eine erste schräge Steuerkante (10), die sich an der Seite des Kolbens (4) befindet, zum Bestimmen der Anfangszeit der Brennstoffeinspritzung der Einspritzpumpe (1) bei einer bestimmten Motorbelastung, und eine zweite schräge Steuerkante (11), die sich an der Seite des Kolbens (4) befindet, zum Bestimmen der Abschlusszeit der Brennstoffeinspritzung der Einspritzpumpe (1) bei einer bestimmten Motorbelastung, wobei sich der Abstand zwischen den Punkten der ersten Steuerkante (10) und der zweiten Steuerkante (11), der der gleichen Belastung in der Achsenrichtung (13) des Kolbens (4) entspricht, in einem Bereich, der der Motorleerlaufgeschwindigkeit und der vollen Belastung entspricht, linear oder im Wesentlichen linear verändert, wobei die erste Steuerkante (10) so geformt ist, dass die Anfangszeit der Brennstoffeinspritzung in einem Bereich (B - C), der einer Belastung von etwa 60 bis 85 % entspricht, im Vergleich zu jener bei einer niedrigeren Belastung vorverlegt ist, **dadurch gekennzeichnet, dass** die erste Steuerkante (10) so geformt ist, dass die Anfangszeit der Brennstoffeinspritzung in einem Bereich (C - D), der einer Belastung von etwa 85 bis 100 % entspricht, im Vergleich zu jener des Belastungsbereichs von 60 bis 85 % (B - C) verzögert ist.
2. Brennstoffeinspritzpumpe (1) eines Kolbenmotors, umfassend:
- ein Zylinderelement (2) mit einer Druckkammer (3), die mit einem Auslasskanal (5), um mit Druck beaufschlagten Brennstoff aus der Druckkammer (3) zu entfernen, und zumindest einem Einlasskanal (8), der in die Druckkammer (3) führt, um Brennstoff in die Druckkammer (3) zu richten,

versehen ist,

dadurch gekennzeichnet, dass in der Druckkammer (3) ein Kolben nach Anspruch 1 bereitgestellt ist.

3. Einspritzpumpe (1) nach Anspruch 2, **gekennzeichnet durch** ein Mittel (14), um den Kolben (4) um seine Längsachse (13) zu drehen, um die Anfangs- und die Abschlusszeit der Brennstoffeinspritzung zu verändern.

Revendications

1. Piston (4) de pompe d'injection de carburant (1) d'un moteur à pistons, comprenant un premier bord de commande incliné (10) disposé sur le côté du piston (4) pour déterminer le temps de départ de l'injection de carburant de la pompe d'injection (1) à une certaine charge du moteur, et un second bord de commande incliné (11) situé sur le côté du piston (4) pour déterminer le temps de fin de l'injection de carburant de la pompe d'injection (1) à une certaine charge du moteur, sachant que la distance entre les points du premier bord de commande (10) et du second bord de commande (11) correspondant à la même charge dans le sens axial (13) du piston (4) se modifie de manière linéaire ou essentiellement linéaire à une plage correspondant à la vitesse au ralenti du moteur et à la pleine charge, ce par quoi le premier bord de commande (10) est formé de manière à ce qu'à une plage (B-C) correspondant à une charge d'environ 60-85%, le temps de départ de l'injection de carburant soit avancé en comparaison à celui d'une charge inférieure, **caractérisé en ce que** le premier bord de commande (10) est formé de manière à ce qu'à une plage (C-D) correspondant à une charge d'environ 85-100%, le temps de départ de l'injection de carburant soit retardé en comparaison à celui de la plage de charge de 60-85% (B-C).

2. Pompe d'injection de carburant (1) d'un moteur à pistons, comprenant
- un élément de cylindre (2) présentant une chambre de pression (3) dotée d'un canal de sortie (5) pour retirer le carburant pressurisé de la chambre de pression (3), et au moins un canal d'entrée (8) menant dans la chambre de pression (3) pour diriger le carburant dans la chambre de pression (3),

caractérisé en ce qu'un piston selon la revendication 1 est prévu dans la chambre de pression (3).

3. Pompe d'injection (1) selon la revendication 2, **caractérisée par** un moyen (14) pour faire tourner le piston (4) sur son axe longitudinal (13) pour modifier les temps de départ et de fin de l'injection de carburant.

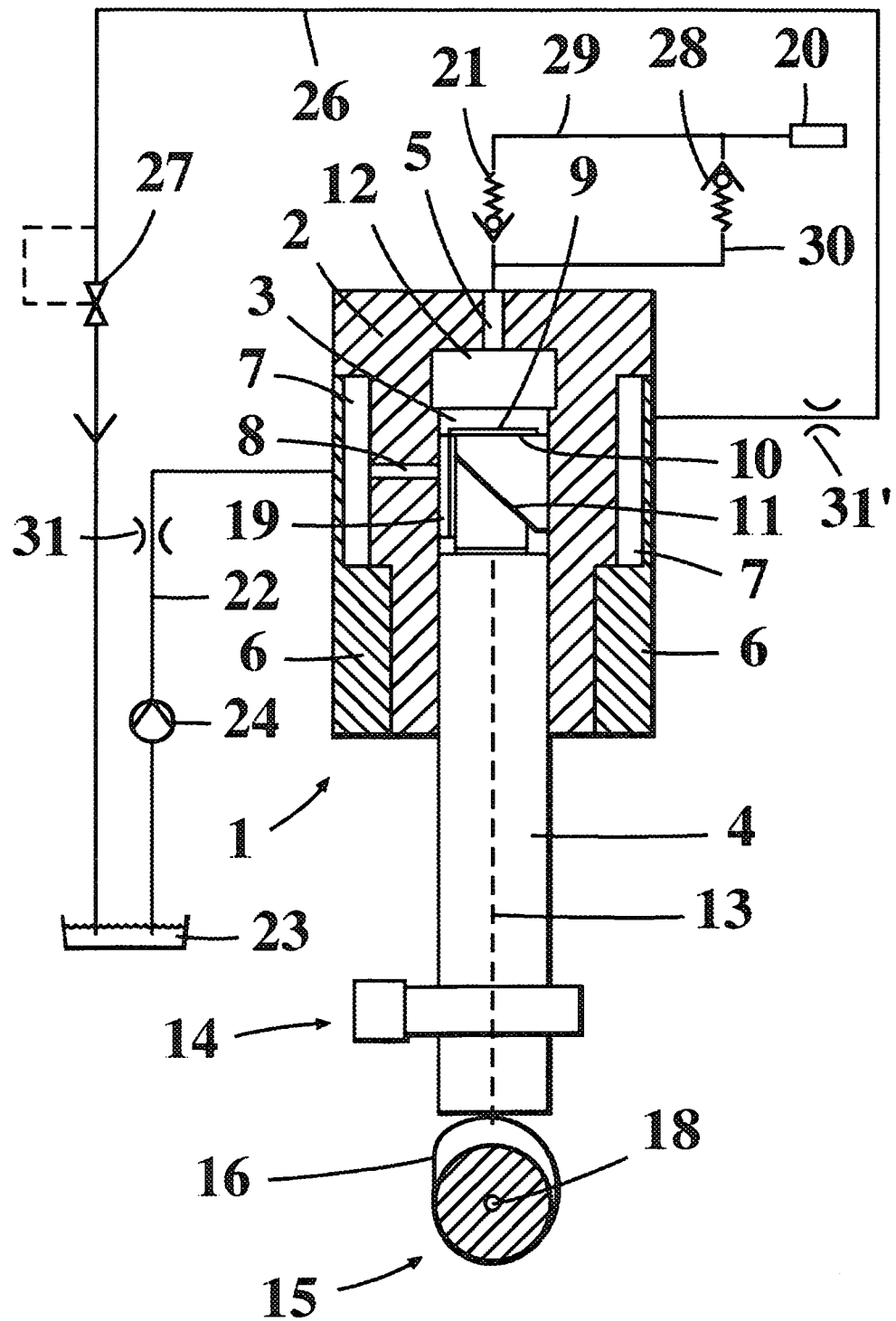


Fig.1

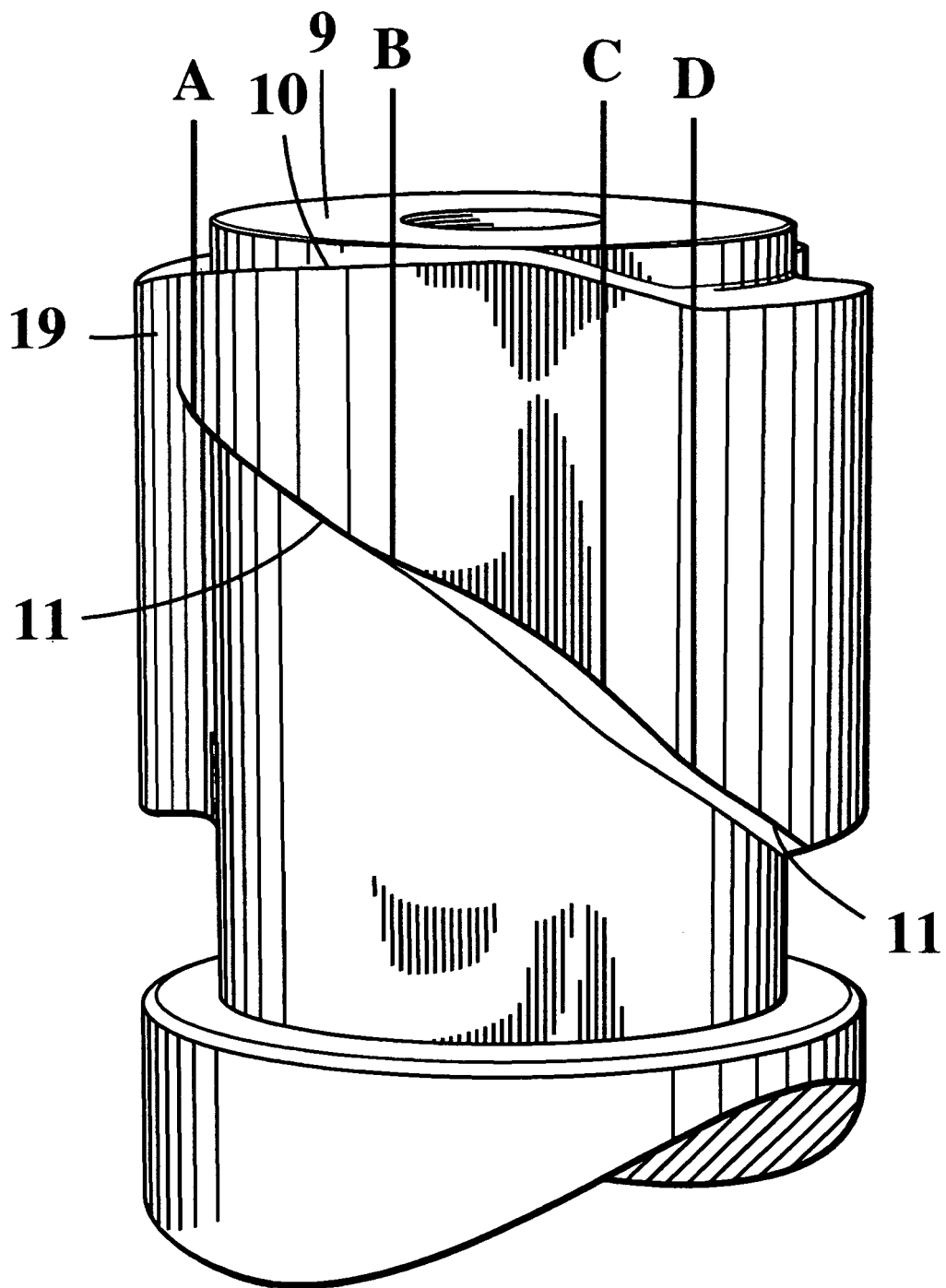


Fig.2

REFERENCES CITED IN THE DESCRIPTION

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