US 20110100599A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2011/0100599 A1**

(43) **Pub. Date: May 5, 2011**

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(54) **SYSTEM FOR CLEANING HEAT EXCHANGERS**

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(21) Appl. No.: **12/843,172**

(22) Filed: **Jul. 26, 2010**

(30) **Foreign Application Priority Data**

Jul. 27, 2009 (DE) 10 2009 034 868.9

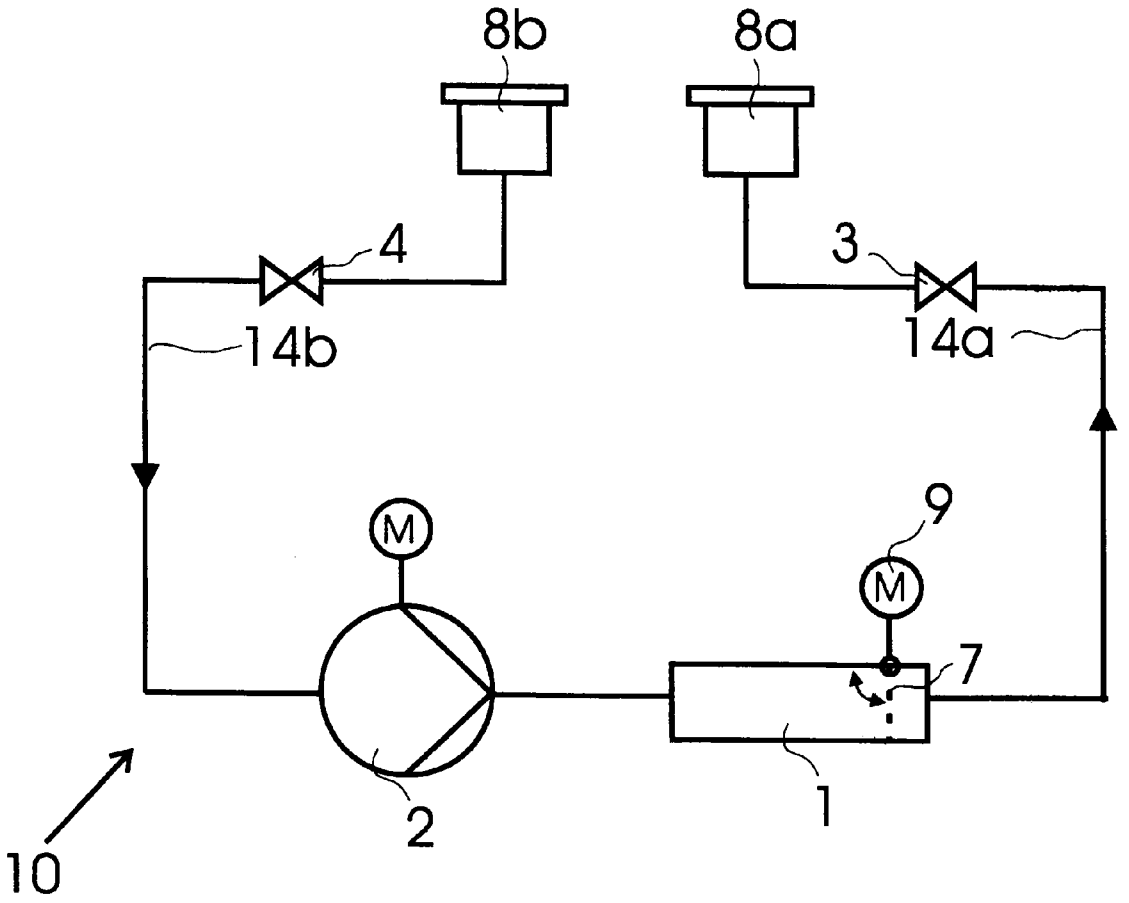
Publication Classification

(51) **Int. Cl.**
F28G 1/16 (2006.01)

(52) **U.S. Cl.** **165/95**

(57) **ABSTRACT**

A mobile heat exchanger cleaning system, in particular for power plant heat exchangers, allows a heat exchanger to be safely and reliably cleaned. The cleaning system has an apparatus for collecting, introducing and removing cleaning bodies, a pump for pumping a fluid with cleaning bodies and at least one connector connected with the apparatus and the pump for releasably connecting the cleaning system with a heat exchanger.



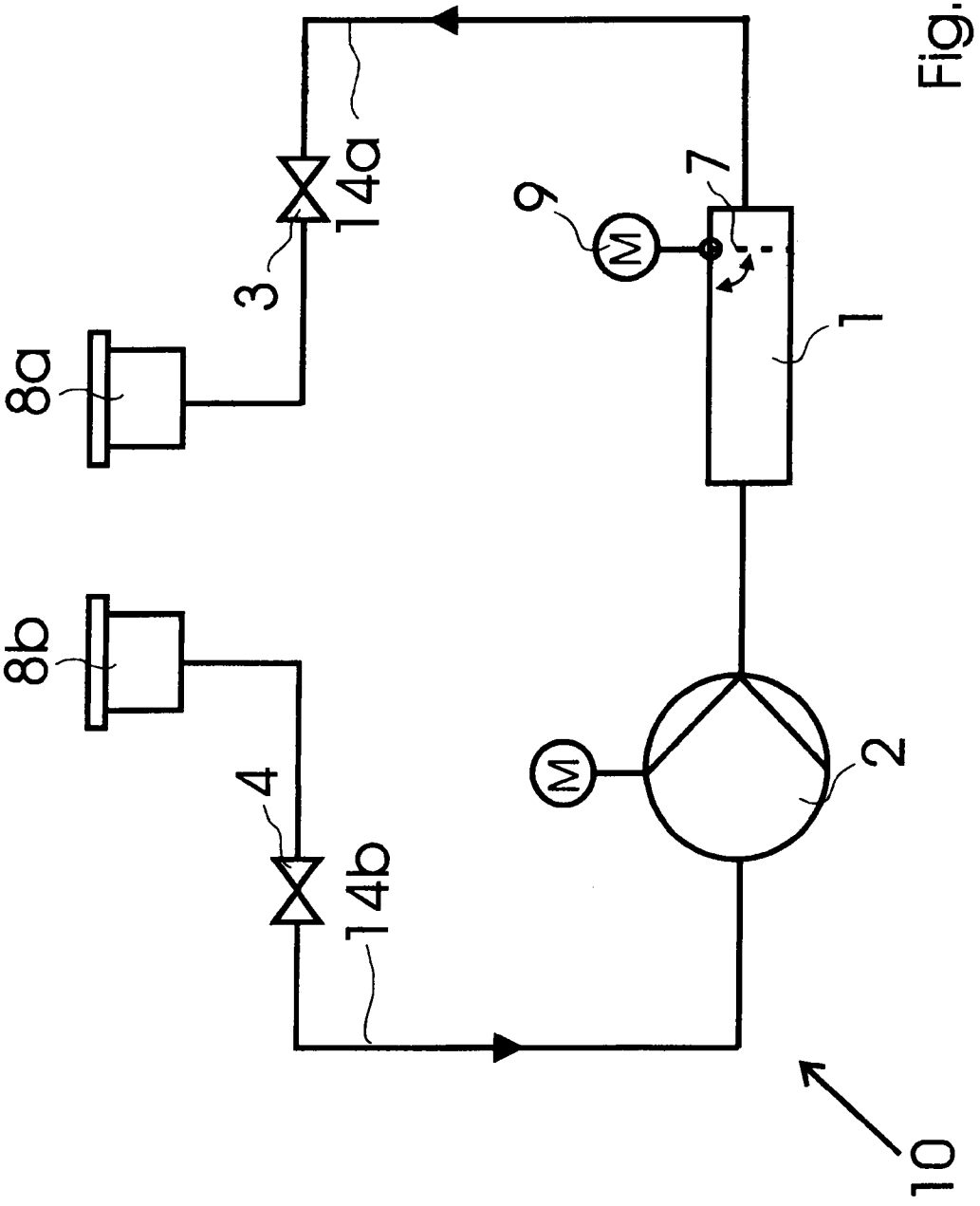


Fig. 1a

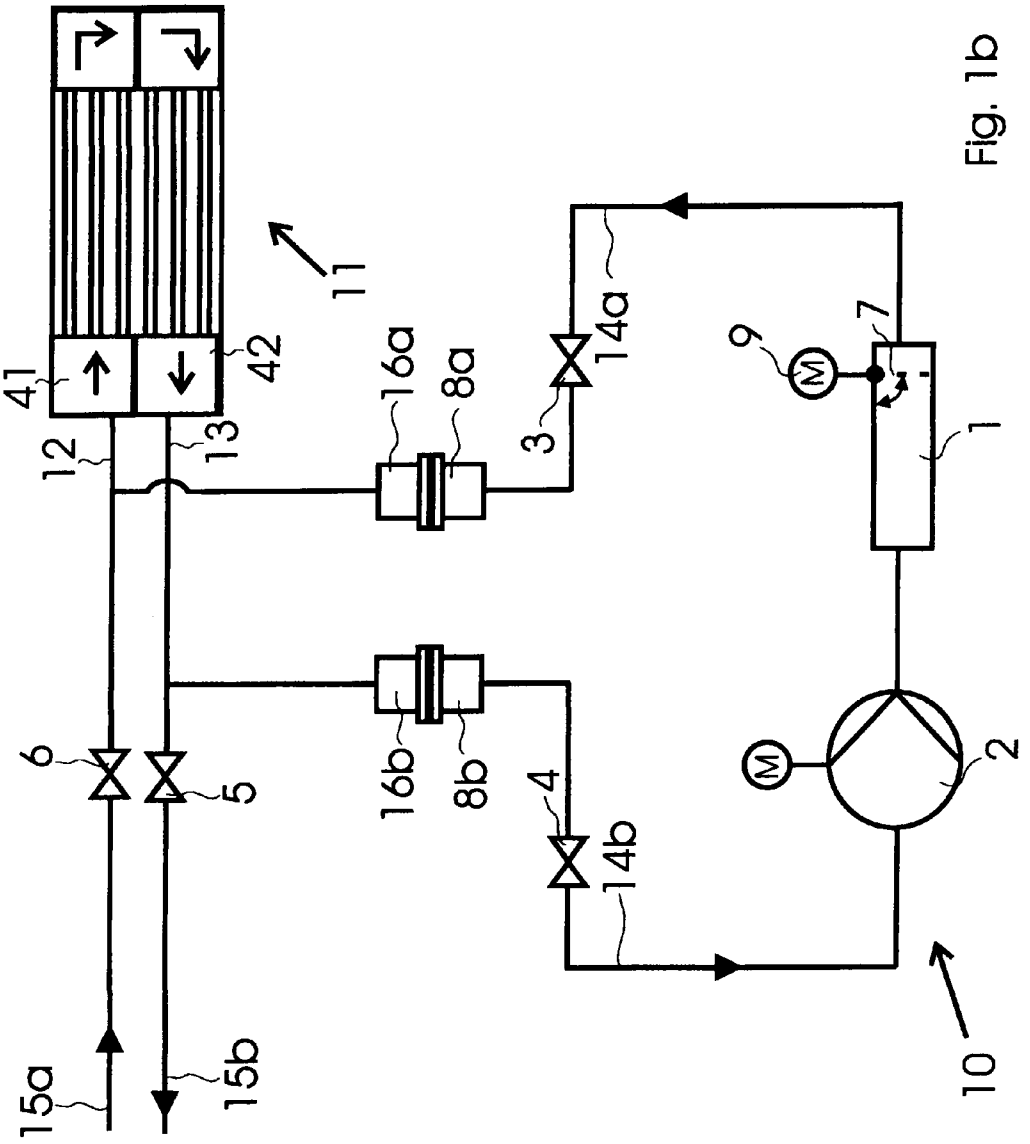


Fig. 1b

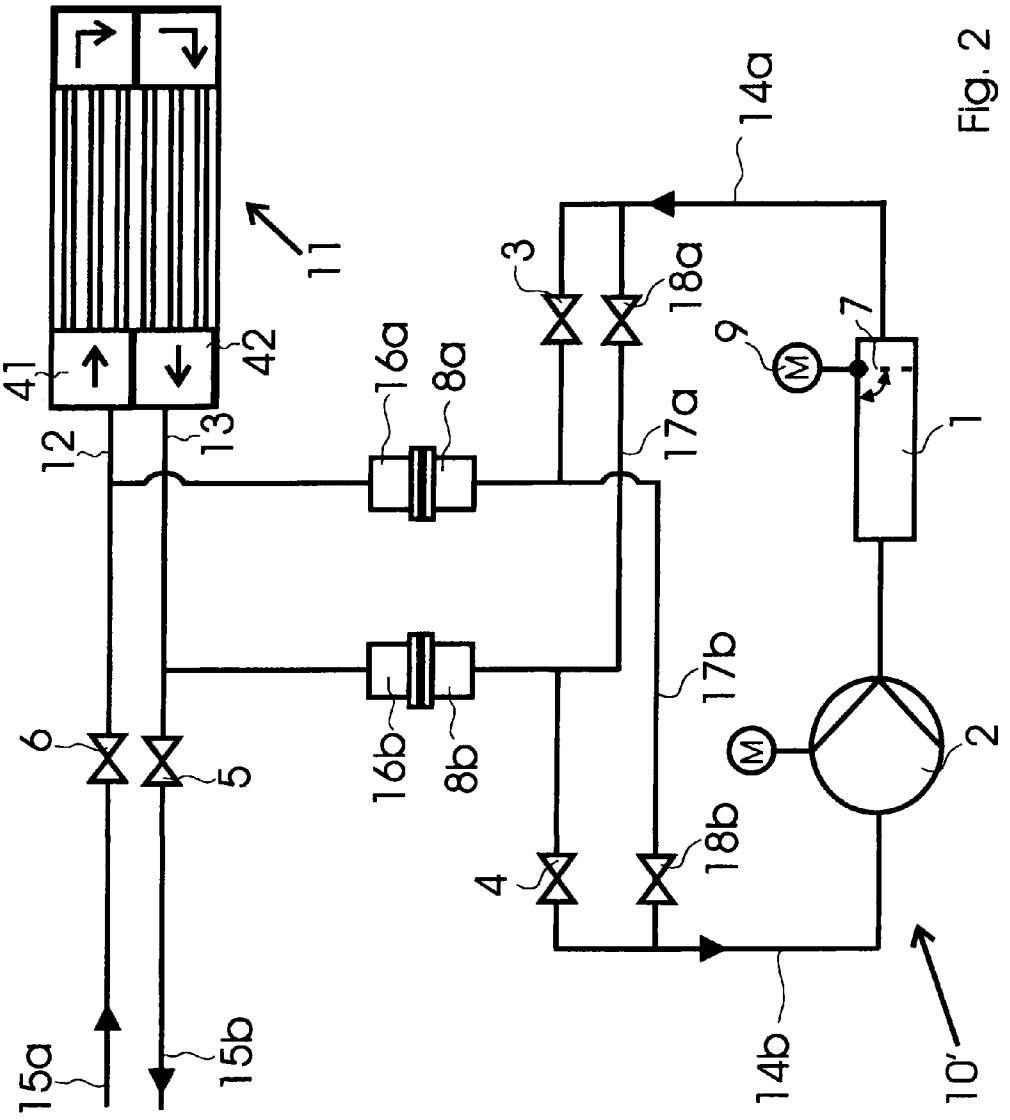

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Fig. 2

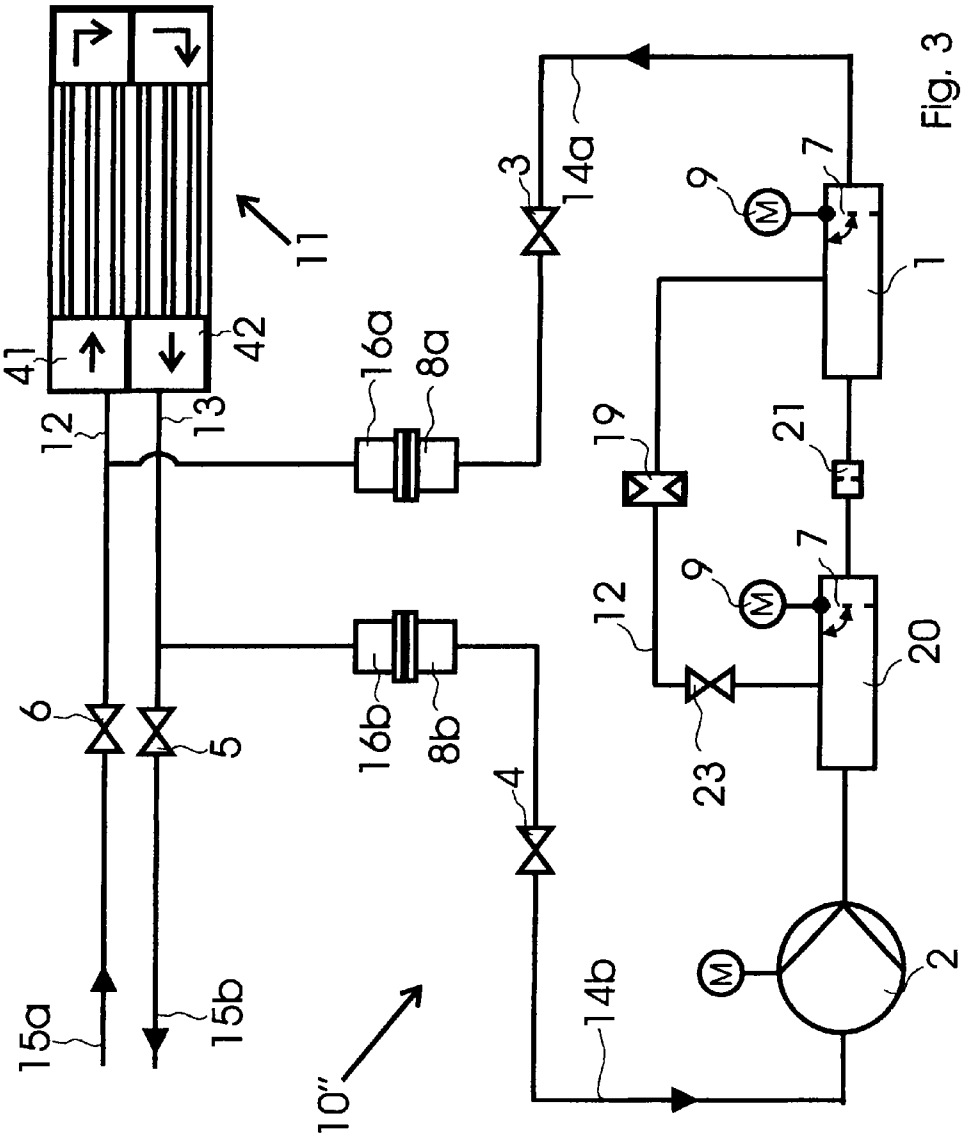
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Fig. 3

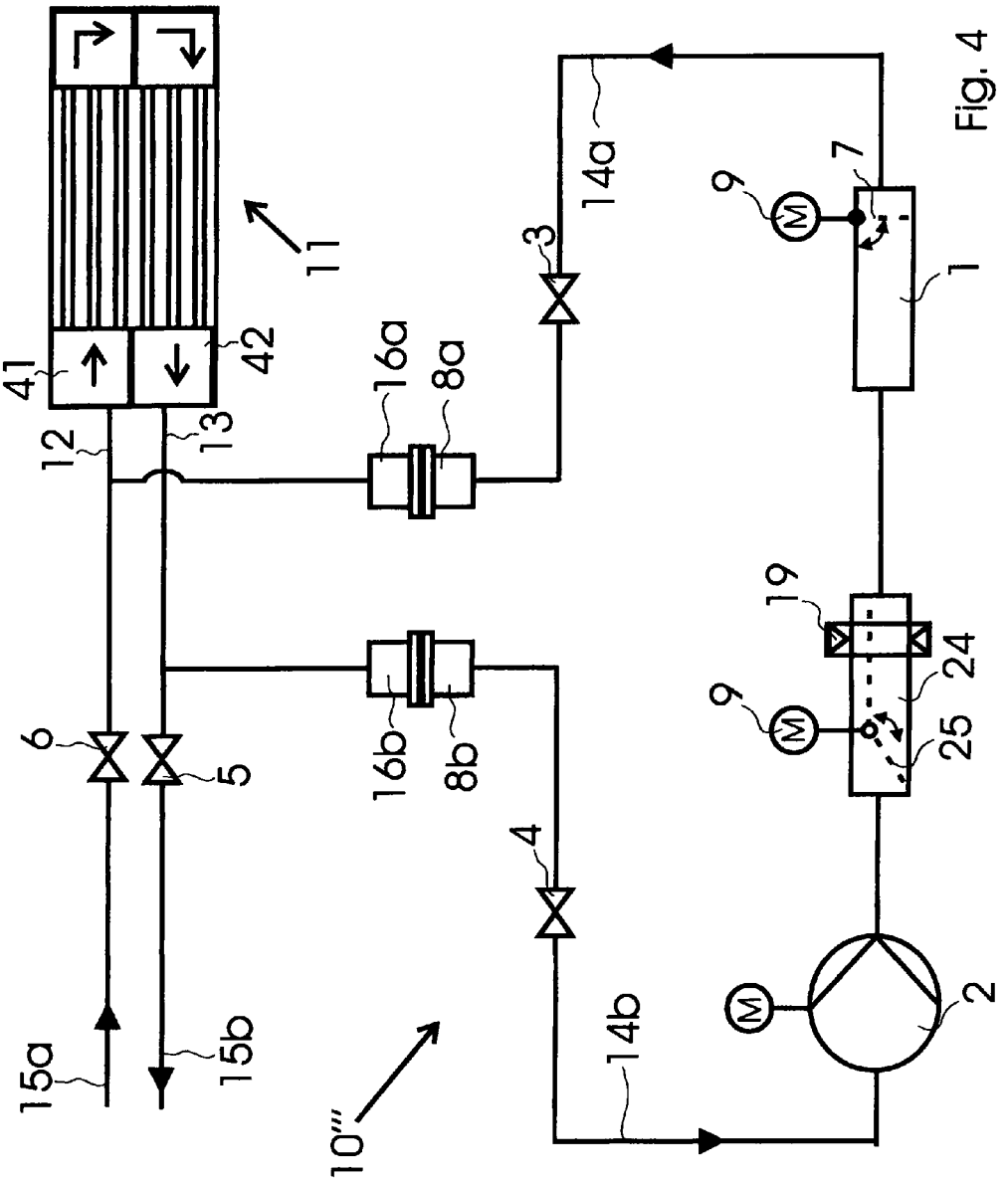

Fig. 4

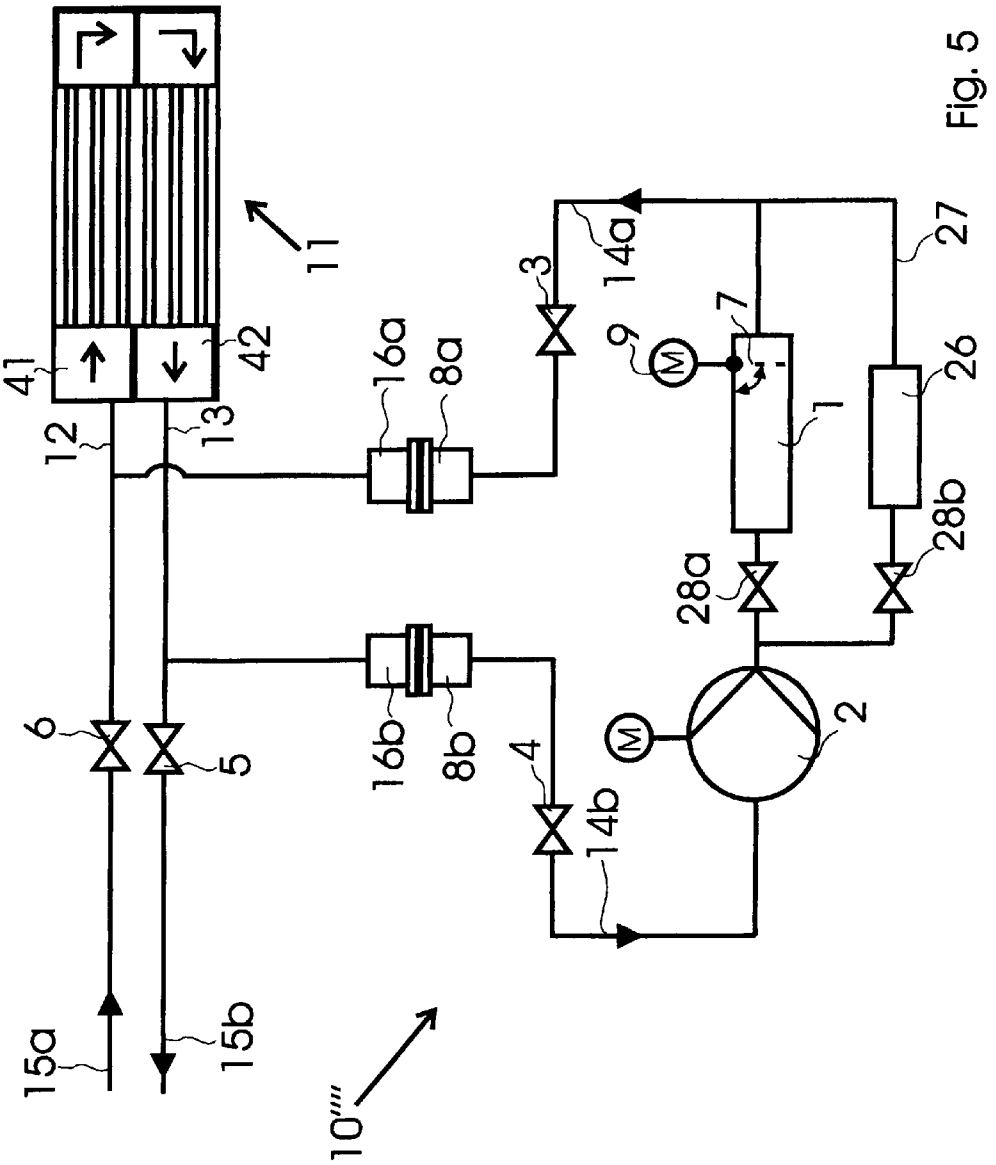
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Fig. 5

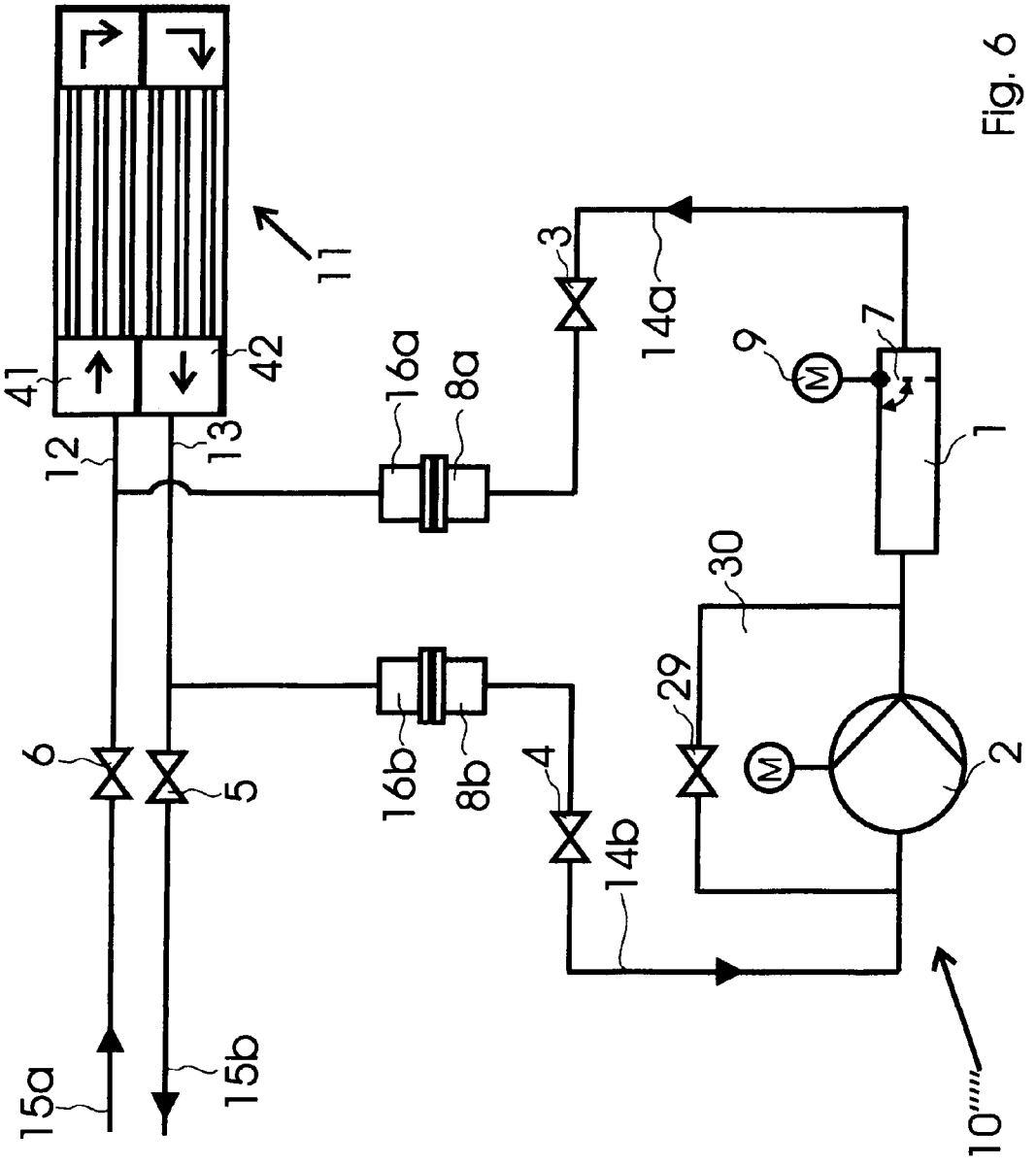

Fig. 6

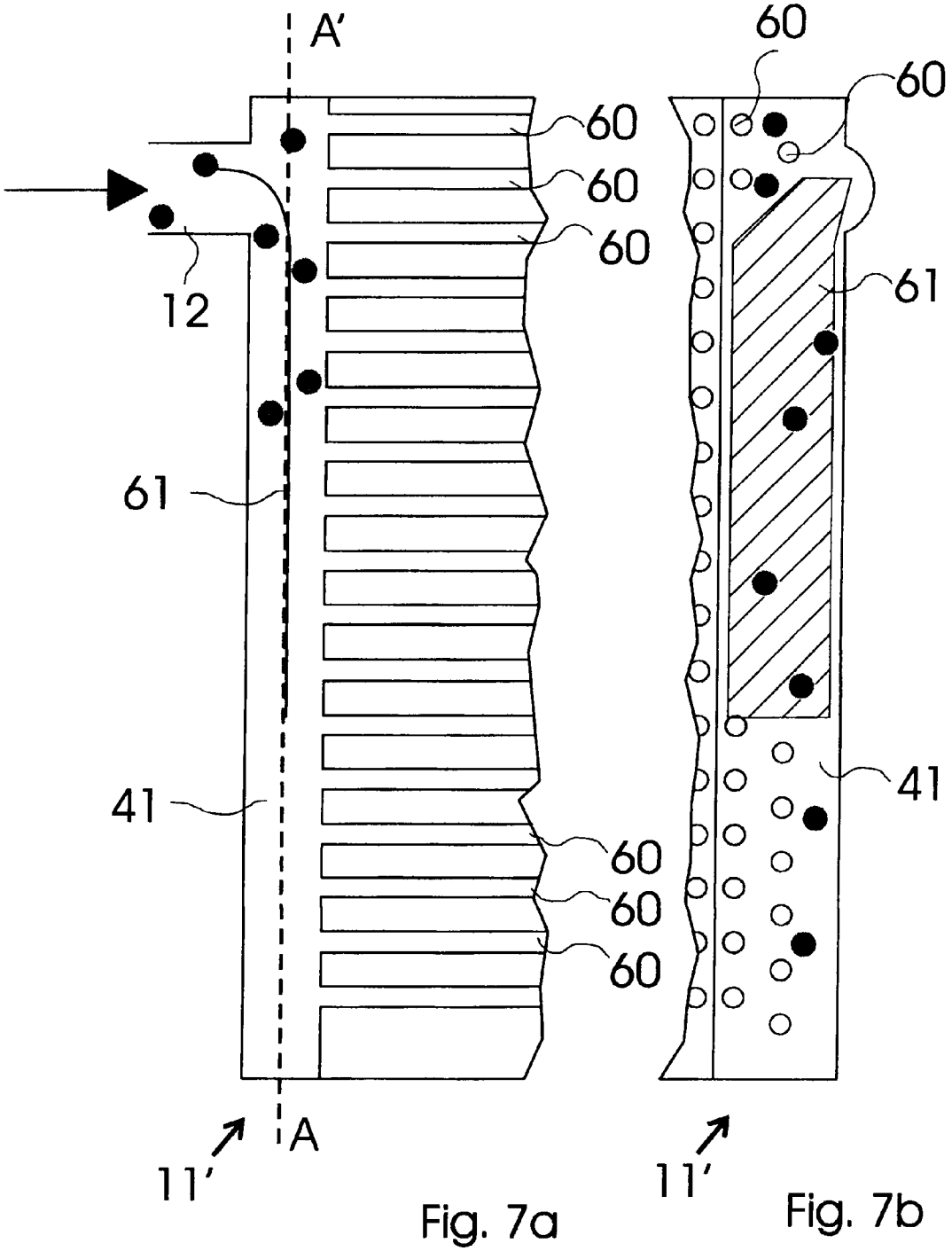

Fig. 7a

Fig. 7b

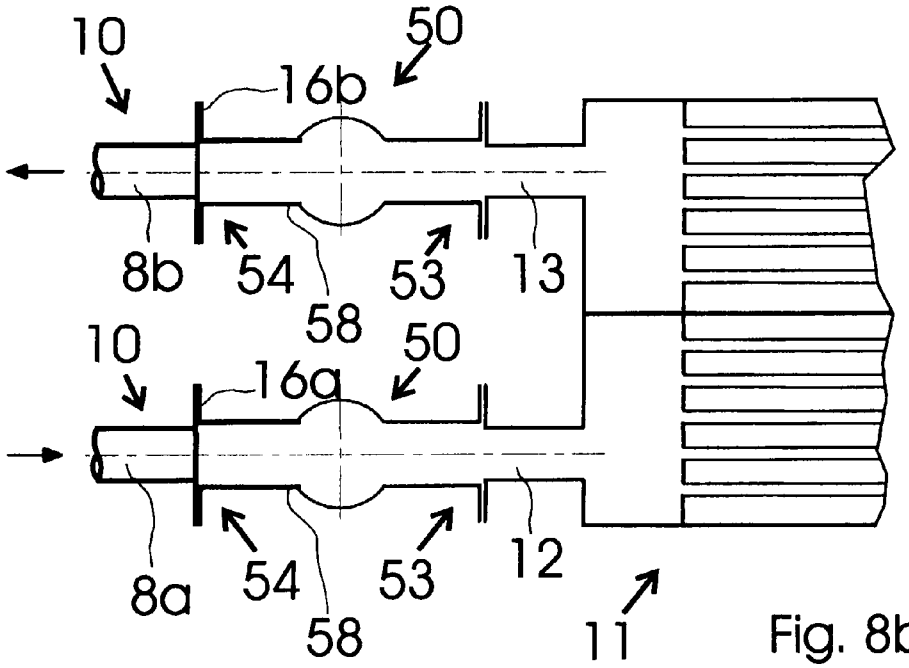
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Fig. 8b

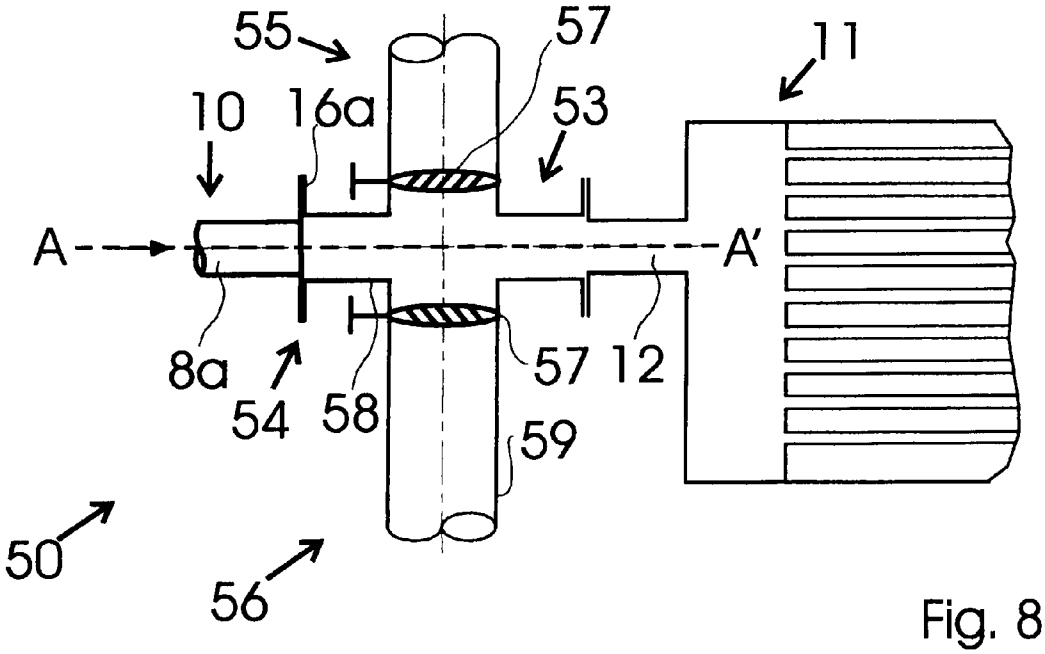
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Fig. 8a

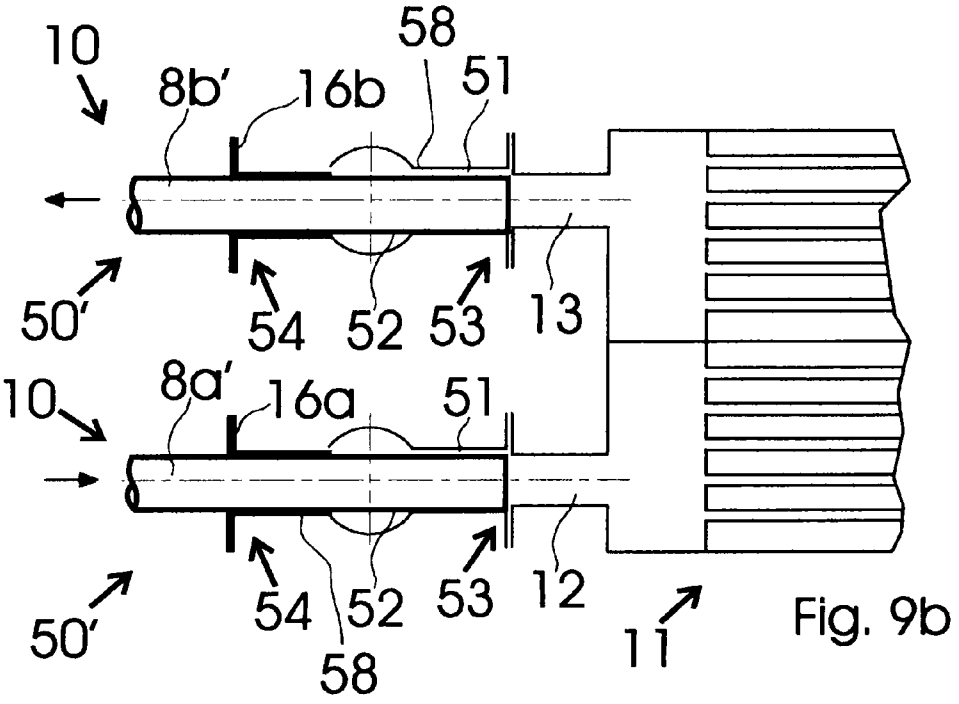
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Fig. 9b

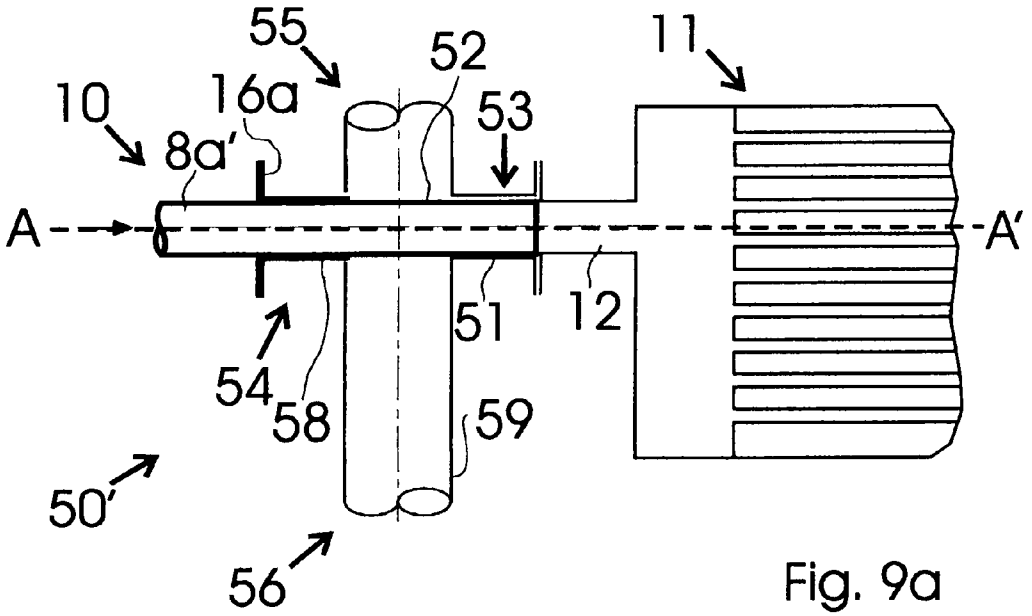
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Fig. 9a

SYSTEM FOR CLEANING HEAT EXCHANGERS

BACKGROUND

[0001] (1) Field of the Invention

[0002] The invention relates to a system for cleaning heat exchangers, in particular power plant heat exchangers, and more particularly, heat exchangers in the hot area of nuclear power plants. Furthermore, the invention relates to an adapter for heat exchangers, a heat exchanger, and a method for operating a cleaning system for heat exchangers.

[0003] (2) Prior Art

[0004] Cleaning plants for heat exchangers are known in the state of the art. Spherical, sponge-like cleaning bodies are injected, for example, into the fluid flow in the inlet line of a tube-bundle heat exchanger during normal operation. The fluid flow, for example the cooling water, carries these cleaning bodies through the individual tubes of the heat exchanger whereby deposits in the heat exchanger are mechanically removed. In the outlet line of the heat exchanger, the cleaning bodies are separated from the fluid flow by means of a screen device after passing through the heat exchanger, and guided into a recirculating line, either to collect them there after a successful cleaning cycle or to reintroduce them into the inlet line of the heat exchanger.

[0005] Such systems are not suitable, however, for all applications. It is thus necessary on the one hand to provide an injector in the inlet line of the heat exchanger that introduces the cleaning bodies into the fluid flow, and on the other hand to provide the initially described screen devices in the outlet line of the heat exchanger allowing the cleaning bodies to be removed from the fluid flow after passing through the heat exchanger. It is thus necessary to make major modifications to the structure of the heat exchanger circuit.

[0006] Such a modification has its drawbacks, however, in certain cooling plants, for example in nuclear power plants, due to the high safety standards. For this reason numerous heat exchangers of cooling and refrigerating applications situated in the hot area of nuclear power plants are not automatically cleaned during running operation but only manually during maintenance periods.

SUMMARY OF THE INVENTION

[0007] It is thus the object of the present invention to create a heat exchanger cleaning system, in particular for heat exchangers in nuclear power plants, which avoids the initially mentioned drawbacks.

[0008] The object is achieved by a mobile heat exchanger cleaning system according to the claims. Further aspects of the invention relate to an adapter for the heat exchanger, a heat exchanger, and a method of operating a heat exchanger cleaning system. The dependent claims relate to preferred embodiments of the invention.

[0009] According to the present invention, the mobile heat exchanger cleaning system comprises a first apparatus for collecting, introducing and removing cleaning bodies, a pump for pumping a fluid with cleaning bodies, and connecting means connected with the apparatus and the pump for releasable connection of the cleaning system to a heat exchanger.

[0010] The system according to the present invention allows safe and reliable cleaning of power plant heat exchangers, for example, whereby the overhead for installation and acquiring permits is advantageously reduced. The system is mobile and can be easily transported to various deployment locations.

[0011] Compared to the previous manual cleaning of heat exchangers in nuclear power plants, the invention further enables the radiation exposure of the operating personnel to be advantageously reduced, since cleaning can be carried out almost entirely automatically.

[0012] In the context of the present invention, a heat exchanger is construed to mean a heat transfer means, in particular, which transfers the thermal energy from a first medium, such as a fluid, for example cooling water, to a further medium, such as air or water. It goes without saying that the invention is basically suitable for all such heat exchangers, irrespective of whether the first medium is cooled or heated. The terminology used in the following should thus be construed in the broader sense.

[0013] In particular, the invention is suitable for heat exchangers in nuclear power plants, preferably for tube-bundle heat exchangers in cooling or refrigerating plants.

[0014] A cleaning body is understood to be any kind of body that has a cleaning effect as it passes through the respective type of heat exchanger to be cleaned. Preferably, spherical cleaning bodies are used, in particular preferably of a sponge-like material, such as plastic material or foamed plastic. The cleaning bodies should be adapted to the dimensions of the heat exchanger tubes and to the respective medium, so that they can be transported through the heat exchanger together with the fluid flow.

[0015] In the context of the present invention, a cooling line is understood to be a connection line, with the aid of which the heat exchanger is connected to a cooling circuit, such as a cooling or refrigerating plant, in operation.

[0016] As far as a separation of individual components from each other, such as the heat exchanger from the cooling line, is referred to in the present invention, complete separation is not necessary. Rather the usual leakages are possible.

[0017] As initially discussed, the system according to the present invention comprises a first apparatus for collecting, introducing and removing the cleaning bodies.

[0018] The apparatus can have any suitable configuration and can have a one-part or multi-part construction. For introducing and removing, the apparatus can have a maintenance opening, for example, which seals the apparatus in operation, but allows removal or introduction of the cleaning bodies.

[0019] Advantageously, the apparatus comprises a screen device to reliably collect the cleaning bodies after completion of a cleaning cycle, or to store them. Preferably, the screen device can be moved or adjusted in at least one first and one second position. A correspondingly configured motor drive, for example, can be used for this purpose.

[0020] Particularly preferably the screen device is formed in such a manner, that it allows collection of the cleaning bodies in the apparatus in the first position, which will be referred to as "collecting" or "catching operation" in the following.

[0021] Particularly preferably the screen device is configured in such a manner that it allows introduction of the cleaning bodies into an inlet line of the system, or into a heat exchanger connected to the system, in a second position. The second position of the screen device therefore corresponds to a "cleaning operation".

[0022] The pump according to the present invention is configured for pumping the fluid and the cleaning bodies con-

tained therein. The pump should be adapted to the respective hydraulic conditions of the system and the heat exchanger, in particular with respect to the volume flow to be pumped or the line cross-section and pressure.

[0023] The pump should be arranged upstream of the apparatus with respect to the flow direction, which results in favorable hydraulic conditions for the catching operation, in particular. The pump preferably has a frequency-controllable motor.

[0024] According to the present invention, connecting means are also provided, which are connected with the apparatus and the pump. The connecting means are further configured for releasable connection of the cleaning system to the heat exchanger so that the system can be easily and simply connected to the heat exchanger to be cleaned. The system according to the present invention is thus easily transportable.

[0025] In operation, a closed cleaning circuit is provided between the apparatus, the pump and the heat exchanger by means of the connecting means.

[0026] Preferably, the connecting means comprise a first connecting element for releasable connection of the cleaning system with an inlet line of the heat exchanger, and a second connecting element for releasable connection of the cleaning system with an outlet line of the heat exchanger.

[0027] The connecting elements can be configured as connection flanges, such as screw or weld flanges to allow secure connection with the heat exchanger. Alternatively, or additionally, the connecting elements can be configured as quick-release couplings so that simple installation is possible. Suitable quick-release coupling systems are known according to the state of the art.

[0028] According to a preferred embodiment of the invention, the first and/or the second connecting element comprises a connecting tube for connection with the inlet or outlet lines of the heat exchanger.

[0029] The connecting tube can be adapted, for example, to the inlet or outlet lines so that the cleaning system can be releasably connected with the heat exchanger by engaging the connecting tube with a section of the inlet or outlet line. By these means, a further simplified connection of the system with the heat exchanger is enabled.

[0030] Preferably, the outer diameter of the connecting tube essentially corresponds to the inner diameter of at least one section of the inlet or outlet line of the heat exchanger so that a secure connection of the cleaning system to the heat exchanger is provided.

[0031] The connecting tube can have the form of a sleeve, or can be conical and/or can be provided with a radially-arranged sealing ring. However, a completely sealed connection is not absolutely necessary for many applications.

[0032] The connecting elements can of course also have a connection flange, or a corresponding quick-release coupling, to further increase connection security even if configured with the above described connecting tube.

[0033] If the heat exchanger is equipped with a connecting adapter, as described below, the outer diameter of the connecting tube should essentially correspond to the inner diameter of at least a section of the respective connection piece of the adapter.

[0034] Particularly preferably, the connecting tube is configured in such a manner that the inlet and/or the outlet lines of the heat exchanger are essentially, i.e. excepting any leakages, separated from a cooling line and connected to the cleaning system in the usage position on the heat exchanger.

[0035] According to the present embodiment, the connecting elements thus advantageously create a connection between the cleaning system and the heat exchanger and, at the same time, separate the heat exchanger from the cooling circuit.

[0036] While a complete separation of the heat exchanger may not be absolutely necessary, it should be made sure that no cleaning bodies pass into the cooling line or the cooling circuit.

[0037] Preferably, the heat exchanger cleaning system can be connected to the heat exchanger in such a manner that, in the usage position, the volume flow flowing through the heat exchanger essentially corresponds to the volume flow flowing through the system.

[0038] According to the present embodiment, the heat exchanger to be cleaned is thus not connected to the cooling circuit during the cleaning operation but only to the cleaning system, excepting any leakages. The system is thus releasably connectable to the heat exchanger for "offline cleaning".

[0039] Particularly preferably the system is configured in such a manner that the volume flow flowing through the heat exchanger essentially, i.e. excepting any leakages, corresponds to the volume flow flowing through the first apparatus for collecting, introducing and removing the cleaning bodies.

[0040] According to a preferred embodiment, the first apparatus is connected to the connecting means, or the first connecting element, via a supply line. The pump is connected to the connecting means or the second connecting element, via a return line.

[0041] The lines can also be configured as hoses, for example. For cleaning ordinary power plant heat exchangers of cooling or refrigerating plants, the lines preferably have a diameter of between 25 and 150 mm, preferably between 30 and 100 mm and particularly preferably between 40 and 80 mm.

[0042] Preferably at least one valve is provided to separate the first apparatus and/or the pump from the connecting means. In particular, a first valve can be arranged in the supply line and/or a second valve can be arranged in the return line. The valves can be integrally formed, for example, with the connecting elements, to achieve a particularly compact structural shape. Preferably the valves can be operated, for example, by means of one or more electric or pneumatic servomotors, via an electric or electronic control.

[0043] According to a preferred embodiment of the invention, a first reversal line with a third valve is provided, wherein the first reversal line connects the supply line or the apparatus with the second connecting element. A second reversal line with a fourth valve is provided, wherein the second reversal line connects the return line or the pump with the first connecting element.

[0044] The reversal lines allow the flow direction to be reversed in the heat exchanger, in particular to free any cleaning bodies jammed in the heat exchanger during a catching operation. Furthermore, a respective reversal operation allows an even better cleaning operation in cases of heavy deposits.

[0045] Preferably, the pump has a control unit to adjust the volume flow of the pump. A volume flow variation of preferably at least 20%, also intermittently if required, should be possible. The control unit can comprise a frequency control or closed-loop control, to vary the rotational speed and pumping rate of the pump. Alternatively or additionally, the control unit can comprise a pump bypass and a respective valve to

achieve an adjustment or reduction of the pumped volume flow by hydraulically short-circuiting the pump.

[0046] Depending on the configuration of the heat exchanger, it is thus advantageously possible to influence the distribution of the cleaning bodies within the heat exchanger and to adapt it to each heat exchanger type.

[0047] Preferably the control unit is alternatively or additionally configured in such a manner that it can operate the pump in intermittent, for example non-continuous operation. Such operation is also suitable to achieve a variation of the volume flow within the heat exchanger and thus to control the distribution of the cleaning bodies in the heat exchanger.

[0048] In the context of the present invention, an intermittent operation of the pump means that the volume flow emitted by the pump is temporarily varied, i.e. reduced or increased. The variation can be in surges or pulses. A control is also possible, i.e. a variation of the emitted volume flow with a greater time constant that can be periodic, for example. It is useful to have a combination of the surging or intermittent operation and the above-described control, i.e. the variation of the volume flow.

[0049] The control unit is preferably configured in such a manner that it operates or controls the pump in correspondence with the dimensions and sinking velocity of the cleaning bodies in such a manner that there is essentially a uniform distribution of the cleaning bodies in the heat exchanger. The variation of the volume flow thus allows varied dwell times of the cleaning bodies in the inlet area of the heat exchanger and thus, in turn, varied distribution profiles of the cleaning bodies in the inlet area of the heat exchanger.

[0050] According to a preferred embodiment of the invention, a counting device is provided for the cleaning bodies. The counting device allows the number of cleaning bodies present in the system or in the heat exchanger to be determined. In the catching operation after cleaning is completed it can thus be determined, for example, whether all cleaning bodies have been removed from the heat exchanger and the cleaning system can thus be switched off and separated from the heat exchanger.

[0051] The counting device can have a one or multi-part configuration and comprise mechanical determination means, for example, such as a counting wheel. Preferably the counting device comprises at least one light barrier enabling a particularly reliable counting operation.

[0052] The counting device can be arranged in the supply and/or return line to count the cleaning bodies passing through the supply and/or return lines. Alternatively or additionally the counting device can be arranged between the pump and the first apparatus.

[0053] Preferably, a supply apparatus is upstream of the counting device to supply the cleaning bodies in an individual or defined manner to the counting device. The precise configuration of the supply apparatus should be adapted to each type of counting device.

[0054] The supply apparatus can preferably comprise a screen that is moveable or pivotable into at least a first and a second position. In the first position, the screen is for supplying the cleaning bodies individually or in a defined manner to the counting device. In the second position, the screen is preferably pivoted in such a manner that it allows cleaning of the screen, for example, by means of backwashing.

[0055] According to a preferred embodiment of the invention, a second apparatus is provided for collecting the cleaning bodies. The second apparatus is preferably arranged between the first apparatus and the pump for temporarily storing or collecting the cleaning bodies in the catching operation.

[0056] Preferably, the second apparatus is arranged such that, in the usage position, the volume flow flowing through the heat exchanger essentially, i.e. excepting any leakages, corresponds to the volume flow flowing through the second apparatus.

[0057] Particularly preferably, the second apparatus can comprise a screen device movable at least into a first and a second position. The screen device can be configured in such a manner that it allows collecting of the cleaning bodies in the second apparatus in its first position.

[0058] Alternatively or additionally the second apparatus can be configured in such a manner that it supplies cleaning bodies to the counting device in its first position. In this way, for example, after completion of the cleaning operation, it is possible to check whether all cleaning bodies have been removed from the heat exchanger or whether further measures, such as the initially discussed reversal operation or an intermittent, i.e., for example, surging operation of the pump is necessary to free the cleaning bodies remaining in the heat exchanger.

[0059] Preferably, the screen device of the second apparatus is configured in such a manner that it allows the cleaning bodies to be supplied to the counting device in the first position and to the first apparatus and/or the supply line in the second position.

[0060] According to an embodiment of the invention, a filter or filter unit for separating out contaminant particles is arranged, for example, between the pump and the first apparatus. The filter should be adapted to each medium and the contamination to be expected. The filter is preferably a particle filter.

[0061] Preferably the filter is arranged in a filtration line arranged parallel to the first and/or second apparatus. Particularly preferably at least one valve arrangement is provided to guide fluid at least partially through the filtration line and/or the first or second apparatus in the usage position.

[0062] For use of the cleaning system according to the present invention it is desirable to simply connect the cleaning system to the heat exchanger as initially described.

[0063] A second aspect of the present invention thus relates to an adapter for a heat exchanger, in particular a power plant heat exchanger. The adapter has at least a first port for connecting it with the heat exchanger, a second port for releasably connecting a heat exchanger cleaning system, and a third port to connect it to a cooling line, for example a cooling circuit of a cooling or refrigerating plant.

[0064] The adapter according to the present aspect permits simple retrofitting of existing heat exchangers so that a cleaning system, for example according to the above described embodiments, can be easily and quickly connected to a heat exchanger. Particularly present heat exchangers can thus be simply operated with the above described cleaning system.

[0065] To establish a releasable connection to a cleaning system, the second port can be configured with a connection flange for connecting it with a corresponding connecting element, such as a screw or weld flange or a quick-release coupling.

[0066] It goes without saying that the first port can serve to establish a connection with an inlet and/or outlet line of the heat exchanger. It is of course also conceivable that the adapter is integrally formed with the heat exchanger.

[0067] Preferably two adapters are provided, namely a first adapter for connecting the inlet line of the heat exchanger with a supply line of the cleaning system, and a second adapter for connecting an outlet line of the heat exchanger with a return line of the cleaning system.

[0068] The adapter can also preferably be provided with a fourth port, as the case may be, to connect further heat exchangers with the cooling line. In particular, the first and the fourth port can be configured for a so-called header line that connects a plurality of heat exchangers in the cooling circuit.

[0069] Preferably, means for flow control are provided to connect the heat exchanger either with the cleaning system or the second port, or the cooling line or the third port.

[0070] The initially discussed means for flow control can feature all suitable configurations to connect the heat exchanger either with the second or the third port. It is thus ensured that the heat exchanger, in the operating condition, is either connected to the cooling circuit or, during cleaning, to the cleaning system. Even though complete separation from the respective other connection is desirable, it is sufficient if the means is configured in such a manner that no cleaning bodies of the cleaning system enter into the cooling circuit. Smaller leakages into the cooling circuit, in particular during the established connection of the cleaning system, are thus by all means possible.

[0071] Preferably, the means are switchable from a first position to a second position to connect the first port either with the second or the third port. Preferably the means comprise at least one switchable valve.

[0072] Alternatively or additionally, the adapter has a connecting portion with at least one section having an inner diameter essentially corresponding to the outer diameter of a connecting tube of a cleaning system to be connected by means of the adapter. Preferably, the section is configured in such a manner that when the connecting tube of the cleaning system is connected, the first port is separated from the third port, i.e. excepting any leakages.

[0073] For this purpose the adapter can be configured, for example, with a first conduit at which the first and second ports face each other. A second conduit or header tube extends perpendicular to the first conduit and is connected to the latter in the area between the first and second ports. The second conduit has the third and fourth port, as the case may be, at its end. The inner diameter of the first conduit preferably essentially corresponds to the outer diameter of the connecting tube.

[0074] The connecting tube in this case can be inserted into the first conduit by means of the second port in such a manner that the second conduit is bridged or covered by the connecting tube. The heat exchanger is then only connected to the cleaning system.

[0075] The above described adapter is suitable, in particular, in combination with the initially described mobile heat exchanger cleaning system.

[0076] According to a further independent aspect of the present invention, a heat exchanger, in particular for power plants, is provided with an inlet line, an outlet line and a plurality of tubes. The tubes connect the inlet line with the outlet line. At least one guiding element is provided for distributing cleaning bodies to the plurality of tubes.

[0077] The guiding element ensures improved distribution of the cleaning bodies in the heat exchanger, in particular in a tube-bundle heat exchanger in cooling or refrigerating plants. An irregular distribution of the cleaning bodies in the individual tubes causing a reduction of performance is thus advantageously avoided.

[0078] The guiding element can have any number of suitable configurations; preferably, the guiding element is configured as a guiding grid or guiding plate. Alternatively or additionally, the guiding element can have an impacting element ensuring a largely random distribution of the cleaning bodies.

[0079] If the inlet line and/or the outlet line is connected to the tubes via at least one tube manifold, the guiding element should preferably be arranged in the tube manifold.

[0080] The above-discussed heat exchanger is particularly advantageous in combination with the inventive mobile heat exchanger cleaning system, or the above-discussed adapter.

[0081] A further independent aspect of the present invention relates to a method of operating a heat exchanger cleaning system, mobile as the case may be, with a pump for pumping a fluid with cleaning bodies through a heat exchanger. Herein, the pump is operated intermittently and/or controlled according to the present aspect in order to achieve a variation of the pumped volume flow in the heat exchanger.

[0082] The present method allows for improved distribution of the cleaning bodies in the heat exchanger, but advantageously without structural modifications of the existing plants. Furthermore, the method allows for the removal of any cleaning bodies stuck during cleaning in the heat exchanger, in a catching operation.

[0083] In the context of the present aspect, an intermitting operation of the pump means that the volume flow pumped by the pump is temporarily varied, i.e. reduced or increased. Herein, the variation can be in surges or pulses. However, a control is also possible, i.e. a variation of the emitted volume flow with a greater time constant, such as for example in a periodic manner. Preferably the operation in surges or pulses and the above mentioned control, i.e. the variation of the volume flow, is combined.

[0084] Preferably, the pump is intermittently operated between at least one first and one second operating state, wherein the emitted volume flow differs by at least 20% between the first and second operating condition, i.e. the volume flow variation is at least 20%.

[0085] Depending on the dimensioning and the sinking velocity of the cleaning bodies, the pump can be preferably operated or controlled in such a manner that an essentially uniform distribution of the cleaning bodies is provided in the heat exchanger. This is because, by varying the volume flow, different dwell times of the cleaning bodies in the inlet area of the heat exchanger and thus, in turn, varied distribution profiles of the cleaning bodies in the inlet area of the heat exchanger are possible.

[0086] To achieve this, the above described intermittent operation can be used, for example. Alternatively or additionally, it is also conceivable to adjust the pumping rate of the pump in such a manner that the cleaning bodies can sink in the inlet area of the heat exchanger and are thus advantageously distributed in the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0087] The invention will be explained in the following with reference to exemplary embodiments. In the drawings:

[0088] FIG. **1***a* shows a first exemplary embodiment of a cleaning system in a schematic view,

[0089] FIG. **1***b* shows the exemplary embodiment of FIG. **1***a* with a connected heat exchanger;

[0090] FIG. **2** shows a second exemplary embodiment of a cleaning system in a schematic view;

[0091] FIG. **3** shows a third exemplary embodiment of a cleaning system in a schematic view;

[0092] FIG. **4** shows a fourth exemplary embodiment of a cleaning system in a schematic view;

[0093] FIG. **5** shows a fifth exemplary embodiment of a cleaning system in a schematic view;

[0094] FIG. **6** shows a sixth exemplary embodiment of a cleaning system in a schematic view;

[0095] FIG. **7***a* is a schematic view of an exemplary embodiment of a heat exchanger in a first sectional view;

[0096] FIG. **7***b* shows the exemplary embodiment according to FIG. **7***a* in a second sectional view;

[0097] FIG. **8***a* is a schematic view of an exemplary embodiment of an adapter for a heat exchanger in a first sectional view;

[0098] FIG. **8***b* is a schematic view of the exemplary embodiment according to FIG. **8***a* in a second sectional view;

[0099] FIG. **9***a* is a schematic view of a second exemplary embodiment of an adapter for a heat exchanger in a first sectional view; and

[0100] FIG. **9***b* is a schematic view of the exemplary embodiment according to FIG. **9***a* in a second sectional view.

[0101] FIG. **1***a* shows a first exemplary embodiment of the cleaning system **10** according to the present invention in a schematic view.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0102] The cleaning system comprises an apparatus **1** which collects or receives the cleaning bodies (not shown) and enables the introduction or removal of these. To achieve this, collection apparatus **1** can have a maintenance opening, for example, which seals apparatus **1** in operation with respect to the environment, but which enables removal or introduction of the cleaning bodies for maintenance purposes. The cleaning bodies in the present example are configured as cleaning spheres of plastic or foamed plastic, wherein they should of course be adapted to the respective cleaning task.

[0103] Apparatus **1** has a pivotable screen device **7** allowing the cleaning operation to be controlled as will be explained in detail in the following. Screen device **7** is driven by means of an associated motor **9** and can thus be pivoted from a first position into at least a second position. Similarly, alternatively or additionally, manual operation is also possible. In the first position shown, which corresponds to the so-called "catching operation", the cleaning bodies are retained in apparatus **1**, while in the second position (not shown), which corresponds to a cleaning operation, the cleaning bodies are released into a supply line **14***a*.

[0104] Cleaning system **10** further comprises a pump **2**, which is connected to apparatus **1** via a respective tube and, as shown in FIG. **1***a*, is arranged upstream of apparatus **1** as seen in the flow direction. Pump **2** comprises a motor which, if it has a frequency-controllable configuration, can achieve a rotational speed variation and thus adapt the volume flow pumped by pump **2**.

[0105] Cleaning system **10** further comprises connecting means for a releasable connection with a heat exchanger. As shown in FIG. **1***a*, for example, first connecting element **8***a* and a second connecting element **8***b* can be provided, which are connected to pump **2** and apparatus **1** via supply line **14***a* and return line **14***b* in a corresponding manner. Lines **14***a* and **14***b* are configured as hoses, for example, in the present case having a diameter of 80 mm. Lines **14***a* and **14***b* can of course also have different configurations or dimensions, and are adapted, in particular, to the heat exchanger to be cleaned.

[0106] Connecting elements **8***a* and **8***b* are configured as a screw-connectable port flange in the present case and enable a releasable connection of cleaning system **10** with the heat exchanger to be cleaned. Connecting elements **8***a* and **8***b* can also have other configurations, but connecting elements **8***a* and **8***b* should enable secure connection with the heat exchanger to be cleaned or a corresponding connecting adapter, as will be explained in the following. Connecting elements **8***a* and **8***b* can also be configured as quick-release couplings or quick-release locks to further simplify handling. Two valves **3** and **4** are provided to separate apparatus **1** and pump **2** from connecting elements **8***a* and **8***b* as needed.

[0107] Cleaning system **10** according to FIG. **1***a* has a mobile configuration so that the plant can be easily transported to the heat exchanger in question. For this purpose, pump **2** and apparatus **1** are mounted on a mobile base frame or chassis (not shown). System **10** can thus be used in various manners so that only one cleaning system **10** is necessary for a plurality of heat exchangers such as is the case in a power plant. For this reason the investment necessary can be substantially lowered as compared to known fixedly installed systems.

[0108] FIG. **1***b* shows cleaning system **10** according to FIG. **1***a* in the usage position on a respective heat exchanger **11**. The latter is a tube-bundle heat exchanger with about 500 individual tubes. Heat exchanger **11** has an inlet line **12** which, in normal cooling operation, is linked to a first cooling line **15***a* of the cooling circuit (not shown), for example, a cooling or refrigerating plant of a nuclear power plant. The cooling circuit is operated with process water in the present case, however, other fluids are also conceivable.

[0109] Inlet line **12** opens out into an inlet-side tube manifold **41** communicating with an outlet-side tube manifold **42** via the individual tubes. Outlet-side tube manifold **42**, in turn, is linked to a second cooling line **15***b* of the cooling circuit via an outlet line **13**. The present cleaning system **10** is of course also suitable for cleaning heat exchangers **11** having a different structure. Similarly, the cooling circuit can have further heat exchangers **11** as the case may be, depending on its dimensioning.

[0110] For cleaning heat exchanger **11**, cleaning system **10** is first connected to inlet line **12** and outlet line **13** of heat exchanger **11**. As shown in FIG. **1***b*, joint elements **16***a* and **16***b* are provided for connection with connecting elements **8***a* and **8***b* in order to connect cleaning system **10** with heat exchanger **11**. Joint elements **16***a* and **16***b* are configured as a flange in correspondence with connecting elements **8***a* and **8***b* in order to create a secure connection.

[0111] Four valves **3**, **4**, **5**, **6** are provided overall to separate heat exchanger **11** from cooling lines **15***a* and **15***b* and thus from the cooling circuit and to connect them with supply line **14***a* and return line **14***b* of cleaning system **10** and thus with the cleaning circuit. After opening valves **3** and **4**, cleaning system **10** is connected with inlet line **12** and outlet line **13** of heat exchanger **11**. In contrast to hitherto known systems, heat exchanger **11** is thus only connected with the cleaning circuit during the cleaning operation, i.e. the cleaning system

10 and no longer with the cooling circuit, which will also be referred to as an "offline operation" in the following. The volume flow flowing through heat exchanger 11 is thus essentially, i.e. excepting any leakages, guided through system 10, or apparatus 1, whereby the screens provided in prior systems for separating a partial flow of the fluid and cleaning bodies contained therein is advantageously avoided. System 10 is thus extremely cost-effective.

[0112] For the cleaning process, system 10 is first filled with water, for example from the cooling circuit. Subsequently, pump 2 is activated and screen 7 of apparatus 1 is brought into the second position (not shown) so that the cleaning bodies pass through supply line 14*a* and inlet line 12 into the individual tubes of heat exchanger 11 to remove deposits or sediment therein. The cleaning bodies subsequently pass through outlet line 13 and return line 14*b* to pump 2 and are returned to apparatus 1 in a corresponding manner.

[0113] With screen device 7 in an open position a continuous cleaning operation is provided, which can be carried out fully automatically as the case may be. System 10 thus only requires little personnel overhead for connection of system 10, while operation is largely automatic. This is advantageous, in particular, in security areas, for example of nuclear power plants, since the radiation exposure of personnel is thereby lowered by a substantial degree.

[0114] After the cleaning process is completed, screen device 7 is moved into the closed, first position by servomotor 9 so that the cleaning bodies are collected in apparatus 1. Subsequently, valves 3 and 4 are closed, valves 5 and 6 are opened, whereby the heat exchanger is connected to the cooling circuit again.

[0115] Cleaning system 10 can then be separated from heat exchanger 11 and used, for example, for cleaning a further heat exchanger 11. The plant is thus extremely flexible.

[0116] Preferably, system 10 comprises an electronic control unit (not shown) for controlling the individual components, in particular pump 2 and apparatus 1, so that the cleaning operation is automatically carried out. The control unit can be configured, for example, as a microprocessor or SPS control, which, in combination with respective programming controls the cleaning operation.

[0117] It has been shown that it is absolutely necessary that the cleaning bodies are completely removed from heat exchanger 11 after completion of the cleaning operation. In particular, blocking of the tubes of heat exchanger 11 by any remaining cleaning bodies must be avoided.

[0118] FIG. 2 thus shows a second exemplary embodiment of the heat exchanger cleaning system 10' according to the present invention which, in the usage position as seen in FIG. 1*b* is shown connected to a heat exchanger 11.

[0119] System 10' largely corresponds to system 10 explained with reference to FIGS. 1*a* and 1*b*, wherein a first reversal line 17*a* and a second reversal line 17*b* are provided allowing fluid to pass through the heat exchanger 11 in a direction reversed with respect to FIG. 1*b*. First reversal line 17*a* connects supply line 14*a* with second connecting element 8*b* via a valve 18*a*. Second reversal line 17*b* connects return line 14*b* with first connecting element 8*a* via a further valve 18*b*. To reverse the flow direction, valves 3 and 4 are closed and subsequently valves 18*a* and 18*b* are opened, whereby the fluid is now supplied to heat exchanger 11 through outlet line 13.

[0120] It has been shown that the reversal of the flow direction advantageously enables any remaining cleaning bodies in the heat exchanger 11 to be released so that after completion of the cleaning process they can be collected in apparatus 1, as initially explained with reference to FIG. 1*b*.

[0121] Furthermore, the configuration of the cleaning system 10' according to FIG. 2 also allows an improved cleaning operation in the case of heavy deposits by reversing the flow direction during the cleaning process.

[0122] FIG. 3 shows a third exemplary embodiment of the heat exchanger cleaning system 10" according to the present invention which, in the usage position as shown in FIG. 1*b*, is shown connected to a heat exchanger 11.

[0123] According to FIG. 3, a further apparatus 20 is provided that is arranged between pump 2 and first apparatus 1. Second apparatus 20, just like first apparatus 1, comprises a pivotable screen device 7 for temporarily collecting the cleaning bodies, but also for supplying them to a counting device 19.

[0124] Counting device 19 enables the number of cleaning bodies to be determined, which pass from heat exchanger 11 back into cleaning system 10", for example, after the cleaning process. It can thus be determined, for example, whether the cleaning bodies have been completely removed from heat exchanger 11 after completion of the cleaning process.

[0125] During the cleaning operation, screen device 7 is also moved into the second, opened position (not shown) as discussed with reference to first apparatus 1. In the second position, screen device 7 allows unhindered passage of the cleaning bodies through second apparatus 20. A shutter 21 takes care of adjusting the volume flow in the line between second apparatus 20 and first apparatus 1.

[0126] After completion of the cleaning operation, both screen devices 7 of first apparatus 1 and second apparatus 20 are moved into the first, closed position for collecting the cleaning bodies in first apparatus 1.

[0127] The cleaning bodies are now temporarily collected in second apparatus 20 and supplied to a bypass line 22 by opening valve 23, which connects second apparatus 20 with first apparatus 1 via counting device 19.

[0128] The number of cleaning bodies is now determined by means of counting device 19. Hereafter, the cleaning bodies pass into first apparatus 1 and are stored there for another cleaning cycle. As soon as the overall number of the cleaning bodies contained in system 10" has been determined by counting device 19, pump 2 is switched off and valves 3-6 are controlled as initially discussed. System 10" can now be separated from heat exchanger 11.

[0129] Counting device 19 is also connected with the initially mentioned control unit, which is not shown in FIG. 3, however, for clarity. Counting device 19 comprises a light barrier in the present case to reliably detect the cleaning bodies. Counting device 19 can also have a different configuration, however, depending on the respective nature of the cleaning bodies, it is thus also conceivable, for example, to provide a camera to detect the cleaning bodies. Alternatively or additionally other counting devices, such as mechanical or electrical, could also be used.

[0130] An alternative exemplary embodiment of a cleaning system 10"' with counting device 19 is shown in FIG. 4. System 10"' largely corresponds to system 10" discussed with reference to FIG. 3, wherein counting device 19 is directly arranged in the line between pump 2 and apparatus 1. A batch operation is thus advantageously enabled.

[0131] Counting device **19** has an integral configuration with an associated supply apparatus **24**, which ensures a defined supply of the cleaning bodies into counting device **19** so that it is possible to reliably detect the cleaning bodies. For this purpose supply apparatus **24** has a pivotable screen **25** forming an inlet funnel in the illustrated first position, to guide the cleaning bodies in the upper area of supply apparatus **24** individually past counting device **19**. In a second position (not shown) screen **25** can be washed backwards and thus cleaned of deposits.

[0132] FIG. **5** shows a fifth exemplary embodiment of a cleaning system **10""** according to the present invention which largely corresponds to cleaning system **10** discussed with reference to FIG. **1***b*, wherein, however, a filter **26** is arranged in a filtration line **27**.

[0133] Filter **27** is configured as a particle filter in order to separate particulate from fluid. By closing a valve **28***a* and opening a valve **28***b*, filtration of the fluid can be carried out prior to and/or after the cleaning operation to remove any dissolved particulate. It should be ensured, of course, that all cleaning bodies are within apparatus **1**.

[0134] As initially mentioned, filter **26** is configured as a particle filter. For this purpose, filter **26** can comprise suitable filter media, for example, which are adapted to the relative filtration degree. For the usual plants, filter **26** can be preferably adapted to a particle size of 50-500 μm. Filter **26** can of course also be variably adapted to each application.

[0135] As initially explained with reference to FIG. **2**, any cleaning bodies remaining in heat exchanger **11** can be released by reversing the flow direction within heat exchanger **11**.

[0136] Alternatively or additionally it is also possible to operate the pump **2** in an intermittent, for example surge-like fashion to release any jammed cleaning bodies. A further, independent aspect of the invention thus relates to a method for operating a heat exchanger cleaning system.

[0137] An intermittent operation of pump **2** means that the volume flow pumped by pump **2** is temporarily varied, i.e. reduced or increased. It can be advantageous, for example, to operate pump **2** in two alternating modes of operation. The precise volume flow should be chosen, however, depending on each application.

[0138] For an intermittent operation, the rotational speed of pump **2** can be correspondingly varied by the control unit.

[0139] Alternatively or additionally, pump **2** can be temporarily short-circuited through a pump bypass **30** and an associated valve **29** to achieve a corresponding reduction of the volume flow as shown in a further exemplary embodiment of heat exchanger cleaning system **10""** according to FIG. **6**.

[0140] Such an embodiment of the system has a further advantage when tube-bundle heat exchangers in cooling or refrigerating plants are cleaned. Due to the relatively small dimensions there is a problem in the tube manifolds of such heat exchangers that the cleaning bodies may not be uniformly distributed throughout the individual tubes of the heat exchanger.

[0141] By intermittently operating pump **2** during the cleaning operation, i.e. by preferably controlling the pumped volume flow, an improvement can be achieved in the distribution of the cleaning bodies throughout the tubes of the heat exchanger.

[0142] This is the case, in particular, if depending on the dimensioning and sinking velocity of the cleaning bodies the pump is operated during the cleaning operation in such a manner that the cleaning bodies sink within the tube manifold of the heat exchanger in a controlled manner and are thus uniformly distributed throughout the individual tubes. Again, the rotational speed of pump **2** can be appropriately varied by the control unit. Alternatively or additionally, an intermittent operation of pump **2** during the cleaning process can also be achieved by the embodiment of system **10** shown in FIG. **6**.

[0143] For better distribution of the cleaning bodies within heat exchanger **11** it is also conceivable to provide mechanical means for guiding the cleaning bodies in heat exchanger **11**. A further, independent aspect of the invention thus relates to an improved heat exchanger.

[0144] FIG. **7***a* shows an exemplary embodiment of a heat exchanger **11'** in a schematic sectional view.

[0145] Heat exchanger **11'** comprises an inlet line **12** opening out into an inlet-side tube manifold **41**. Tube manifold **41** connects inlet line **12** with individual tubes **60** of heat exchanger **11'**. For reasons of clarity, the outlet side of heat exchanger **11'** is not shown in FIG. **7***a*.

[0146] A guiding element **61** extends from inlet line **12** into tube manifold **41**. Guiding element **61** is a guiding plate in the present case for guiding the cleaning bodies introduced into heat exchanger **11'** during the cleaning process through inlet line **12**, also to tubes **60** remote from inlet line **12**. To achieve this, guiding element **61** extends to about two thirds of the overall length of tube manifold **41** as can also be seen from FIG. **7***b*, in particular. FIG. **7***b* shows the exemplary embodiment of heat exchanger **11'** in a further sectional view along line A-A'.

[0147] Even though FIGS. **7***a* and **7***b* only show guiding element **61** in inlet-side tube manifold **41**, it is also conceivable, of course, alternatively or additionally to arrange a corresponding guiding element **61** in further tube manifolds, for example, in outlet-side tube manifold **42** (cf. FIG. **1***b*) of heat exchanger **11'**.

[0148] Alternatively to an embodiment of guiding element **61** as a guiding plate, guiding element **61** can also be configured as a guiding grid. Alternatively or additionally, guiding element **61** can also comprise an impacting element on which the cleaning bodies impact as they enter into line **12** and/or into tube manifold **41** and are thus distributed throughout tubes **60**.

[0149] A further independent aspect of the present invention relates to an adapter for releasably connecting a heat exchanger cleaning system with a heat exchanger. A first exemplary embodiment of such an adapter **50** is shown in FIG. **8***a* in the first sectional view in the usage position, i.e. with a connected heat exchanger **11** and cleaning system **10**.

[0150] Adapter **50** is suitable, in particular, for retrofitting existing heat exchangers **11** so that the initially described heat exchanger cleaning system **10** can be easily connected with heat exchanger **11**. It is thus possible to connect a mobile cleaning system **10** easily with heat exchanger **11**, which avoids, in particular, the overhead of acquiring permits otherwise necessary for fixed installations, and cleaning of several heat exchangers **11** with only one cleaning system **10** is advantageously possible.

[0151] As shown in FIG. **8***a*, adapter **50** comprises a first port **53** for connection with a heat exchanger **11**. In the present example, first port **53** is configured as a flange and connected with inlet line **12** of heat exchanger **11**. Alternatively, first port **53** can be welded, as the case may be, to inlet line **12** of heat exchanger **11**.

[0152] A second port **54** is arranged on an opposite end of a first conduit **58**, having a joint element **16***a* for the releasable connection with a connecting element **8***a* of a heat exchanger cleaning system **10**. For reasons of clarity, only connecting element **8***a* of cleaning system **10** is shown. Joint element **16***a* is also configured as a flange in the present case, wherein, again, different embodiments, such as a quick-release coupling or a quick-release lock are also conceivable.

[0153] A third port **55** is connected with a cooling circuit (not shown). A fourth port **56** enables the optional connection of adapter **50** with further heat exchangers **11** or further adapters **50** (not shown), which is advantageous, in particular, with larger cooling plants. Adapter **50** can of course also be configured without fourth port **56**. As shown, third port **55** and fourth port **56** are connected via a second conduit **59** vertical to first conduit **58**.

[0154] Two valves **57** are arranged to control the flow within adapter **50**. In normal operation, valves **57** are open, whereby heat exchanger **11** is connected to the cooling circuit. Joint element **16***a* is closed by means of a blind cover (not shown).

[0155] Valves **57** are closed for the cleaning operation, which corresponds to the position as shown in FIG. **8***a*. Heat exchanger **11** is now separated from the cooling circuit and is connected to cleaning system **10** after connection of connecting element **8***a*. After the completion of the cleaning process, connecting element **8***a* is separated from adapter **50** and joint element **16***a* is closed by the blind cover. After opening valves **57**, heat exchanger **11** is connected with the cooling circuit again.

[0156] A corresponding adapter **50** can, of course, also be provided at outlet line **13** of heat exchanger **11**, as can be seen, in particular, from FIG. **8***b*, which is a second sectional view along line A-A'. As shown in FIG. **8***b*, an adapter **50** is arranged both at inlet line **12** and at outlet line **13** of heat exchanger **11**.

[0157] FIGS. **9***a* and **9***b* show an alternative exemplary embodiment of an adapter **50'** corresponding to the views of FIGS. **8***a* and **8***b*.

[0158] Adapter **50'** largely corresponds to adapter **50** discussed with reference to FIGS. **8***a* and **8***b*, wherein, in the present case, valve **57** is dispensed with. As explained above with reference to FIGS. **8***a* and **8***b*, connecting element **8***a'* is also connected with joint element **16***a* of adapter **50'** in the present case. A connecting tube **52** extends axially from the flange of connecting element **8***a'*, in the usage position shown, into a tube section **51** of adapter **50'**. Connecting tube **52** covers second conduit **59** and thus bridges third port **55** and fourth port **56**.

[0159] In the present case, heat exchanger **11** is separated from the cooling circuit by the cooperation of tube section **51** of adapter **50'** with connecting tube **52** of connecting element **8***a'* of cleaning system **10** for the cleaning operation. The inner diameter of tube section **51** in the present case corresponds essentially to the outer diameter of connecting tube **52**.

[0160] For example a suitable sealing element (not shown) or a sealing ring can be used in the present case, to achieve complete separation of the cleaning circuit from the cooling circuit. Complete sealing can be dispensed with, as the case may be, however, as long as it is ensured that no cleaning bodies are introduced into the cooling circuit. FIG. **9***b* shows two adapters **50'** connecting inlet line **12** of heat exchanger **11** with connecting element **8***a'* and, similarly, outlet line **13** with connecting element **8***b'* of cleaning system **10**.

[0161] The heat exchanger cleaning system according to the present invention, a heat exchanger, and an adapter for connecting a heat exchanger cleaning system have been described above with reference to exemplary embodiments. It is of course easily possible to combine the exemplary embodiments shown or individual aspects of the respective exemplary embodiments with each other.

1-13. (canceled)

14. A mobile heat exchanger cleaning system for power plant heat exchangers, comprising

an apparatus for collecting, introducing and removing cleaning bodies,

a pump for pumping a fluid with cleaning bodies, and

connecting means connected to the apparatus and the pump for the releasable connection of the cleaning system with a heat exchanger.

15. The mobile heat exchanger cleaning system according to claim **14**, wherein the system is connectable with the heat exchanger in such a manner that, in a usage position, a volume flow flowing through the heat exchanger essentially corresponds to a volume flow flowing through at least one of the heat exchanger cleaning system and the apparatus.

16. The mobile heat exchanger cleaning system according to claim **14**, wherein the connecting means comprise:

a first connecting element for the releasably connecting of the cleaning system with an inlet line of the heat exchanger, and

a second connecting element for the releasably connecting the cleaning system with an outlet line of the heat exchanger.

17. The mobile heat exchanger cleaning system according to claim **16**, wherein:

the pump and the apparatus are connected in series,

the apparatus is connected with the first connecting element via a supply line,

the pump is connected with the second connecting element via a return line, and

at least a first valve is arranged in the supply line and a second valve is arranged in the return line to separate at least one of the apparatus and the pump from the connecting means.

18. The mobile heat exchanger cleaning system according to claim **17**, comprising:

a first reversal line with at least a third valve, wherein the first reversal line connects the apparatus with the second connecting element, and

a second reversal line with at least a fourth valve, wherein the second reversal line connects the pump with the first connecting element.

19. The mobile heat exchanger cleaning system according to claim **14**, wherein the pump comprises a control unit to adjust a volume flow of the pump.

20. The mobile heat exchanger cleaning system according to claim **19**, wherein the control unit is adapted to intermittently operate the pump.

21. The mobile heat exchanger cleaning system according to claim **14**, wherein a counting device is provided for the cleaning bodies.

22. The mobile heat exchanger cleaning system according to claim **14**, wherein a second apparatus is provided for collecting the cleaning bodies.

23. The mobile heat exchanger cleaning system according to claim **14**, wherein a filter is provided for separating out particulate material.

24. An adapter for a heat exchanger comprising at least

a first port for connection with a heat exchanger,

a second port for the releasable connection of a heat exchanger cleaning system, and

a third port for connection with a cooling line of a cooling circuit.

25. A heat exchanger for power plants, comprising an inlet line and an outlet line and a plurality of tubes connecting the inlet line with the outlet line, wherein at least one guiding element is arranged for distributing cleaning bodies to the plurality of tubes.

26. A method of operating a heat exchanger cleaning system comprising providing a pump, using said pump to pump a fluid with cleaning bodies through a heat exchanger, and operating the pump intermittently and/or controlling the pump to achieve a variation of a pumped volume flow in the heat exchanger.

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