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(54) Fluid pump

(57) A pump (100) for fluid, comprising a pump body (102) defining a bore (104), a pumping plunger (108) having an end region which is slidably received within the bore, a spill port (154) defined by the pump body (102) in a wall of the bore (104) which port is coverable by the end region of the pumping plunger (108) as the plunger is driven on a pumping stroke, in use, so as to initiate fluid pressurisation within a pumping chamber (134); and a spill groove (172) defined by the pumping plunger (108) being arranged to uncover the spill port (154) during a pumping stroke so as to cause depressurisation of the pumping chamber (134). The pumping plunger (108) further defines a speed sensitive feature (176) configured to permit a controlled leak of fluid from the pumping chamber (134) to the spill port (154) towards the end of a pumping stoke. The invention also encompasses a pumping plunger particularly suited for use in the above described pump.

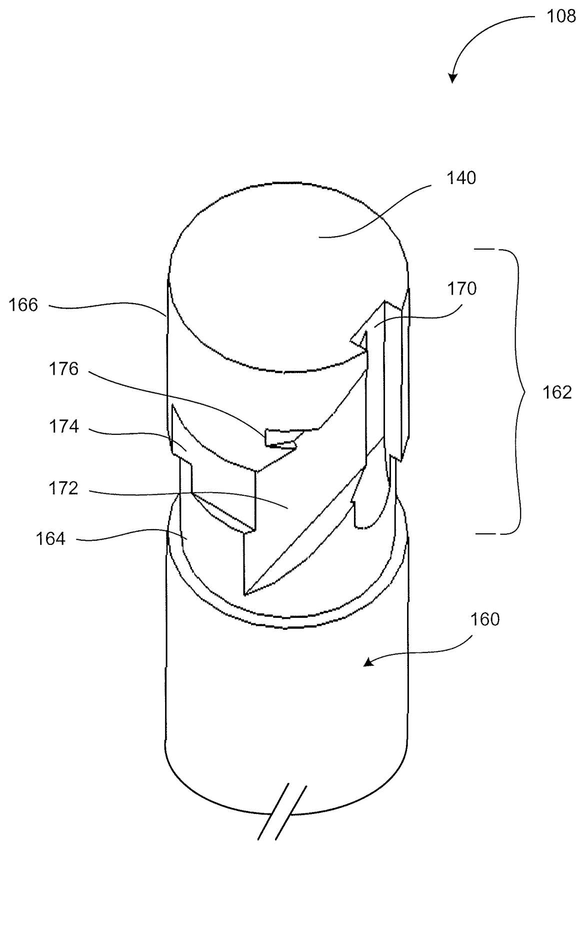

FIGURE 3

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Description

Technical Field

[0001] The present invention relates to a fluid pump. More specifically the invention relates to a 'unit pump' type fuel injection pump for use in a compression ignition internal combustion engine in which a pumping plunger reciprocates within a plunger bore in order to pressurise fuel within a pumping chamber. In addition, the invention relates to a pumping plunger for use within such a pump.

Background Art

[0002] Figure 1 shows a sectional view of a known fuel injection pump, indicated generally as 2, which is suitable for use as a means of supplying pressurised fuel to a fuel injector of an internal combustion engine. Such a pump is generally known in the art as a mechanical 'unit pump'. The fuel pump 2 includes a generally tubular pump housing 4 having an axially disposed bore 6 within which a pumping plunger 8 is slidable. The plunger 8 has a lower end 10 (in the orientation shown in Figure 1) that is coupled to a lower spring plate 12. Although not shown in Figure 1, in practice the lower spring plate 12 may couple to a tappet member against which a driving means (also not shown) acts, a cam for example, to transmit reciprocating motion to the plunger 8.

[0003] A biasing means in the form of a helical spring 17 is received over the plunger 8 such that the spring 17 is disposed between the pump housing 4 and the lower spring plate 12. An upper end 18 of the spring 17 abuts a spring plate 20 that is attached to a lower end of the pump housing 4, and a lower end 22 of the spring 17 abuts the lower spring plate 12, the spring 17 thus serving to bias the plunger 8 downwards in the orientation shown.

[0004] An upper end of the pump housing 4 defines a cup-shaped recess 26 into which a lower end of an outlet valve arrangement 28 is received. The lower end of the outlet valve arrangement 28 closes off the plunger bore 6 and defines a pumping chamber 30 between it and the upper end of the plunger 8. The other end of the outlet valve arrangement 28 remote from the recess 26 defines an outlet connection 31.

[0005] The inner surface of the bore 6 in the region of the pumping chamber 30 defines two opposed ports: a fill port 32 and a spill port 33. The fill port 32 is shown to the left in Figure 1 and is connectable to a fuel supply circuit such that fuel is permitted to fill the pumping chamber 30 through the fill port 32. The spill port 33 is shown on the right in Figure 1 and is connectable to a drain connection such that high pressure fuel from the pumping chamber 30 can escape to low pressure through the spill port 33.

[0006] In use, the plunger 8 is driven on a pumping stroke during which fuel within the chamber 30 is pressurised. When the pressure of fuel within the chamber 30 reaches a predetermined pressure, the outlet valve arrangement 28 opens to permit pressurised fuel to flow through the outlet connection 31. Although not shown in Figure 1, a fuel conduit may be attached to the outlet connection 31 to convey fuel to a fuel injector, for example.

[0007] In order to terminate fuel delivery, the plunger 8 is provided with a spill groove 41. As the plunger 8 is driven further on its pumping stroke, a point will be reached at which the spill groove 41 overlaps the spill port 33 so that pressurised fuel can escape from the pumping chamber 30 along the spill groove 41 to the spill port 33 which terminates pressurisation and, thus, fuel delivery from the pump 2.

[0008] Following termination of pumping, the plunger 8 is driven further such that it passes a top dead centre position and thus commences a return stroke under the force of the spring 17. During the return stroke, fuel is permitted to fill the chamber 30 through the fill port 32 which is connected to a source of fuel at a relatively low pressure.

[0009] In order to vary the delivery volume of the pump 2, the plunger 8 is provided with a control arm 40 which extends radially away from the approximate mid point of the plunger 8. Angular movement of the control arm 40 varies the angular position of the plunger 8.

[0010] In use, the control arm 40 engages a fuel delivery rack (not shown) via a control pin 42 that depends downwardly from a radially outer end of the control arm 40. The position of the fuel delivery rack is determined by the engine governor and the rack, in turn, acts on the control arm 40 to cause radial movement of the plunger 8 about its longitudinal axis. The radial position of the plunger 8 determines the point of the pumping stoke that the spill groove 41 registers with the low pressure spill port 33, thus terminating fuel pressurisation earlier, or later, in the pumping stroke depending on the direction and extent of angular movement of the plunger 8. The variation of the effective stroke between the upper surface of the plunger 8 and the spill groove 41 varies the fuel delivery to the associated engine.

[0011] In circumstances where mechanical unit pumps are used in low emission engines, for example in relatively small cubic-capacity road vehicles, some unit pumps are fitted with constant-pressure unloading delivery valves.

[0012] The general configuration and function of such delivery valves is known in the art and an example of which is shown in Figure 1 as the outlet valve arrangement 28. Their purpose is to trap fuel in a fuel passageway downstream of the outlet connection 31 at a predetermined pressure at the end of the pumping stroke. By way of explanation, when pressure in the pumping chamber 30 collapses at the end of a pumping stroke, fuel pressure in the fuel passageway is at an injectable pressure level. It would be undesirable for the pressure of fuel to remain at this level since there would be a risk of secondary injection events. Conversely, it would be undesirable to permit pressure uncontrolled collapse in the fuel passageway. Therefore, the constant pressure unloading valve 28 allows a sufficient amount of fuel to pass back from the high pressure fuel passageway through to the pumping chamber 30, and thus to the spill port 33, so as to reduce the pressure in the fuel passageway by a predetermined amount. The controlled pressure reduction supresses pressure waves emanating from the pump in the direction of the associated injector so as to avoid undesirable secondary injection events. In addition, cavitation is guarded against since fuel pressure downstream of the outlet connection is not permitted to collapse completely and in an uncontrolled manner.

[0013] Although such valves have associated benefits, the characteristic fuel delivery curve shape produced by mechanical unit pumps incorporating the aforementioned outlet valve arrangements usually exhibits considerably higher fuel delivery at rated load when the pumps are running at low speed compared to when the pumps are running at high speed. This characteristic tends to cause excessive smoking from the associated engine which can limit the use of such pumps for low emission engines despite the advantage they provide in eliminating the risk of secondary injections.

Disclosure of the Invention

[0014] It is against this background that the invention provides, in a first aspect, a pump for fluid, comprising a pump body defining a bore, and a pumping plunger having an end region which is slidably received within the bore, a spill port defined by the pump body in a wall of the bore which port is coverable by the end region of the pumping plunger as the plunger is driven on a pumping stroke, in use, so as to initiate fluid pressurisation within a pumping chamber, and a spill groove defined by the pumping plunger and being arranged to uncover the spill port during a pumping stroke so as to cause depressurisation of the pumping chamber. The pumping plunger further defines a speed sensitive feature configured to permit a controlled leak of fluid from the pumping chamber to the spill port towards the end of a pumping stoke, the leak rate being dependent on the speed of operation of the pump.

[0015] The speed sensitive feature is adapted preferably to be effective during a rated load operating condition of the pump and has the effect of reducing the delivery of the pump at lower pump speeds compared to a pump having plungers without the speed sensitive feature. However, at higher pump speeds delivery remains substantially unaffected. The invention has particular utility in internal combustion engines in which it is important to minimise exhaust emissions, for example small capacity road vehicles. Moreover, the speed sensitive feature is configured to be effective towards the end of a pumping stroke which enables the relationship between fuel delivery and injection timing for high speed operation to be preserved. Although the speed sensitive feature may be effective over a broad range of angular movement of the plunger, it is preferred that it is effective during approximately the last 20 percent of the range of angular movement of the plunger which corresponds approximately to the rated load operating condition of the pump.

[0016] Preferably the spill feature may be a groove extending around a portion of the outer surface of the pumping plunger at an angle to the longitudinal axis of the pumping plunger. Similarly, the speed sensitive feature may also be a groove disposed in the surface of the plunger, and preferably may be in advance of the spill groove.

[0017] Furthermore, the speed sensitive groove may communicate with the spill groove and, preferably, is configured to extend away from the spill groove in a direction substantially perpendicular to the longitudinal axis of the plunger.

[0018] Although the pumping plunger may be manufactured so to have various cross sections, for example oval, elliptical, or square, for convenience it is preferred that the pumping plunger is substantially circular in cross section. As a result of this, the spill groove is substantially helical in shape since it is machined in the surface of the plunger at an angle to its longitudinal axis.

[0019] The precise dimensions of the speed sensitive groove are to a large extent dependent on the size of the pump, the associated plunger and the desired effect on the pump delivery. However, for a plunger that is typically approximately 7 to 10 millimetres in diameter it is preferred that the depth of the speed sensitive groove is approximately 30 to 60 micrometres and, more preferably between 40 and 50 micrometres. It should be appreciated, however, that some pumping plungers may have greater diameters than this in certain applications, large capacity marine engines for example.

[0020] In a second aspect the invention provides a pumping plunger comprising an elongate rod defining an end face and a side surface, and including a spill groove provided in the side surface of the plunger defining an angle with a longitudinal axis of the plunger, and a speed sensitive feature in communication with the spill groove and configured to permit a controlled flow of fluid therethrough, in use, at an end of a pumping stroke of the plunger.

[0021] The plunger is particularly suited to use in a mechanical unit-type fuel injection pump, for example the pump of the first aspect, the spill groove and speed sensitive feature being arranged to communicate with a spill port of the pump during at least a part of the pumping stroke.

[0022] The plunger is preferably circular in cross section, chiefly for convenience of design and manufacture, and to minimise leakage past the plunger, in use. However, it should be appreciated that the inventive concept also encompasses plungers that have other cross sectional shapes, for example elliptical or square.

[0023] Preferably, the spill groove winds around the circumference of a portion of the plunger. In other words, the spill groove is approximately helical in shape and, preferably, subtends a central angle of approximately 30 to 70 degrees.

[0024] The speed sensitive groove may be in direct communication with the spill groove and arranged to extend away from the spill groove to define an angle therewith. In this embodiment it is preferred that the speed sensitive groove defines an angle of approximately 30 to 70 degrees with the spill groove.

[0025] Preferably, the speed sensitive groove extends away from the spill groove in a direction substantially perpendicular to the longitudinal axis of the pumping plunger, although an angle in the range of about 70 to 110 degrees is also applicable.

[0026] It should be appreciated that preferred and/or optional features of the first aspect of the invention may be combined with the second aspect of the invention, and vice versa.

Brief Description of the Drawings

[0027] Reference has already been made to Figure 1 which shows a known fuel pump. In order that the invention may be more readily understood, reference will now be made, by way of example only, to the accompanying drawings in which:

Figure 2 is a sectional view of a fuel pump in accordance with a first embodiment of the invention;

Figure 3 is a perspective view of a pumping plunger of the fuel pump in Figure 2;

Figure 4 is a side view of the pumping plunger in Figure 3; and

Figure 5 is a graph of delivery against pump speed comparing the delivery characteristics, at rated load, for the fuel pumps in Figure 1 and Figure 2.

Detailed Description

[0028] Referring to Figure 2, a mechanical fuel injection pump 100 (hereinafter 'fuel pump') is shown that is similar to the fuel pump 2 described above with reference to Figure 1.

[0029] The fuel pump 100 includes a block-like pump body, or housing 102 having an axially disposed bore 104 within which a pumping plunger 108 is slidable. The plunger 108 has a lower end 110 (in the orientation shown in Figure 2) that is coupled to a lower spring plate 112 for transmitting reciprocating motion to the plunger 108. Although not shown in the diagram, a tappet and cam member (not shown) may be arranged with respect to the lower spring plate 112 such that rotation of the cam member causes reciprocation of the plunger 108. This form of plunger drive arrangement is known in the art.

[0030] A biasing means in the form of a helical spring 114 is received over the plunger 108 such that the spring 114 is disposed between the pump housing 102 and the lower spring plate 112. An upper end 116 of the spring 114 abuts a spring plate 120 attached to a lower end of the pump housing 102 and a lower end 122 of the spring 114 abuts the lower spring 112, the spring 114 thus serving to bias the plunger 108 downwards in the orientation shown.

[0031] An upper end of the pump housing 102 defines a cup-shaped recess 130 into which an outlet valve arrangement 132 is received. A lower end 133 of the outlet valve arrangement 130 closes off the plunger bore 104 and defines a pumping chamber 134 between it and an upper end face 140 of the plunger 108. The outlet valve arrangement 132 is of the type referred to in the art as a 'constant pressure unloading valve' and the general configuration thereof is known in the art.

[0032] The inner surface of the bore 104 in the region of the pumping chamber 134 defines two opposed ports: a fill port 142 and a spill port 154. The fill port is shown to the left in Figure 2 and is connectable to a fuel supply circuit (not shown) such that fuel is permitted to fill the pumping chamber 134 through the fill port 142. The spill port 154 is shown on the right in Figure 2 and is connectable to a drain connection (not shown) such that high pressure fuel from the pumping chamber 134 can escape to low pressure through the spill port 154.

[0033] In use, the plunger 108 is driven from its bottom dead centre position on a pumping stroke during which pressurisation of fuel within the pumping chamber 134 is started when the upper end face 140 of the plunger 108 travels past both the fill port 142 and the spill port 154 so the ports are covered by an end region of the plunger 108.

[0034] When the pressure of fuel within the pumping chamber 134 reaches a predetermined pressure, the outlet valve arrangement 132 opens to permit pressurised fuel to flow through an associated outlet connection 135. Although not shown in Figure 1, a fuel conduit may be attached to the outlet connection 135 to convey fuel to a fuel injector, for example.

[0035] In order to terminate fuel delivery, the plunger 108 is provided with a groove formation, shown generally as 156. As the plunger 108 is driven further on its pumping stroke a point will be reached at which the groove formation 156 overlaps the spill port 154 so that pressurised fuel can escape from the pumping chamber 134 along the groove formation 156 to the spill port 154, which terminates pressurisation and, thus, fuel delivery from the pump 100.

[0036] Following termination of pumping, the plunger 108 is driven further such that it passes a top dead centre position and thus commences a return stroke under the force of the spring 114. During the return stroke, the upper end face 140 of the plunger 108 travels past the fill port 142 so the port 142 is uncovered by the plunger 108 and fuel is therefore permitted to fill the pumping chamber 134.

[0037] In order to vary the delivery volume of the fuel pump 100, the plunger 108 is provided with a control arm

150 which extends radially away from the approximate mid point of the plunger 108. Angular movement of the control arm 150 varies the angular position of the plunger 108.

[0038] In use, the control arm 150 engages a fuel delivery rack. The position of the fuel delivery rack is determined by the engine governor and the rack, in turn, acts on the control arm 150 to cause radial movement of the plunger 108 about its longitudinal axis. The radial position of the plunger 108 determines the point of the pumping stoke that the groove formation 156 registers with the spill port 154, thus terminating fuel pressurisation earlier, or later, in the pumping stroke depending on the direction and extent of rotation of the plunger 108. The variation of the effective stroke between the upper end face of the plunger 108 and the groove formation 156 varies the fuel delivery by an associated injector to an engine.

[0039] With reference now also to Figures 3 and 4, the plunger 108 is a generally cylindrical rod formed of a high strength material such as through-hardened alloy steel having a diameter of 8 millimetres, although it should be noted that this is not essential to the invention and such plungers in small automotive applications typically have diameters in the range of 7 to 10 millimetres. The pumping plunger 108 includes a lower end region 160 of substantially uniform diameter (only partially shown in Figure 3) and a upper end region 162 that bears the groove formation 156 in the form of a plurality of grooves, slots or recesses machined onto the outer surface of the plunger 108.

[0040] The upper end region 162 of the plunger 108 is provided with an annular recess 164 which divides the upper end region 162 into two approximately equal length portions: the annular recess 164 and a plunger head 166 that has a greater diameter than the recess 164. In use fuel surrounds the annular recess 164 which serves to pressure balance the plunger 108 within the bore 104 in order to ensure smooth movement.

[0041] The plunger head 166 has a diameter that is substantially equal to the lower end region 160 of the plunger 108.

[0042] The plunger head 166 is provided with a longitudinal groove 170 that cuts through and extends away from the upper end face 140 of the plunger 108 and communicates with the annular recess 162. Hereinafter, the longitudinal groove 170 is referred to as the 'stop groove'.

[0043] The function of the stop groove 170 is to reduce delivery of the fuel pump substantially to zero when desired. To this end the plunger 108 is moved angularly, or rotated, so that the stop groove 170 is axially aligned with the spill port 154. Therefore, the spill port 154 is never fully covered and so as the plunger 108 reciprocates within the bore 104 fuel can flow from the pumping chamber 134 along the stop groove 170 and to the spill port 154. As a result, pressurisation of fuel pressure in the pressurisation chamber 134 does not begin.

[0044] The plunger head 166 is also provided with a second groove 172 which is cut at an angle to the stop groove 170 so as to extend around the outer surface of the plunger 108 for approximately one quarter of its circumference - the groove 172 is thus approximately helical in shape. As shown in Figures 3 and 4, the groove 172 is cut into the plunger 108 so as to define an angle with the longitudinal axis of the plunger 108 of approximately 45 degrees. However, it should be appreciated that this need not be the case and that the angle the groove 172 defines depends on the pump application. Typically, however, in such pumps the groove is cut to define angles in the range of about 30 to 70 degrees with the plunger axis.

[0045] The purpose of the groove 172 is to provide a means to vary the volume of pressurised fuel that is expelled or 'spilled' from the fuel pump 100 through angular movement of the plunger 108. Hereafter, the groove 172 will be referred to as the 'spill groove'.

[0046] Depending on the angular position of the plunger 108, in use, the upper edge of the spill groove 172 will uncover the spill port 154 earlier or later in the pumping stroke as the case may be, thus varying the point at which pressurised fuel is spilled from the pumping chamber 134. It should be noted at this point that although the spill groove 172 has been described as extending around approximately a quarter of the circumference of the plunger 108, this is only exemplary and the spill groove 172 could be configured to extend around more or less of the surface of the plunger 108 depending on the requirements of the pump application. Typically, however, such spill grooves extend around the surface of the associated plunger so as to subtend a central angle in the range of about 30 to 70 degrees.

[0047] One end of the spill groove 172 communicates with the stop groove 170 and its other end communicates with a further groove 174, hereinafter referred to as the 'start fuelling groove'. The start fuelling groove 174 is, in effect, a continuation of the spill groove 172 but extends laterally around the surface of the plunger 108, substantially perpendicular to the plunger axis. In use, prior to engine start, the plunger 108 is moved angularly such that the start fuelling groove 174 is axially aligned with the spill port 154. It should be appreciated that in this position, the plunger is at one extremity of the range of its angular movement. Due to the relatively large distance between the upper end face 140 of the plunger 108 and the start fuelling groove 174, the fuel pump 100 delivers a relatively large volume of fuel per pumping stroke when the plunger 108 is in this angular position. Such an operational mode is beneficial for engine starting, particularly during cold conditions.

[0048] Approximately two thirds of the way along the spill groove 172, the plunger 108 is provided with a third groove 176 that extends away from the spill groove 172 along a plane substantially perpendicular to the longitudinal axis of the pumping plunger 108.

[0049] The third groove 176 is configured as a speed sensitive feature that permits a controlled leak or 'spill' of fuel to flow from the pumping chamber 134 to the spill port 154 toward the end of a pumping stroke (preferably in the last 10% to 25% of the effective pumping stroke) and, thus, at the end of an injection period. Hereinafter, the third groove 176 will be referred to as the 'speed sensitive groove'.

[0050] The dimensions of the speed sensitive groove 176 are selected so that, at lower pump speeds, for example, below about 60 percent of rated speed, a comparatively large volume of fuel is permitted to flow through the speed sensitive groove 176 to the spill port 154. Conversely, at higher engine speeds, for example between about 60 percent and 100 percent of rated speed, the dimensions of the speed sensitive groove 176 are such that the flow of fuel through it has a negligible effect on the delivery from the fuel pump 100. Therefore, a greater amount of fuel flows through the speed sensitive groove 176 at relatively low pump speeds compared to when the pump is operating at a relatively high speed.

[0051] The pumping plunger 108 is mounted in the bore 104 so as to be able to move angularly and has a range of angular movement during which the fuel delivery from the pump is caused to be varied. The speed sensitive groove 176 becomes effective during circumstances in which the angular position of the plunger 108 causes the speed sensitive groove 176 to be in axial alignment with the spill port 154, which is approximately during the last 20 percent of its angular movement and, more preferably, during the last 15 percent of angular movement. Therefore, as the plunger 108 rises from a bottom dead centre position within the bore 104 during a pumping stroke, firstly the upper end face 140 of the plunger 108 will traverse across and eventually occlude the spill port 154. When the upper end face 140 of the pumping plunger fully covers the spill port 154, fuel is trapped within the pumping chamber 134 and is therefore pressurised with further upward movement of the plunger 108.

[0052] Continued upward movement of the plunger 108 (in the orientation shown in Figures 2, 3 and 4) eventually causes the upper edge of the speed sensitive groove 176 to uncover the spill port 154, since the groove 176 is in advance of the spill groove 172, and fuel is permitted to flow at a predetermined rate from the pumping chamber 134 to the spill port 154 through the speed sensitive groove 176.

[0053] At low engine speeds, the movement of the plunger 108 is relatively slow so the flow area of the speed sensitive groove 176 is sufficient for it to act as the control edge of the spill groove 172 as the restriction to fuel flow is minimal. As a result, at lower engine speeds, at rated load, the volume of fuel delivered by the fuel pump 100 is reduced compared to a fuel pump using a similar plunger without the speed sensitive groove 176. A skilled person will appreciate that the term 'rated load' relates to the maximum load for which the engine is designed to operate safely and continuously.

[0054] Conversely, at higher engine speeds, and at rated load, the flow area of the speed sensitive groove 176 has a restrictive effect on the flow of fuel through it since the groove 176 registers with the spill port 154 for such a short period of time. Due to the viscosity of the fuel, when the speed sensitive groove 176 registers with the spill port 154 fuel cannot escape quickly though the groove 176 to reduce fuel delivery significantly. Instead, pressurisation of the fuel within the pumping chamber 134 continues until the control edge defined by the spill groove 172, having a larger flow area, registers with the spill port 154.

[0055] The effect of the speed sensitive groove 176 can be seen clearly in Figure 5 which is a graph showing the delivery of the fuel pumps 2, 100 of Figures 1 and 2, respectively, on the vertical axis and the speed of the fuel pumps 2, 100 on the horizontal axis. It should be appreciated that in Figure 5 the delivery of the fuel pumps 2, 100 is shown across a range of speeds with the pumps 2, 100 having a plunger angular position that provides the correct fuel delivery to an engine for running at a rated load and full speed condition.

[0056] Line A represents the fuel delivery across a range of pump speeds for the pump 2 fitted with a known pumping plunger as described above with reference to Figure 1. It is seen that at lower engine speeds, for example between approximately 400 and 1000 revolutions per minute (rpm), the delivery of the fuel pump 2 is above that obtained at higher engine speeds. This is disadvantageous since the increased delivery results in an increased level of unburned hydrocarbons (generally visible in the form of smoke emissions) being emitted from the engine.

[0057] In contrast, line B represents the fuel pump 100 of the above described embodiment of the invention with a pumping plunger 108 bearing the speed sensitive groove 176. As is seen, line B exhibits a more regularly shaped delivery curve with a comparatively reduced delivery at lower engine speeds which is a desirable characteristic of the curve in order to reduce smoke emissions from the engine with which the fuel pump 100 is used. More specifically, at an engine speed of approximately 200rpm the speed sensitive groove reduces the delivery volume by about 50 percent. The percentage reduction in delivery volume reduces in magnitude gradually over the pump speed range between approximately 200rpm and approximately 1300rpm at which point the delivery volume is substantially equal for Line A and Line B.

[0058] In order to provide the required characteristics it is preferred that the speed sensitive groove 176 has a depth in the range of 30 to 60 micrometres and a width in the range of 0.3 to 1 millimetres. The inventors have determined that particularly beneficial dimensions for the groove 176 on a plunger having a diameter of 8.5 millimetres are a depth of between 40 to 50 micrometres and a width of 0.5 millimetres. However, it should be appreciated that the stated dimensions are exemplary only and that the precise dimensions are specific to the size and shape of a given pump and the associated pumping plunger. The overriding aim is to dimension to slot so as to achieve an approximate reduction in the delivered fuel volume of between approximately 5 percent and 20 percent when the pumping plunger occupies an angular position of between about 80 and 100 percent of full load position, for engine speeds up to approximately 70 percent of rated speed.

[0059] The length of the speed sensitive groove 176 is dependent on the other features that are machined into the surface of the plunger 108 and it is important that the length of the groove 176 is selected so that it does not interfere with the correct functioning of the other features. For example, on Figures 3 and 4 it can be seen that the end of the groove 176 does not overlap with the start fuelling groove 174.

[0060] It should be appreciated that various modifications and/or improvements may be made to the above described embodiment(s) without departing from the broad concept of the invention, as defined by the claims.

[0061] For example, although the speed sensitive groove 176 is described above and shown in Figure 3 and 4 as extending away from the spill groove 172 in a direction perpendicular to the longitudinal axis of the plunger 108, it should appreciated that this need not be the case and that, instead, the speed sensitive groove 176 could be arranged to form a range of angles with the plunger axis, for example in order fine tune the fuel delivery rate. In this respect, it is envisaged that the speed sensitive groove 176 could extend away from the spill groove 172 so as to define an angle between approximately 75 and 110 degrees with the longitudinal axis of the plunger 108.

[0062] Further, although the speed sensitive groove 176 has been described to have a specific length and depth, it should be appreciated that the above specified dimensions are not essential and, as such, may be modified in order to attain the desired effect on the torque curve of the engine in which the pump is installed.

[0063] For purposes of manufacturing efficiency, it is preferred that the speed sensitive groove 176 is manufactured as a straight slot cut into the surface of the plunger 108. However, such a feature could also be provided by other means. For example, instead of a slot, the functionality of the speed sensitive groove 176 could be provided by a shallow flat or a reduced diameter portion of the plunger at a longitudinal plunger position that corresponds to the end region of a pumping stroke.

[0064] Also, it should be appreciated that the stop groove 170 is an optional feature of the plunger 108 and is not essential to the invention. For example, the spill groove 172 could be configured so that a part thereof extends so as to cut through the end face 140 of the plunger 108.

Claims

1. A pump (100) for fluid, comprising:

a pump body (102) defining a bore (104), and a pumping plunger (108) having an end region which is slidably received within the bore (104);
a spill port (154) defined by the pump body (102) in a wall of the bore (104) which port is coverable by the end region of the pumping plunger (108) as the plunger is driven on a pumping stroke, in use, so as to initiate fluid pressurisation within a pumping chamber (134); and
a spill groove (172) defined by the pumping plunger (108) being arranged to uncover the spill port (154) during a pumping stroke so as to cause depressurisation of the pumping chamber (134);

wherein the pumping plunger (108) further defines a speed sensitive feature (176) configured to permit a controlled leak of fluid from the pumping chamber (134) to the spill port (154) towards the end of a pumping stoke, the leak rate being dependent on the speed of operation of the pump (100).

2. The pump of claim 1, wherein the speed sensitive feature (176) is adapted to be effective during a rated load operating condition of the pump (100).

3. The pump of claim 1 or claim 2, wherein the pumping plunger (108) has a range of angular movement and the speed sensitive feature (176) is effective in approximately the last 20 percent of the range of angular movement.

4. The pump of any one of the preceding claims, wherein the speed sensitive feature (176) is a groove disposed in the surface of the pumping plunger (108) in advance of the spill groove (172) and in communication therewith and extends away from the spill groove (172) in a direction to define an angle to the longitudinal axis of the pumping plunger (108).

5. The pump of claim 4, wherein the speed sensitive groove (176) has a depth in the range of 30 to 60 micrometres.

6. The pump of claim 4 or claim 5, wherein the speed sensitive groove (176) has a width in the range of 0.3 to 1.0 millimetres.

7. A pumping plunger (108) for a fluid pump (100), comprising an elongate rod defining an end face (140) and a side surface, the pumping plunger (108) including a spill groove (172) provided in the side surface of the plunger (108) defining an angle with a longitudinal axis of the plunger (108), and a speed sensitive feature (176) in communication with the spill groove (172) and configured to permit a controlled flow of fluid therethrough, in use, at an end of a pumping stroke of the plunger (108), the leak rate being dependent on the speed of operation of the fluid pump (100).

8. The pumping plunger of claim 7, wherein the speed sensitive feature (176) is adapted to be effective during a rated load operating condition of the pump (100).

9. The pumping plunger of claim 7 or claim 8, wherein the pumping plunger (108) has a range of angular movement and the speed sensitive feature (176) is adapted to be effective in approximately the last 20 percent of the range of rotation.

10. The pumping plunger of any one of claims 7 to 9, wherein the speed sensitive feature (176) is a groove that is disposed in the surface of the pumping plunger (108) in advance of the spill groove (172) and in communication therewith and extends away from the spill groove (172) in a direction to define an angle to the longitudinal axis of the pumping plunger (108).

11. The pumping plunger of claim 10, wherein the angle is between approximately 70 and 110 degrees.

12. The pumping plunger of claim 10 or claim 11, wherein the speed sensitive groove (176) extends away from the spill groove (172) in a direction substantially perpendicular to the longitudinal axis of the pumping plunger (108).

13. The pumping plunger of any one of claims 10 to 12, wherein the speed sensitive groove (176) has a depth in the range of 30 to 60 micrometres.

14. The pumping plunger of any one of claims 10 to 13, wherein the speed sensitive groove (176) has a width in the range of 0.3 to 1.0 millimetres.

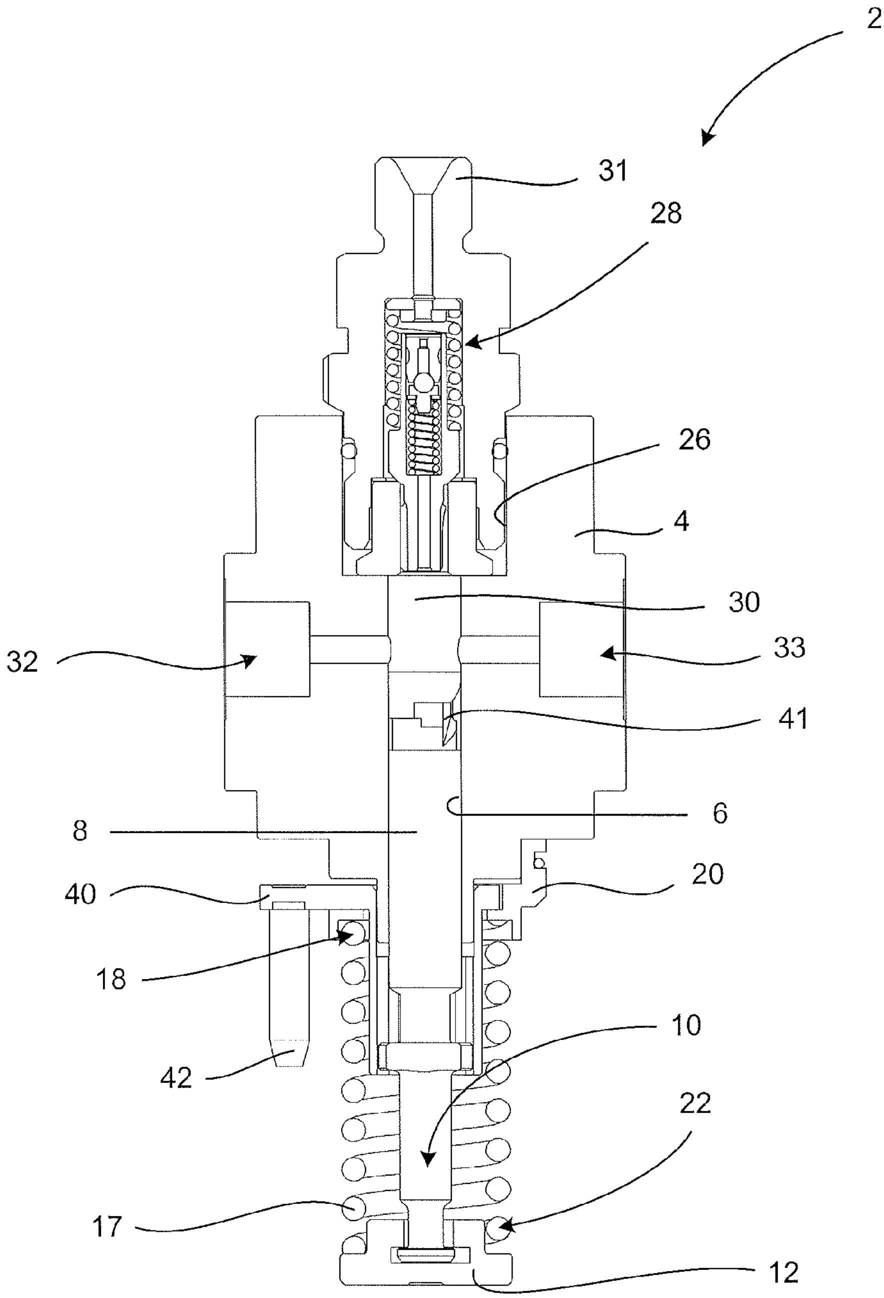

FIGURE 1

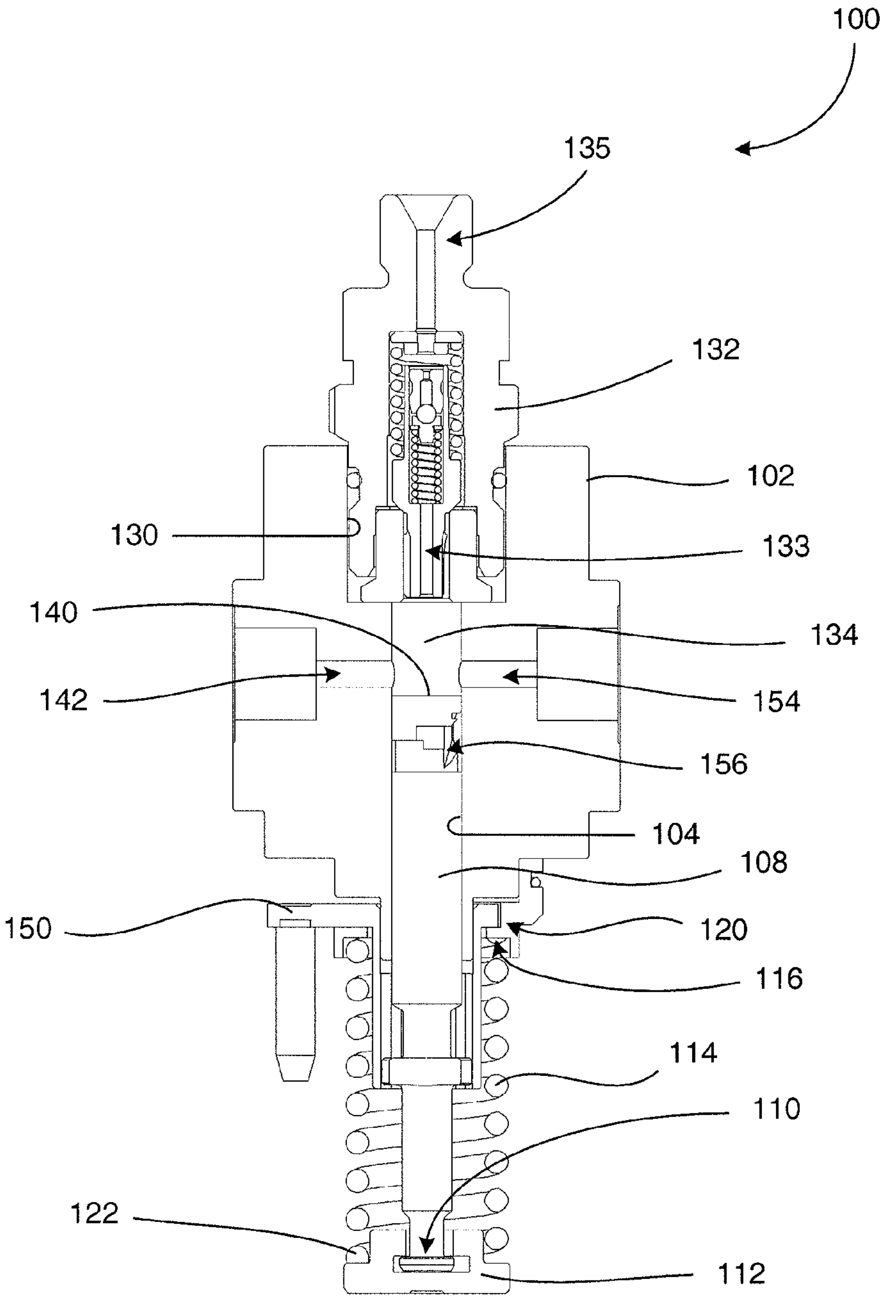
100
135
132
102
130
133
140
134
142
154
156
104
108
150
120
116
114
110
122
112

FIGURE 2

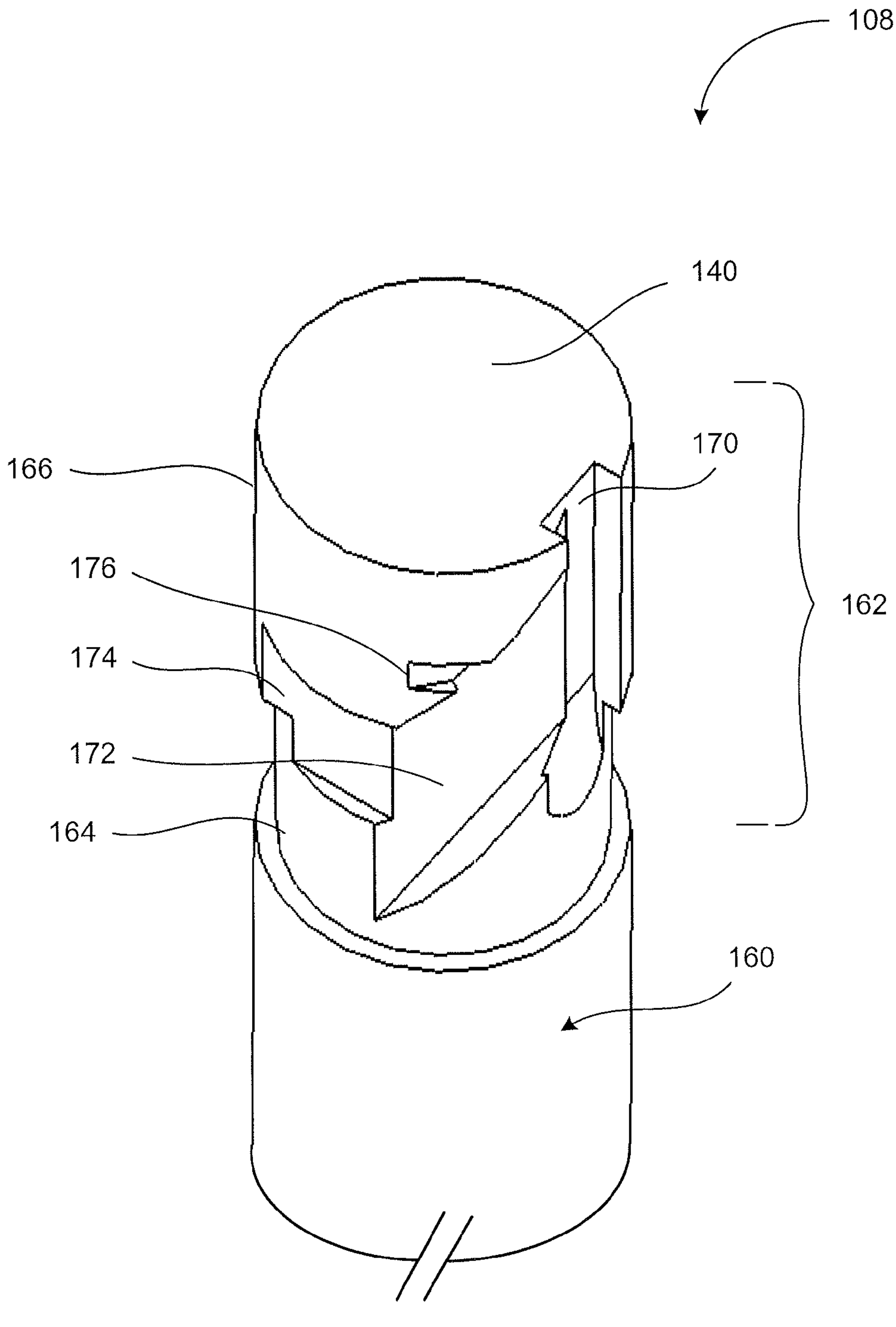

FIGURE 3

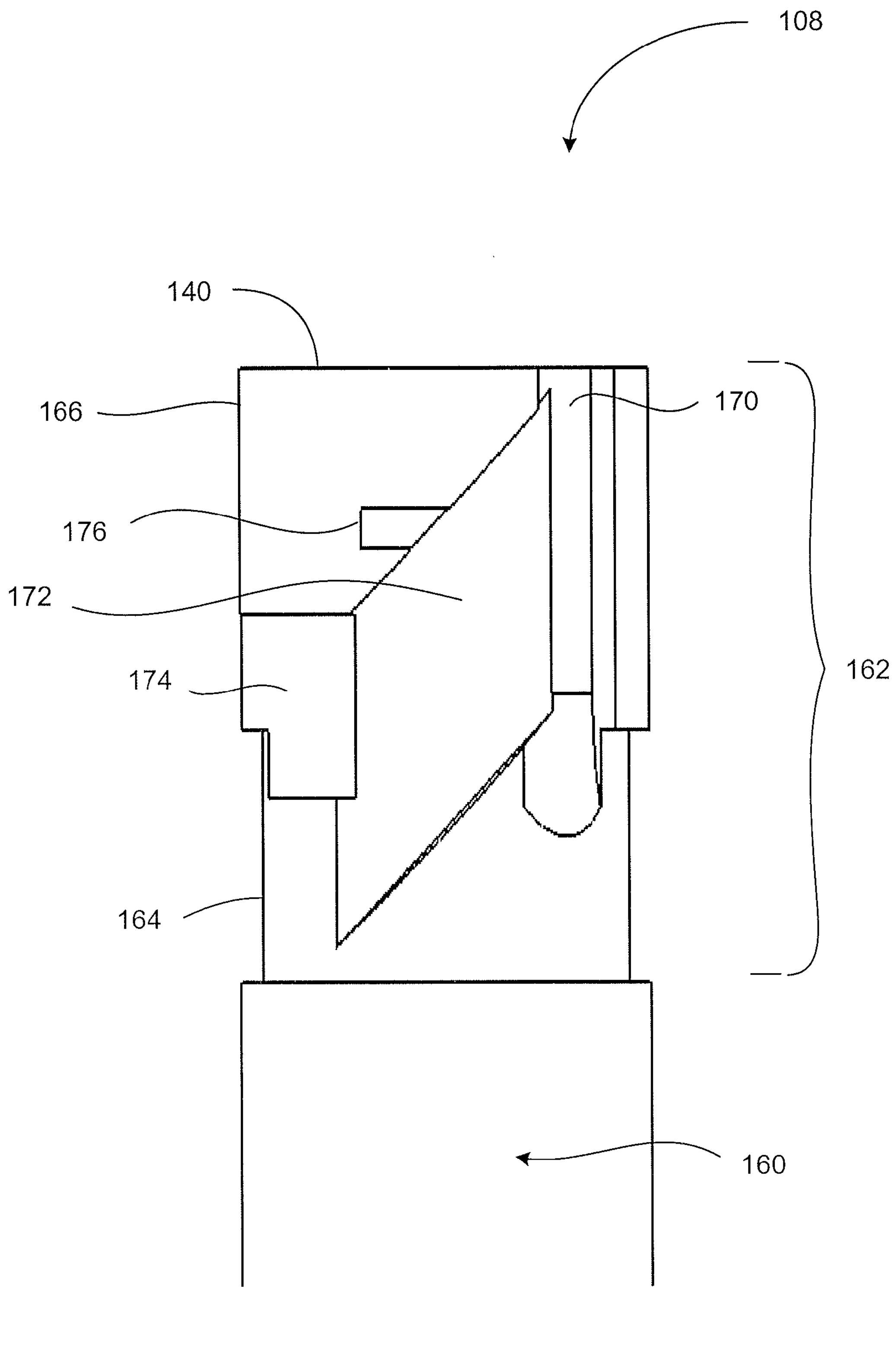

FIGURE 4

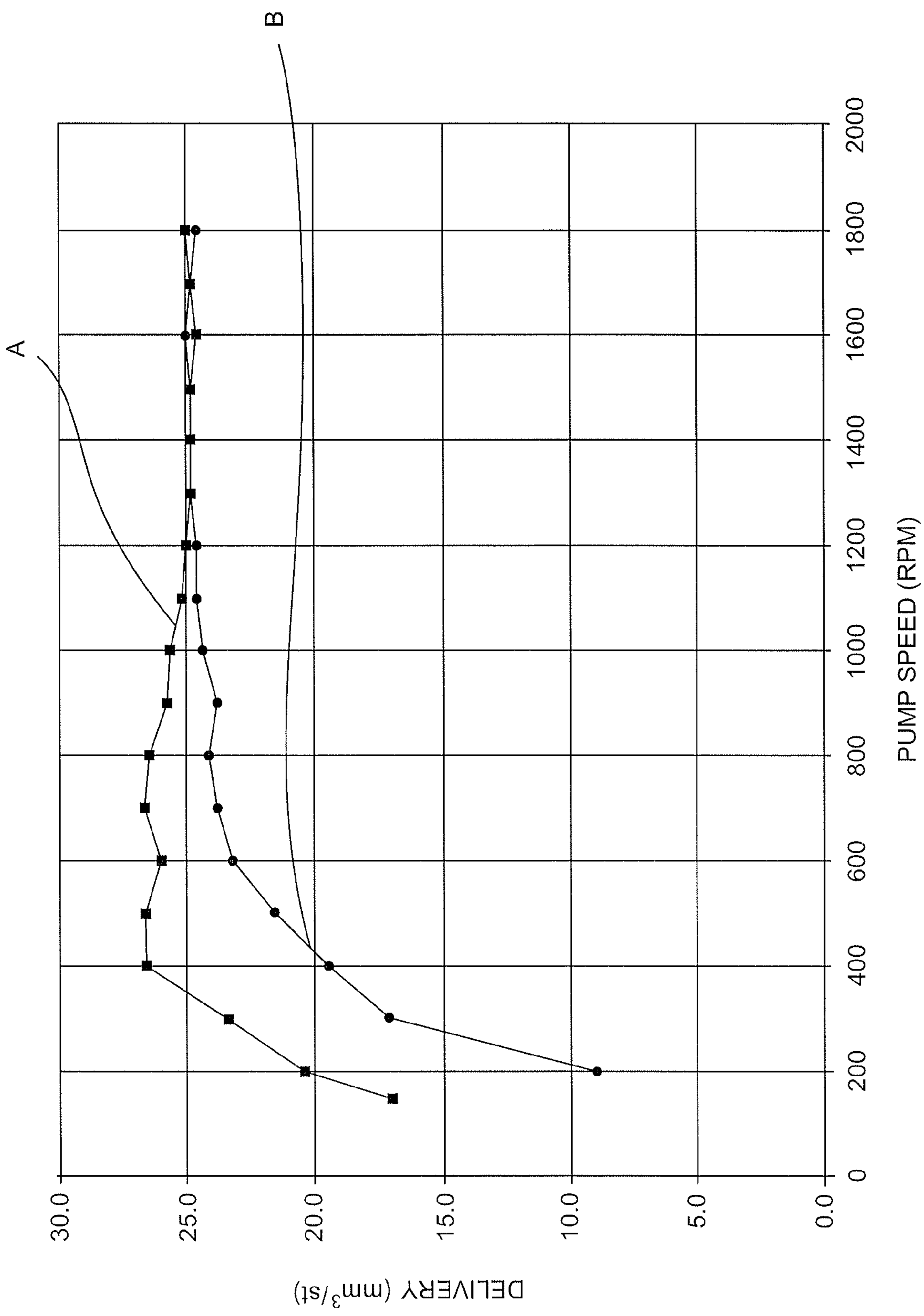
A
B
DELIVERY (mm³/st)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PUMP SPEED (RPM)

FIGURE 5