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(54) **ENERGY REDUCTION PROCESS AND INTERFACE FOR OPEN OR CLOSED LOOP FLUID SYSTEMS WITH OR WITHOUT FILTERS**

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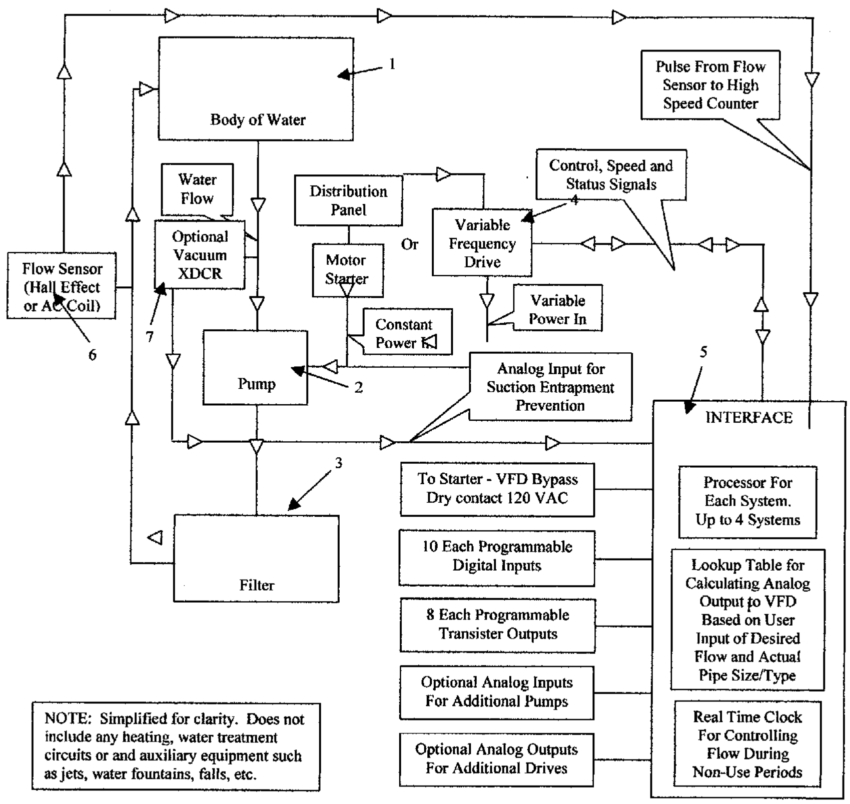
(57) **ABSTRACT**

A Process and Interface to reduce the energy required to operate a swimming pool pump. The process improves the conventional process by causing the pump to vary its operation based on variable filter loading conditions. The process uses a flow sensor to send a signal to the interface which then signals a variable frequency drive to increase or decrease the speed of the pump motor in compliance with user programmed flow. The pump operates at reduced energy until the filter load increases due to captured debris. As the filter load increases, the pump speed increases.

Improved Swimming Pool Process



Improved System Operational Standards:

1). Pump is variable speed (dynamic operation).
2). Filter load varies as it gets dirty (dynamic operation).
3). Pump performance (flow) is relatively constant as filter load changes.
4). With a clean filter (low TDH) pump operates at lower speed and in the preferred portion of the performance curve eliminating cavitation damage.
5). With a dirty filter (high TDH) flow can be maintained at or above statutory requirements.

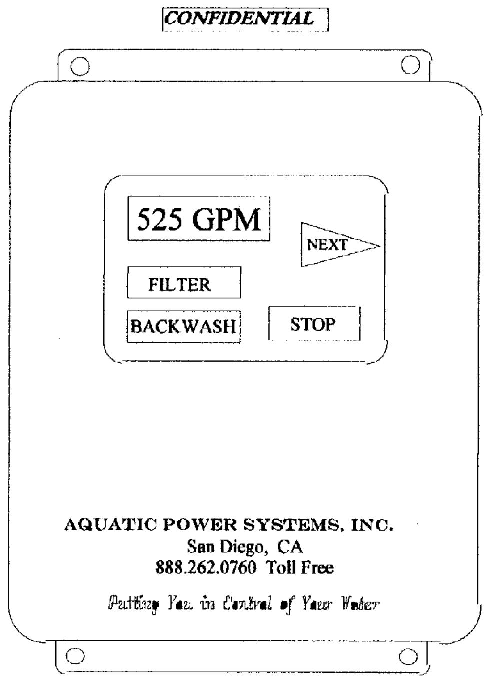


Figure 1

Figure 1 illustrates a concept of the front of the interface. The interface may have a touch screen as shown or could have an LCD display with operation keys mounted below. It will be housed in a nonmetallic NEMA 4 enclosure, approximately 8" high by 6" wide by 4" deep.

All inputs and outputs will be low voltage or analog entering the enclosure through watertight cord grips.

Power will come from a UL listed 120 VAC to 24 VDC power supply incorporated into the enclosure.

Figure 2

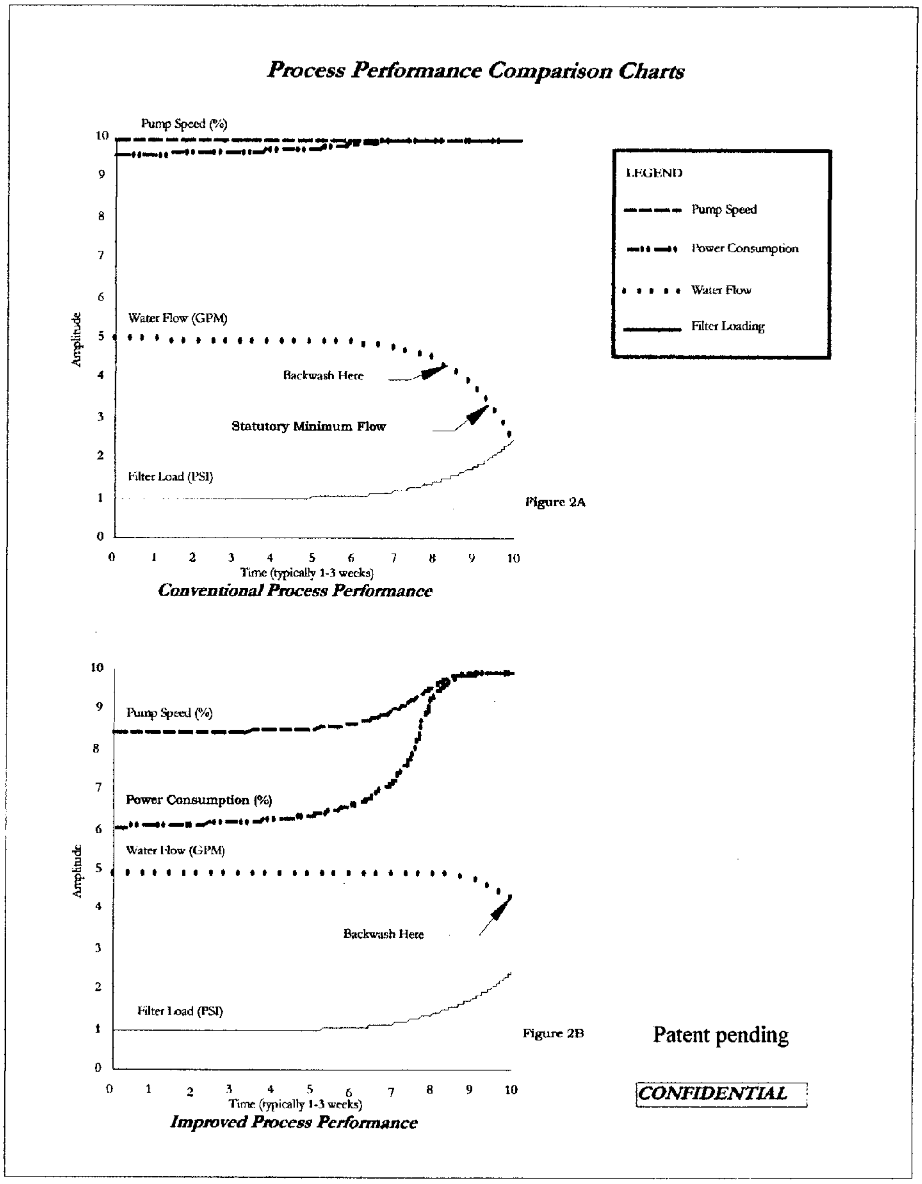
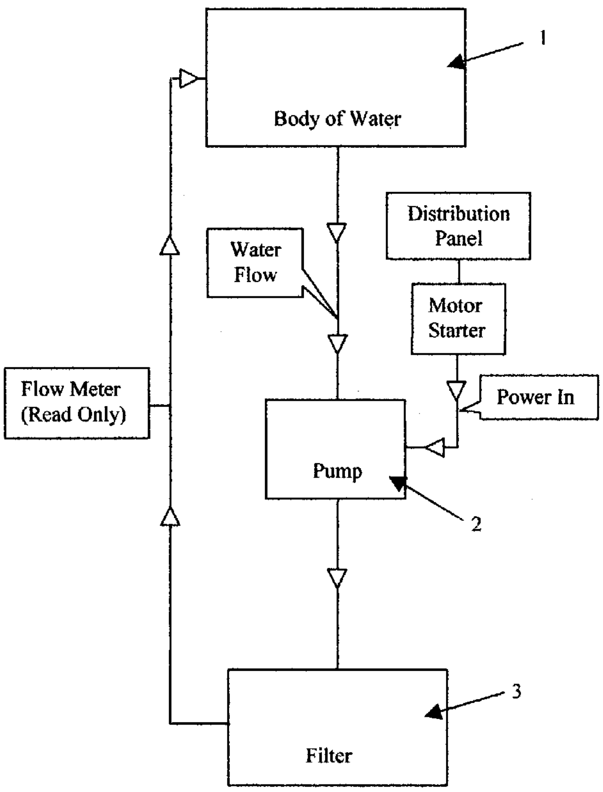


Figure 2A illustrates the performance of the conventional process and Figure 2B illustrates the performance of the improved process. The graphs show the relative comparison. In the conventional process, as the filter load increases, the flow decreases, but the pump speed and energy consumption remain relatively constant. In the improved process, pump speed starts off lower and increases as the filter load increases while the flow remains relatively constant. In the improved process, the % load equals the cube of the % speed (90% speed = 72.9% load). The effect is that the pump performance curve dynamically changes to meet the dynamic changes in the filter demand. Beyond the energy reduction, the cavitation at low TDH is eliminated.

Figure 3

Conventional Swimming Pool Process



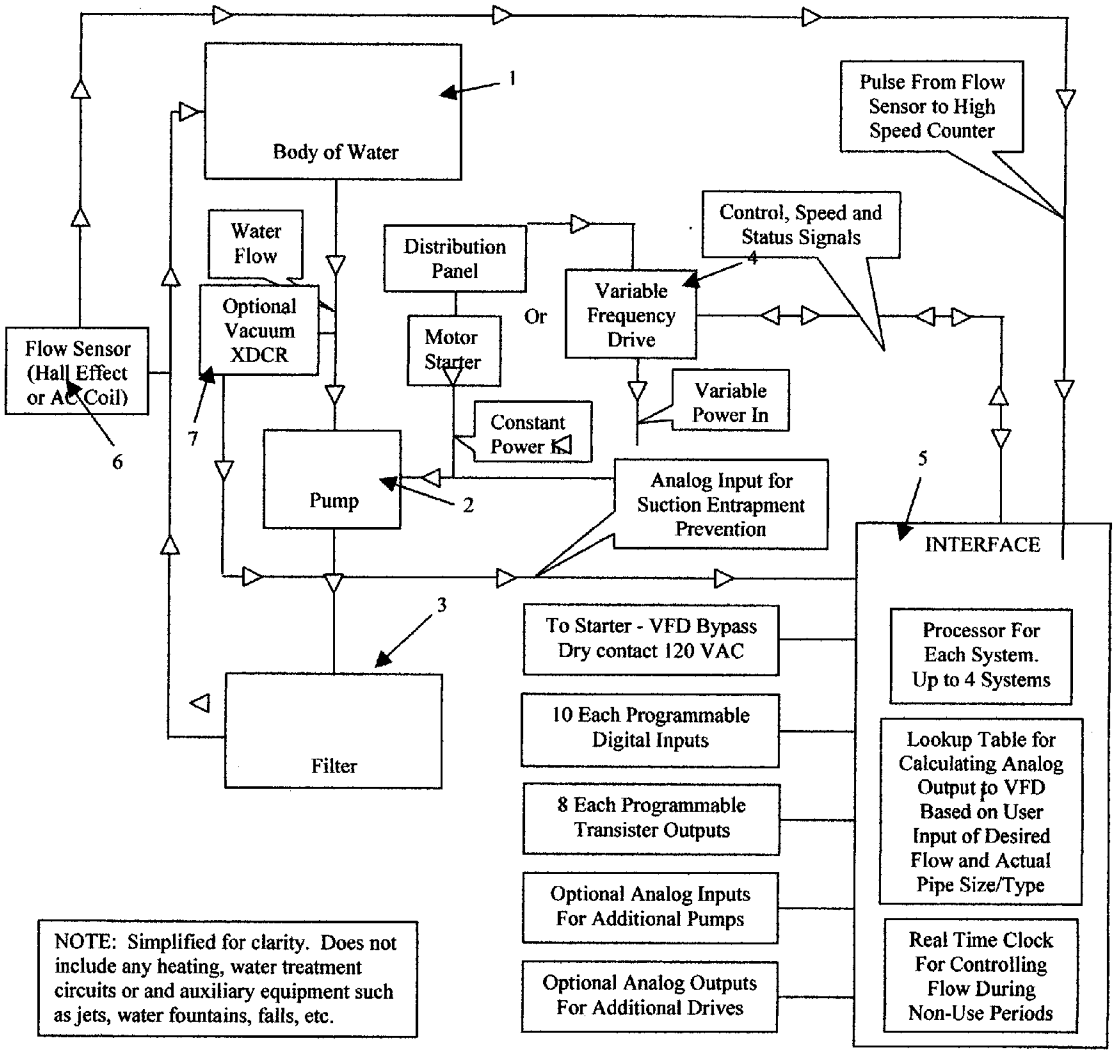
NOTE: Simplified for clarity. Does not include any heating, water treatment circuits or and auxiliary equipment such as jets, water fountains, falls, etc.

Conventional System Operational Standards:

1). Pump is fixed speed (static operation).
2). Filter load varies as it gets dirty (dynamic operation).
3). Pump performance (flow) varies as filter load changes.
4). With a clean filter (low TDH) pump operates at the extreme of its performance curve causing cavitation damage.
5). With a dirty filter (high TDH) flow may be diminished below statutory requirements.

Figure 4

Improved Swimming Pool Process



Improved System Operational Standards:

1). Pump is variable speed (dynamic operation).
2). Filter load varies as it gets dirty (dynamic operation).
3). Pump performance (flow) is relatively constant as filter load changes.
4). With a clean filter (low TDH) pump operates at lower speed and in the preferred portion of the performance curve eliminating cavitation damage.
5). With a dirty filter (high TDH) flow can be maintained at or above statutory requirements.

ENERGY REDUCTION PROCESS AND INTERFACE FOR OPEN OR CLOSED LOOP FLUID SYSTEMS WITH OR WITHOUT FILTERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Provisional Patent Application No. 60/373,555

[0002] Title: Energy Reduction Process and Interface for Open or Closed Loop Water

[0003] Systems With or Without Filters

[0004] Filing Date: Apr. 18, 2002

[0005] Relationship: Provisional Patent Application filed preceding this Utility Patent Application

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0006] Not Applicable

REFERENCE TO SEQUENCE LISTING, A TATBLE, OR A COMPUTER PROGRAM LISTING COMPACT DISK INDEX

[0007] Not Applicable

BACKGROUND OF THE INVENTION

[0008] This invention pertains to the field of pumping fluids. While this process and interface can be used on a variety of applications, a commercial swimming pool is the clearest example of the use and will be used for this specification. The use of swimming pools as an example is strictly for illustration purposes only and should not be construed as to limit the use of this invention to swimming pools.

[0009] The conventional process for circulation swimming pool water has been used for decades without improvement. It uses a "static" element—the pump to push or pull water through a "dynamic" element—the filter. This process has several inherent faults. There is cavitation damage to the pump components when the filter is clean. The pump cannot maintain statutorily required flows if the filter is allowed to collect the amount of debris it is designed for. Since the filter cannot collect enough debris, larger particulate matter passes through the filter. Filters must be back washed more frequently, wasting water, chemicals and heat. Pump motors operate at full speed continuously, wasting electricity.

[0010] The invented improved Process addresses every one of these faults. Cavitation damage caused by low head pressure is eliminated. Pumps can be sized to maintain flows for longer periods of time allowing the filter to capture more debris. Filters can operate longer in between back-washes saving water, chemicals, heat and labor. Pump motors operate at minimum required speed to achieve desired flow, saving energy,

[0011] Conventional commercial swimming pool systems circulate water from the pool through one of several types of filters and back to the pool using one or more centrifugal pump(s) operating at one speed (**FIG. 3**). As the filter collects debris, the Total Dynamic Head (TDH) of the system increases and eventually the flow decreases. After the filter is cleaned, the TDH is reduced again and the cycle starts over. The filter cycle generally repeats itself once every 1-30 days based on the filter type, filter size, the debris and the velocity of water through the filter. The filter, then, is a dynamic part of the system. The pump, on the other hand, runs at a constant speed with a constant operational curve. This makes the pump a static part of the system (**FIG. 2A**).

[0012] It is generally accepted in the industry that a filter's influent pressure should be allowed to increase by 12-15 PSI to achieve the best filtration. This calculates to an increase of 28-35 Feet of Head (FOH). This dynamic change to the hydraulic characteristics of the system causes the pump to have to operate at or beyond its efficiency range. A pump operating against low TDH (clean filter) can cause damage to the internal components as cavitation occurs. A pump operating against high TDH (dirty filter) results in reduced water flow. Often the flow becomes unacceptably low before the filter reaches its best filtering capability.

[0013] Consequently, the conventional process of circulating commercial swimming pool water either sacrifices filtration capability or accepts physical pump damage. A pump sized to deliver adequate flow with a dirty filter will experience cavitation with a clean filter. A pump sized to minimize cavitation when the filter is clean cannot produce enough flow when the filter is dirty.

BRIEF SUMMARY OF INVENTION

[0014] The invention is a process and interface that causes the pump to dynamically respond to the change in system hydraulic characteristics that occurs during the filter cycle (**FIG. 4**). This process allows the pump to operate without cavitation (caused by operating at an inefficient area of the pump performance curve) when the filter is clean (low TDH) and to have the ability to produce adequate flow with a dirty filter (high TDH).

[0015] In addition to minimizing damage and maximizing flow throughout the filter loading cycle, the process and interface will reduce energy consumption by 30% or more. The interface directs the pump motor to operate at the minimum speed required to achieve the desired water flow. As the TDH increases, the speed increases (**FIG. 2B**). In addition, the interface can be programmed to reduce the speed during non-use periods automatically. This results in dramatic energy savings during those periods. The new percentage of energy consumed is the cube of the new speed (example–90% speed=73% energy used).

[0016] Moreover, the pump can be sized for a slower filtration rate while having the capability to attain sufficient flow to adequately backwash the filters. Sand filters require 15 GPM/SF for proper backwash (cleaning). However, filters remove smaller particulates with a slower filter rate (10 GPM/SF). This invention allows the optimum performance for all states of the filter cycle.

[0017] The Process and Interface allows the normally static pump to respond dynamically to the variable load inherent to filter circulation systems. In essence, the pump curve is changed to accommodate the TDH during all phases of the filter loading period. When the filter is clean, the pump speed is low. As the filter gets dirty, the pump speeds up automatically as required to maintain programmed flow.

Conventional Process	New Process
Pump is static	Pump is dynamic
Flow decreases as filter gets dirty	Flow remains constant as filter gets dirty
Maximum energy consumed	30% or more energy reduction
Pump operates outside of design parameters	Design parameters change as needed
Cavitation damage at low TDH	Eliminates cavitation at low TDH
	Increased pump life (no cavitation)
	Increased motor life
	Quieter motor/pump operation
	Decreased maintenance costs

[0018] This new process and interface radically modifies and improves the traditional process of circulating water through a filter. The process improves filtering capability, lengthens pump and motor life, reduces maintenance, eliminates cavitation due to oversized pumps (low TDH), minimizes physical damage to pumps, increases time between backwashes, allows proper backwash rate (12-15 GPM/SF) even if the pump is to small (in some cases the pump can be operated above 60 Hz for a short period of time) or too large and allows for "Idle" flow during non-use periods. The process and interface does all this while reducing the energy consumption by 30% or more. Optionally, the system can provide a layer of suction entrapment prevention (statutorily required) can initiate an automatic backwash process and can perform other programmable functions.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0019] **FIG. 1**: A concept of the front panel of the interface. The interface may have a touch screen as shown or could have an LCD display with "soft keys" mounted on the outside of the enclosure. The housing is non-metalic NEMA 4, approximately 8"×6"×4"

[0020] **FIG. 2**: Process Performance Comparison Charts. **FIG. 2A** illustrates the performance of the conventional process and **FIG. 2B** illustrates the performance of the improved process. The graphs show the relative comparison. In the conventional process, as the filter load increases, the flow decreases, but the pump speed and energy consumption remain relatively constant. In the improved process, pump speed starts off lower and increases as the filter load increases while the flow remains relatively constant. In the improved process, the % load equals the cube of the % speed (90% speed=72.9% load). The effect is that the pump performance curve dynamically changes to meet the dynamic changes in the filter demand. Beyond the energy reduction, the cavitation at low TDH is eliminated.

[0021] **FIG. 3**: Conventional Swimming Pool Process Block Drawing. This drawing shows the major components of a conventional swimming pool circulation process.

[0022] **FIG. 4**: Improved Swimming Pool Process Block Drawing. This drawing shows the major components of the improved swimming pool circulation process.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The first component of the invented Process and Interface is the interface. The following specifications detail the interface and its operation.

[0024] Interface Specifications

[0025] Interface shall be housed in a NEMA 4× non-metallic enclosure.

[0026] User accessible parameters shall be accessed from the outside of the enclosure via a touch screen pad or buttons with a LCD display.

[0027] User shall be able to initiate Run, Stop, VFD Bypass, In-Use Filter, Non-Use Filter, Backwash and Idle commands from front access.

[0028] Interface shall generate variable analog speed control signal to direct VFD.

[0029] Variable analog signal shall be derived from user input of desired GPM and pipe size/type based on a lookup table of "K Factors".

[0030] The processor will compare the desired flow with the actual flow signal received from the flow sensor input and either increase or decrease the analog speed control signal to the VFD if there is an error between the actual and calculated flow.

[0031] The variable analog output shall default to a user programmable amplitude in the event of loss of flow sensor signal.

[0032] Interface shall have individual programmable flow set points for In-Use Filter, Non-Use Filter, Backwash and Idle Modes.

[0033] The user shall be able to program individual start and stop times for each different Mode.

[0034] Interface shall have a Real Time Clock with battery backup to program Mode actuation.

[0035] Interface shall allow for an optional analog input from a vacuum transducer to actuate a Suction Entrapment Prevention subroutine that will issue a stop command to the VFD in the event of sudden increase in vacuum.

[0036] Interface core programming shall be either PLC resident or printed circuit card chip resident.

[0037] Interface shall easily provide for software upgrades via modem or serial port.

[0038] Interface shall indicate status for Run, Ready, Stop, In-Use Filter, Non-Use Filter, Backwash, Idle, VFD Bypass and Flow (in GPM).

[0039] Alarm indications for Loss of Sensor and Suction Hazard.

[0040] Improved Basic Operation

[0041] User programs pipe size/type and desired GPM.

[0042] User programs Mode times.

[0043] Processor determines calculated frequency of pulses for each Mode.

[0044] User selects Start.

[0045] Processor sends Run command to VFD.

[0046] Processor sends analog speed signal to VFD.

[0047] As calculated flow frequency is approached, processor slows analog signal change.

[**0048**] When actual pulse frequency equals calculated pulse frequency, processor stops changing amplitude of analog speed signal.

[**0049**] In the event of error between actual and calculated frequencies, processor inversely adjusts amplitude of analog speed signal to compensate.

[**0050**] For each selected Mode, processor shall adjust amplitude of analog speed signal to accommodate that Mode's calculated frequency.

[**0051**] The In-Use Filter and Non-Use Filter Modes shall be programmable to occur at specified times. The Modes shall change automatically. The user shall be able to manually change these Modes.

[**0052**] The Interface is depicted in **FIG. 1**. This is a concept view only to illustrate the general appearance of the interface. The invention is the function of the Interface and not the form of the Interface. The function of the interface is to receive user input specific to his application, monitor performance of the pump by way of flow feedback and adjust the performance of the pump to achieve the user's input. The Interface directs the Variable Frequency Drive (VFD) to send the minimum amount of power required for maintaining the programmed flow to the pump motor. The output of the Interface varies as the flow input signal varies in response to changes in the filter load. The output also varies per the timing on the program.

[**0053**] The invented Process is an improvement over the conventional process. The improved performance is illustrated in **FIG. 2**. The process is improved over the old process by making the pump act dynamically in response to changes in the dynamics of the filter due to debris captured in the filter. **FIG. 2A** (conventional process) depicts a reduced water flow corresponding to an increased filter load using constant speed and fairly constant energy. **FIG. 2B** (invented improved process) depicts fairly constant flow even with an increased filter load using variable speed and reduced energy consumption at low filter load.

[**0054**] **FIG. 3** shows the elements of a conventional swimming pool circulation process. This process has been used for decades without improvement. Water is draw from a basin **1** by a pump **2** operating at full speed. It is pushed or pulled through a filter **3** and returned to the basin **1**.

[**0055**] **FIG. 4** shows the elements of the invented improved swimming pool circulation process. Water is still drawn from a basin **1** by a pump **2**, pushed or pulled through a filter **3** and returned to the basin **1**. However, the pump speed is controlled by Variable Frequency Drive (VFD) **4**. The VFD gets its signal from the invented Interface **5**. The Interface adjusts the signal up or down based on feedback from the Flow Sensor **6** compared to the desired flow inputted by the user.

[**0056**] The Flow Sensor sends a specific number of pulses per gallon of water depending on the size of the pipe. The pipe size is inputted to the Interface by the user. The Interface has a lookup table with the number of pulses per gallon for each pipe size. The Interface calculates the number of pulses it expects for the flow desired by the user. In the event the Interface receives too many pulses, the Interface reduces the output signal to the VFD. With too few pulses, the Interface increases the output the VFD.

[**0057**] The interface can also receive a signal from a vacuum transducer **7** to interpret the occurrence of suction entrapment. The interface monitors the signal form the transducer. In the event of a sudden increase in signal, the interface issues an emergency shutdown to the VFD.

What is claimed is

1). An energy reduction process for swimming pool circulation systems having a pump, filter, flow sensor, variable frequency drive and interface comprising:

a flow sensor located away from the interface; and

a signal cable to connect said flow sensor with said interface, wherein;

said interface receives a signal from said flow sensor;

said interface has a program to interpret said signal; and

said program will compare said signal to program parameters; and

a signal cable connecting said interface with said variable frequency drive; wherein;

said interface program sends a signal to said variable frequency drive to control the functions of said pump, therefore;

said pump operates using the minimum energy required throughout the loading cycle of said filer.

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