MECHANISM

(54) Title: AN OPTIMIZED SINGLE CYLINDER CONCRETE PUMP WITH AUTOMATIC & MANUAL BY-PASS MECHANISM & EVAPORATIVE OIL COOLER

(57) Abstract: An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler” as described in accordance with the present application is an optimized concrete pump driven typically & essentially by minimum one low pressure fixed displacement fluid power source which can develop concrete pressures comparable or more than the presently available twin cylinder concrete pumps driven by variable displacement axial piston pumps. This is achieved by having the stroke-length of the said single concrete pumping cylinder (7) less than four times of the diameter of the concrete piston (6) and or having a hydraulic piston (5A) having an area of cross-section not less than one-third of the said concrete piston(7). The pump is also provided with a plurality of operating modes wherein the said pump is provided with a plurality of fixed displacement fluid power sources & automatic & manual by-pass mechanism wherein a particular fluid power source is unloaded so as to have more concrete pressure within the power equation.

[Continued on next page]
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"An optimized Single cylinder Concrete pump with automatic & manual by-pass mechanism & evaporative oil cooler"

[001] TECHNICAL FIELD OF INVENTION:

This invention relates to a concrete pump having a single concrete pumping cylinder & driven by hydraulic fluid irrespective of the gate valve mechanism & the nature of the source of fluid power.

[002] BACKGROUND OF THE INVENTION & DESCRIPTION OF PRIOR ART:

Our earlier Indian patent application 3871/MUM/2013 & its corresponding PCT application PCT/IN2014/000088 has effectively disclosed a hydraulically operated, self-regulating, single cylinder concrete pump operated by drive fluid displaced by forceful operation of a hydraulic cylinder. The PCT application PCT/IN2014/000088 has been examined by the ISA & then the IPEA & the examination reports have established the novelty, Inventive step & the Industrial applicability. We have extensively operated the said invention and a number of field trials have been taken. The present invention in accordance with this application is a result of the feedback received from the field trials. Please refer to the Fig. No. 1 on sheet No. 1 which shows the invention as disclosed by our earlier application no. 3871/MUM/2013 & PCT/IN2014/000088.

Our earlier patent applications as mentioned above, disclose a single cylinder concrete pump which is operated by hydraulic fluid displaced from the forceful operation of a hydraulic cylinder. Which is inherently a low pressure hydraulic fluid when compared to conventionally used high pressure hydraulic fluids displaced by high pressure variable displacement hydraulic pumps such as an axial piston or a radial piston pump.

In the context of this application, the term high pressure concrete pump is used for concrete pumps which develop pressures on concrete typically ranging from 45 bar and above. Similarly the squeeze type pumps & purely mechanical pumps are called low pressure concrete pumps wherein the pressures generated by these pumps are typically lower than 45 bar. Similarly in the context of this patent application it is clarified here that a high pressure hydraulic circuit is called so herein-after when the maximum pressure generated in the hydraulic fluid is ranging from 250 bar & above. At the same time a low pressure hydraulic circuit is called so when the maximum hydraulic pressure is typically less than 250 bar.
Other Prior Art:

A presently available typical twin pumping cylinder concrete pump driven by a variable displacement axial piston hydraulic pump is as shown in the fig. No. 2 on sheet No. 2.

It is very important to note here that this type of concrete pump cannot be operated by a simple gear pump or low pressure fluid source as disclosed by patent application no. 3871/MUM/2013 & PCT/IN2014/000088 due to its high flow & high pressure requirement for achieving high pressures on concrete due to its long stroke small hydraulic piston design.

[003] TECHNICAL PROBLEM ASSOCIATED WITH THE EXISTING PRIOR ARTS:

As mentioned earlier, our earlier Indian patent application 3871/MUM/2013 & its corresponding PCT application PCT/IN2014/000088 disclose a Hydraulically operated self-regulating, Single cylinder concrete pump which was operated by fluid displaced from a hydraulic cylinder which is relatively having a lower pressure compared to a fluid displaced by a axial piston high pressure conventional hydraulic pump. This invention is shown in the Fig. No.1 on sheet No.1 which is further improved by way of having very novel & inventive features to make it highly effective & efficient which are subject of the present patent application.

Limitations observed during field trials of our earlier invention disclosed by our application no. 3871/MUM/2013 & PCT/IN2014/000088:

1. Since the hydraulic fluid has been typically a low pressure hydraulic fluid similar to hydraulic fluids displaced by gear pumps wherein the maximum pressure is typically below 250 bar, the said invention cannot develop a pressure on concrete comparable to presently available twin cylinder pumps driven by high pressure drive fluids, if the said invention uses a small diameter hydraulic piston (5A).

2. Similarly, the said invention cannot develop concrete pressures comparable to presently available twin cylinder concrete pumps driven by variable displacement pumps if the said invention is provided with a long stroke-length. This is typically due to absence of a variable displacement fluid power source which can reduce the flow & increase the pressure at a constant power.

3. Further the invention disclosed by the earlier patent applications 3871/MUM/2013 and its corresponding PCT application no. PCT/IN2014/000088, used a slide gate valve for connecting the suction & delivery ports to the pumping cylinder. The
invention has been made & operated in the field with actual materials and
the slide gate valve has been found having a considerable maintenance &
less effective sealing at high concrete pressures apart from requiring high
pressure fluid for its operation.

4. During various field trials of the said invention for overcoming the above
two issues, a suitable valve for the said invention was subsequently
developed and a separate Indian patent application no. 2198/MUM/2014 has
already been filed for the same which is under examination.

5. During various field trials it was observed that the hydraulic oil was getting
overheated due to absence of a cooling system. However it was also
observed that the presently available oil coolers have a maximum
temperature drop of 10-12 degrees. Therefore there was a need to have a
special oil cooler which can have a minimum temperature drop of 20-30
degrees Celsius.

6. Further the said concrete pump as disclosed by our earlier patent applications as
mentioned above does not have a HPLO (high pressure low out-put) and LPHO
(low pressure high output) modes of operation which are available in present day
conventional twin cylinder concrete pumps wherein these pumps are driven by
high pressure hydraulic fluids displaced by variable displacement axial piston
pumps. Hence there is a need to have both these modes in manual as well as
automatic operation.

7. There is no automatic load-sensing system which can automatically reduce flow if
the pressure is increased beyond a certain pre-set limit. Such a system is
available in the presently available twin cylinder concrete pumps which typically
use a variable displacement load-sensing axial piston hydraulic pumps.

It is however well known that the cost of high pressure variable
displacement axial piston pumps is quite high when compared to the
simple hydraulic cylinder used as a source of hydraulic fluid power or a low
pressure hydraulic circuit typically driven by a gear pump.

Because of the same reason, there is a specific need in the market for a small &
compact high pressure concrete pump which can be operated by drive
fluids having relatively lower pressures displaced by fixed displacement
fluid power sources such as a hydraulic cylinder or a simple gear pump;
compared to the high pressure drive fluids displaced by high pressure variable
displacement axial piston hydraulic pumps. Alternatively, there are further cost-effective fluid power sources are available other than a hydraulic cylinder which can be utilized if a low pressure drive fluid is made able to develop high pressures on concrete & any resistance in the path of concrete due to valve action is eliminated.

Further there are a number of equipment already existing in the market which are operated by comparatively low pressure hydraulic circuits typically driven by gear pumps which are much cost-effective even compared with a hydraulic cylinder coupled with a gearbox as disclosed by the above application.

HENCE there is a need of a small compact concrete pump which can develop high concrete pressures & can be easily driven by the low pressure drive fluid made available from the existing hydraulic circuits of the above equipment and has all the above features.

However such circuits having low pressure drive fluids also cannot drive the presently available twin cylinder concrete pumps (prior art No. 2) because of two reasons:

1. The presently available twin cylinder concrete pumps driven by high pressure fluid displaced by axial piston pumps have a combined stroke-length ranging from 1400 to 4000 mm. Please refer to the Fig. No.2 on sheet No. 2 which shows a presently available twin cylinder concrete pump having two long pumping cylinders 3 & 4 each having stroke-length ranging from 700 to 2000 mm. This type of pumps cannot develop very high pressures on concrete if the drive fluid itself has a low pressure & hence these pumps are driven by high flow high pressure drive fluids displaced by conventional axial piston hydraulic pumps. The Fig. No. 2 on sheet No. 2 also shows an axial piston pump -10 providing the high pressure drive fluid.

2. The second most important reason is the valve system used by the presently available twin cylinder concrete pumps. The most popular valve types used by the presently available twin cylinder concrete pumps are swing tube valves (popularly called as S-tube & a rock valve. Apart from the constructional differences, the swing tube valve & the rock valve work in similar fashion. Please refer to the Fig. No.2 on sheet no. 2 which also shows a swinging gate valve

9. These valves require very high force for their operation due to following reasons:
a. Both of these valves are made to oscillate inside the pump hopper (please refer to the Fig. No. 2 on sheet No. 2 which shows the valve 9 oscillating inside the hopper) around an axis wherein the pumping cylinders (3 & 4) do not share the same axis as that of the delivery pipe (11). In other words the delivery pipe (11) which is at a different axis is connected to the pumping cylinder (3 & 4) having a different axis. This means that the valve (9) has to have a curvature & has a lot of resistance. These bends offer immediate resistance to the flow of concrete coming out from the pumping cylinders.

b. Further the pumped concrete has to flow through both the above valves which also means that the concrete-inside has to oscillate along-with the valve adding its weight to the weight of the valve.

c. Very importantly, both the above valves are actually submerged in the concrete as these valves are designed to operate at almost the bottom of the hopper, (please refer to the position of valve 9 in the Fig. No. 2 on sheet no. 2). So these valves have to displace a large amount of concrete in the confined area in the hopper by their outer surfaces as well during their movement. This requires a lot of power and also results in wear.

d. The bend or curvature which is the design requirement of these valves, means that the pumping cylinder (3 & 4) & the delivery pipe (11) do not share a common axis. The resistance is further increased by the fact that the twin pumping cylinders (3 & 4) have two different axis separated by a distance & the valve needs to have that much curve so as to connect each of these pumping cylinders (3& 4) to the delivery pipe (11).

e. In terms of rock valve similar to as shown in the fig. no. 2 on sheet no. 2, due to the design of the valve, the concrete flow is resisted by the concrete which is already present on one side of the rock valve. Which means that the pumped concrete has to find its way under pressure through a mass of stationary concrete. This requires more power.

The presently available equipment having comparatively low pressure drive fluids include various makes of loader-backhoes, skid steers & similar equipment. There are low cost drive options available on tractors which also include low pressure high flow gear pumps. These gear pumps operate at relatively low pressure ranging from 100 to 250 bar. Hence there has been a need of a highly compact, high pressure concrete pump which can be operated with the help of a low pressure drive fluid.
The presently available twin cylinder concrete pumps have the following issues which are of interest in accordance with the present invention:

1. The capital cost is very high as they require variable displacement axial piston conventional hydraulic pumps (10) due to their long stroke-length & small hydraulic piston design. Please refer to the Fig. No.2 on sheet no. 2 due to very high stroke-lengths of the twin hydraulic cylinders (1 & 2) the diameters of the hydraulic pistons (5 & 6) have to be smaller so as to compensate for the larger swept volumes resulted due to longer stroke lengths. This means that the hydraulic pistons (5 & 6) are having very less area of cross-section, when compared to the concrete pistons & due to this area difference a high hydraulic pressure is required to generate high pressure on concrete.

To simplify the relation of size of hydraulic piston (5&6) & pressure on concrete is given by the equations:

\[
\text{Pressure on concrete} = \frac{\text{hydraulic pressure}}{\text{pressure ratio}}
\]

Wherein the pressure ratio = cross sectional area of concrete piston / cross sectional area of hydraulic piston.

2. The presently available twin cylinder piston pumps as shown in Fig. no.2 on sheet no.2 use two separate concrete pumping cylinders (3 & 4) driven by two separate hydraulic cylinders (1 & 2) and a swing tube valve or a rock valve (9) at the end of the pumping cylinders (3&4).

3. The swing tube valve & the rock valve (9) operate in such a way that they have a swinging body along an axis wherein the said swinging body has to move along with the concrete inside. It therefore needs a curved body inducing an immediate bend after the pumping cylinders (3 &4). Both these valves connect the pumping cylinder (3 or 4) to the delivery pipe (11) which are having two separate axis and hence require higher operation force due to displacement of large amount of concrete.

4. The presently available twin cylinder concrete pumps as shown in Fig. No. 2 on sheet No.2, are provided with two modes of operation apart from the load sensing function of the axial piston pump (10). These two modes are HPLO (high pressure low output- piston side drive) & LPHO (Low pressure high output-rod side drive) modes of operation.
5. The switching over from HPLO to LPHO mode means interchanging of the entry of drive fluid from piston side drive to rod side. This has to be done by physically changing the hoses or by having a costly additional DC valve.

Presently available Twin cylinder Concrete Pumps with rod & piston side drives:

Please refer to the Fig. No. 2 on sheet No. 2 wherein the presently available twin cylinder high pressure concrete pump is operated by high pressure hydraulic fluid displaced by variable displacement load sensing axial displacement pump (10). These axial piston pumps load sensing hydraulic pumps can vary the flows depending upon the load requirement of the hydraulic circuit. However these pumps are very costly wherein they have very high initial cost & are sensitive to impurities in the hydraulic oil.

Further, in presently available twin cylinder concrete pumps there are two modes of operation provided wherein:

1. The drive fluid is provided to the piston side of the hydraulic cylinder:

   Since the cross-sectional area on the piston side is higher than that of the rod side, same pressure fluid results in higher pushing force & hence higher pressures on concrete are achieved but at the same time due to a large swept volume on the piston side, the speed of operation reduces resulting in less output. Which means the pump operates in a high pressure low output mode when the drive fluid is applied from the piston side. (HPLO mode).

2. The drive fluid is provided to the rod end side of the hydraulic cylinder:

   Now the rod side has a smaller available cross-sectional area which means less volume of fluid is required to have one stroke. So the speed of the hydraulic cylinder increases resulting in higher output but at the cost of the pressure exerted on concrete due to pressurized fluid acting on a smaller area generates a pushing force which is much smaller compared to the piston side drive. In other words the pump operates in a LPHO mode (Low pressure High output) at the same horsepower utilization.

Method of switching from HPLO to LPHO mode in presently available twin cylinder concrete pumps:

As explained above, in order to switch the pump from one mode to another, in majority of the pumps, the hoses supplying drive fluid needs to be interchanged physically from rod side to the piston side.
This takes considerable amount of time & effort & loss of some fluid due to leakage during hose changing.

In some concrete pumps, a switch over valve resembling to a normal Directional control valve is provided which can be operated electrically to change the drive from piston side to the rod side or vice versa.

In this case, the cost goes up as an extra valve is required along-with plurality of additional hoses.

Requirement of costly variable displacement axial piston pumps in presently available twin cylinder concrete pumps as shown in Fig. No. 2 On sheet No. 2:

1. The Nomo-graph (graph of pressure on concrete Vs output of concrete) of a hydraulically operated twin cylinder concrete pump clearly shows that as the required pumping pressure increases the output volume comes down and when required pumping pressure is less, the output goes up. This is achieved by having a variable displacement axial piston pump which increases or decreases the flow of oil depending on the required pressure (load). This is in line with the energy conservation law where the available prime mover power is constant but the form changes (high pressure or high flow) depending upon the requirement.

2. Because of the above arrangement, the presently available twin cylinder concrete pump catalogues display the maximum output volume (in cubic meters or cubic yards) and the max. pressure (in Bar or PSI) but both cannot be achieved at the same time. Which misleads the buyer as many times the concrete pump catalogue is not provided with a Nomo-graph. For example a popular twin cylinder concrete pump catalogue shows max. pressure of 76 bar and output of 30 cubic meter with a prime-mover of 32 kw. However if anybody calculates even using the entire available power without considering any losses, the maximum output @ 76 bar pressure with a prime mover of 32 kw is only 10.53 cubic meter as per the energy conservation law.

Long Stroke-length small diameter hydraulic piston design of presently available twin cylinder concrete pumps as shown in the Fig. No. 2 on sheet No. 2:

The presently available concrete pumps have a twin concrete pumping cylinders (3 & 4) design wherein these pumping cylinders are provided with very long stroke-lengths typically ranging from 700 mm to 2000 mm each cylinder.
When adding the stroke-lengths of the twin pumping cylinders (3 & 4) together, a presently available twin pumping cylinder concrete pump has a combined stroke-length ranging from 1400 mm to 4000 mm. These long stroke lengths necessarily result in small bore diameters of the hydraulic cylinders (1 & 2) which drive the pumping cylinders (3 & 4) at a given pump displacement of the axial piston pump (10).

Therefore the presently available pumps require very high fluid pressure to achieve high concrete pressures. This is because of the fact that the pressure developed on concrete by a concrete pump depends upon the proportionate areas of the hydraulic piston (5 & 6) & the concrete pistons (7 & 8).

"In other words, smaller is the cross-sectional area of hydraulic piston, higher is the hydraulic pressure required to develop a certain amount of concrete pressure".

Use of small diameter hydraulic pistons is common even in very big presently available twin cylinder concrete pumps as shown in Fig. No.2 on sheet No.2. These diameters range from 80 mm to 120 mm and more than 120 mm only in case of very big pumps. But since the concrete pumping pistons (7 & 8) have a much bigger diameter (the typical diameters are DN 180, DN 200 & DN 230); all these pumps require very high fluid pressure in the range of 250 to 380 bar because of the small diameter hydraulic pistons (5&6). Further the twin pumping cylinder design results in higher maintenance as well as higher capital cost as the twin pumping cylinders (3 &4) are hard-chrome plated from inside for the reciprocation of rubber pistons. In addition to drive two pumping cylinders two separate hydraulic cylinders (1&2) having same stroke length are required. In general, it is observed that the high stroke-length small diameter hydraulic piston design prevailing in the presently available twin cylinder concrete pumps is a result of high focus on reducing valve wear by reducing the no. of strokes per minute rather than the basic relation of the hydraulic piston with the concrete piston.

It is also ample clear from the Fig. No.2 on sheet No. 2 that the presently available twin cylinder concrete pumps have a much longer length & weight making it impossible to install these pumps on tractors & commercial vehicles in such a way that the axis of the said concrete pump is perpendicular to that of the tractor or any commercial vehicle. This is typically because the width of a commercial vehicle or tractor plying on city roads is less than 2500 mm. Therefore it is impossible to install the presently available twin cylinder concrete pumps (even without their prime mover) on the rear of the tractor or commercial vehicles where in the axis of the said pump needs to be perpendicular to the
axis of the tractor or a commercial vehicle. Further since the pump needs to be attached at the rear of the tractor or a commercial vehicle, it needs to be light-weight pump which is not possible with the presently available twin cylinder concrete pumps.

Technological barrier in adopting the presently available twin cylinder concrete pumps to tractors:

As discussed in detail, the presently available twin cylinder concrete pumps cannot be mounted on the three point hitch of a tractor because of their lengthy design & high weight. Further the tractor PTO has limited power which cannot meet the pressure & flow requirements of the said presently available twin cylinder concrete pumps. The Three point hitch in majority of the tractors is designed to carry a much less weight thereby making it impossible to install the presently available twin cylinder concrete pumps on the three point hitch due to their very high weight. Similarly the presently available twin cylinder concrete pumps cannot be accommodated at the rear of a commercial vehicle when mounted perpendicular to the axis of the vehicle which is a typical requirement.

Hence there is a need of a compact, lightweight but highly effective concrete pump which can generate pressures on concrete comparable to the presently available twin cylinder concrete pumps and it can also be mounted without its prime mover on three point hitch of a tractor or at a rear of a commercial vehicle wherein:

1. The longitudinal axis of the said compact concrete pump is perpendicular to the longitudinal axis of the tractor or commercial vehicle

2. The weight of the said concrete pump is less than 1500kg.

3. The length of the said concrete pump is less than 2500 mm so in accordance with the RTO guidelines.

4. The said pump has to be operable by a low pressure drive fluid

5. The said pump has to be able to generate high pressures on concrete even after operated by a low pressure fluid.

All the above requirements cannot be met by presently available Twin cylinder concrete pumps as shown in Fig. No. 2 on sheet No. 2.

Other related objectives:
Similarly there are techno-commercial barriers to adopt the presently available twin cylinder concrete pumps as shown in Fig. No. 2 on sheet no. 2, to loader-backhoe circuits which are as follows:

1. The presently available twin cylinder concrete pumps cannot be operated effectively by the low pressure drive fluids made available by the existing circuits of the most popular loader-backhoe machines which are typically having low pressures below 250 bar & low flows below 115 lpm.

2. The presently available twin cylinder concrete pumps cannot be handled effectively by the loader bucket of loader backhoes as the presently available twin cylinder concrete pumps cannot be accommodated in the loader bucket due to their long stroke-lengths & bulky high weight design.

Therefore there has been a specific need of an optimized concrete pump adoptable to the existing loader backhoe circuits wherein:

1. The said pump should be able to develop comparable pressures on concrete even when it is driven by the low pressure drive fluid made available from the loader-backhoe hydraulic circuit.

2. The said pump should be compact enough to be accommodated with a skid in the loader bucket of a loader-backhoe thereby enabling the end user to have a greater flexibility in terms of site movements.

3. Though the said adoption is a subject of an independent patent application, its basic requirement is to have a compact concrete pump driven by a low pressure fluid, which can generate concrete pressures comparable to concrete pumps driven by variable displacement high pressure axial piston hydraulic pumps.

Cooling of hydraulic oil in presently available concrete pumps:

The presently available hydraulically driven concrete pumps have very high flows & pressures. In a hydraulic circuit having high flows and pressures, a considerable amount of heat is generated which many times result in overheating of the entire hydraulic system. Over the years it has been a challenge to control the temperature of the hydraulic drive fluid especially in hot weather conditions prevailing in countries like India.
Conventional ways of controlling the temperature of hydraulic fluid in presently available concrete pumps:

a. By having a very large reservoir having capacity in multiples of the flow of the hydraulic pump in LPM plus 10% empty space:

b. By having a heat exchanger separate from the main hydraulic reservoir:

c. By having an engineered reservoir where the oil is made to rest by using baffle plates & diffusers.

d. By having a simple oil cooler with a rotary cooler Fan driven hydraulically or electrically.

e. By using a variable displacement pump so as to control the pump displacement so as to in turn control the oil temperature.

However all the above methods have their own disadvantages & limitations mainly in terms of mobility & capital & operation cost. These are explained below:

a. Large capacity hydraulic reservoir:

Conventionally the hydraulic reservoir is sized depending upon the flow of hydraulic fluid per minute. Conventionally as a rule of thumb a hydraulic reservoir should be big enough at least to hold a volume of hydraulic fluid 3 to 5 times that of the LPM (flow in Liters/minute) of the hydraulic fluid source or a hydraulic pump. Additionally the said reservoir should also be provided with at least 10% empty space for effective cooling of the fluid. However this results in high capital cost. It also results in a high operation & maintenance cost as the fluid replacement costs are very high. Further the weight of the equipment especially during transit is considerable.

b. A separate heat exchanger:

A conventional heat exchanger transfers heat from the hot hydraulic fluid to a coolant wherein both need to continuously circulate in order to have an effective cooling.

The cooling in this case depends majorly on the rate of coolant flow through the heat exchanger and a continuous supply of low temperature coolant at the inlet enabling heat transfer. However this is not ideal for a mobile equipment. Further to have effective circulation we need a pump which can circulate the coolant through the heat exchanger. The pump obviously requires a continuous supply of
coolant apart from a drive mechanism & power input. All this not only make the machine bulky but also add to the capital cost and many times a heat exchanger may still be required even after having a large size reservoir.

c. An engineered reservoir:

A thoroughly engineered reservoir ensures that the fluid is allowed to rest, cool, settle down and is ready for re-circulation without air bubbles. However even that may not cut down on the volume requirement of the hydraulic fluid.

d. A simple conventional oil cooler with FAN:

Cooling depends upon the input power to the FAN. It also adds to cost and not be as effective as an oil water heat exchanger. Further the size of the FAN further makes the equipment bulky.

e. By using a variable displacement hydraulic Pump:

However as mentioned earlier, this is a very costly option apart from the fact that it will not work with a hydraulic circuit such as the one disclosed by our patent application No. PCT/IN2013/000088 & the Indian application No. 3871/MUM/2013 Since it does not use a conventional variable displacement hydraulic pump as a source of power.

Therefore there has been a need to have a custom designed hydraulic oil cooler which has:

1. No requirement of cooling medium (water or air) to be circulated continuously.

2. A higher temperature drop in the range of 25-30 deg. Celsius when measured across the input & output line.

3. No power requirement for cooling.

4. Low capital & maintenance cost.

[004] OBJECT OF INVENTION & SOLUTION TO THE PROBLEM:

Therefore the primary object of this invention is to have a optimized single cylinder high pressure concrete pump which-
1. Can generate high concrete pressures comparable to presently available twin cylinder concrete pumps on concrete even when driven by a low pressure drive fluid typically less than 250 bar such as fluid flow generated by forceful operation of a hydraulic cylinder or alternatively a low pressure hydraulic fluid displaced by a simple gear pump.

2. Has a simple & highly cost-effective mechanism to change the mode of operation from higher volume output to higher concrete pressure without physically changing hoses or without having a solenoid operated DC valve. Further it has an optional fully automatic by-pass mechanism which also acts as an automatic load sensing system wherein the system itself by-passes excess flow when the pressure rises beyond a pre-set limit. Such a system is presently not available when the concrete pump is typically driven by one or more fixed displacement fluid power sources.

3. **Has a plurality of modes of operations** clearly specifying the maximum pressure & maximum output in clearly each mode without creating any doubts in the buyer's mind.

4. **Has a gate valve mechanism which is also operable by low pressure fluid**, which is off-set from the axis of the pumping cylinder & the delivery pipe wherein the pumping cylinder & the delivery cylinder are co-axial. This eliminates the resistance to concrete flow which is present in presently available twin cylinder concrete pumps which use rock valve or swing tube valves as both these valves have to necessarily have a bend immediately after pumping cylinder due to their swinging design.

5. **Is able to generate high concrete pressures even when driven by relatively low pressure fluid power** from various existing equipment which typically use low pressure hydraulic circuits driven by gear pumps.

6. **Is alternatively able to generate exceptionally higher pressures on concrete when operated by a high pressure drive fluid** at a much lower cost when compared to the presently available twin cylinder concrete pumps.

7. Can be mounted on a three point hitch of a tractor wherein the longitudinal axis of the said concrete pump is perpendicular to the axis of the tractor & weight of the pump is less than 1500 kg.

8. Can be easily mounted on the rear of a commercial vehicle wherein the longitudinal axis of the said concrete pump is perpendicular to the longitudinal axis of the said commercial vehicle.

9. Can be effectively operated & is able to generate high concrete pressure by low pressure drive fluid made available from the existing circuit of loader-backhoes.
10. Should be so compact, that it could be accommodated in the loader bucket of a loader backhoe enabling greater flexibility at site.

11. is provided with an effective but highly low cost cooling system which has a minimum temperature drop of 25-30 deg. Celsius when compared to presently available air fan hydraulic coolers which typically have a temperature drop less than 10-15 deg. Celsius. Further the cooler needs to work with zero input power & does not require continuous circulation of the cooling medium such as water or air.

Another very important object of this improvement is to make the said invention highly compact thereby having techno-commercial advantages which can be passed on to the end users.

Another very important objective of this invention is to make the invention easy to manufacture and cost effective.

Another object of this invention is to have a high pressure concrete pump having low capital cost when compared to the presently available twin cylinder hydraulically operated concrete pumps.

[005] SUMMARY & DISCLOSURE OF THE INVENTION:

In accordance with the present invention "An optimized Single cylinder Concrete pump with automatic & manual by-pass mechanism & evaporative oil cooler" is hereby disclosed typically & essentially comprising off:

a. A single concrete pumping cylinder (7) provided with a stroke-length typically & essentially less than four times of the diameter of the concrete piston (6) driven by a single hydraulic cylinder (5) having a single Hydraulic piston (5A) wherein the cross-sectional area of the hydraulic piston (5A) is not less than one third of the cross-sectional area of the said concrete piston (6).

b. A self-regulating hydraulic circuit for operation of the said invention provided with a hydraulic tank with a high volume static water compartment with a drain valve wherein the hydraulic tank itself is used as an evaporative cooler & the water volume is in multiples of the quantity of hydraulic oil. Alternatively a separate cooler is provided having a high volume static compartment for water with a drain valve, wherein the water can be drained after getting hot simply by opening the drain valve.
C. A rotary gate valve (8) wherein the valve body center is off-set with respect to
the pumping cylinder & the delivery pipe which are co-axial which reduces the
resistance & reduces the power required to operate the said gate valve.

d. A low pressure drive fluid displaced by a variety of means such as but not
limited to a plurality of forcefully operated hydraulic cylinders; alternatively a
single hydraulic cylinder is used to have only one mode of operation as
disclosed in the earlier applications.

e. A low pressure drive fluid alternatively displaced from a plurality of back to
back mounted independent gear pumps; typically a single gear pump is used
to have only one mode of operation.

f. A BY-PASS mechanism for minimum one source of fluid power wherein the
low pressure fluid is typically & essentially allowed to go back to tank without
doing any work so as to have various modes of operation within the energy
conservation law & the said by-pass mechanism is provided with manual as
well as automatic actuation.

Thus the earlier invention disclosed by PCT/IN2014/000088 is further improved by
this patent application wherein the earlier invention is provided with an automatic
force multiplying system by means of a short stroke-length related to the diameter
of the concrete piston & diameter of the hydraulic drive piston. The pump can
also have HPLO & LPHO modes even with a fixed displacement open center low
pressure hydraulic circuit utilizing relatively low pressure fluid generated by
forceful operation of a hydraulic cylinder or alternatively by a low pressure gear
pump developing max. oil pressure less than or equal to 250 bar.

It is very important here to note that, in context of this application, the off-center rotary
gate valve is provided in the present invention so as to lower the required force for the
operation of the slide gate valve or swing tube valve or the rock valve in order to make it
operable by low pressure drive fluid. Apart from above, the said gate valve patent
application no. 2198/MUM/2014 filed by us has no further relation with the disclosure
made in this particular patent application. Since the said valve is having a no. of other
techno-commercial advantages, it is a subject of an independent patent
application & hence is not discussed here in detail except for the reduction in
force required for operation of this valve which is critical in the context of the
present application.
Thus the said invention disclosed by earlier patent application no. 3871/MUM/2013 & corresponding PCT application no. PCT/IN2014/000088 has been further improved so as to generate higher concrete pressures even by using a low pressure hydraulic drive fluid and thereby improving the invention further where it can be effectively used with low pressure drive fluids already available from various fluid sources of existing equipment as well.

[006] BRIEF DESCRIPTION OF THE DRAWINGS:

1. The Fig. No. 1 on Sheet no. 1 shows the most preferred embodiment of hydraulically operated, self-regulating, Single cylinder concrete pump as disclosed by our earlier Indian Patent application no. 3871/MUM/2013 & PCT application No. PCT/IN2014/000088.

2. The Fig. No. 2 shows a typical presently available twin cylinder concrete pumps operated by high pressure drive fluid displaced by a variable displacement high pressure axial piston pump.

3. The Fig. No. 3 on sheet no. 3 discloses "An optimized Single cylinder Concrete pump" in accordance with this application having a manually operated by-pass mechanism.

4. The Fig. No. 4 on sheet no. 4 discloses an alternative hydraulic circuit with automatic by-pass mechanism.

5. The Fig. No. 5 on sheet no. 5 discloses the hydraulic tank having an in-built evaporative cooler used for cooling of hydraulic fluid in accordance with the present application.

[007] DETAILED DISCRIPTION & WORKING OF THE INVENTION WITH REFERENCE TO THE DRAWINGS:

In accordance with the present application, the Fig. No. 3 on sheet no. 3 discloses "An optimized Single cylinder Concrete pump". The said invention is described hereinafter in detail with reference to the drawings.

Please refer to the Fig. No. 1 on sheet No. 1; which shows our earlier invention disclosed by our earlier patent applications showing A single concrete pumping cylinder (7) having a single reciprocating rubber piston (6) for pumping concrete wherein the rubber concrete piston (6) is mounted on the drive shaft of a hydraulic cylinder (5) having a hydraulic piston (5A). The single concrete pumping cylinder (7) is provided with a slide gate valve (8) which is made to
operate in a self-regulatory manner synchronized with the reciprocating piston (6) in such a way that it closes the suction port & opens the discharge port when the piston (6) moves forward. Similarly it closes the discharge port & opens the suction port when the piston (6) moves backwards. Another hydraulic cylinder (4) forcefully operated by the prime-mover displaces low pressure fluid which operates the hydraulic cylinder (5) by acting on the hydraulic piston (5A) resulting in the pumping operation.

This invention is further improved as shown in the Fig. No. 3 on sheet no. 3.

As shown in the Fig. the low pressure fluid results in to & fro reciprocation of the hydraulic piston (5A). Since the rubber concrete piston (6) pushing concrete is directly mounted on the rod driven by hydraulic piston (5A), the pressure developed by the rubber concrete piston (6) on concrete is directly proportional to the cross-sectional area of the hydraulic piston (5A). In other words the pressure developed by the rubber piston (6) on concrete is higher when the cross-sectional area of the hydraulic piston (5A) is higher. However in order to increase the cross-sectional area of the hydraulic piston (5A) we need to compromise on the stroke-length of the said hydraulic piston (5) for a fixed amount of flow.

The earlier invention is therefore optimized to have a single concrete pumping cylinder having a stroke length which is typically & essentially less than four times of the diameter of the concrete piston (6). The ultra-short stroke-length compensates for increased flow due to use of a large diameter hydraulic piston (5A). Which means that a low pressure fluid acting on the large cross-sectional area of the piston (5A) can effectively generate a high force on the rubber piston (6) resulting in a higher pressure on concrete.

If the cross-sectional area of hydraulic piston (5A) is increased further & if it is made equal to the cross-sectional area of the reciprocating piston, the hydraulic pressure will be the same as concrete pressure. In other words, if low pressure hydraulic oil having 100 bar pressure acts on the hydraulic piston (5A) shall generate 100 bar pressure on concrete if the cross-sectional area of the piston (5A) is equal to the cross-sectional area of rubber piston (6). Any further increase in the cross-sectional area of piston (5A) with respect to the cross-sectional area of rubber piston (6) shall result in concrete pressure higher than hydraulic oil pressure in the same proportion and the hydraulic piston (5A) shall start working as a force multiplier driven by low pressure high flow.
hydraulic oil. In this condition it can even be driven by a simple gear pump or a simple hydraulic cylinder displacing low pressure fluid. A further increase in the cross-sectional diameter of the hydraulic piston shall lower the required pressure of the drive fluid by a huge margin but at the same time shall increase the flow requirement. One way of reducing this flow requirement is by increasing the rod diameter as much as possible so that less volume of fluid is required in the non-productive stroke.

As explained above, any further increase in the cross-sectional area of hydraulic piston (5A) shall bring down the operating pressure of the entire hydraulic circuit and even lower pressure oil can be used to generate very high pressure on concrete and even a simple gear pump having much lower pressure compared to a axial piston pump can be used. At one point, a high pressure on concrete can be obtained even by having a very low pressure in the range of 10-12 bar however as said earlier, the flow requirement to have same concrete output shall go up by a huge margin as the swept volume is increased multi-fold. In one embodiment even high pressure air or water can be used in high flow volumes, to develop high pressures on concrete.

Therefore the earlier invention is optimized further to have the largest possible area of cross-section of the hydraulic piston (5A). However due to the increased cross-sectional area, the swept volume increases which has to be compensated by shortening the stroke-length of the hydraulic cylinder (5). Since the hydraulic cylinder (5) & Concrete pumping cylinder (7) should necessarily have equal stroke lengths, the pumping cylinder (7) is also improved so as to match the hydraulic cylinder. In line with the above relation, the hydraulic piston (5A) is further optimized to have a cross-sectional area not less than one third of the cross-sectional area of the rubber concrete piston (6).

Further as discussed earlier in this application, in order to remove any resistance & leakage under high pressures, the slide gate valve (8) as shown in the earlier Fig. No. 1 on sheet no. 1 is replaced by an rotating valve (8A) inside a off-set valve body (9) as shown in the Fig. No. 3 on sheet no. 3. The Off-center gate valve assembly ensures that there is no resistance to the flow of concrete from the pumping cylinder (7) to the delivery pipe & ensures that the complete invention as whole is now operable by a low pressure drive fluid and is able to generate comparable or higher pressure on concrete when compared to presently available twin cylinder concrete pumps driven by variable displacement axial piston pumps.
The off-center gate valve assembly is designed in such a way that the center of the valve body (9) is off-set with respect to the common axis of the pumping cylinder (7) and delivery pipe (10) as the pumping cylinder (7) & delivery pipe (10) which are co-axial. Further the off-center valve body is provided with a cut section which acts as a rotating valve (8A) whose rotary oscillatory movement is synchronized with the movement of the hydraulic piston (5A) so as to have a perfect pumping action. The detailed self-regulating hydraulic circuit is as shown in the fig no. 3 on sheet no. 3. This is the driven side of the said concrete pump. It is very important to note here that, during operation of the off-center rotary gate valve, only the gate valve (8A) oscillates & the valve body (9) remains stationary which causes very less displacement of concrete when compared to the swing tube or rock valve as discussed above. Therefore it requires relatively less power for its operation.

Due to the above optimization, as evident from above explanation, even a low pressure high flow hydraulic fluid can generate very high pressure on concrete, a plurality of hydraulic cylinders can be used to forcefully displace the required fluid flow. The part A on Fig. No. 3 sheet no. 3 shows a plurality of hydraulic cylinders (4) & (4X) which are made to operate forcefully and therefore are forced to displace low pressure hydraulic fluid required for the operation of the hydraulic piston (5A). The displacing piston 4A is sized suitably so as to meet the flow requirement of the present invention.

Thus the above optimization completely eliminates the use of costly high pressure axial piston pumps bringing down the cost by huge margin, it also opens another possibility of the optimized pump can now develop still higher pressures on concrete if it is provided with a high pressure drive fluid apart from making it highly effective even with a low pressure drive fluid.

Now in today's context, the cheapest alternative way to have low pressure high flow hydraulic fluid is simply by having a simple fixed displacement gear pump, the said invention can now also be alternatively worked by using a simple gear pump. Hence the PART B on Fig. No. 3 on sheet no. 3 shows an alternative arrangement to operate the said single cylinder pump wherein one or more simple gear pumps are installed back to back wherein each displacing a certain amount of fluid. The important point to note that the hydraulic cylinder (4 & 4X) used for forceful displacement of low pressure fluid is also a fixed displacement device & a gear pump is also a fixed displacement device and hence both are technically interchangeable. The part A & Part B in the Fig. No. 3 on sheet no. 3 also show a
simple by-pass mechanism wherein any one of the hydraulic cylinders (4 & 4X) in PART A or any one of the said gear pumps (G1 or G2) in PART B can be bypassed simply by operating a simple ball valve (BV) wherein the fluid displaced by that particular hydraulic cylinder or that particular gear pump is allowed to flow back to the tank without doing any useful work.

This results in cutting off one part of the flow while the other hydraulic cylinder or gear pumps operate independently and utilize all the available power displacing less flow compared to the original combined flow. Thus the mode of operation is changed from LPHO (low pressure high output) to HPLO (High pressure low output). Since one part of the flow is cut off it results in slower operation of hydraulic piston (5A) resulting in less no. of strokes of rubber piston (6) per minute. This subsequently results in reduction in concrete output. Now as per the energy equation, the available power can now be used to have higher hydraulic oil pressure. The circuit also shows two separate safety valves (SV1 & SV2) which are also operated in the same manner. The safety valves are set according to the modes of operation.

CONCLUSION:

As mentioned above, it was observed very closely, during working of the earlier invention, that the cross sectional area of the rubber concrete piston (6), the cross-sectional area of the hydraulic piston (5A), the stroke-length of the Single concrete pumping cylinder (7), pressure of the hydraulic drive fluid & the pressure developed on concrete by the concrete piston (6) are critical factors wherein all are related to each other & the said single cylinder concrete pump can be made operable by even by a drive fluid having relatively low hydraulic pressure when compared to the hydraulic fluid displaced by conventional axial piston hydraulic pumps.

Another factor here is the rod diameter (Rd) which is highly useful in reducing the flow requirement and also in ensuring that the backward stroke speed is higher than that of the forward stroke.

There has been found a certain relation, wherein the most ideal conditions exist for the high pressure single cylinder concrete pump to be driven by a relatively low pressure fluid, typically in the range of 100 to 250 bar when a concrete pumping cylinder (7) is having a stroke-length less than three times the diameter of the pumping cylinder and the said hydraulic piston (5A) driving the said concrete piston (6) has a cross-sectional area not less than one third of the cross-sectional area of the concrete piston (6). The required power is further reduced by
having an off-center gate valve (9) so as to make the pump operable by low pressure hydraulic fluid as a whole.

The said concrete pump is further optimized to have two separate modes of operation by having plurality of independent fluid power sources (such as 4,4X & G1 & G2) operated by single prime mover wherein each of these sources whether a forcefully operated hydraulic cylinder or a gear pump is provided with a By-pass mechanism thereby allowing the fluid displaced by that particular source to flow back to tank. Thus the said concrete pump can be now operated with a plurality of operating modes.

Another optimization is that in the HPLO mode, the said pump utilizes optimum power and discharges same amount of concrete even at high pressure due to the fixed displacement hydraulic circuit which is actually unlike the variable displacement axial piston pump circuits of the presently available twin cylinder concrete pumps. Thus the high performance part of the NOMOGRAPH is achieved at a relatively much lower capital cost.

Theory behind the invention:

As mentioned earlier the pressure (in pounds per sq. inch) developed by a concrete piston on concrete depends upon:

Force (in pounds) acting on the concrete piston (7) & the cross-sectional area of the concrete piston (7) in square inches.

However the force acting on the concrete piston (7) is same as the force (in Pounds) exerted by the hydraulic piston (5A) which depends upon the hydraulic fluid pressure (in pounds) & the cross-sectional area of hydraulic piston (5A) in square inches.

At the same time:

A longer stroke-length means higher required flow (in LPM).

Where for a fixed displacement power source the flow (in LPM) is fixed & hence the pressure (in Bar) is fixed at a fixed value of power (in Kw). The relation is given by the equation:

Prime mover power (in Kw) = flow (in LPM) X pressure (in Bar) / 600.
Automatic By-Pass mechanism: Please refer to the Fig. No. 4 on sheet No. 4 which discloses a simplified hydraulic circuit for the present invention showing an automatic by-pass mechanism wherein minimum one fixed displacement power source is automatically unloaded to tank without doing any work, thereby allowing the other fluid source to utilize higher hydraulic pressure at the same power input.

As shown in the fig. no 4 on sheet No. 4, the hydraulic cylinder (S) is provided with a hydraulic pressure switch (PS) in the pressure line acting on hydraulic piston (5A) to effect pumping stroke. The output signal of the pressure switch (PS) operates a normally closed two direction valve (NC) resulting in unloading of the power source (G2) to the tank resulting in automatic by-passing of the said power source (G2). Which allows the other power source (G1) to utilize the available power to generate more pressure on concrete. It is important to note here that the pre-set pressure - X at which the said hydraulic pressure switch (PS) operates is carefully calculated by keeping in mind the available flow & available power. Due to any resistance in the pipeline of the said concrete pump, the hydraulic pressure rises. Once it rises beyond the pre-set value of the pressure switch (PS), it generates an electrical signal which in turn operates the solenoid control valve (NC) resulting in unloading or by-passing the said source of fluid power (G1). When the resistance in the pipeline is reduced, the hydraulic pressure comes down below the pre-set pressure X and hence the valve NC remains firmly closed & the combined flows of both fluid power sources G1 & G2 are now available for pump operation.

Working of evaporative oil cooler:

The Fig. No. 5 on sheet No. 5 discloses a hydraulic tank specially developed for the present invention, wherein the said hydraulic tank (T) is provided with a water compartment (W) sandwiched between two oil compartments (01 & 02) wherein the oil compartments 01 & 02 are interconnected by means of tubes passing through the said water compartment (W). The water compartment (W) is provided with a drain valve (D) at the bottom & a open filling pipe (F) wherein the open pipe allows evaporation of static water to the atmosphere which cools down the hydraulic oil. Further the quantity of static water in liters is in multiples of the quantity of hydraulic oil in liters. The drain valve (D) enables draining of hot water when required & the filler pipe (F) enables adding of cold water if required.

The said cooler has already been made & tested to have a temperature drop of 30 deg. Celsius between the inlet port (T1) & the outlet port (T2) which is on the
suction side of the pump (S) & thus keeps the oil super cool even when the pump is operating continuously on load. The water can be mixed with anti-freezing materials so as to enable the use in colder surroundings. Additionally the water is added with anti-rust.

The rate of evaporation can be increased either by keeping the top open by opening the top door (3) or having a small 12 V Dc exhaust Fan fitted into the top door to have higher movement of water molecules on the top of the water surface.

Further it is important to note here that the shape & size of the said tubes passing through the oil compartment do not in any way restrict the scope of this invention and the tubes can be made of any size & shape. The important thing is that the return oil is made to travel through a water compartment wherein the said water is static & cooling takes place due to conduction which causes the oil to lose its heat to water increasing the rate of evaporation of water & in process cooling the oil further. This is because of the fact that the higher the rate of evaporation, higher cooling can be achieved. The energy required for evaporation is taken from the stock of water and hence the stock of water is cooled.

[008] TECHNOLOGICAL ADVANTAGES & ECONOMIC SIGNIFICANCE: As mentioned above, the optimized invention brings down the capital cost of concrete pumps by huge margin and provides similar and even better features at a very low cost than majority of the presently available twin cylinder concrete pumps.

1. The invention can now develop very high pressures on concrete even by using a low pressure drive fluid available from still cost-effective options such as gear pumps.

2. The flow requirements are still kept at minimum due to use of the short stroke length of single concrete pumping cylinder which is typically & essentially less than four times of the diameter of concrete piston; it compensates for the higher swept volumes due to larger area hydraulic piston (5A).

3. An off-center rotary gate valve (8) brings down the power requirement for the valve actuation apart from offering many other advantages; which makes the complete pump operable by low pressure hydraulic fluid.

4. The invention can now be easily adopted on various equipment wherein these equipment are having their hydraulic circuits driven by low pressure hydraulic
fluid typically having pressures below 250 bar & displaced by a simple gear pump.

5. The said invention can generate very high pressures on concrete when a high pressure fluid is used for its operation this can result in making very big pumps domestically without any import content.

6. The above mentioned improvements make the invention a very light weight and highly compact equipment especially due to its short stroke-length & single cylinder design, it can now be very easily adopted without its drive mechanism to various equipment such as tractors, commercial vehicles, loader-backhoes, skid steers & excavators and can be operated by the low pressure drive fluid already available in the drive mechanisms of these equipment.

7. The above improvements make the invention use bigger diameter pumping cylinders due to the large diameter hydraulic drive piston (5A). Which results in higher output & optimum suction especially because of the short stroke lengths, thereby reducing the per cubic meter cost of pumping of concrete & increasing the volumetric efficiency of the concrete pump.

8. The above improvement also enables the end user to use compressed air or even water to operate similar pumps having small diameter pumping cylinders however the drive cylinder piston (5A) used in such an embodiment may have bigger diameters and higher swept volumes.

9. The above optimization, enables the said concrete pump without its drive mechanism to be installed on a three point hitch of a tractor wherein the said concrete pump can now be installed in such a way that the longitudinal axis of the concrete pump is perpendicular to the axis of the tractor & the weight of the said basic concrete pump unit is less than 500 Kg without considering the weight of oil tank & cooler.

10. The optimization enables the said concrete pump without its drive mechanism to be installed on the rear of a commercial vehicle in such a way that the longitudinal axis of the said concrete pump is perpendicular to the longitudinal axis of a commercial vehicle and the weight of the said concrete pump is less than 500 kg.

11. The said optimized concrete pump can now be effectively operated & is able to generate high concrete pressure by low pressure drive fluid made available from the existing circuit of loader-backhoes.
12. The said optimized pump is made now so compact due to its short stroke-length, that it could be accommodated in the loader bucket of a loader backhoe enabling greater flexibility at site.

13. The use of hydraulic tank as an evaporative cooler brings a huge cost reduction as water is available at a construction site & the said cooler does not require a continuous circulation & hence does not require continuous power input. Further a temperature drop of 25-30 deg Celsius, ensures a very efficient working in very hot weather conditions at a very low input cost.
WE CLAIM:

1. In accordance with the present invention, "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" is disclosed wherein the invention is an optimized concrete pump which typically & essentially comprises of:

a. A single concrete pumping cylinder (7) provided with a stroke-length typically & essentially less than four times of the diameter of the concrete piston (6) driven by a single hydraulic cylinder (5) having a single Hydraulic piston (5A) wherein the cross-sectional area of the hydraulic piston (5A) is not less than one third of the cross-sectional area of the said concrete piston (6).

b. A self-regulating hydraulic circuit for operation of the said invention provided with a hydraulic tank with a high volume static water compartment with a drain valve wherein the hydraulic tank itself is used as an evaporative cooler & the water volume is in multiples of the quantity of hydraulic oil. Alternatively a separate cooler is provided having a high volume static compartment for water with a drain valve, wherein the water can be drained after getting hot simply by opening the drain valve.

c. A rotary gate valve (8) wherein the valve body center is off-set with respect to the pumping cylinder & the delivery pipe which are co-axial which reduces the resistance & reduces the power required to operate the said gate valve.

d. A low pressure drive fluid displaced by a variety of means such as but not limited to a plurality of forcefully operated hydraulic cylinders; alternatively a single hydraulic cylinder is used to have only one mode of operation as disclosed in the earlier applications.

e. A low pressure drive fluid alternatively displaced from a plurality of back to back mounted independent gear pumps; typically a single gear pump is used to have only one mode of operation.

f. A BY-PASS mechanism for minimum one source of fluid power wherein the low pressure fluid is typically & essentially allowed to go back to tank without doing any work so as to have various modes of operation within the energy conservation law & the said by-pass mechanism is provided with manual as well as automatic actuation.
2. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, is a concrete pump typically & essentially provided with a combination of a single pumping cylinder (7) having a stroke-length less than four times of the diameter of the rubber concrete piston (6) & a hydraulic drive piston (5A) having a cross-sectional area not less than one third of the cross-sectional area of the said rubber concrete piston (6).

3. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, is an improved concrete pump typically & essentially provided with a single pumping cylinder (7) having stroke-length less than four times of the diameter of the rubber concrete piston (6) & the said rubber concrete piston (6) mounted on the shaft of a hydraulic piston (5A) wherein the hydraulic piston (5A) is typically & essentially driven by a low pressure drive fluid.

4. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump which is provided with a Single concrete pumping cylinder (7) driven by a single Hydraulic cylinder (5) by means of a low pressure fluid displaced by a typical gear pump & the stroke-length of the said pumping cylinder is less than four times of the diameter of the concrete piston (6).

5. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described in claim 1, wherein the said invention is a concrete pump which is typically & essentially provided with a single concrete pumping cylinder (7) which is co-axial with the delivery pipe & the stroke-length of the said concrete pumping cylinder (7) is typically & essentially less than four times of the diameter of the concrete piston (6).

6. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a high pressure concrete pump having a single pumping cylinder (7) which is typically & essentially operated by a low pressure fluid typically below 250 bar, alternatively displaced by a variety of sources of fluid power such as but not limited to a forcefully operated hydraulic cylinder.

7. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially provided with a single concrete pumping cylinder (7) wherein the said single pumping cylinder (7) is provided with a
rotary gate valve having a valve body (9) off-set from the axis of the pumping Cylinder (7) which is co-axial with the delivery pipe.

8. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a high pressure concrete pump having a single concrete pumping cylinder (7) which is alternatively combined with plurality of identical units to have a multi cylinder concrete pump driven by a single fluid power source wherein the stroke-length of each pumping cylinder is less than four times of the diameter of the concrete piston (6).

9. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump made operable by low pressure hydraulic circuits of existing equipment driven by gear pumps such as but not limited to tractors, loader-backhoes, skid steers, commercial vehicles, etc by typically & essentially having a single concrete pumping cylinder (7) of stroke-length less than four times of the diameter concrete piston (6) compensating for the swept volume resulted by having a large diameter hydraulic piston (5A) having a cross-sectional area not less than one third of the cross-sectional area of the said concrete piston(6).

10. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump having a single concrete pumping cylinder (7) of stroke-length less than four times of the diameter of the concrete piston (6) & the said concrete piston (6) is driven by a hydraulic piston (5A) which has a cross-sectional area not less than one third of the said concrete piston (6) and the hydraulic piston is alternatively operated by means of fluid displaced by hydraulic pumps attached to the power take offs of various commercial vehicles.

11. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump having a single pumping cylinder (7) of stroke-length less than four times the diameter of the concrete piston (6) driven by a hydraulic piston (5A) having a cross-sectional area not less than one third of the cross-sectional area of the concrete piston (6) wherein the drive fluid is provided from a fixed displacement fluid source.

12. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically having Single concrete pumping cylinder (7)
of stroke-length less than four times of the diameter of the concrete piston (6) & a hydraulic drive piston(5A) having a cross-sectional area not less than one third of the cross-sectional area of the said concrete piston(6); and the concrete pump is alternatively used to develop very high pressures on concrete when supplied with high pressure hydraulic fluid.

13. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) and a single hydraulic cylinder (5) where the cross-sectional area of the hydraulic piston (5A) is typically & essentially not less than one third of the cross-sectional area of the concrete piston (6).

14."An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically having Single concrete pumping cylinder (7) of stroke-length less than four times of the diameter of the concrete piston (6) & a hydraulic drive piston(5A) having a cross-sectional area not less than one third of the cross-sectional area of the said concrete piston(6); and the said concrete pump is alternatively provided with a slide gate valve.

15"An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) driven hydraulically by a plurality of independent fixed displacement fluid sources wherein the said pump is provided a mechanism to cut off the flow of any fluid source resulting in plurality of modes of operation in terms of pressure on concrete & output of concrete.

16. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically having a Single concrete pumping cylinder (7) of stroke-length less than four times of the diameter of the concrete piston (6) & a hydraulic drive piston(5A) having a cross-sectional area not less than one third of the concrete piston(6); and the concrete pump is alternatively provided with a quick coupling attachment so as to receive fluid power from a variety of external sources.

17. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping
cylinder (7), wherein the said concrete pump is typically & essentially adopted on a three point hitch of a tractor wherein the longitudinal axis of the said pump is perpendicular to the axis of the tractor.

18. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) having a stroke length less than four times of the diameter of the concrete piston(6) wherein the said concrete pump is typically & essentially adopted on the rear of a commercial vehicle & the longitudinal axis of the concrete pump is perpendicular to the longitudinal axis of the said commercial vehicle.

19. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) having its stroke-length less than four times that of the diameter of the concrete piston (6) wherein the said concrete pump is adopted to the rear of a commercial vehicle & the longitudinal axis of the said pump is parallel to the longitudinal axis of the said commercial vehicle.

20. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) having its stroke-length less than four times that of the diameter of the concrete piston (6) & the said concrete pump is provided with a rotary gate valve.

21. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) having its stroke-length less than four times that of the diameter of the concrete piston (6) driven by a hydraulic piston (5A) typically & essentially having a cross-sectional area not less than one third of the cross-sectional area of the said concrete piston (6) And the said concrete pump is alternatively driven by a variable displacement pump so as to have higher fuel economy.

22. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a high pressure concrete pump alternatively provided with a low pressure fluid such as but not limited to hydraulic fluid, water & air, wherein the said pump is made operable by such a low pressure fluid by having a single pumping cylinder
(7) of stroke-length less than four times the diameter of the concrete piston (6) and the cross-sectional area of the said hydraulic piston (5A) is higher than the cross-sectional area of the rubber piston (6).

23. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a high pressure Single cylinder concrete pump alternatively made operable by the low pressure drive fluid from an existing circuit of a loader-backhoe machine wherein the said single concrete pumping cylinder (7) has a stroke-length less than four times of the diameter of the concrete piston (7) driven by a hydraulic piston (5A) having a cross-sectional area not less than one third of the cross-sectional area of the said concrete piston (7).

24. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a high pressure Single cylinder concrete pump alternatively accommodated in the loader bucket of a loader-backhoe machine wherein the said pump typically & essentially has a single concrete pumping cylinder having stroke-length less than four times the diameter of the concrete piston (7).

25. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) having its stroke-length less than four times that of the diameter of the concrete piston (6) & the said concrete pump is provided with a slide gate valve.

26. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having a single concrete pumping cylinder (7) having its stroke-length less than four times that of the diameter of the concrete piston (6) & the said concrete pump is typically & essentially driven by a fixed displacement fluid power source.

27. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) having its stroke-length less than four times that of the diameter of the concrete piston (6) & the said concrete pump is typically & essentially provided with a plurality of fixed displacement fluid power sources.
28. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having a Single concrete pumping cylinder (7) driven by a single hydraulic cylinder (5) wherein the said concrete pump is provided with an self-regulating hydraulic circuit comprising of two separate solenoid operated directional control valves each operating the said single hydraulic cylinder (5) & the gate cylinder (10) respectively.

29. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is an optimized concrete pump typically & essentially having a Single concrete pumping cylinder (7) housing a single concrete piston (6) wherein the said single concrete pumping cylinder has a stroke-length less than four times of the diameter of the said concrete piston (6).

30. "An optimized Single cylinder Concrete pump with automatic & manual By-Pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) wherein the said concrete pump is provided with a minimum two fixed displacement fluid power sources out which one is unloaded when required thereby having two separate modes of operations.

31. "An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially having Single concrete pumping cylinder (7) wherein the said concrete pump is provided with a hydraulic tank having minimum one compartment for holding static water, wherein the said water compartment is provided with a drain valve.

32. "An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially provided with evaporative oil cooler which has a water compartment sandwiched between two oil compartments joined together by means of tubes wherein the water volume is in multiples of the volume of hydraulic oil & the said water compartment is provided with a drain valve.

33. "An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump alternatively provided with a separate evaporative cooler.
where the heat of hydraulic oil is passed on to a static water storage & the cooling of oil is achieved when the water is allowed to evaporate to atmosphere.

34. "An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially driven by fixed displacement fluid power sources wherein minimum one fluid power source is unloaded automatically by alternatively using a typical unloading circuit using an unloading valve.

35. "An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially provided with a hydraulic tank having minimum one inbuilt water compartment wherein the total water storage volume is in multiples of the hydraulic oil volume & has a filling plug to add cold water & a drain valve to drain hot water.

36. "An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially with an evaporative cooler having a static storage of water and the water is allowed to evaporate at normal rate; alternatively the rate of evaporation of water is increased by having a small FAN fitted in the top door of the said water compartment.

35. "An Optimized single cylinder concrete pump with automatic & manual By-pass mechanism & evaporative oil cooler" as described by claim 1, wherein the said invention is a concrete pump typically & essentially provided with a water storage (w) through which the return oil is passed so as to take away the heat & the said water storage is provided with a filling pipe to add cold water & a drain valve to drain hot water.
FIG. NO. 5
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
F04B 1/00, E04G 2/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B*

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Patsearch, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CN201074574 Y (ZHENGZHOU ZHIXIN MECHANICAL) Published on 18 June 2008. Claim 8, figure 8, Embodiment 1 Para 2-3</td>
<td>1-35</td>
</tr>
<tr>
<td>A</td>
<td>IN-MUM-2 015-0168 5 A (AMIT ARUN GOKHALE IN, ARUN ARUN GOKHALE) Published on 04 November 2016. Abstract</td>
<td>1-35</td>
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</table>

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search 31-07-2017
Date of mailing of the international search report 31-07-2017

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