Title: MAGNETIC SEPARATOR COMPRISING A FLEXIBLE MEMBER

Abstract: A fluid circulation system for circulating an amount of fluid between heat exchangers through a circulation circuit, the fluid circulation system comprising a magnetic separator 1, 101, 201 including: a collection chamber 3, 03, 203 having an inlet 5, 105, 205 for receiving a flow of fluid susceptible of containing suspended particles 21, 121 having ferromagnetic properties and an outlet 7, 107, 207 for allowing the fluid to flow out of the collection chamber; a fluid flow path defined between the inlet and the outlet, including an interior 9, 109, 209 of the collection chamber; a substantially tubular sleeve 11, 111, 211 positioned in the fluid flow path interiorly of the collection chamber, the substantially tubular sleeve having a fluid tight interior; a magnet device 13, 13, 213 accommodated within the fluid tight interior of the substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve. The magnet device is adapted for translatory movement along a predefined first path 16A, 116A, 216A in a first sense in the substantially tubular sleeve. The magnetic separator further includes a substantially elongate flexible member 19, 119, 219 having a first end 19A, 119A, 219A attached to the magnet device and a second end 19B, 19B, 219B extending externally of the substantially tubular sleeve, the second end of the flexible member being arranged to be subjected to an actuating movement along a second path 16B, 116B, 216B in a second sense so as to actuate the translatory movement of the magnet device.

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Title: Magnetic separator comprising a flexible member

The invention relates to a magnetic separator and a method for separating particles having ferromagnetic properties from a fluid. The invention also relates to a magnetic separator for a fluid circulation system for circulating an amount of fluid, susceptible of containing suspended particles having ferromagnetic properties. More in particular, the invention relates to a magnetic separator for a fluid circulation system for circulating an amount of fluid between heat exchangers, such as a heating or cooling system.

It is known to provide fluid circulation systems with a magnetic separator to collect ferromagnetic particles from a fluid flow that is susceptible to contain such particles in suspension. Fluid circulation systems, especially heating and cooling systems, generally make use of large complex networks of pipes, valves, and heat exchangers. Incorporating magnetic separators into these complicated systems is not trivial, and typically leads to confined installations making operation of the magnetic separator difficult.

Accordingly, it is an object of the present invention to propose a magnetic separator that is simple and reliable to operate and only requires a minimum of space. More in general, it is an object of the present invention to propose an improved magnetic separator for a fluid circulation system for circulating an amount of fluid that is susceptible of containing suspended particles having ferromagnetic properties. In a more general sense, it is thus an object of the invention to overcome or ameliorate at least one of the disadvantages of the prior art. It is also an object of the present invention to provide alternative structures which are less cumbersome in assembly and operation and which moreover can be made relatively inexpensively.

Alternatively, it is an object of the invention to at least provide the public with a useful choice.

To this end, the invention provides a magnetic separator for collecting particles having ferromagnetic properties comprising a magnet
device and a substantially elongate flexible member for releasing the collected particles. The magnet device is adapted for translatory movement along a predefined first path in a first sense by the flexible member having a first end attached to the magnet device. The flexible member has a second end extending externally of the magnetic separator. The second end of the flexible member being arranged to be subjected to an actuating movement along a second path in a second sense so as to actuate the translatory movement of the magnet device. Such a magnetic separator is simple to operate, and owing to the flexible member, provides operational flexibility in what is typically a confined working environment.

It is yet another object of the present invention to provide a fluid circulation system for circulating an amount of fluid between heat exchangers through a circulation circuit, the fluid circulation system comprising a magnetic separator including: a collection chamber having an inlet for receiving a flow of fluid susceptible of containing suspended particles having ferromagnetic properties and an outlet for allowing the fluid to flow out of the collection chamber; a fluid flow path defined between the inlet and the outlet, including an interior of the collection chamber; a substantially tubular sleeve positioned in the fluid flow path interiorly of the collection chamber, the substantially tubular sleeve having a fluid tight interior; a magnet device accommodated within the fluid tight interior of the substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve. The magnet device is adapted for translatory movement along a predefined first path in a first sense in the substantially tubular sleeve. The magnetic separator further includes a substantially elongate flexible member having a first end attached to the magnet device and a second end extending externally of the substantially tubular sleeve, the second end of the flexible member being arranged to be subjected to an actuating movement along a second path in a second sense so as to actuate the translatory movement of the magnet device. Such a circulation system is
simple to operate via the flexible member. Furthermore, the flexible member provides operational flexibility in what is typically a confined working environment. Generally the fluid circulation system may be configured as a heating or cooling system.

Optionally, the second path is substantially different from the first path. Optionally, the second path is substantially perpendicular to the first path. In normal installations, when the second path is substantially different from the first path, the magnetic separator can be easily operated in an area not conflicting with ancillaries of the magnetic separator. In some installations, it may be advantageous that the second path is substantially perpendicular to the first path. Optionally, the second path is substantially parallel to and offset laterally from the first path. Optionally, the second sense is opposite to the first sense. This may be desirable for severely cramped installations.

Optionally, the magnetic separator further comprises a redirecting element. The redirecting element is adapted to transfer the flexible member and/or its movement from the first path to the second path at an intersection, or projected or virtual intersection, of the first path and the second path. The redirecting element controls the transition of the flexible member or its movement from the first path to the second path and/or ensures that the transition occurs smoothly. Optionally, the redirecting element may be a pulley, a (metal) guide, a deflector, a crank, or like element.

Optionally, the flexible member extends through a bottom wall of the magnetic separator. It is conceivable that the flexible member extends through a top wall or a side wall of the magnetic separator depending on the predefined first path and other features of the magnetic separator.

Optionally, the magnetic device is movable from a first position for collecting particles having ferromagnetic properties to a second position axially spaced from the first position for releasing collected particles having ferromagnetic properties. The magnet device is optionally biased into the first
Alternatively, the magnet device is optionally biased into the second position. Optionally, the magnet device is further movable from the second position for releasing the particles having ferromagnetic properties to a third position axially spaced from the second position for discharging the particles having ferromagnetic properties. Conveniently, the flexible member allows the magnetic separator to cycle through collecting, releasing, and discharging particles having ferromagnetic properties.

Optionally, the flexible member is calibrated to provide an indication as to which position the magnet device is located in. Optionally, the indication is a marking on the flexible member. In certain embodiments and certain installations, the location of the magnet device may not be ascertainable from the outside of the magnetic separator. It is therefore desirable that the flexible member is calibrated to provide an indication as to which position the magnet device is located in. It is possible that the flexible member includes markings such as first position, second position, etc. It is also possible that sections of the flexible member are a different color in order to give an indication of the magnet device's location. For example red may indicate that the magnet device is in the second position.

Optionally, the flexible member is arranged to provide sensory feedback when the magnet device is located in one of the first position, second position, and third position. Optionally, the flexible member includes protrusions arranged to provide sensory feedback in the form of resistance when the magnet device is located in one of the first position, second position, and third position. It is conceivable that the magnetic separator is installed in a dark environment where it would be difficult to interpret the calibrated flexible member. In such cases it is desirable to provide sensory feedback, such as a force, resistance, vibration, tactile information, sound or light. Providing alternative sensory feedback ensures that the magnetic separator can be operated effectively in a wide range of environments. Sensory feedback may
also be used to control or for monitoring automated operation of the magnetic separator.

According to a preferred embodiment the first position is located in a middle region of the magnetic separator and the second position is located in a lower region of the magnetic separator. Optionally, the third position is located at a base of the magnetic separator.

Optionally, the magnet device is biased by a resilient member. Optionally, the resilient member is a tension spring. It is also possible that the resilient member is one of a coil spring, compression spring, and a resilient plastic. Such resilient members are simple, cost effective, and robust.

Optionally, the magnetic separator further comprises an actuating device adapted to actuate the flexible member. Optionally, the actuating device is a handle and the actuating device is driven manually by a pulling motion. This provides a simple and robust interface for operating the flexible member of the magnetic separator. It is also possible that the actuating device is one of a loop, a grip, and a hook.

Optionally, the actuating device includes a motor adapted to drive the flexible member. In this case, the actuating device is driven by a motor. The motor may be controllable via a switch. Preferably, the actuating device comprises a controller adapted to drive the motor at predefined intervals. This is ideal when the magnetic separator is located in a remote or inaccessible location, and/or when the magnetic separator must be operated frequently owing to the inherent characteristics of the system in which it is applied.

Optionally, the flexible member is one of a cable, a string, a chain, and a flexible rod. Preferably, the elongate flexible member is flexible in view of bending relative to a direction of elongation. Preferably, the elongate flexible member is resistant against extension in the direction of elongation. Where in this specification reference is made to a cable, the skilled person will appreciate that any flexible member, including a cord, a chain, or strap can take the place of a cable.
Optionally, the magnetic device includes at least one permanent magnet. Optionally, the at least one permanent magnet is one of a rare earth magnet, a ceramic magnet, a ferrite magnet, a neodymium magnet, a samarium cobalt magnet, and an alnico magnet. Permanent magnets offer flexibility and allow the magnet separator to be easily adapted to a specific fluid circulation system. Furthermore, these magnets are commercially available in a multitude of shapes, sizes and strengths.

Optionally, the magnetic separator includes a plurality of magnetic assemblies positioned in the fluid flow path interiorly of the collection chamber. Each magnetic assembly of the plurality of magnetic assemblies includes a respective substantially tubular sleeve, a respective magnetic device, and a respective substantially elongate flexible member. In large fluid circulation systems and/or large magnet separators it may be desirable to include additional magnetic assemblies in order to sufficiently separate particles having ferromagnetic properties from the fluid flow path. Optionally, the respective flexible members of the plurality of magnetic assemblies are arranged to be actuated as a group. Actuating the flexible members as a group allows the respective magnetic separator to remain simple and easy to operate yet at the same time allows the efficient collection of particles having ferromagnetic properties in large systems and/or large magnetic separators.

The present invention also relates to a method for separating suspended particles having ferromagnetic properties from a fluid circulating between heat exchangers in a fluid circulation using a magnetic separator, the method including: providing a collection chamber having an inlet for receiving a flow of the and an outlet for allowing the fluid to flow out of the collection chamber, a fluid flow path being defined between the inlet and the outlet and including an interior of the collection chamber; providing a substantially tubular sleeve positioned in the fluid flow path interiorly of the collection chamber, the substantially tubular sleeve having a fluid tight interior; providing a magnet device accommodated within the fluid tight interior of the
substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve, wherein the magnet device is adapted for translatory movement along a predefined first path in a first sense in the substantially tubular sleeve; providing a substantially elongate flexible member having a first end attached to the magnet device and a second end extending externally of the substantially tubular sleeve; actuating the second end of the flexible member along a second path in a second sense so as to actuate the translatory movement of the magnet device.

Optionally, the method includes actuating the second end of the flexible member along the second path in the second sense so as to move the magnet device between a first position for collecting particles having ferromagnetic properties to a second position axially spaced from the first position for releasing collected particles having ferromagnetic properties.

Optionally, the method includes actuating the second end of the flexible member along the second path in the second sense so as to further move the magnet device from the second position for releasing the particles having ferromagnetic properties to a third position axially spaced from the second position for discharging the particles having ferromagnetic properties.

It is yet another object of the present invention to provide a kit of parts for constructing a magnetic separator for collecting particles having ferromagnetic properties comprising a substantially tubular sleeve having a fluid tight interior, a magnet device and a substantially elongate flexible member for releasing the collected particles. The magnet device is accommodated within the fluid tight interior of the substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve. The magnet device is adapted for translatory movement along a predefined first path in a first sense in the substantially tubular sleeve. A first end of the flexible member is attached to the magnet device and a second end of the flexible member extends externally of the substantially tubular sleeve. The second end of the flexible member is
arranged to be subjected to an actuating movement along a second path in a second sense so as to actuate the translatory movement of the magnet device.

Further advantageous aspects of the invention will become clear from the appended description and in reference to the accompanying drawings, in which:

Figure 1 is a schematic cross section of a portion of a fluid circulation system according to a first embodiment of the invention;

Figure 2 is a schematic cross section as in Figure 1, but showing the system in a second position of operation;

Figure 3 schematically shows a first principle of short circuiting the magnetic field of a permanent magnet;

Figure 4 shows a modified permanent magnet;

Figure 5 shows a principle of short circuiting the magnetic field of the modified permanent magnet;

Figure 6 schematically shows a second embodiment of the invention in a first position of operation;

Figure 7 shows the second embodiment of Figure 6 in a second position of operation; and

Figure 8 is a cross section showing a third embodiment.

In Figure 1 a magnetic separator 1 is shown schematically. The magnetic separator 1 is part of a fluid circulation system for circulating an amount of fluid between heat exchangers. The fluid circulation system, in as far as it is conventional, has been omitted from Figure 1 for clarity. The amount of fluid that is in circulation between the heat exchangers, such as a heating or cooling system, enters a collection chamber 3 through an inlet 5 and leaves the collection chamber 3 through an outlet 7. The fluid flow path is indicated by arrows 5A and 7A. The inflow of fluid through inlet 5 is a flow of fluid that is susceptible of containing suspended particles that have ferromagnetic properties. Such particles are often found in heating systems and may have originated from wear of parts, such as pumps and valves within
the fluid circulation system. The collection chamber 3 has a hollow interior 9 that is normally filled with the fluid that is in circulation. Also exposed to the fluid in circulation is a substantially tubular sleeve 11 that is accommodated within the hollow interior 9 of collection chamber 3. Contained for translatory movement in the substantially tubular sleeve 11 is a magnet device 13. Thus the substantially tubular sleeve 11 defines a predefined, in this example linear, first path indicated by dashed line 16A. In Figure 1 the magnet device 13 has its North pole N and south pole S aligned with a direction of the translatory movement of the magnet device 13 along the predefined first path 16A. The tubular sleeve 11 is of substantially non-ferromagnetic material, so that in the position shown in Figure 1 the magnet device 13 has its magnetic field extending to the exterior of an upper portion of the tubular sleeve 11. Also positioned within the interior 12 of the substantially tubular sleeve 11 is an auxiliary sleeve 15 of ferromagnetic material. The interior 12 of the tubular sleeve 11 is fluid tight, so that the circulating fluid has no access to the magnet device 13. The magnet device 13 as shown in Figure 1 is kept in its first position in the upper portion of the sleeve 11 against the action of a resilient member, in this example embodied as a compression spring 17, by means of an elongate flexible member, in this embodiment the elongate flexible member is cable 19. The flexible member 19 is attached to the magnet device 13 at a first end 19A. The flexible member 19 comprises a second end 19B which extends externally of the sleeve 11. With the magnet device 13 in its first position, ferromagnetic debris 21 when present in the flow of fluid passing the collection chamber 3 will be intercepted and retained by the magnetic field created around the magnet device 13. As the circulating fluid will pass continuously through the magnetic field around the tubular sleeve 11 all ferromagnetic matter will eventually be captured by the magnetic separator 1. Optionally the magnetic separator 1 may also be provided with an inlet valve 23 associated with fluid inlet 5 and an outlet valve 25 associated with the fluid outlet 7. Further the sleeve 11 may be closed by a bottom 27 to ensure its fluid
tightness independent of the collection chamber 3. The collection chamber 3 may optionally also be provided with a discharge drain 29, which may have an associated drain valve 31.

Referring now to Figure 2, the magnetic separator is shown with its magnet device 13 positioned at a second position, in a lower portion of the sleeve 11, in which its magnetic field is eliminated (or at least diminished) by the auxiliary sleeve 15 of ferromagnetic material that forms a short circuit for the magnetic field. The elimination or diminishing of the magnetic field allows the collected ferromagnetic debris particles to be extracted from the collection chamber 3. By actuating the second end 19B of the flexible member 19 so as to move along a second path, indicated by dashed line 16B, the magnet device 13 is caused to travel in a first sense from the first position in Figure 1 to the second position illustrated in Figure 2. During this travel the resilient member, here compression spring 17, is released and the cable 19 moves along the first path 16A and along the second path in a second sense indicated by arrow 33. In this embodiment the first path 16A is perpendicular to the second path 16B. Additionally, the magnet device is biased into the second position by the resilient member. A redirecting element, in this example embodied as pulley wheel 18, transfers the movement of the flexible member, cable 19, from the predefined first path 16A to the second path 16B.

In Figure 2 the lower end of the substantially tubular sleeve 11 also has an enlarged diameter. The enlarged lower sleeve diameter further reduces the magnetic field strength experienced by the collected ferromagnetic debris particles 21, allowing them to be extracted from the collection chamber 3 because there is no magnetic field strong enough to retain them. It will be appreciated that when thus the magnetic field is not capable of holding the collected ferromagnetic debris particles 21, the ferromagnetic debris particles can sink to the bottom of the collection chamber 3 due to gravity. For draining the collected ferromagnetic debris particles 21 from the collection chamber 3 it then may suffice to open the drain valve 31 (during normal circulation of the
circulating fluid) for flushing the collected particles 21 through the discharge drain 29. It will be clear that some of the circulating fluid will be discharged together with the particles 21. It will be appreciated that it is also possible to halt the circulation of the circulating fluid prior to opening of the discharge drain 29.

In order to reduce the amount of circulating fluid discharged, the inlet and outlet valves 23, 25 may be closed and a portion of the circulating fluid may be allowed to be drained off through the discharge drain 29 when the drain valve 31 is opened. This purging of magnetically collected contaminations needs only be performed periodically and at relatively large time intervals. To ensure proper draining and preventing the entrance of air, the closing of the outlet valve 25 may be timed to precede the closing of the inlet valve 23 in an amount sufficient to ensure replenishment of the interior 9 of the collection chamber 3. The operation of the various valves can be entrusted to an automatic control device which may be triggered by programmable software. In an alternative arrangement the inlet and outlet valves 23, 25 may also be arranged to bypass the magnetic separator when the purging process is being carried out. It is also possible to use a separate flushing fluid to carry the collected particles from the collecting chamber 5 to the discharge drain 29.

Referring now to Figure 3 the magnet device 13 is shown between the walls of auxiliary sleeve 15. The magnet device 13 may suitably be a permanent magnet of, e.g. sintered, rare earth materials, ferrite, neodymium, alnico or samarium cobalt. One particularity of magnets is that the magnetic field lines 35 at the opposite North and South poles N, S extend in an axial direction, from which these are gradually deflected radially outwardly. By capping the North and South poles of a magnet 37, by caps 39 of ferromagnetic material such as iron or steel, the field lines 35 can be deflected in a radial direction at a shorter distance, as shown in Figure 4 and 5. Such ferromagnetic caps 39 not only improve the short cutting effect of the auxiliary sleeve 15, but
also ensure an improved attraction of particles suspended in the circulating fluid, when the magnet device 13 is in its first position shown in Figure 1.

In Figures 6 and 7 an alternative embodiment of the magnetic separator of Figures 1 and 2 is shown. Reference numerals of like parts will be referred to with the addition of 100. Hence, magnetic separator 101 is also provided with a collection chamber 103 that has an inlet 105 and an outlet 107A. Within the hollow interior 109 a substantially tubular and fluid tight sleeve 111 is positioned within the flow path between the inlet 105 and the outlet 107. A magnet device 113 of the kind described with respect to Figures 1-5 is again accommodated within the substantially tubular sleeve 111 for translatory movement therein. Thus the substantially tubular sleeve 111 defines a predefined, here linear, first path indicated by dashed line 116A.

As shown in Figure 7, the magnet device 113 can be moved along the predefined first path 116A in a first sense from a first position, located in a lower portion of the tubular sleeve 111, to a second position, located in an upper portion of the tubular sleeve, by a elongate flexible member. In this embodiment the elongate flexible member is cable 119, which partly moves along a second path, indicated by dashed line 116B, in a second sense indicated by arrow 133. The flexible member 119 is attached to the magnet device 113 at a first end 119A. The flexible member 119 comprises a second end 119B which extends externally of the sleeve 111. In this embodiment the first path 116A is perpendicular to the second path 116B. A redirecting element, pulley wheel 118, transfers the flexible member, cable 119, from the predefined first path 116A to the second path 116B. In the second position, the magnet device 113 is positioned within an auxiliary sleeve 115 of ferromagnetic material against the action of a resilient member, here compression spring 117. The resilient member, compression spring 117, in the second embodiment biases the magnet device 113 into the first position. An upper end of the substantially tubular sleeve 111 has a frustoconical shape with an upwardly increasing diameter. In its first position, the lowermost
position, the magnet device 113 attracts ferromagnetic particles that are in suspension in the circulating fluid. The substantially tubular sleeve 111 is of a non-magnetic material, so that the magnetic flux lines of the magnet device 113 extend to the exterior of the tubular sleeve 111, which closely surrounds the magnet device 113. As shown in Figure 6, the ferromagnetic particles 121 are collected around the lower part of the tubular sleeve 111. When the magnet device 113 is retracted against compression spring 117 in its second position, the upper most position, as shown in Figure 7 the collected particles are no longer under the influence of a magnetic field and are released. The collected particles can now be drained through a discharge drain 129. In this situation an outlet valve 125 will first have closed the outlet 107 so that the collected debris cannot continue in the fluid circulation system. Rinsing of the high concentration of debris 121 in the collection chamber 3 can be done by the circulation fluid by continuing allowing the fluid to enter through inlet 105. However a certain amount of fluid will be lost from the system through the discharge drain 129 for as long as the drain valve 131 is kept open and the outlet valve 125 closed. It may therefore be preferred to provide a bypass for the circulating fluid and execute the inlet valve 123 as a selector valve that redirects the circulating fluid into a bypass and at the same time connect to a rinsing fluid that is allowed to enter the collection chamber 3 through the same inlet 105. Clearly it is also possible to provide a separate inlet and inlet valve for a rinsing fluid, but this would generally complicate the construction more than is necessary. Operation of the various valves and operation of the pull cable 119 may be carried out with automatic control means of predetermined intervals.

A third embodiment of the invention in the form of a combined de-aerator and particle separator 201 is shown in cross section in Figure 8. Reference numerals of parts corresponding with parts in the previous Figures will be referred to with the addition of 200 with respect to Figures 1-5. This combined de-aerator and particle separator 201 has a collection chamber 203
and a fluid inlet 205, as well as a fluid outlet 207 that do not require any inlet
and outlet valves. With the embodiment of Figure 8 ferromagnetic dirt
particles can be discharged from the system while the system is in operation.
Since discharging of the collected particles can be performed in a very short
time, it is not necessary to shut down or bypass the fluid circulation. In
particular this option has been made possible because the accumulated
particles are collected outside the main flow. To this end a tubular sleeve 211
only extends from the level of the inlet 205 and outlet 207 downwardly. An
upper end of the tubular sleeve 211 is closed in a fluid tight manner by an end
plug 227. Attached to the end plug 227 in an interior 212 of the tubular sleeve
211 is a resilient member, tension spring 217, which has an opposite end
thereof connected to a sliding magnet device 213. An opposite end of the
sliding magnet device 213, which is guided in the non-ferromagnetic tubular
sleeve 211, has an elongate flexible member, in this embodiment the elongate
flexible member is cable 219, attached thereto. The flexible member 219 is
attached to the magnet device 213 at a first end 219A. The flexible member
219 comprises a second end 219B which extends externally of the sleeve 211.
The non-ferromagnetic tubular sleeve 211 defines a predefined, in this
example linear, first path, indicated by dashed line 216A, for the translatory
movement of the magnet device 213. As mentioned before, the cable 219 may
be replaced by another flexible member, such as chain having pivotally
interconnected chain links. The cable 219 is guided from the fluid tight interior
212 of the tubular sleeve 211 to an exterior of the magnetic separator 201. The
magnetic separator 201 includes an actuating device, in this example
embodied as a handle 222 at the second end 219B of the flexible member 219,
and the actuating device is driven manually by a pulling motion. If required
the flexible member, cable 219, may also be driven by an actuating device
including a motor. Magnetic separator 201 may further comprise a controller
adapted to drive the motor of the actuating device at predefined intervals
resulting in automatic operation of the magnetic separator 201. With the cable
219 in a non-operated position the spring 217 is relaxed and biases the magnet device 213 into a first position just below the level of the inlet 205 and outlet 207. In this position the ferromagnetic dirt particles are collected outside the main flow of the circulating fluid.

In Figure 8, the actuating device, handle 222, is driven manually along a second path, indicated by dashed line 216B, in a second sense, by a pulling motion, resulting in the translatory movement of the magnet device 213 along the predefined first path 216A in a first sense from the first position to a second position. Here, the magnet device's magnetic force is eliminated and the collected particles are released. In this embodiment the first path 216A is perpendicular to the second path 216B. An auxiliary sleeve 215 is positioned concentrically around the tubular sleeve 211 at the second position, to an exterior thereof. An enlarged diameter portion is provided on a lower portion of the tubular sleeve 211, in the form of a collar 214. The collar 214, which has a conical upper portion and a cavity for the auxiliary sleeve 215 in its bottom portion, can be clamped onto the exterior of the tubular sleeve 211. In such a case the collar may be in a non-magnetic plastic material. When the collar 214 is in a non-magnetic metal, it may also be brazed or soldered to the exterior of the tubular sleeve 211. In the example of Figure 8 the tubular sleeve 211 also extends below the auxiliary sleeve 215 in a region closely adjacent to a discharge drain 229. The discharge drain, as in the previous examples, may be associated with a drain valve (not shown, but conventional).

In this example, the magnet device 213 can be further moved along the predefined first path 216A in the first sense to a third position, the lowermost position, below the second position and in close proximity to the discharge drain 229. Prior to the opening of the discharge drain 229, the magnet device 213 can be moved from the second position within the auxiliary sleeve 215, where its magnetic force is eliminated and the particles are released, to the third position in the tubular sleeve 211 below the auxiliary sleeve 215. In this position, the magnet device 213 becomes again effective in
catching the suspended concentration of previously collected particles on a portion of the tubular sleeve 211 that is directly adjacent to the discharge drain 229. When the magnet device 213 is allowed to return to its first position, the uppermost position, prior to or substantially simultaneously with the opening of the discharge drain 229, then the collected particles will be retained by the bottom of the collar 214 and be drained off upon opening of the discharge drain 229. Fluid losses will be minimal and the fluid circulation can be continued without risk of the collected particles escaping through the outlet 207 where the fluid flow velocity is much higher than at the lower portion of the hollow interior 209 of the collection chamber 203.

The flexible member of this embodiment may be calibrated and include protrusions at positions 220A, 220B, and 220C to provide sensory feedback, in the form of resistance feedback, to the operator. The sensory feedback is intended to provide an indication of the position of magnet device 213. It is also possible that instead of or in addition to the protrusions, the flexible member, cable 219, is provided with markings indicating the three positions of the magnet device at positions 220A, 220B, and 220C.

It may be desirable to provide the collection chamber 203 of such dimension that it allows to position a plurality of magnetic assemblies in the fluid flow path interiorly of the collection chamber. It may also be desirable to actuate the respective flexible members of the plurality of magnetic assemblies as a group or via a single additional substantially elongate flexible member attached thereto.

A further aspect of the de-aerator and separator 201 of the embodiment of Figure 8 is that it also includes a de-aerator that in a known manner includes an array of so-called spirotubes 241, of which in this example six are arranged about the perimeter of the tubular sleeve 211. These spirotubes 241 comprise a core tube 243, surrounded by a coil of wire 245. The construction of these spirotubes 241 is generally as described in patent documents GB 1,579,516, US 4,655,282, US 3,854,906, US 4,027,691 or US
4,381,928 and reference can be had to these documents for further details. For the present invention it suffices to mention that these spirotubes 241 promote the separation of air and (non-magnetic) dirt particles from the fluid and offer only minimal flow resistance. While the spirotube 241 can trap the smallest micro bubbles of air, it also has a very open structure, so that it cannot clog up with dirt particles. The trapped air bubbles may be drained off through an air vent opening 247 in the uppermost portion of the collecting chamber 203. The air vent opening 247 will be provided with a conventional air bleed valve, which for clarity is omitted in Figure 8. The core tube 243 of each spirotube 241 can be made from a magnetisable material, such as steel or iron. Then, the spirotube acts as a magnetisable insert which further assists in spreading and amplifying the magnetic field of the magnet device 213.

Thus is described a fluid circulation system for circulating an amount of fluid between heat exchangers through a circulation circuit, the fluid circulation system comprising a magnetic separator 1, 101, 201 including: a collection chamber 3, 103, 203 having an inlet 5, 105, 205 for receiving a flow of fluid susceptible of containing suspended particles 21, 121 having ferromagnetic properties and an outlet 7, 107, 207 for allowing the fluid to flow out of the collection chamber; a fluid flow path defined between the inlet and the outlet, including an interior 9, 109, 209 of the collection chamber; a substantially tubular sleeve 11, 111, 211 positioned in the fluid flow path interiorly of the collection chamber, the substantially tubular sleeve having a fluid tight interior; a magnet device 13, 113, 213 accommodated within the fluid tight interior of the substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve. The magnet device is adapted for translatory movement along a predefined first path 16A, 116A, 216A in a first sense in the substantially tubular sleeve. The magnetic separator further includes a substantially elongate flexible member 19, 119, 219 having a first end 19A, 119A, 219A attached to the magnet device and a second end 19B, 119B, 219B extending externally of the substantially
tubular sleeve, the second end of the flexible member being arranged to be subjected to an actuating movement along a second path 16B, 116B, 216B in a second sense so as to actuate the translatory movement of the magnet device.

It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description and drawings appended thereto. It will be clear to the skilled person that the invention is not limited to any embodiment herein described and that modifications are possible which should be considered within the scope of the appended claims. Also kinematic inversions are considered inherently disclosed and to be within the scope of the invention. In the claims, any reference signs shall not be construed as limiting the claim. The term 'comprising' and 'including' when used in this description or the appended claims should not be construed in an exclusive or exhaustive sense but rather in an inclusive sense. Thus the expression 'comprising' as used herein does not exclude the presence of other elements or steps in addition to those listed in any claim. Furthermore, the words 'a' and 'an' shall not be construed as limited to 'only one', but instead are used to mean 'at least one', and do not exclude a plurality. Features that are not specifically or explicitly described or claimed may be additionally included in the structure of the invention within its scope. Expressions such as: "means for ..." should be read as: "component configured for ..." or "member constructed to ..." and should be construed to include equivalents for the structures disclosed. The use of expressions like: "critical", "preferred", "especially preferred" etc. is not intended to limit the invention. Additions, deletions, and modifications within the purview of the skilled person may generally be made without departing from the spirit and scope of the invention, as is determined by the claims.
1. Fluid circulation system for circulating an amount of fluid between heat exchangers through a circulation circuit, the fluid circulation system comprising a magnetic separator including:
   a collection chamber having an inlet for receiving a flow of fluid susceptible of containing suspended particles having ferromagnetic properties and an outlet for allowing the fluid to flow out of the collection chamber; a fluid flow path defined between the inlet and the outlet, including an interior of the collection chamber; a substantially tubular sleeve positioned in the fluid flow path interiorly of the collection chamber, the substantially tubular sleeve having a fluid tight interior; a magnet device accommodated within the fluid tight interior of the substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve; wherein the magnet device is adapted for translatory movement along a predefined first path in a first sense in the substantially tubular sleeve; wherein the magnetic separator further includes a substantially elongate flexible member having a first end attached to the magnet device and a second end extending externally of the substantially tubular sleeve, the second end of the flexible member being arranged to be subjected to an actuating movement along a second path in a second sense so as to actuate the translatory movement of the magnet device.

2. Fluid circulation system according to claim 1, wherein the second path is substantially different from the first path.
3. Fluid circulation system according to claim 2, wherein the second path is substantially perpendicular to the first path

4. Fluid circulation system according to claim 1 or 2, wherein the second sense is opposite to the first sense.

5. Fluid circulation system according to any one of claims 1-4, wherein the magnetic separator further comprises a redirecting element, and wherein the redirecting element is adapted to transfer the flexible member from the first path to the second path at an, e.g. projected, intersection of the first path and the second path.

6. Fluid circulation system according to any one of claims 1-5, wherein the flexible member extends through a bottom wall of the magnetic separator.

7. Fluid circulation system according to any one of claims 1-6, wherein the magnetic device is movable from a first position for collecting particles having ferromagnetic properties to a second position axially spaced from the first position for releasing collected particles having ferromagnetic properties, and wherein the magnet device is biased into the first position.

8. Fluid circulation system according to claim 7, wherein the first position is located in a middle region of the magnetic separator and the second position is located in a lower region of the magnetic separator.

9. Fluid circulation system according to claim 7 or 8, wherein the magnet device is further movable from the second position for releasing the particles having ferromagnetic properties to a third position axially spaced from the second position for discharging the particles having ferromagnetic properties.
10. Fluid circulation system according to claim 9, wherein the third position is located at a base of the magnetic separator.

11. Fluid circulation system according to any one of claims 7-10, wherein the flexible member is calibrated to provide an indication as to which position the magnet device is located in.

12. Fluid circulation system according to claim 11, wherein the indication is a marking on the flexible member.

13. Fluid circulation system according to any one of claims 7-10, wherein the flexible member is arranged to provide sensory feedback when the magnet device is located in one of the first position, second position, and third position.

14. Fluid circulation system according to claim 13, wherein the flexible member includes protrusions arranged to provide sensory feedback in the form of resistance when the magnet device is located in one of the first position, second position, and third position.

15. Fluid circulation system according to any one of claims 7-10, wherein the magnet device is biased by a resilient member.

16. Fluid circulation system according to claim 15, wherein the resilient member is a tension spring.

17. Fluid circulation system according any one of claims 1-16, further comprising an actuating device adapted to actuate the flexible member.
18. Fluid circulation system according to claim 17, wherein the actuating device is a handle and the actuating device is driven manually by a pulling motion.

19. Fluid circulation system according to claim 17, wherein the actuating device includes a motor adapted to drive the flexible member.

20. Fluid circulation system according to claim 18, further comprising a controller adapted to drive the motor at predefined intervals.

21. Fluid circulation system according to any one of claims 1-20, wherein the flexible member is one of a cable, a string, a chain, and a flexible rod.

22. Fluid circulation system according to any one of claims 1-21, wherein the collection chamber includes a discharge drain with an associated drain valve.

23. Fluid circulation system according to any one of claims 1-22, wherein the fluid circulation system is a heating system.

24. Fluid circulation system according to any one of claims 1-22, wherein the fluid circulation system is a cooling system.

25. Fluid circulation system according to any one of claims 1-24, wherein the magnetic device includes at least one permanent magnet.

26. Fluid circulation system according to claim 25, wherein the at least one permanent magnet is one of a rare earth magnet, a ceramic magnet, a
ferrite magnet, a neodymium magnet, a samarium cobalt magnet, and an alnico magnet.

27. Fluid circulation system according to any one of claims 1-26, wherein the magnetic separator includes a plurality of magnetic assemblies positioned in the fluid flow path interiorly of the collection chamber, wherein each magnetic assembly of the plurality of magnetic assemblies includes a respective substantially tubular sleeve, a respective magnetic device, and a respective substantially elongate flexible member.

28. Fluid circulation system according to claim 27, wherein the respective flexible members of the plurality of magnetic assemblies are arranged to be actuated as a group.

29. Fluid circulation system according to claim 27 or 28, wherein the respective flexible members are mutually attached.

30. Magnetic separator of the fluid circulation system according to any one of the preceding claims.

31. Method for separating suspended particles having ferromagnetic properties from a fluid circulating between heat exchangers in a fluid circulation using a magnetic separator, the method including:

- providing a collection chamber having an inlet for receiving a flow of the and an outlet for allowing the fluid to flow out of the collection chamber, a fluid flow path being defined between the inlet and the outlet and including an interior of the collection chamber;
- providing a substantially tubular sleeve positioned in the fluid flow path interiorly of the collection chamber, the substantially tubular sleeve having a fluid tight interior;
providing a magnet device accommodated within the fluid tight interior of the substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve, wherein the magnet device is adapted for translatory movement along a predefined first path in a first sense in the substantially tubular sleeve;

providing a substantially elongate flexible member having a first end attached to the magnet device and a second end extending externally of the substantially tubular sleeve;

actuating the second end of the flexible member along a second path in a second sense so as to actuate the translatory movement of the magnet device.

32. Method according to claim 31, including actuating the second end of the flexible member along the second path in the second sense so as to move the magnet device between a first position for collecting particles having ferromagnetic properties to a second position axially spaced from the first position for releasing collected particles having ferromagnetic properties.

33. Method according to claim 32, including actuating the second end of the flexible member along the second path in the second sense so as to further move the magnet device from the second position for releasing the particles having ferromagnetic properties to a third position axially spaced from the second position for discharging the particles having ferromagnetic properties.

34. A kit of parts for constructing a magnetic separator for collecting particles having ferromagnetic properties comprising a substantially tubular sleeve having a fluid tight interior, a magnet device and a substantially elongate flexible member for releasing the collected particles,
wherein the magnet device is accommodated within the fluid tight interior of the substantially tubular sleeve for creating a magnetic field on at least a first exterior portion of the substantially tubular sleeve;

wherein the magnet device is adapted for translatory movement along a predefined first path in a first sense in the substantially tubular sleeve;

wherein a first end of the flexible member is attached to the magnet device and a second end of the flexible member extends externally of the substantially tubular sleeve,

wherein the second end of the flexible member is arranged to be subjected to an actuating movement along a second path in a second sense so as to actuate the translatory movement of the magnet device.
**INTERNATIONAL SEARCH REPORT**

A. CLASSIFICATION OF SUBJECT MATTER

INV. B03C1/28

ADD.

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)

B03C B01D

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Category*</th>
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Further documents are listed in the continuation of Box C. See patent family annex.

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Name and mailing address of the ISA:

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Authorized officer: Holubov, Carol

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