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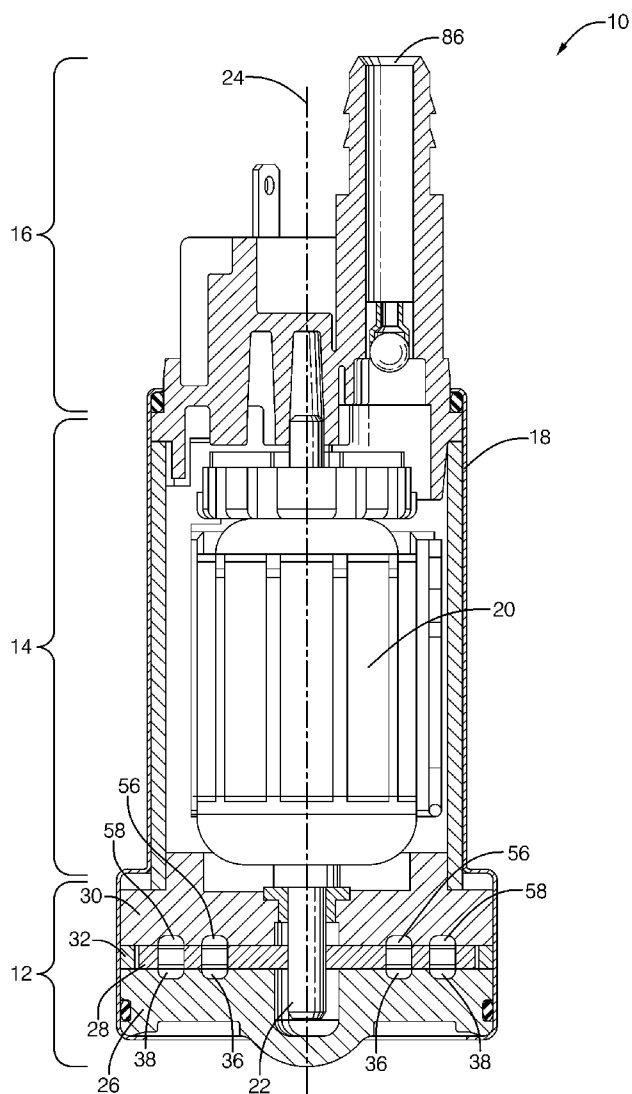
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(57) **ABSTRACT**

A fluid pump includes an outlet for discharging fluid from the fluid pump, a housing, and a motor with a shaft that rotates about an axis. The fluid pump also includes an impeller having a first array of blades radially surrounding the axis and a second array of blades radially surrounding the first array of blades. The fluid pump also includes an inlet plate adjacent to the impeller and has an inlet for introducing fluid into the fluid pump, a first inlet plate flow channel aligned with the first array of blades and having a first inlet plate flow channel cross-sectional area, and a second inlet plate flow channel aligned with the second array of blades and having a second inlet plate flow channel cross-sectional area. The second inlet plate flow channel cross-sectional area is synchronized with the first inlet plate flow channel cross-sectional area.



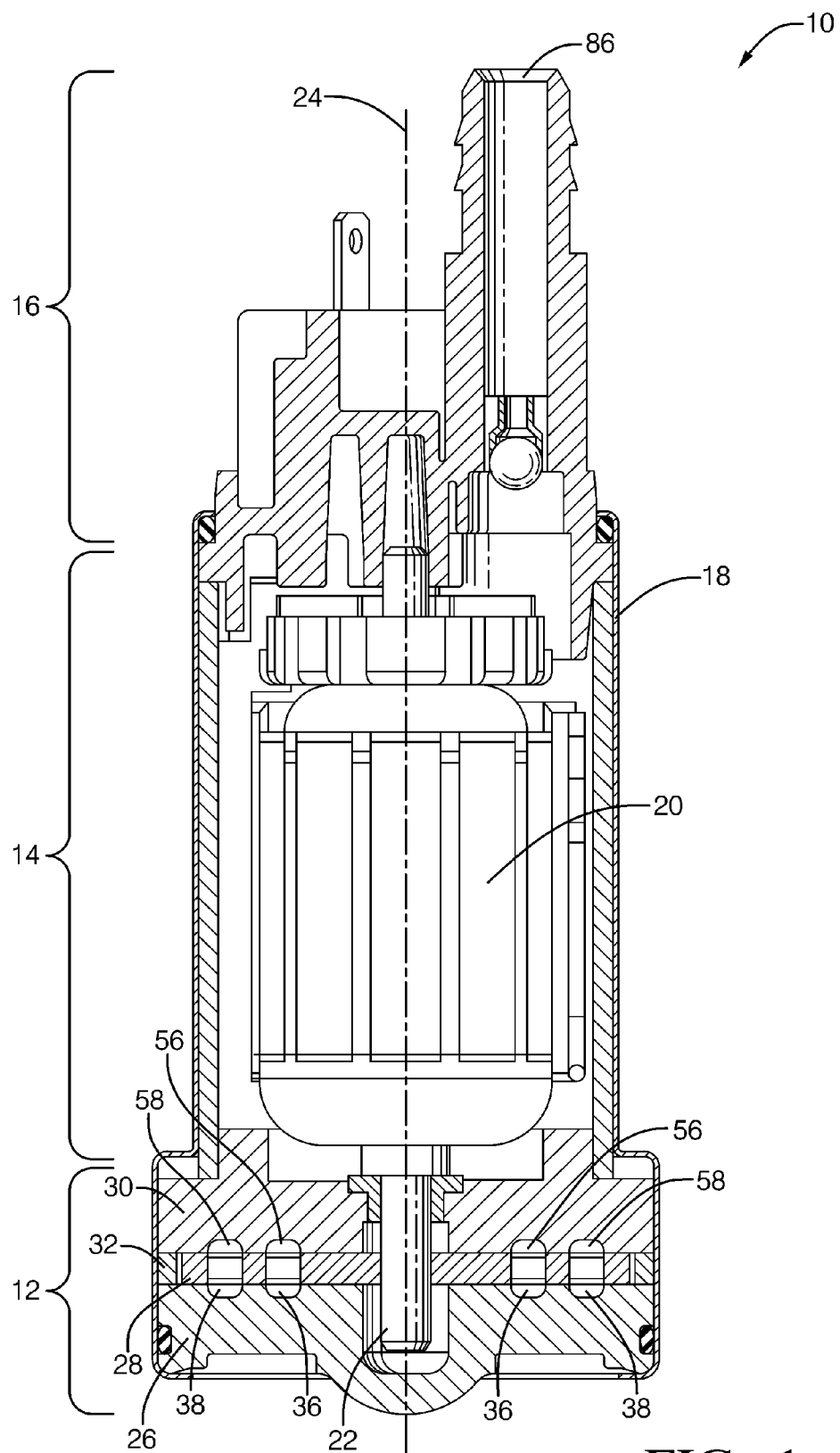


FIG. 1

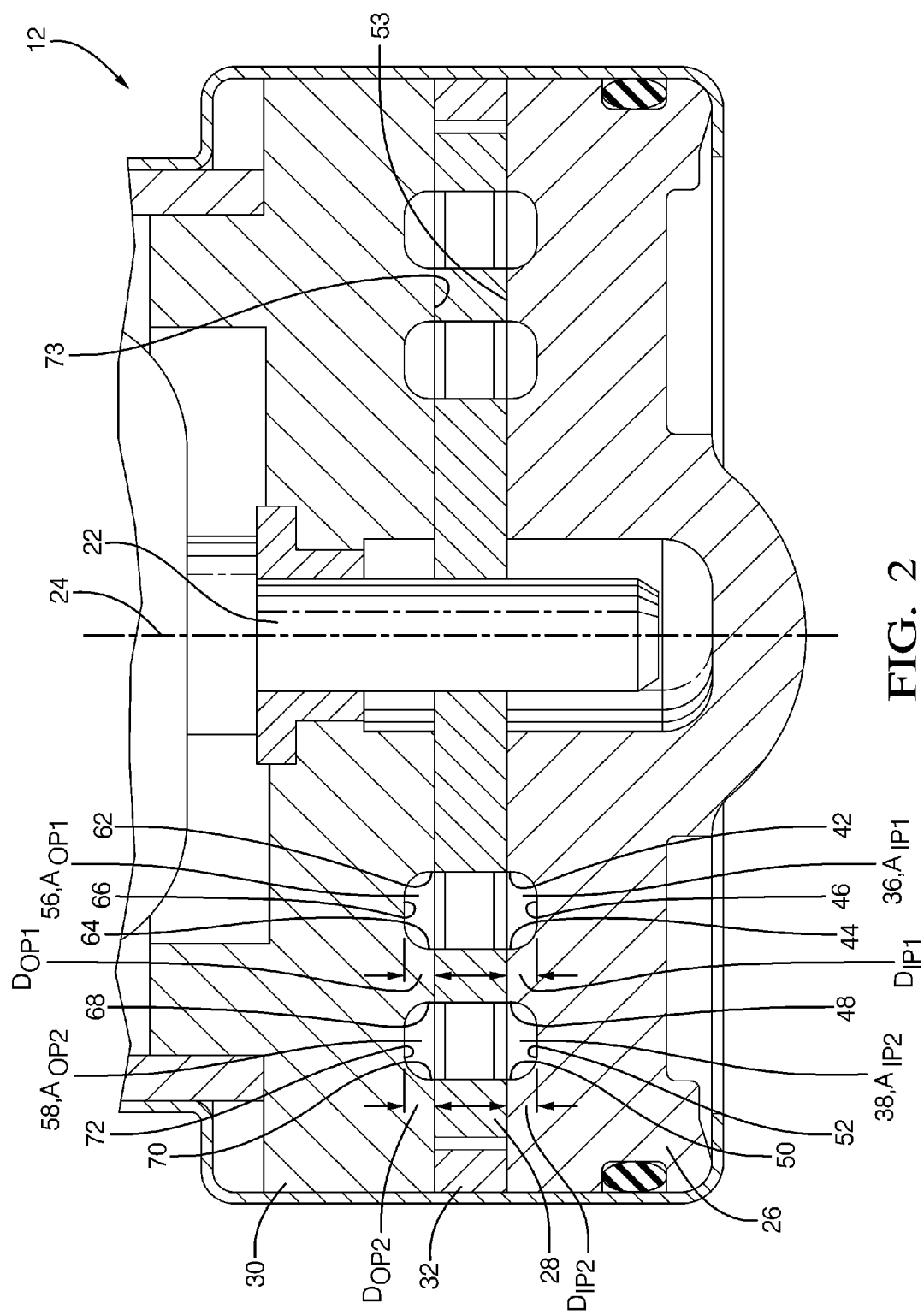


FIG. 2

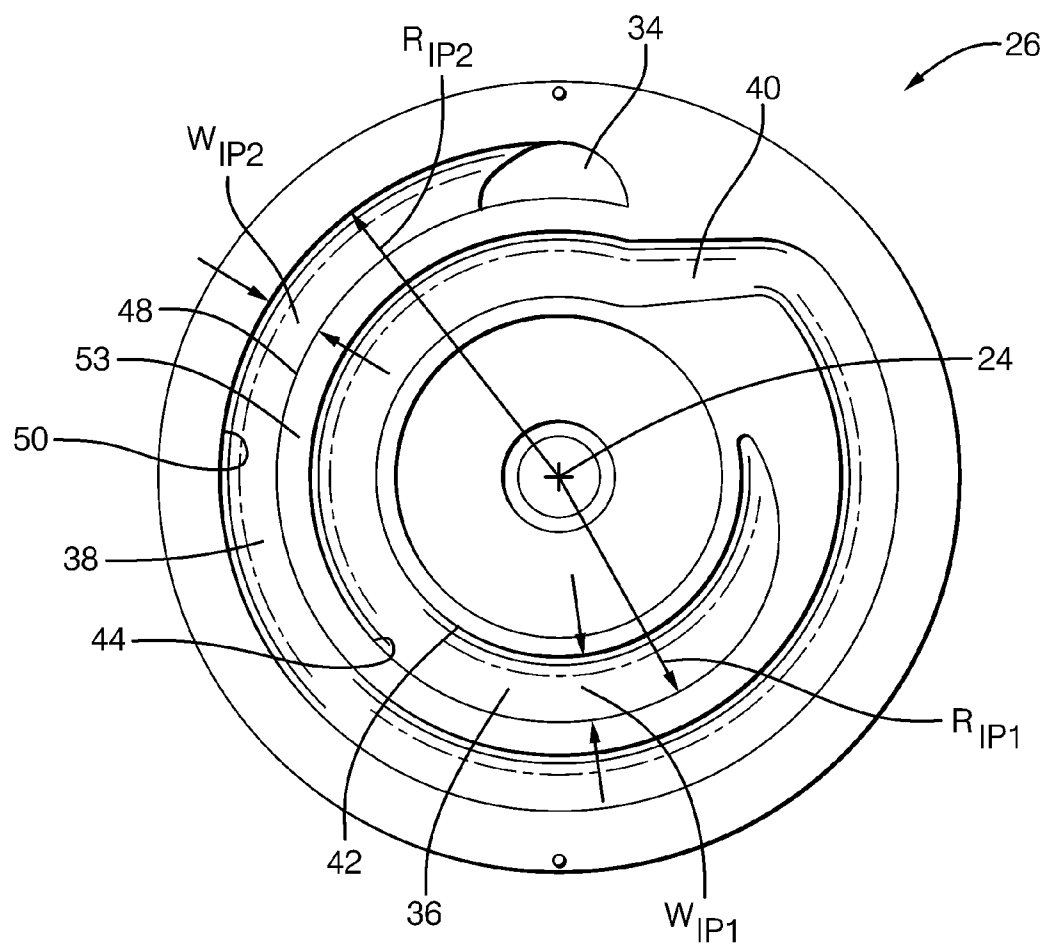


FIG. 3

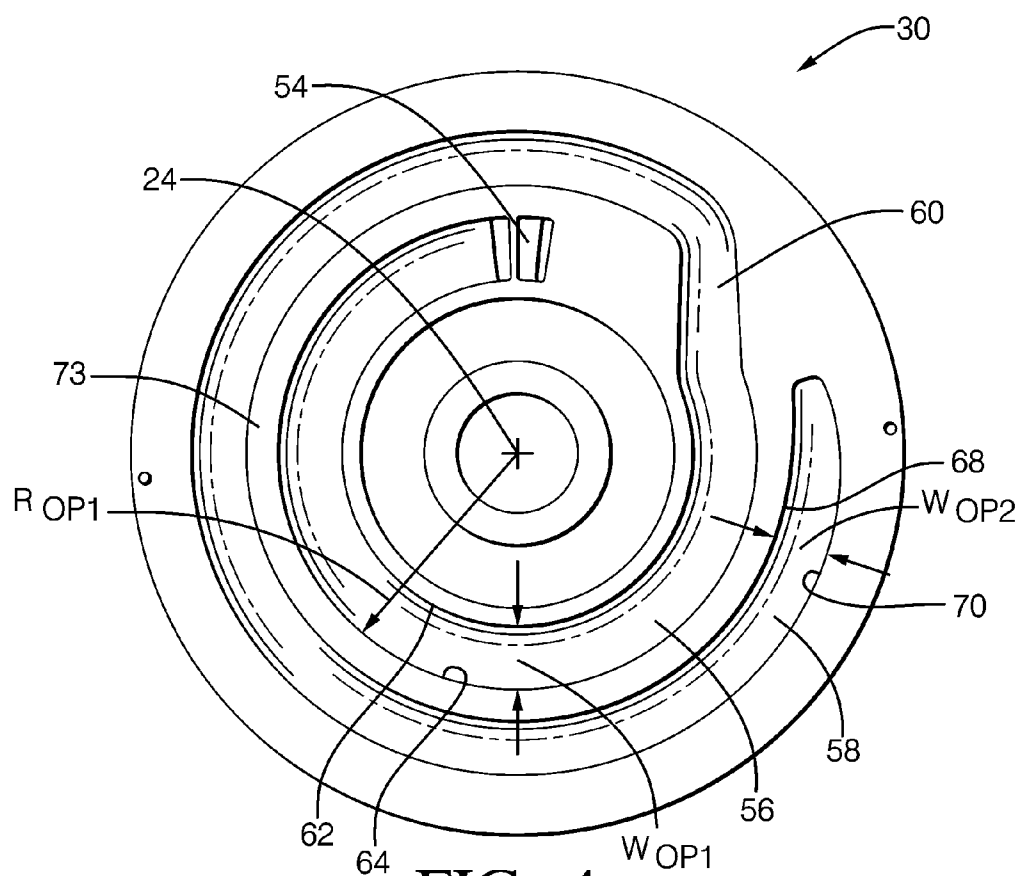


FIG. 4

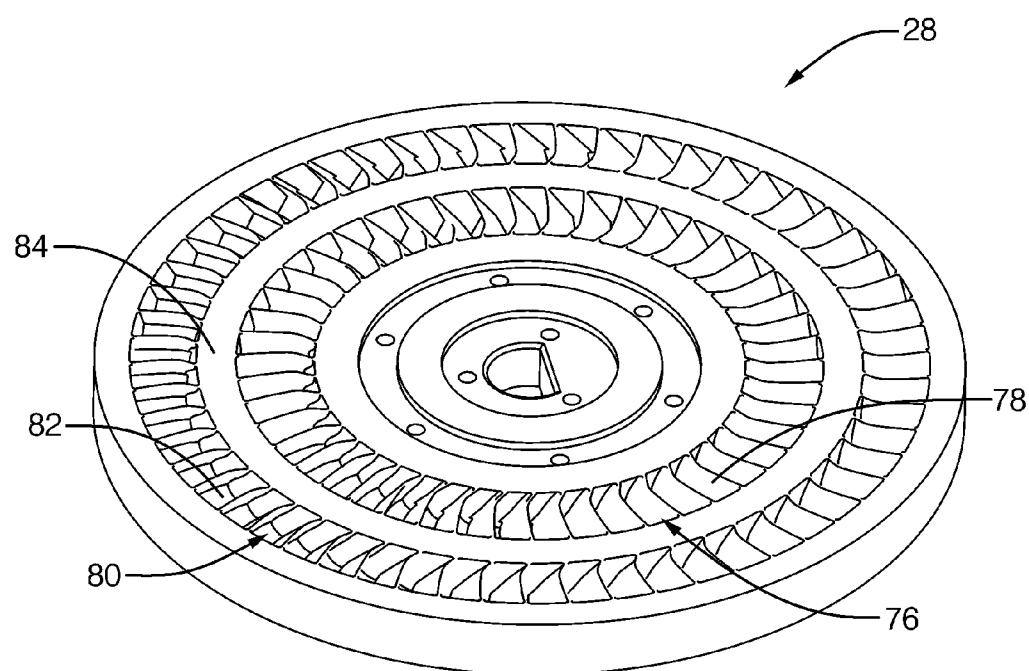


FIG. 5

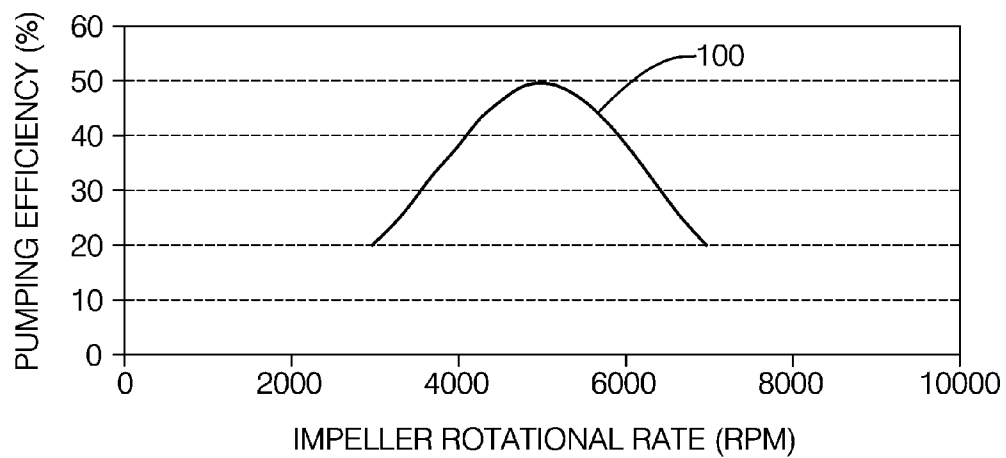


FIG. 6

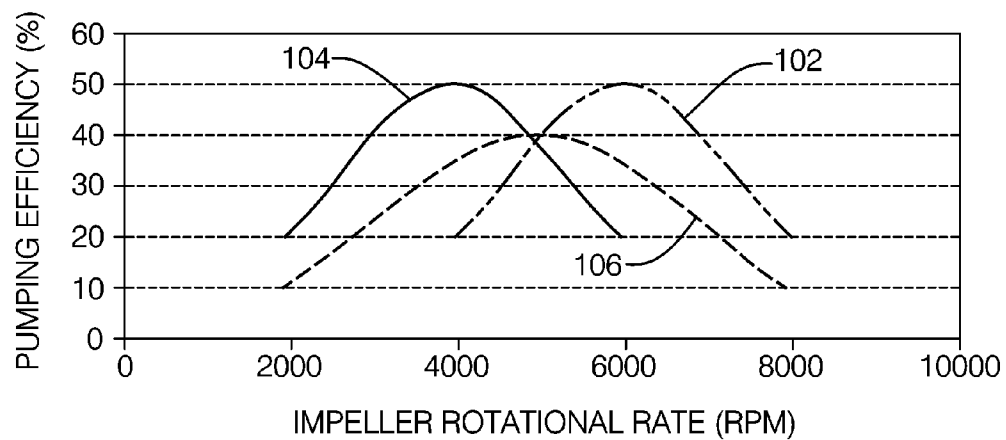


FIG. 7

MULTI-CHANNEL FUEL PUMP

TECHNICAL FIELD OF INVENTION

[0001] The present invention relates to a fluid pump; more particularly to a fuel pump; even more particularly to a multi-channel fuel pump; and still even more particularly to a multi-channel fuel pump in which the channels are synchronized.

BACKGROUND OF INVENTION

[0002] Fluid pumps, and more particularly fuel pumps for pumping fuel, for example, from a fuel tank of a motor vehicle to an internal combustion engine of the motor vehicle, are known. U.S. Pat. No. 5,338,151 shows one type of fuel pump which includes an impeller with two arrays of blades that are concentric to each other such that one array of blades radially surrounds the other array of blades. An inlet plate is disposed adjacent to one face of the impeller and includes first and second inlet plate flow channels that are arranged in series to each other. One inlet plate flow channel is aligned with the first array of blades while the other inlet plate flow channel is aligned with the second array of blades, accordingly, one inlet plate flow channel is disposed radially outward of the other inlet plate flow channel. An outlet plate is disposed adjacent to the face of the impeller that is opposite the inlet plate. The outlet plate includes first and second outlet plate flow channels that are arranged in series to each other. One outlet plate flow channel is aligned with the first array of blades while the other outlet plate flow channel is aligned with the second array of blades, accordingly, one outlet plate flow channel is disposed radially outward of the other outlet plate flow channel. Rotation of the impeller by an electric motor pumps fuel from an inlet of the fuel pump, through one or more of the inlet and outlet plate flow channels, and subsequently to an outlet of the fuel pump. The pumping efficiency of each inlet and outlet flow channel is affected by the radial distance of the flow channel from the center of rotation of the impeller, the cross-sectional area of the flow channel, and the rotational rate of impeller. Without consideration to the geometry of each of the flow channels relative to each other, the maximum pumping efficiency for each flow channel may occur at different rotational rates of the impeller which reduces the overall efficiency of the fuel pump.

[0003] What is needed is a fuel pump which minimizes or eliminates one or more of the shortcomings as set forth above.

SUMMARY OF THE INVENTION

[0004] Briefly described, a fluid pump includes an outlet for discharging fluid from the fluid pump, a housing, and a motor with a shaft that rotates about an axis. The fluid pump also includes an impeller having a first array of blades radially surrounding the axis and a second array of blades radially surrounding the first array of blades. The impeller is rotatable by the shaft of the motor. The fluid pump also includes an inlet plate adjacent to the impeller and has an inlet for introducing fluid into the fluid pump, a first inlet plate flow channel aligned with the first array of blades and having a first inlet plate flow channel cross-sectional area, and a second inlet plate flow channel aligned with the second array of blades and having a second inlet plate flow channel cross-sectional area. Rotation of the impeller pumps fluid from the inlet to the outlet. The second inlet plate flow channel cross-sectional area is synchronized with the first inlet plate flow channel cross-sectional area.

BRIEF DESCRIPTION OF DRAWINGS

[0005] This invention will be further described with reference to the accompanying drawings in which:

[0006] FIG. 1 is an axial cross-sectional view of a fuel pump in accordance with the present invention;

[0007] FIG. 2 is an enlarged axial cross-sectional view of a pump section of the fuel pump of FIG. 1;

[0008] FIG. 3 is an axial view of an inlet plate of the pump section of FIG. 2;

[0009] FIG. 4 is an axial view of an outlet plate of the pump section of FIG. 2;

[0010] FIG. 5 is an isometric view of an impeller of the pump section of FIG. 2;

[0011] FIG. 6 is graph showing the pumping efficiency of pumping channels of the fuel pump of FIG. 1 and the overall pumping efficiency of the fuel pump of FIG. 1; and

[0012] FIG. 7 is a graph showing the pumping efficiency of the pumping channels of a non-synchronized fuel pump and the overall pumping efficiency of the non-synchronized fuel pump.

DETAILED DESCRIPTION OF INVENTION

[0013] Reference will be made to FIG. 1 which is an axial cross-sectional view of a fluid pump illustrated as fuel pump 10 for pumping liquid fuel, for example gasoline or diesel fuel, from a fuel tank (not shown) to an internal combustion engine (not shown). While the fluid pump is illustrated as fuel pump 10, it should be understood that the invention is not to be limited to a fuel pump, but could also be applied to fluid pumps for pumping fluids other than fuel. Fuel pump 10 generally includes a pump section 12 at one end, a motor section 14 adjacent to pump section 12, and an outlet section 16 adjacent to motor section 14 at the end of fuel pump 10 opposite pump section 12. A housing 18 of fuel pump 10 retains pump section 12, motor section 14 and outlet section 16 together. Fuel enters fuel pump 10 at pump section 12, a portion of which is rotated by motor section 14 as will be described in more detail later, and is pumped past motor section 14 to outlet section 16 where the fuel exits fuel pump 10.

[0014] Motor section 14 includes electric motor 20 which is disposed within housing 18. Electric motor 20 includes a shaft 22 extending therefrom into pump section 12. Shaft 22 rotates about axis 24 when an electric current is applied to electric motor 20. Electric motors and their operation are well known, consequently, electric motor 20 will not be discussed further herein.

[0015] With continued reference to FIG. 1 and with additional reference to FIGS. 2-5, pump section 12 includes an inlet plate 26, an impeller 28, an outlet plate 30, and a spacer ring 32. Inlet plate 26 is disposed at the end of pump section 12 that is distal from motor section 14 while outlet plate 30 is disposed at the end of pump section 12 that is proximal to motor section 14. Both inlet plate 26 and outlet plate 30 are fixed relative to housing 18 to prevent relative movement between inlet plate 26 and outlet plate 30 with respect to housing 18. Impeller 28 is disposed axially between inlet plate 26 and outlet plate 30 and is fixed to shaft 22 such that impeller 28 rotates with shaft 22 in a one-to-one relationship. Spacer ring 32 is also disposed axially between inlet plate 26 and outlet plate 30, however, spacer ring 32 is fixed relative to housing 18 to prevent relative movement between housing 18 and spacer ring 32. Spacer ring 32 is dimensioned to be

slightly thicker, i.e. the dimension of spacer ring 32 in the direction of axis 24 is slightly greater than the dimension of impeller 28 in the direction of axis 24. In this way, inlet plate 26, outlet plate 30, and spacer ring 32 are fixed within housing 18, for example by crimping the end of housing 18 proximal to outlet plate 30. Axial forces created by the crimping process will be carried by spacer ring 32, thereby preventing impeller 28 from being clamped tightly between inlet plate 26 and outlet plate 30 which would prevent impeller 28 from rotating freely. Spacer ring 32 is also dimensioned to have an inside diameter that is larger than the outside diameter of impeller 28 to allow impeller 28 to rotate freely within spacer ring 32 and axially between inlet plate 26 and outlet plate 30.

[0016] Inlet plate 26 is generally planar and circular in shape, i.e. disk shaped, and includes an inlet 34 that extends through inlet plate 26 in the same direction as axis 24. Inlet 34 is a passage which introduces fuel into fuel pump 10. Inlet plate 26 also includes an inlet plate first flow channel 36 and an inlet plate second flow channel 38 that are both formed in the face of inlet plate 26 that faces toward impeller 28. Inlet plate first flow channel 36 and inlet plate second flow channel 38 are joined together in series by inlet plate transition channel 40. Inlet plate first flow channel 36 is defined by an inner wall 42, an outer wall 44, and a bottom 46 such that inner wall 42 is radially inward of outer wall 44. Inlet plate first flow channel 36 has a width W_{IP1} and a depth D_{IP1} such that outer wall 44 has a radius R_{IP1} with a center at axis 24. Preferably, the ratio of width W_{IP1} to depth D_{IP1} is about 2.5:1. Inlet plate first flow channel 36 has a cross-sectional area A_{IP1} defined by a plane passing through and parallel to axis 24 as viewed in FIG. 2.

[0017] Inlet plate second flow channel 38 is defined by an inner wall 48, an outer wall 50, and a bottom 52. Inlet plate second flow channel 38 has a width W_{IP2} and a depth D_{IP2} such that outer wall 50 has a radius R_{IP2} with a center at axis 24 such that inner wall 48 is radially inward of outer wall 50. Preferably, the ratio of width W_{IP2} to depth D_{IP2} is about 2.5:1. Inlet plate second flow channel 38 has a cross-sectional area A_{IP2} defined by a plane passing through and parallel to axis 24 as viewed in FIG. 2. One end of inlet plate second flow channel 38 is connected to inlet 34 while the other end of inlet plate second flow channel 38 is connected to one end of inlet plate first flow channel 36 via inlet plate transition channel 40. Radius R_{IP2} and width W_{IP2} are sized such that inlet plate second flow channel 38 is radially outward of inlet plate first flow channel 36 to define an inlet plate separation surface 53 radially between outer wall 44 of inlet plate first flow channel 36 and inner wall 48 of inlet plate second flow channel 38.

[0018] Outlet plate 30 is generally planar and circular in shape, i.e. disk shaped, and includes an outlet plate outlet passage 54 that extends through outlet plate 30 in the same direction as axis 24. Outlet plate outlet passage 54 is in fluid communication with outlet section 16 as will be describe in more detail later. Outlet plate 30 also includes an outlet plate first flow channel 56 and an outlet plate second flow channel 58 that are both formed in the face of outlet plate 30 that faces toward impeller 28. Outlet plate first flow channel 56 and outlet plate second flow channel 58 are joined together in series by outlet plate transition channel 60. Outlet plate first flow channel 56 is defined by an inner wall 62, an outer wall 64, and a bottom 66 such that inner wall 62 is radially inward of outer wall 64. Outlet plate first flow channel 56 has a width W_{OP1} and a depth D_{OP1} such that outer wall 64 has a radius R_{OP1} with a center at axis 24. Preferably, the ratio of width

W_{OP1} to depth D_{OP1} is about 2.5:1. Outlet plate first flow channel 56 has a cross-sectional area A_{OP1} defined by a plane passing through and parallel to axis 24 as viewed in FIG. 2. One end of outlet plate first flow channel 56 is connected to outlet plate outlet passage 54 while the other end of outlet plate first flow channel 56 is connected to one end of outlet plate second flow channel 58 via outlet plate transition channel 60.

[0019] Outlet plate second flow channel 58 is defined by an inner wall 68, an outer wall 70, and a bottom 72 such that inner wall 68 is radially inward of outer wall 70. Outlet plate second flow channel 58 has a width W_{OP2} and a depth D_{OP2} such that outer wall 70 has a radius R_{OP2} with a center at axis 24. Preferably, the ratio of width W_{OP2} to depth D_{OP2} is about 2.5:1. Outlet plate second flow channel 58 has a cross-sectional area A_{OP2} defined by a plane passing through and parallel to axis 24 as viewed in FIG. 2. Radius R_{OP2} and width W_{OP2} are sized such that outlet plate second flow channel 58 is radially outward of outlet plate first flow channel 56 to define an outlet plate separation surface 73 radially between outer wall 64 of outlet plate first flow channel 56 and inner wall 68 of outlet plate second flow channel 58.

[0020] Impeller 28 includes a first plurality of blades 76 arranged in a polar array radially surrounding and centered about axis 24 such that blades 76 are aligned with inlet plate first flow channel 36 and outlet plate first flow channel 56. Blades 76 are each separated from each other by a first blade chamber 78 that passes through impeller 28 in the general direction of axis 24. Impeller 28 also includes a second plurality of blades 80 arranged in a polar array radially surrounding and centered about axis 24 and first array of blades 76 such that blades 80 are aligned with inlet plate second flow channel 38 and outlet plate second flow channel 58. Blades 80 are each separated from each other by a second blade chamber 82 that passes through impeller 28 in the general direction of axis 24. The first plurality of blades 76 are radially separated from the second plurality of blades 80 by a blade separation wall 84 that is located radially between the first plurality of blades 76 and the second plurality of blades 80. Impeller 28 may be made, for example only, by a plastic injection molding process in which the preceding features of impeller 28 are integrally molded as a single piece of plastic.

[0021] Outlet section 16 includes outlet 86 for discharging fuel from fuel pump 10. Outlet 86 may be connected to, for example, a conduit (not shown) for supplying fuel to an internal combustion engine (not shown). Outlet 86 is in fluid communication with outlet plate outlet passage 54 of outlet plate 30 for receiving fuel that has been pumped by pump section 12.

[0022] In operation, inlet 34 is exposed to a volume of fuel (not shown) which is to be pumped to, for example, an internal combustion engine (not shown). An electric current is supplied to electric motor 20 in order to rotate shaft 22 and impeller 28. As impeller 28 rotates, fuel is drawn through inlet 34 into inlet plate first flow channel 36, inlet plate second flow channel 38, and inlet plate transition channel 40. First blade chambers 78 and second blade chambers 82 allow fuel from inlet plate first flow channel 36, inlet plate second flow channel 38, and inlet plate transition channel 40 to flow to outlet plate first flow channel 56, outlet plate second flow channel 58, and outlet plate transition channel 60. Impeller 28 subsequently discharges the fuel through outlet plate outlet passage 54 and consequently through outlet 86.

[0023] In order to improve the pumping efficiency of fuel pump 10, inlet plate first flow channel 36 is synchronized with inlet plate second flow channel 38, i.e. area A_{IP1} is synchronized with area A_{IP2} , to provide maximum or near maximum pumping efficiency of inlet plate first flow channel 36 and inlet plate second flow channel 38 for a desired rate of rotation of impeller 28. Similarly, outlet plate first flow channel 56 is synchronized with outlet plate second flow channel 58, i.e. area A_{OP1} is synchronized with area A_{OP2} , to provide maximum or near maximum efficiency of outlet plate first flow channel 56 and outlet plate second flow channel 58 at the desired rate of rotation of impeller 28. As related to inlet plate first flow channel 36, inlet plate second flow channel 38, outlet plate first flow channel 56 and outlet plate second flow channel 58, the term “synchronized” signifies that the geometry of inlet plate first flow channel 36 and the geometry of inlet plate second flow channel 38 have been given consideration relative to each other in order to provide maximum or near maximum pumping efficiency at a common rotational rate of impeller 28 and that the geometry of outlet plate first flow channel 56 and the geometry of outlet plate second flow channel 58 have been given consideration relative to each other in order to provide maximum or near maximum pumping efficiency at a common rotational rate of impeller 28. In the paragraphs that follow, the synchronization will be described in further detail.

[0024] Let us assume that fuel pump 10 is to have a maximum efficiency at a rotational rate of impeller 28 of ω radians per second while delivering a volumetric flow rate Q m³/s at pressure P pascals. The non-dimensional pressure ψ and non-dimensional flow ϕ follow the characteristic equation $\psi=f(\phi)$ where f is a known function. Maximum pumping efficiency of fuel pump 10 occurs at $\phi=\phi_0=0.7$. At this point, $\psi=\psi_0=f(\phi_0)$ where ψ may be obtained from empirical data.

[0025] In the following equations, let P_1 be the pressure generated by inlet plate first flow channel 36 and outlet plate first flow channel 56, let P_2 be the pressure generated by inlet plate second flow channel 38 and outlet plate second flow channel 58, let R_1 be equal to R_{IP1} and R_{OP1} , let R_2 be equal to R_{IP2} and R_{OP2} , and let ρ be the fluid density in kg/m³ of the fuel being pumped.

$$\psi_0 = \frac{P_1}{\rho \cdot \omega^2 \cdot R_1^2} \quad \text{equation 1}$$

$$\psi_0 = \frac{P_2}{\rho \cdot \omega^2 \cdot R_2^2} \quad \text{equation 2}$$

[0026] The total pressure P generated by the fuel pump 10 equals the sum of pressures generated by inlet plate first flow channel 36 and outlet plate first flow channel 56, inlet plate second flow channel 38, and outlet plate second flow channel 58 as indicated by the following equation:

$$P=P_1+P_2 \quad \text{equation 3}$$

[0027] It may be desirable to minimize leakage between inlet plate first flow channel 36 and inlet plate second flow channel 38 and between outlet plate first flow channel 56 and outlet plate second flow channel 58. In order to minimize this leakage, a separation ϵ , for example about 0.006 m, is provided between inlet plate first flow channel 36 and inlet plate second flow channel 38 and between outlet plate first flow channel 56 and outlet plate second flow channel 58 such that

ϵ is equal to the radial dimension of inlet plate separation surface 53 plus W_{IP2} and also equal to the radial dimension of outlet plate separation surface 73 plus W_{OP2} . Consequently, inlet plate second flow channel 38 is related to inlet plate first flow channel 36 as shown by equation 4 below. Similarly, outlet plate second flow channel 58 is related to outlet plate first flow channel 56 as shown by equation 4.

$$R_2=R_1+\epsilon \quad \text{equation 4}$$

[0028] The four equations; equation 1, equation 2, equation 3, and equation 4; can now be solved for the four unknowns: P_1 , P_2 , R_1 , R_2 . Having determined R_1 and R_2 , the cross section areas A_{IP1} , A_{IP2} , A_{OP1} , and A_{OP2} can be determined from the following equations where $A_{IP1}=A_{OP1}$, $A_1=A_{IP1}+A_{OP1}$, $A_{IP2}=A_{OP2}$, and $A_2=A_{IP2}+A_{OP2}$:

$$\psi_0 = \frac{Q}{\omega \cdot R_1 \cdot A_1} \quad \text{which can be rearranged as } A_1 = \frac{Q}{\omega \cdot R_1 \cdot \psi_0} \quad \text{equation 5}$$

$$\psi_0 = \frac{Q}{\omega \cdot R_2 \cdot A_2} \quad \text{which can be rearranged as } A_2 = \frac{Q}{\omega \cdot R_2 \cdot \psi_0} \quad \text{equation 6}$$

[0029] By using equations 5 and 6, the cross section areas A_{IP1} , A_{IP2} , A_{OP1} , and A_{OP2} can be determined such that inlet plate first flow channel 36 and inlet plate second flow channel 38 are synchronized with each other and such that outlet plate first flow channel 56 and outlet plate second flow channel 58 are synchronized with each other. In this way, the pumping efficiency of inlet plate first flow channel 36, inlet plate second flow channel 38, outlet plate first flow channel 56, and outlet plate second flow channel 58 are all substantially the same. Consequently, the overall pumping efficiency of fuel pump 10 is the same as each of inlet plate first flow channel 36, inlet plate second flow channel 38, outlet plate first flow channel 56, and outlet plate second flow channel 58. This synchronization is illustrated in FIG. 6 which is a plot of the pumping efficiency of each of inlet plate first flow channel 36, inlet plate second flow channel 38, outlet plate first flow channel 56, and outlet plate second flow channel 58 as well as the overall pumping efficiency of fuel pump 10. Trace 100 is shown which represents the pumping efficiency of each of inlet plate first flow channel 36, inlet plate second flow channel 38, outlet plate first flow channel 56, and outlet plate second flow channel 58 as well as the overall pumping efficiency of fuel pump 10. Since inlet plate first flow channel 36 is synchronized with inlet plate second flow channel 38 and outlet plate first flow channel 56 is synchronized with outlet plate second flow channel 58, the pumping efficiency of each of inlet plate first flow channel 36, inlet plate second flow channel 38, outlet plate first flow channel 56, and outlet plate second flow channel 58, and consequently, the overall pumping efficiency of fuel pump 10 is represented by a single trace in FIG. 6, that is, trace 100. As can be seen, the maximum pumping efficiency of each of inlet plate first flow channel 36, inlet plate second flow channel 38, outlet plate first flow channel 56, and outlet plate second flow channel 58 as well as the overall pumping efficiency of fuel pump 10 occurs at a rotational rate of about 5000 RPM of impeller 28. Also as can be seen, the maximum pumping efficiency is about 50%.

[0030] In contrast to FIG. 6 which represents the pumping efficiency of a fuel pump 10 having multiple flow channels 36, 38, 56, 58 which are synchronized, FIG. 7 represents the pumping efficiency of a fuel pump (not shown) with multiple

flow channels that are not synchronized. FIG. 7 includes traces **102**, **104**, and **106** which correspond to the pumping efficiency of first flow channels in the inlet and outlet plates of the fuel pump, the pumping efficiency of second flow channels in the inlet and outlet plates of the fuel pump, and the overall pumping efficiency of the fuel pump respectively. As can be seen, the maximum pumping efficiency of the first flow channels in the inlet and outlet plates is about 50% which occurs at about 6000 RPM while the maximum pumping efficiency of the second flow channels in the inlet and outlet plates is also about 50%, but occurs at about 4000 RPM. This results in a maximum overall pumping efficiency of only about 40% occurring at about 5000 RPM. Consequently, the overall pumping efficiency of a multi-channel fuel pump that is not synchronized is less than the overall pumping efficiency of a multi-channel fuel pump that is synchronized. It should be stressed that FIGS. 6 and 7 are provided for example only and greater pumping efficiencies may be realized and that maximum pumping efficiency may be realized at rotational rates of the impeller that differ from that shown in FIGS. 6 and 7.

[0031] While fuel pump **10** has been shown having impeller **28** with first and second arrays of blades **76**, **80**, it should now be understood that fuel pump **10** may have an impeller with a greater number of arrays of blades, such that in general, there are N arrays of blades where $N \geq 2$. It should also be understood that the inlet plate and the outlet plate will each have flow channels that correspond to the number of arrays of blades in the impeller and that the flow channels of the inlet plate will be synchronized with each other and the flow channels of the outlet plate will be synchronized with each other. In this arrangement, the flow channels are synchronized by determining the cross-sectional area of each pair of flow channels corresponding to one array of blades of the impeller, e.g. the cross sectional area of the flow channels of the inlet and outlet plates corresponding to the first array of blades of the impeller, from the following equation which is similar to equations 5 and 6 above where n is the number representing the flow channel as counted from the inside moving radially outward:

$$A_n = \frac{Q}{\omega \cdot R_n \cdot \phi_0}, \quad \text{equation 7}$$

n is an integer from 1 to N

[0032] In equation 7, N is the number of arrays of blades of the impeller, and consequently, the number of flow channels in each of the inlet plate and the outlet plate, i.e. the inlet plate has N flow channels and the outlet plate has N flow channels.

[0033] Equations 1-4 can also be expressed generically in order to determine R_n used in equation 7 above. The equations expressed generically are as follows:

$$\psi_0 = \frac{P_n}{\rho \cdot \omega^2 \cdot R_n^2}, \quad \text{equation 8}$$

n is an integer from 1 to N

$$P = \sum P_n, \quad \text{equation 9}$$

n is an integer from 1 to N

$$R_{n+1} = R_n + \varepsilon, \quad \text{equation 10}$$

n is an integer from 1 to N - 1

[0034] While fuel pump **10** has been described as having flow channels in both inlet plate **26** and outlet plate **30**, it

should now be understood that the equations set forth herein are equally applicable to fluid pumps that have multiple flow channels in only one plate. Consequently, in such a fluid pump having multiple flow channels in only one plate, A_n in equation 7 will determine the area of each n^{th} flow channel in the plate having multiple flow channels.

[0035] While this invention has been described in terms of preferred embodiments thereof, it is not intended to be so limited.

We claim:

1. A fluid pump comprising:

an outlet for discharging fluid from said fluid pump;

a housing;

a motor with a shaft that rotates about an axis;

an impeller having a first array of blades radially surrounding said axis and a second array of blades radially surrounding said first array of blades, said impeller being rotatable by said shaft of said motor;

an inlet plate adjacent to said impeller and having an inlet for introducing fluid into said fluid pump, a first inlet plate flow channel aligned with said first array of blades and having a first inlet plate flow channel cross-sectional area, and a second inlet plate flow channel aligned with said second array of blades and having a second inlet plate flow channel cross-sectional area;

wherein rotation of said impeller pumps fluid from said inlet to said outlet; and

wherein said second inlet plate flow channel cross-sectional area is synchronized with said first inlet plate flow channel cross-sectional area.

2. A fluid pump as in claim 1 wherein said first inlet plate flow channel cross-sectional area and said second inlet plate flow channel cross-sectional area are synchronized according to the equation:

$$A_n = \frac{Q}{\omega \cdot R_n \cdot \phi_0}$$

where Q is the volumetric flow rate of said fluid pump, ω is the rotational rate of said impeller, R_n is the radius of said first inlet plate flow channel or said second inlet plate flow channel where n signifies the number of the inlet plate flow channel, and ϕ_0 is the non-dimensional flow of said fluid pump.

3. A fluid pump as in claim 2 wherein ϕ_0 is about 0.7.

4. A fluid pump as in claim 2 wherein ϕ_0 is the non-dimensional flow of said fluid pump at maximum efficiency.

5. A fluid pump as in claim 2 wherein R_n is determined from the equations:

$$\psi_0 = \frac{P_1}{\rho \cdot \omega^2 \cdot R_1^2}$$

$$\psi_0 = \frac{P_2}{\rho \cdot \omega^2 \cdot R_2^2}$$

$$P = P_1 + P_2$$

$$R_2 = R_1 + \varepsilon$$

where P is the total pressure generated by said fuel pump, P_1 is the pressure generated by said first inlet plate flow

channel, P_2 is the pressure generated by said second inlet plate second flow channel, and ϵ is the radial separation between R_1 and R_2 .

6. A fluid pump as in claim 1 wherein an inlet plate transition channel fluidly connects said first inlet plate flow channel with said second inlet plate flow channel.

7. A fluid pump as in claim 6 wherein said inlet plate transition channel fluidly connects said first inlet plate flow channel with said second inlet plate flow channel in series.

8. A fluid pump as in claim 1 further comprising:

an outlet plate adjacent to said impeller on the side said impeller that is opposite said inlet plate, said outlet plate having an outlet passage in fluid communication with said outlet; a first outlet plate flow channel aligned with said first array of blades and having a first outlet plate flow channel cross-sectional area; and a second outlet plate flow channel aligned with said second array of blades and having a second outlet plate flow channel cross-sectional area;

wherein said second outlet plate flow channel cross-sectional area is synchronized with said first outlet plate flow channel cross-sectional area.

9. A fluid pump as in claim 8 wherein the combined cross-sectional area of said first inlet plate flow channel cross-sectional area and said first outlet plate flow channel cross-sectional area and the combined cross-sectional area of said second inlet plate flow channel cross-sectional area and said second outlet plate flow channel cross-sectional area are synchronized.

10. A fluid pump as in claim 9 wherein the combined cross-sectional area of said first inlet plate flow channel cross-sectional area and said first outlet plate flow channel cross-sectional area and the combined cross-sectional area of said second inlet plate flow channel cross-sectional area and said second outlet plate flow channel cross-sectional area are synchronized according to the equation:

$$A_n = \frac{Q}{\omega \cdot R_n \cdot \phi_0}$$

where Q is the volumetric flow rate of said fluid pump, ω is the rotational rate of said impeller, R_n is the radius of said first inlet plate flow channel and said first outlet plate flow channel or said second inlet plate flow channel and said second outlet plate flow channel where n signifies the number of the outlet plate flow channel, and ϕ_0 is the non-dimensional flow of said fluid pump.

11. A fluid pump as in claim 10 wherein R_n is determined from the equations:

$$\psi_0 = \frac{P_1}{\rho \cdot \omega^2 \cdot R_1^2}$$

$$\psi_0 = \frac{P_2}{\rho \cdot \omega^2 \cdot R_2^2}$$

$$P = P_1 + P_2$$

$$R_2 = R_1 + \epsilon$$

where P is the total pressure generated by said fuel pump, P_1 is the pressure generated by said first inlet plate flow channel together with said first outlet plate flow channel, P_2 is the pressure generated by said second inlet plate

flow channel together with said second outlet plate flow channel, and ϵ is the radial separation between R_1 and R_2 .

12. A fluid pump as in claim 8 wherein the ratio of the width to the depth of first inlet plate flow channel is about 2.5:1, the ratio of the width to the depth of second inlet plate flow channel is about 2.5:1, the ratio of the width to the depth of first outlet plate flow channel is about 2.5:1, and the ratio of the width to the depth of second outlet plate flow channel is about 2.5:1.

13. A fluid pump comprising:

an outlet for discharging fluid from said fluid pump;

a housing;

a motor with a shaft that rotates about an axis;

an impeller having N arrays of blades such that $N \geq 2$ wherein each array of blades radially surrounds said axis, and wherein each one of said arrays of blades are spaced radially from every other of said arrays of blades, said impeller being rotatable by said shaft of said motor;

an inlet plate adjacent to said impeller and having an inlet for introducing fluid into said fluid pump, a plurality of inlet plate flow channels such that each one of said plurality of inlet plate flow channels is aligned with one of said arrays of blades and such that each of said arrays of blades are aligned with one of said inlet plate flow channels, wherein each of said inlet plate flow channels has a corresponding inlet plate flow channel cross-sectional area;

wherein rotation of said impeller pumps fluid from said inlet to said outlet; and

wherein said inlet plate flow channel cross-sectional area of each of said inlet plate flow channels is synchronized with said inlet plate flow channel cross-sectional area of every other of said inlet plate flow channels.

14. A fluid pump as in claim 13 wherein said first inlet plate flow channel cross-sectional area and said second inlet plate flow channel cross-sectional area are synchronized according to the equation:

$$A_n = \frac{Q}{\omega \cdot R_n \cdot \phi_0},$$

n is an integer from 1 to N

where Q is the volumetric flow rate of said fluid pump, ω is the rotational rate of said impeller, R_n is the radius of the n^{th} inlet plate flow channel, and ϕ_0 is the non-dimensional flow of said fluid pump.

15. A fluid pump as in claim 14 wherein ϕ_0 is about 0.7.

16. A fluid pump as in claim 14 wherein ϕ_0 is the non-dimensional flow of said fluid pump at maximum efficiency.

17. A fluid pump as in claim 14 wherein R_n is determined from the equations:

$$\psi_0 = \frac{P_n}{\rho \cdot \omega^2 \cdot R_n^2},$$

n is an integer from 1 to N

$$P = \sum P_n, n \text{ is an integer from 1 to } N$$

$$R_{n+1} = R_n + \epsilon, n \text{ is an integer from 1 to } N-1$$

where P is the total pressure generated by said fuel pump, P_n is the pressure generated by the n^{th} flow channel, and ϵ is the radial separation between adjacent said inlet plate flow channels.

18. A fluid pump as in claim **13** further comprising:

an outlet plate adjacent to said impeller on the side said impeller that is opposite said inlet plate, said outlet plate having an outlet passage in fluid communication with said outlet; a plurality of outlet plate flow channels such that each one of said plurality of outlet plate flow channels is aligned with one of said arrays of blades and such that each of said arrays of blades are aligned with one of said outlet plate flow channels, wherein each of said outlet plate flow channels has a corresponding outlet plate flow channel cross-sectional area;

wherein said outlet plate flow channel cross-sectional area of each of said outlet plate flow channels is synchronized with said outlet plate flow channel cross-sectional area of every other of said outlet plate flow channels.

19. A fluid pump as in claim **18** wherein the combined cross-sectional area of each n^{th} inlet plate flow channel cross-sectional area and each corresponding n^{th} outlet plate flow channel cross-section area and the combined cross-sectional area of every other n^{th} inlet plate flow channel cross-sectional area and every other corresponding n^{th} outlet plate flow channel cross-sectional area are synchronized.

20. A fluid pump as in claim **19** wherein the combined cross-sectional area of each n^{th} inlet plate flow channel cross-sectional area and each corresponding n^{th} outlet plate flow channel cross-section area and the combined cross-sectional area of every other n^{th} inlet plate flow channel cross-sectional area and every other corresponding n^{th} outlet plate flow channel cross-sectional area are synchronized according to the equation:

$$A_n = \frac{Q}{\omega \cdot R_n \cdot \phi_0},$$

n is an integer from 1 to N

where Q is the volumetric flow rate of said fluid pump, ω is the rotational rate of said impeller, R_n is the radius of the n^{th} inlet plate flow channel and n^{th} outlet plate flow channel, and ϕ_0 is the non-dimensional flow of said fluid pump.

21. A fluid pump as in claim **20** wherein R_n is determined from the equations:

$$\psi_0 = \frac{P_n}{\rho \cdot \omega^2 \cdot R_n^2},$$

n is an integer from 1 to N

$$P = \sum P_n, \quad n \text{ is an integer from 1 to } N$$

$$R_{n+1} = R_n + \epsilon, \quad n \text{ is an integer from 1 to } N-1$$

where P is the total pressure generated by said fuel pump, P_n is the pressure generated by the n^{th} flow channel, and ϵ is the radial separation between adjacent said inlet plate flow channels or between adjacent said outlet plate flow channels.

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