(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 561 494 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **93300805.4**

(51) Int. Cl.[5]: **F04C 2/107**

(22) Date of filing: **03.02.93**

(30) Priority: **17.02.92 ZA 921133**

(43) Date of publication of application:
**22.09.93 Bulletin 93/38**

(84) Designated Contracting States:
**AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL PT SE**

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(54) **Moineau-type pump.**

(57) A positive displacement pump 10 includes a pressure chamber 62 having a pumping outlet 79 connected to a delivery conduit 58. The pump 10 includes a bypass outlet 64 connected to the pressure chamber and a valve 70 in the bypass outlet. The valve 70 is open when the pump is not operative and closes automatically when a predetermined pumping volume is attained. The pump may advantageously be a submersible progressive cavity pump, the delivery conduit being a rising main having a foot valve 80 associated therewith. The bypass outlet is in communication with a body of fluid external of the rising main, eg with a borehole. Initially, during start-up, delivery of the pump is directed via the bypass outlet against a low head or substantially no head. Only after start-up, is the delivery directed via the pumping outlet 79, into the delivery conduit at a head prevailing in the rising main 58.

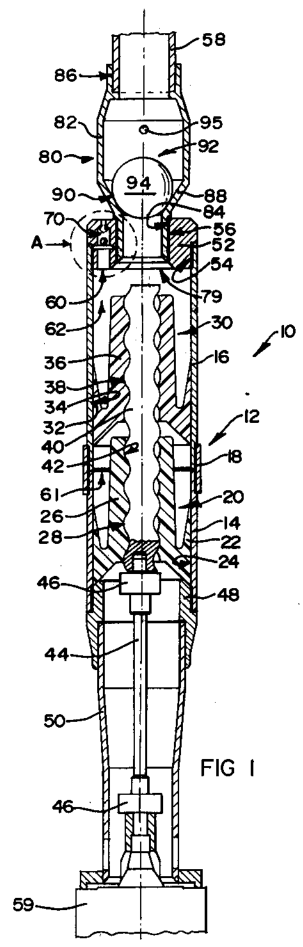

FIG I

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THIS INVENTION relates to a positive displacement pump, to a method of operation thereof, to a start-up accessory for a positive displacement pump and to a pumping installation.

The Applicant is of opinion that the invention will find particular application in the field of progressive cavity pumps such as positive displacement helical gear rotary pumps, and that application will predominantly be borne in mind for purposes of this specification. The invention is, however, not limited to that application.

The Applicant is further of opinion that this invention will find application primarily in start-up of a positive displacement pump, especially a progressive cavity pump, against a head.

Even further, the Applicant believes that the application will advantageously be applicable to borehole pumping installations, and other similar pumping installations, especially when using submersible motor-pump units. A borehole pumping installation with a submersible motor-pump unit will specifically be dealt with in this specification, but the invention is not limited to such an installation.

In accordance with a first aspect of the invention, there is provided a method of operating a positive displacement pump arranged to deliver a fluid from a pressure chamber of the pump via a pumping outlet into a delivery conduit against a relatively high head, the method including directing delivery of the pump, initially, during start-up, via a bypass outlet against a relatively low head or substantially no head, and only after start-up has occurred re-directing the delivery via said pumping outlet into the delivery conduit at said relatively high head.

The method may include, when no flow is taking place, automatically communicating said bypass outlet with the pressure chamber of the pump, and, when flow has reached a predetermined volume or velocity, automatically closing the bypass outlet. This may be effected by means of a valve which is arranged in the bypass outlet and which is normally open, e.g. by providing a valve element or closure which is biassed to an open condition and which is arranged to be swept against its seat to a closed condition when such predetermined volume or velocity is attained.

The method may further include automatically preventing return flow from taking place from the delivery conduit into the pressure chamber when pumping is not taking place by means of a non-return valve intermediate the pressure chamber and the delivery conduit.

Advantageously, the method may be applied to a positive displacement pump forming part of a pumping installation, especially a borehole pumping installation, in which water or other fluid is pumped into a rising main, the method including exhausting flow through the bypass outlet into a body of water from which pumping takes place, e.g. the borehole, external of the rising main.

In accordance with a further aspect of the invention, there is provided a positive displacement pump including a pressure chamber having a pumping outlet which is connectable to a delivery conduit, the pump including a bypass outlet in communication with the pressure chamber and a valve in the bypass outlet arranged to be open when the pump is not operative and to close automatically when a predetermined pumping volume or velocity is attained in use.

In an advantageous embodiment, the bypass outlet may be arranged to be upwardly directed in use, the valve having a downwardly directed seat and a valve element or closure which is biassed downwardly under gravity, and which is arranged to be swept upwardly against gravity onto the seat when said flow of predetermined volume or velocity occurs.

The invention may advantageously be applied to a positive displacement pump which is in the form of a submersible progressive cavity pump, e.g. a borehole pump, the pump having connection means for connection to a rising main and a foot valve associated with or proximate said connection means, and the bypass outlet being arranged to be in communicating with a body of fluid, e.g. the borehole, external of the rising main in use.

In accordance with yet a further aspect, there is provided a start-up accessory for a positive displacement pump, the accessory comprising means for mounting it in communication with a pressure chamber of the pump, a bypass outlet arranged in relation to said mounting means to be communicated with a pressure chamber of the pump in use and a valve in the bypass outlet which valve is arranged to be open when the pump is not operative and to close automatically when a predetermined pumping volume or velocity is attained in use.

In accordance with another aspect of the invention there is provided a pumping installation comprising

a positive displacement pump submerged in a body of fluid to be pumped and including a pressure chamber having a pumping outlet;

a rising main communicated with the pressure chamber via the pumping outlet,

the pump having a bypass outlet communicated with the pressure chamber and a valve in the bypass outlet which valve is arranged to be open when the pump is not operative and to close automatically when a predetermined pumping volume or velocity is attained in operation.

The pumping installation may be a borehole pumping installation.

The pump may have a foot valve associated with the pumping outlet.

The positive displacement pump may be in the form of a progressive cavity pump.

The invention is now described by way of example with reference to the accompanying diagrammatic drawings. In the drawings:

Figure 1 shows, in axial section, a positive displacement pump of the progressive cavity kind suitable for use, in vertical attitude, as shown submerged in a borehole;

Figure 2 shows a detail marked A in Figure 1 to a larger scale; and

Figure 3 shows, in axial section, to an enlarged scale, a flexible coupling of the pump of Figure 1.

With reference to the drawing, a pump in accordance with the invention is generally indicated by reference numeral 10. It is a positive displacement pump of the progressive cavity kind and is suitable for use submerged in a borehole. It is also suitable for use submerged in a body of another kind of fluid to be pumped. For convenience, pumping water from a borehole is described by way of example.

The pump 10 comprises an outer cylindrical casing 12 including a lower section 14, an upper section 16 and a socket 18 interconnecting the lower and upper sections 14, 16.

In the lower section 14, there is provided a lower stator 20 comprising an outer barrel 22 having an outer periphery 24 which is moulded within the lower section 14. It further comprises a sleeve 26 arranged integrally with the barrel 22, canti-lever fashion. The sleeve 26 has an inner periphery 28 defining a female helical groove with a predetermined number of starts.

Similarly, the pump 10 comprises an upper stator 30 which is of similar construction to the lower stator 20 and like reference numerals refer to like components.

The lower and upper stators 20, 30 are provided in register in series. It is to be appreciated that the lower and upper stators 20, 30 are moulded of a resilient synthetic plastics material.

Within the registered inner peripheries 28, 38 of the stators 20, 30, there is provided a complemental rotor 40 having an outer periphery 42 formed of a male helical formation having a predetermined number of starts which number is either one more or one fewer than the number of starts of the stators. The rotor, in this embodiment, is of corrosion resistant metal e.g. stainless steel.

The pump 10 is driven from a submersible motor 59 via a driving rod 44. The driving rod 44 is flexibly connected to respectively the motor 59 and the rotor 40 by means of flexible couplings 46.

The pump 10 further comprises a stator adaptor intake 48 screwed to a lower end of the cylindrical casing 12 and having female screw threaded connecting means 50 for connection to the motor 59 and a strainer or the like to prevent ingress of particulate material.

Toward a top of the pump 10, there is provided a stator adaptor top 52 connected as shown at 54 to a top of the cylindrical casing 12 and having a female screw threaded connecting means 56 mounting a non-return valve arrangement 80. The non-return valve arrangement 80, in turn, mounts the rising main 58 as shown at 86. A pumping outlet 79 is provided from the pressure chamber 62 via the valve arrangement 80 into the rising main 58. The non-return valve arrangement 80 comprises a casing 82 defining, immediately above male connection means 84 engaged with the female connection means 56, a divergence 88 and above that a cavity 92 within which a spherical closure 94 is provided. A concave seat 90 is defined by the divergence 88. When pumping is not in operation, the spherical valve element or closure 94 is biassed under gravity onto the seat 90 and it acts as a foot valve for water in the rising main 58, in conventional fashion. A transverse pin 95 is provided through the cavity 92 to limit upward displacement of the valve element or closure 94 in use. The pump 10 further has starting means 60 provided in the stator adaptor top 52 and which will be described hereinafter.

Operation of the pump 10, as if it was a conventional pump not comprising the starting means 60, will now be described.

It is to be appreciated that the pump 10 is submerged in water in the borehole and that the cavities intermediate the rotor 40 and the stators 20, 30, as well as an intermediate pressure chamber 61 intermediate the lower stator 20 and the upper stator 30, as well as a pressure chamber 62 above the stator 30 will be flooded with water. It is to be appreciated that the non-return valve 80 maintains a column of water in the rising main 58. Thus, when the pump is restarted, water is immediately pumped into the pressure chamber 62 and thence into the rising main 58 when sufficient pressure has been generated to open the non-return valve 80. Thus, virtually immediately during start-up, the pump 10 in general and more specifically the interfaces between the outer periphery 42 of the rotor 40 and the inner peripheries 28, 38 of the stators 20, 30 are under full pressure. Thus, initially, the relative speed of the components across the interfaces mentioned above is too low to generate a lubrication film of water in the interface, or is too low to maintain such a lubrication film where it may be formed. Thus, at least a certain amount of binding between the rotor 40 and the stators 20, 30 takes place. Only when the normal operating rotation speed of the rotor is approached are the basic seal lines in said interfaces allowed to attain a suitable velocity so that the lubricating film is maintained in those interfaces.

Thus, because the pump 10 is started against a head, high torque loads are imposed on the drive motor of the pump. This is detrimental to the pump motor and a start-up period of short duration cannot be attained. Thus, binding between the rotor and the stators is aggravated or prolonged which is detrimental to the pump. The drive motor may not even be capable of delivering the required torque, and the pump may stall.

Furthermore, advantageously, the driving rod 44 has flexible couplings 46 as illustrated in Figure 3. Each coupling 46 has, at opposed ends, metal attachment formations 46.1, 46.2 for attachment to respectively the driving rod 44 and either the drive shaft of the motor 59 or the rotor 40. Integral with each attachment formation 46.1, 46.2, there is provided an anchor disc 46.3. The anchor discs 46.3 are moulded into a body 46.4 in the form of a moulding of an appropriate flexible synthetic plastics material.

In this regard it is to be appreciated that the rotor 40 orbits about a centre line through the casing 12, ie it does not rotate on axis. Thus, the flexible couplings 46 allow flexing respectively between the motor 59 and the drive shaft 44, and between the drive shaft 44 and the rotor 40. This is conducive to smooth operation of the pump and ameliorates wear of the rotor 40 and also of the motor bearings.

However, to be effective the couplings should be designed for a torque as close as possible to the actual operating torque, and then the maximum torque which they can be subjected to is only a limited amount higher than the design torque. Thus, frequently, even generally, the maximum torque (ie the starting torque) is the limiting factor, and the flexible couplings have to be designed to be able to withstand the maximum torque. This results in flexible couplings being much more stiff than what is required for the actual operating torque and prevents full use being made of the advantage of the flexible couplings as described above.

In accordance with the invention, the starting means 60 is provided which includes a bypass conduit 64 having an inlet 66 in the pressure chamber 62 and an exhaust 68 in the borehole external of the rising main 58. In the bypass conduit 64, there is provided a valve generally indicated by reference numeral 70 and comprising a downwardly directed concave seat 72 proximate the exhaust 68, and a spherical valve element or closure 74 complemental to the concave seat 72 and movable between an open condition (shown in solid) in which it is spaced from the concave seat 72, and a closed condition (shown in dotted) in which it seats on the concave seat 72. The spherical valve element or closure 74 is retained within the conduit 64 by means of a transverse retaining pin 76. The valve element or closure 74 is received in the bypass conduit with clearance to allow passage of water when in its open condition.

In other embodiments, other types of valves such as poppet-type valves may be used, valve elements of shapes other than spherical may be used, retention within the conduit may be by means of retention means other than a pin, and the like.

Operation of the pump 10 in accordance with the invention i.e. involving the starting means 60, is now described.

The valve 70 is normally closed. Prior to start-up, the spherical valve element or closure 74 is biassed under gravity away from the concave seat 72 and lies against the retaining pin 76. Thus, the pressure chamber 62 is in communication with the water in the borehole and the pressure in the pressure chamber which is equivalent to the head against which pumping will commence is commensurate with the level of water in the borehole above the pump rather than the normal operating head in the rising main 58. The pressure or head is thus relatively low.

Thus, initially when start-up occurs, the water being pumped will follow the route of least resistance and will thus predominantly be pumped through the starting means 60. When the volume of water being pumped attains a specific value i.e. the velocity in the bypass conduit 64 attains a specific value, the spherical valve element or closure 74 is swept by means of the flowstream of water against the concave seat 72 and it closes off the bypass conduit 64. Thus, pressure in the pressure chamber 62 increases immediately thus generating a pressure gradient over the bypass conduit 64 and the exhaust 68 which pressure gradient is sufficient to maintain the spherical valve element or closure 74 in its closed condition against the concave seat 72. Furthermore, sufficient pressure is virtually immediately generated to open the non-return valve 80, and water being pumped is then pumped into the rising main 58 and operation of the pump 10 continues in conventional fashion.

It is to be appreciated that, during start-up, the head against which water is delivered is substantially reduced in comparison to conventional pumping. Thus, the starting torque required from the drive motor is reduced which is beneficial to the motor. Furthermore, start-up can occur in a shorter period of time and the basic seal lines to attain a suitable velocity to provide a lubricating film in the interfaces described above are established in a shorter period of time which is beneficial to the pump. Because the starting torque required from the drive motor is much reduced, stalling of the pump is substantially eliminated. Furthermore, the maximum torque-requirement imposed on the flexible couplings 46 is alleviated, thus allowing more flexible couplings to be used and thus enhancing the advantages of the flexible couplings.

It is thus an important advantage that the motor-pump combination is started against a low head (i.e. a low load) which has the advantages mentioned above, and that full load is only experienced after start-up when operating speed has been reached or has nearly been reached when the motor-pump combination is well suited to deliver the torque required by the load.

## Claims

**1.** A method of operating a positive displacement pump (10) arranged to deliver a fluid from a pressure chamber (62) of the pump via a pumping outlet (79) into a delivery conduit (58) against a relatively high head, characterised in that the method includes directing delivery of the pump, initially, during start-up, via a bypass outlet (64) against a relatively low head or substantially no head, and only after start-up has occurred re-directing the delivery via said pumping outlet into the delivery conduit at said relatively high head.

**2.** A method as claimed in Claim 1, characterised in that the method includes automatically communicating said bypass outlet with the pressure chamber of the pump when no flow is taking place, and automatically closing the bypass outlet when flow has reached a predetermined volume or velocity.

**3.** A method as claimed in Claim 1 or Claim 2, characterised in that the method includes automatically preventing return flow from taking place from the delivery conduit into the pressure chamber when pumping is not taking place by means of a non-return valve (80) intermediate the pressure chamber and the delivery conduit.

**4.** A method as claimed in Claim 1, Claim 2 or Claim 3 when applied to a positive displacement pump forming part of a pumping installation in which fluid is pumped from a body of said fluid into a rising main (58), characterised in that the method includes exhausting flow through the bypass outlet into said body of fluid, external of the rising main.

**5.** A positive displacement pump (10) including a pressure chamber (62) having a pumping outlet (79) which is connectable to a delivery conduit (58), characterised in that the pump includes a bypass outlet (64) in communication with the pressure chamber and a valve (70) in the bypass outlet which valve is arranged to be open when the pump is not operative and to close automatically when a predetermined pumping volume or velocity is attained in use.

**6.** A positive displacement pump as claimed in Claim 5, characterised in that the bypass outlet is arranged to be upwardly directed in use, in that the valve has a downwardly directed seat (72) and a valve element or closure (74) which is biassed downwardly under gravity, and in that said valve element or closure is arranged to be swept upwardly against gravity onto the seat when said flow of predetermined volume or velocity occurs.

**7.** A positive displacement pump as claimed in Claim 5 or Claim 6, which pump is in the form of a submersible progressive cavity pump, which has connection means (52) for connection to a rising main (58) and a foot valve (80) associated with or proximate said connection means, characterised in that the bypass outlet is arranged to be in communication with a body of fluid external of the rising main from which pumping is to take place in use.

**8.** A start-up accessory (60) for a positive displacement pump (10), characterised in that the accessory comprises mounting means (52) for mounting it in communication with a pressure chamber (62) of the pump, a bypass outlet (64) arranged in relation to said mounting means to be communicated with the pressure chamber of the pump in use and a valve (70) in the bypass outlet which valve is arranged to be open when the pump is not operative and to close automatically when a predetermined pumping volume or velocity is attained in use.

**9.** A pumping installation comprising

a positive displacement pump (10) submerged in a body of fluid which is to be pumped and including a pressure chamber (62) having a pumping outlet (79);

a rising main (58) communicated with the pressure chamber via the pumping outlet,

characterised in that the pump has a bypass outlet (64) communicated with the pressure chamber and a valve (70) in the bypass outlet which valve is arranged to be open when the pump is not operative and to close automatically when a predetermined pumping volume or velocity is attained in operation.

**10.** A pumping installation as claimed in Claim 9 characterised in that the pump has a foot valve (80) associated with the pumping outlet.

**11.** A pumping installation as claimed in Claim 9 or Claim 10 characterised in that the positive displacement pump is in the form of a progressive cavity pump.

**12.** A pumping installation as claimed in Claim 9, Claim 10 or Claim 11 characterised in that the pumping installation is in the form of a borehole pumping installation.

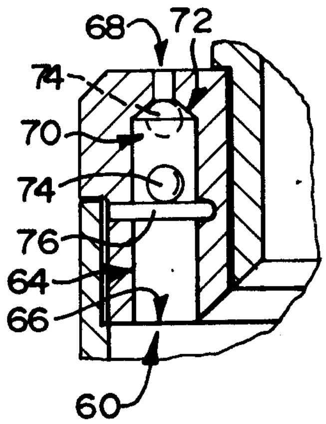


FIG 2

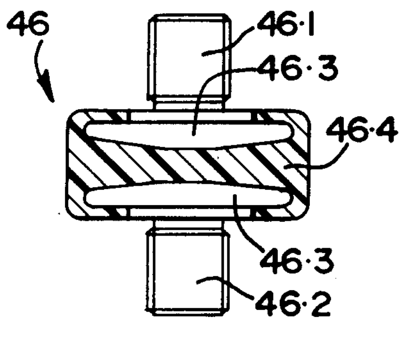


FIG 3

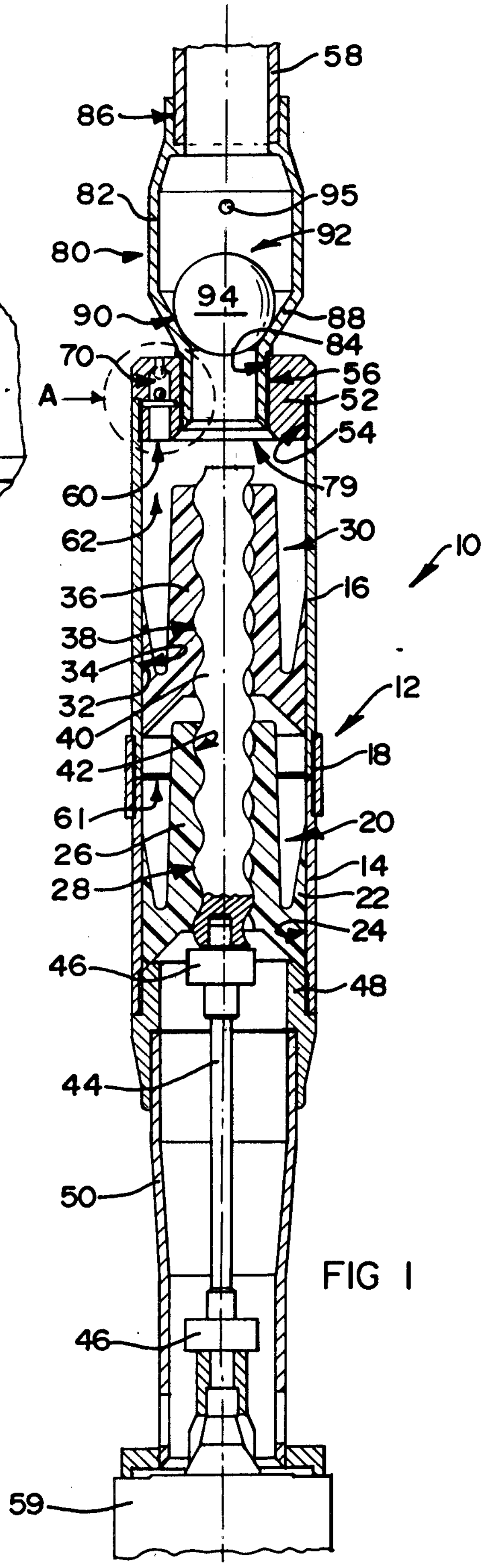


FIG 1