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(54) **METHOD OF PICKLING AND/OR PASSIVATING AT LEAST AN INSIDE OF A CONTAINER, AND MANIPULATOR OF OR FOR SUCH A METHOD**

(57) Method of pickling and/or passivating at least an inside of a container, comprising: holding the container by a manipulator; arranging a pickling and/or passivation liquid inside the container; manipulating the container along a pre-determined trajectory, thereby successively distributing the liquid inside said container and draining the liquid out of said container, wherein the step of arranging the liquid inside the container comprises at least partly submerging said container in a bath containing said

liquid; and wherein the step of manipulating the container in the pre-determined trajectory is preceded by determining said trajectory in dependence of the position of at least one opening in one or more than one wall of said container, wherein said at least one opening is selected for allowing a fluid to leave said container.

The invention further relates to a manipulator of or for such a method of pickling and/or passivating at least an inside of a container.

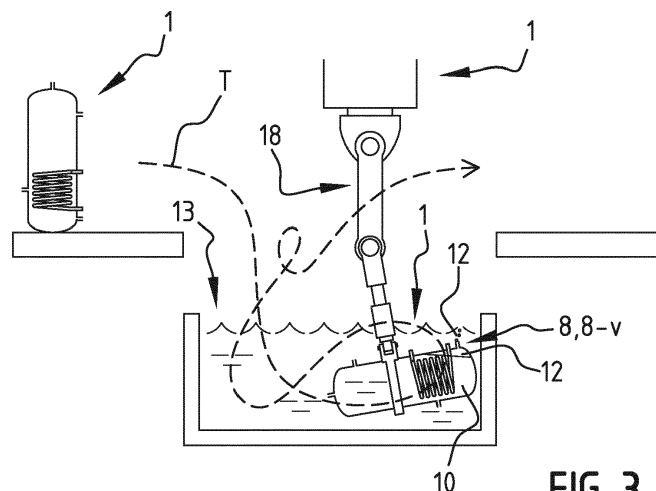


FIG. 3

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Description

[0001] The present invention relates to a method of pickling and/or passivating at least an inside of a container. The invention further relates to a manipulator of or for such a method of pickling and/or passivating at least an inside of a container.

[0002] Tanks or (pressure) vessels are applied in many varieties and applications, and may comprise storage tanks for containing, storing or preparing a fluid, such as in an industrial process. They may also comprise a pressure vessel in a system, such as a vessel of a boiler or other (domestic) heating or hot water system. In this application, the general wording container is used to comprise both tanks and (pressure) vessels.

[0003] For many applications, it is desirable to protect a container with a coating. Such a coating may protect an inner side of said container against an aggressive fluid, or otherwise make said container less susceptible to degradation and possibly failure.

[0004] In relation to e.g. steel containers, a protective coating against corrosion may be applied using passivation. Passivation, in physical chemistry and engineering, refers to a material becoming "passive," that is, less affected or corroded by the environment of future use. Passivation involves creation of an outer layer of shield material that is applied as a micro coating, created by chemical reaction with the base material, or allowed to build from spontaneous oxidation in the air. As a technique, passivation is the use of a light coat of a protective material, such as metal oxide, to create a shell against corrosion. Passivation media are of an aggressive nature, and contact to the human skin is to be prevented at all times. Prior to passivation, the container may be exposed to a pickling operation for thoroughly cleaning the container in anticipation of the passivation process.

[0005] In an ongoing challenge to further improve efficiency of processes, there is a tendency towards interiors of containers becoming more and more complex. For example, in order to obtain an improved heat transfer, one or more than one conduit inside a container may be bend in a complex three dimensional shape to define a coil of a heat exchanger. In case of multiple conduits, they may be interwoven. These complex interiors impose challenges to provide a protective coating substantially covering the complete interior surface of a container, i.e. also providing protection in all corners and irregular spots. As the lifetime of a container will be determined by the weakest spot, it is desirable to obtain a reliable and substantially full coverage of pickling and/or passivation inside the interior of also the most complex containers. It is especially for such complex containers, for which manufacturing is laborious and costly, that a reliable and prolonged lifetime is highly desired.

[0006] US 2,726,201 A1 is considered the closest prior art, relative to which at least the characterizing features of claim 1 are novel. It discloses a method for anodic pickling and nickel plating of an interior of a tank using a

single electrolyte. The tank may be a container such as are used in chemical process industries and in railway and truck tank cars. The tank car container is provided with supporting hydraulic jacks at each end of the tank container. While a pickling operation is performed, it may "rock" the tank car container by alternately actuating the hydraulic jacks, and a valve connected to an opening in the bottom of the tank container may be opened to allow a circulation of the electrolyte through a filter and an electrolyte cell.

[0007] US 6,074,752 A1, CN 204825058 U, JP 408144069 A, CN 207713816 U, EP 2 345 483 A1 and DE 3 921 220 A1 are acknowledged as further prior art.

[0008] An objective of the present invention is to provide a method of pickling and/or passivating at least an inside of a container that is improved relative to the prior art and wherein at least one of the above stated problems is obviated or alleviated.

[0009] Said objective is achieved with the method of pickling and/or passivating at least an inside of a container according to claim 1 of the present invention, comprising the steps of:

- holding the container by a manipulator;
- arranging a pickling and/or passivation liquid inside the container;
- manipulating the container along a pre-determined trajectory, thereby successively:
 - distributing the pickling and/or passivation liquid inside said container; and
 - draining the pickling and/or passivation liquid out of said container;
- wherein the step of arranging the pickling and/or passivation liquid inside the container comprises the step of at least partly submerging said container in a bath containing said pickling and/or passivation liquid; and
- wherein the step of manipulating the container in the pre-determined trajectory is preceded by the step of determining said trajectory in dependence of the position of at least one opening in one or more than one wall of said container, wherein said at least one opening is selected for allowing a fluid to leave said container.

[0010] By manipulating the container along a pre-determined trajectory, the method is capable of distributing the pickling and/or passivation liquid inside said container and to thereby provide a substantially full coverage of pickling and/or passivation inside the interior of even the most complex types of containers. Moreover, since the trajectory is a pre-determined trajectory, it may be controlled and optimized, thereby providing a reliable end product having a consistent quality. Simultaneously, the method may be automated to a high level, thereby reducing the need for manual labour and associated health

risks for said workers. A substantially complete draining of pickling and/or passivation liquid out of said container further improves the end product and reduces health risks for any worker handling the container after pickling and/or passivation thereof. The pre-determined trajectory may effectively prevent any pickling and/or passivation liquid residue to remain in said container after draining.

[0011] According to the invention, the step of manipulating the container in the pre-determined trajectory is preceded by the step of determining said trajectory in dependence of - the position of at least one opening in the one or more than one wall of said container. The position of the at least one opening may selectively be positioned either at an uppermost position to allow any air to escape during submersion of said container, or a lowermost position for draining the pickling and/or passivation liquid out of said container. According to the invention, the said at least one opening is at least selected for allowing a fluid to leave said container. This fluid may be air during submersion of the container in a bath comprising pickling and/or passivation liquid, or pickling and/or passivation liquid that is to be drained after pickling and/or passivation. The skilled person will understand that the at least one opening for venting air or draining pickling and/or passivation liquid may be the same opening, as well as different openings, arranged in a wall of the container.

[0012] According to a preferred embodiment, the step of manipulating the container in the pre-determined trajectory is preceded by the step of determining said trajectory is furthermore also in dependence of an inner contour of said container being defined by an inner side of one or more than one wall and one or more than one internal conduit of said container.

[0013] The inner contour may cause entrapment of fluid. This fluid may be air during submersion of the container in a bath comprising pickling and/or passivation liquid, or pickling and/or passivation liquid after pickling and/or passivation. According to the invention, the pre-determined trajectory may be determined to follow a path that may guarantee on the one hand that substantially all air may be vented during filling of the container with pickling and/or passivation liquid, while it on the other hand may also guarantee that substantially all pickling and/or passivation liquid is forced to flow out of any potential entrapment positions and corners under the influence of gravity or movement of said container, before said pickling and/or passivation liquid is effectively drained. In this way it may be prevented that any pickling and/or passivation liquid residue is left in the container after the step of draining thereof.

[0014] The invention further relates to a manipulator of or for a method of pickling and/or passivating at least an inside of a container according to any of the foregoing claims, said manipulator comprising:

- an articulated arm and/or a guide configured to guide at least one carriage; and

- a controller configured to manipulate the container along a pre-determined trajectory to thereby successfully:

- 5 - distribute the pickling and/or passivation liquid inside said container; and
- drain the pickling and/or passivation liquid out of said container

[0015] Preferred embodiments are the subject of the dependent claims.

[0016] The various aspects and features described and shown in the specification can be applied, individually, wherever possible. These individual aspects, and in particular the aspects and features described in the attached dependent claims, may be an invention in its own right that is related to a different problem relative to the prior art.

[0017] In the following description preferred embodiments of the present invention are further elucidated with reference to the drawing, in which:

Figure 1 is a partly cross sectional view of a container having a complex inner contour defined by an internal conduit;

Figures 2-6 show schematic views of a system according to a first preferred embodiment illustrating successive steps of a method of pickling and/or passivating at least an inside of a container according to the invention;

Figure 7 shows a top view of a pickling and/or passivation system according to a second preferred embodiment;

Figure 8 is a side view of the system of Figure 7 having carriages of a first type;

Figure 9 is a side view of the system of Figure 7 having carriages of a second type; and

Figure 10 shows a top view of a pickling and/or passivation system according to a third preferred embodiment having a plurality of baths with pickling and/or passivation liquid.

[0018] An exemplary container 1 shown in Figure 1 comprises a surrounding wall 2 and an internal conduit 3 arranged inside an inner space 4 of said container 1. The internal conduit 3 in the shown embodiment is a spiral shaped internal conduit 3 that provides a relative large contact surface for heat transfer between a fluid to be transported through said conduit 3 and a fluid to be contained inside the inner space 4 of said container 1. Such a container 1 is an example of a container 1 having a relatively complex inner contour 6 defined by an inner side 7 of the one or more than one wall 2 and the one or more than one internal conduit 3 of said container 1. The skilled person will however understand that containers 1 having an inner contour of a complex shape may be provided in a great variety, each providing their own specific challenges during pickling and/or passivation. The

shown container 1 further comprises a plurality of openings 8 in the wall 2 thereof.

[0019] Using Figures 2-6, the method of pickling and/or passivating at least an inside of the container 1 is now elucidated. Said method comprises the steps of:

- holding the container 1 by a manipulator 9 (Figure 2);
 - arranging the pickling and/or passivation liquid 10 inside the container 1 (Figure 3);
 - manipulating the container 1 along a pre-determined trajectory T, thereby successively:
 - distributing the pickling and/or passivation liquid 10 inside said container 1 (Figure 3 to Figure 4); and
 - draining the pickling and/or passivation liquid 10 out of said container 1 (Figure 4 to Figure 5).
- The pre-determined trajectory T is preferably set to control that substantially all pickling and/or passivation liquid 10 is drained, thereby preventing that any pickling and/or passivation liquid residue is left inside container 1 after draining.

[0020] The step of manipulating the container 1 in the pre-determined trajectory T may be preceded by the step of determining said trajectory T in dependence of the inner contour 6 of said container 1 being defined by the inner side 7 of one or more than one wall 2 and the one of more than one internal conduit 3 of said container 1.

[0021] The step of determining said trajectory T in dependence of the inner contour 6 of said container 1 may comprise determining said trajectory T for collecting the pickling and/or passivation liquid 10 out of potential collection spots defined by said inner contour 6.

[0022] The step of manipulating the container 1 in the pre-determined trajectory T may be preceded by the step of determining said trajectory in dependence of the position of at least one opening 8 in the one or more than one wall 2 of said container 1, wherein said at least one opening is selected for allowing a fluid to leave said container 1. Said fluid may be air 12 or pickling and/or passivation liquid 10. More in particular, said at least one opening 8 may be selected for the steps of venting air 12 out of the container 1 during filling thereof with a pickling and/or passivation liquid 10 (Figure 3), and/or draining the pickling and/or passivation liquid 10 out of said container 1 (Figure 5). By draining substantially all pickling and/or passivation liquid 10, it may be prevented that any pickling and/or passivation liquid residue is left in the container 1 after draining.

[0023] In a preferred embodiment, the step of manipulating the container 1 in the pre-determined trajectory T is preceded by the step of determining said trajectory in dependence of both the inner contour 6 of said container 1 and the position of at least one opening 8 in the one or more than one wall 2 of said container 1.

[0024] In a further preferred embodiment, the step of determining said trajectory T in dependence of the posi-

tion of the at least one opening 8 selected for allowing the fluid to leave said container 1 comprises determining said trajectory T for temporarily orienting and holding said container 1 with said opening 8, 8-d selected for draining the pickling and/or passivation liquid at a lowermost position of said container 1 (Figure 5).

[0025] Although it is conceivable that pickling and/or passivation liquid 10 may be arranged inside said container using (not shown) nozzles entering said container 1 via at least one of the openings 8 and spraying said pickling and/or passivation liquid 10 inside said container 1, the invention proposes the step of at least partly submerging said container 1 in a bath 13 containing said pickling and/or passivation liquid 10. In a more preferred embodiment, the method comprises the step of fully submerging said container 1 in said bath 13. It is remarked that the method according to the invention is related to pickling and/or passivating at least an inside of the container 1, because said inside causes the most problems. However, in practice also the outside of said container 1 may be passivated, especially and automatically when the container 1 is fully submersed in the pickling and/or passivation liquid 10.

[0026] If the internal conduit 3 would have a complex three-dimensional shape and pickling and/or passivation liquid 10 would enter said internal conduit 3, it may be difficult to fully drain said internal conduit 3. In order to prevent any pickling and/or passivation liquid 10 to enter the internal conduit 3 during submersion of the container 1, the ends of the internal conduit 3 may be temporarily closed off.

[0027] According to an even further preferred embodiment, the step of determining said trajectory T in dependence of the inner contour 6 of said container 1 comprises determining said trajectory T for guiding any air 12 that may be trapped by said inner contour 6 to an uppermost position in the container 1 (Figure 3).

[0028] In that case, determining said trajectory T may be done in dependence of the position of the at least one opening 8 in the one or more than one wall 2 of said container 1, and comprises determining said trajectory T for temporarily orienting and holding said container 1 with said opening 8, 8-v at an uppermost position of said container 1 to allow any air 12 to escape, i.e. vent, out of said container 1.

[0029] A pickling and/or passivation system according to a further embodiment is shown in the top view of Figure 7, in relation to two alternative side views in Figures 8 and 9 showing carriages 14 of a first type 15 and of a second type 16, respectively.

[0030] The step of holding the container 1 by the manipulator 9 may thus comprise the step of supporting said container 1 by a carriage 14 that is moveable along a guide 17.

[0031] The step of arranging the pickling and/or passivation liquid 10 inside the container 1 may comprise the step of guiding said container 1 in and out of the bath 13 by moving said carriage 14 along the guide 17. The

movement may be in a single direction as shown in Figures 8 and 9, or a movement back and forth, as will be described in more detail for the third embodiment shown in Figure 10.

[0032] Manipulating of said container 1 may comprise the step of manipulating the container 1 along the pre-determined trajectory T having a three-dimensional shape. By moving the container 1 along a three-dimensional trajectory T in space, any fluid may be effectively transferred to an associated opening 8, 8-d, 8-v.

[0033] Manipulating the container 1 along the pre-determined trajectory T may be performed with an articulated arm 18 of said manipulator 9.

[0034] The manipulator 9 may thus comprise an articulated arm 18 and/or a guide 17 and at least one carriage 14, and a controller 19 (only shown in Figure 2) configured to manipulate the container 1 along the pre-determined trajectory T to thereby distribute the pickling and/or passivation liquid 10 inside said container 1, and successively drain the pickling and/or passivation liquid 10 out of said container 1. In the embodiment of Figures 2-6, the manipulator 9 may only comprise an articulated arm 18, effectively forming a standalone robot that is configured to manipulate the container 1 along the predetermined trajectory T.

[0035] In the embodiment shown in Figure 8, the manipulator 9 comprises both the guide 17 and at least one carriage 14 and the articulated arm 18, wherein the at least one carriage 14 comprises the articulated arm 18. In this embodiment a high level of flexibility to move said container 1 along the pre-determined three-dimensional trajectory T is obtained.

[0036] The embodiment of Figure 9 differs from the embodiment shown in Figure 8 in that the articulated arm 18 is replaced by a length adjustable arm 20 that may extend to lower the carriage 14 relative to the guide 17 and thereby submerge the container 1 in the bath 13 of pickling and/or passivation liquid 10. Alternatively, the guide 17 itself may approach the bath 13 (not shown).

[0037] The top view of the third embodiment shown in Figure 10 discloses a pickling and/or passivation system using a plurality of baths 13 with pickling and/or passivation liquid 10. Applying a plurality of baths 13 results in an increased flexibility. After all, containers 1 may ideally be exposed to submersion in said pickling and/or passivation liquid 10 for different time intervals. For example, a single big container 1 or two smaller containers 1 carried on either side of one carriage 14 may require a longer exposure to the pickling and/or passivation liquid 10 than a single container 1 of a smaller size. Using multiple baths 13, each container 1 may be exposed for an optimal exposure time, without delaying other containers 1 as would be the case in a single throughflow bath 13 as shown in Figure 7. Also, each of the baths 13 may be temporarily taken out of business for maintenance work, such a cleaning of said respective bath 13, while not having any negative effect on production capability in the other baths 3 that are not being serviced at that time. It is also con-

ceivable that some baths 13 contain pickling liquid, while other baths 13 contain passivation liquid.

[0038] Figure 10 also shows that one carriage 14 may carry multiple containers 1, which are preferably arranged on opposite sides to maintain a balance. In case one carriage 14 may carry two containers 1 of different weight, this difference in weight may be compensated for by a compensator 21 (see upper and lower right baths 13 in Figure 10). The compensator 21 may simply comprise a weight 22 (shown in upper right bath 13 in Figure 10), but it preferably comprises a weight 22 arranged on an arm 23 that may be extended sideward relative to the carriage to provide a moment arm (shown in lower right bath 13 in Figure 10). This extension of said arm may be controlled by said controller 19, so that an automated balancing is obtained and it is prevented that a human worker needs to manually add or remove a weight of the compensator 21.

[0039] It is remarked that pickling and passivation have been consequently mentioned in an and/or construction to define that the invention may either concern pickling or passivation, or a combination of both pickling and passivation. In view of the invention, the process is identical, but the respective liquid differs and is a pickling and a passivation liquid, respectively. If pickling and passivation are applied both, this may either be obtained by the container 1 to be e.g. first submerged in a bath 13 containing pickling liquid, and successively in a bath 13 containing passivation liquid. It is however also conceivable that a bath 13 may comprise a mixture of a pickling liquid and a passivation liquid, allowing the pickling and passivation of the container 1 to be applied in one go.

[0040] Although they show preferred embodiments of the invention, the above described embodiments are intended only to illustrate the invention and not to limit in any way the scope of the invention. Accordingly, it should be understood that where features mentioned in the appended claims are followed by reference signs, such signs are included solely for the purpose of enhancing the intelligibility of the claims and are in no way limiting on the scope of the claims. Furthermore, it is particularly noted that the skilled person can combine technical measures of the different embodiments. The scope of the invention is therefore defined solely by the following claims.

Claims

1. Method of pickling and/or passivating at least an inside of a container (1), comprising the steps of:
 - holding the container by a manipulator (9);
 - arranging a pickling and/or passivation liquid (10) inside the container (1);
 - manipulating the container (1) along a pre-determined trajectory (T), thereby successively:

- distributing the pickling and/or passivation liquid (10) inside said container (1); and
- draining the pickling and/or passivation liquid (10) out of said container (1),

characterized in that

- the step of arranging the pickling and/or passivation liquid (10) inside the container (1) comprises the step of at least partly submerging said container (1) in a bath (13) containing said pickling and/or passivation liquid (10); and
 - the step of manipulating the container (1) in the pre-determined trajectory (T) is preceded by the step of determining said trajectory (T) in dependence of the position of at least one opening (8) in one or more than one wall (2) of said container (1), wherein said at least one opening (8) is selected for allowing a fluid to leave said container (1).
2. Method according to claim 1, wherein the step of manipulating the container (1) in the pre-determined trajectory (T) is preceded by the step of determining said trajectory (T) in dependence of:
- an inner contour of said container (1) being defined by an inner side (7) of one or more than one wall (2) and one or more than one internal conduit (3) of said container (1).
3. Method according to claim 2, wherein the step of determining said trajectory (T) in dependence of the inner contour of said container (1) comprises determining said trajectory (T) for collecting the pickling and/or passivation liquid (10) out of potential collection spots defined by said inner contour.
4. Method according to one or more than one of the foregoing claims, wherein the step of determining said trajectory (T) in dependence of the position of the at least one opening (8) selected for allowing the fluid to leave said container (1) comprises determining said trajectory (T) for temporarily orienting and holding said container (1) with said opening (8, 8-d) selected for draining the pickling and/or passivation liquid (10) at a lowermost position of said container (1).
5. Method according to one or more than one of the foregoing claims, comprising fully submerging said container (1) in said bath (13).
6. Method according to one or more than one of claims 2-5, wherein the step of determining said trajectory (T) in dependence of the inner contour of said container (1) comprises determining said trajectory (T) for guiding any air (12) that may be trapped by said

inner contour to an uppermost position in the container (1).

7. Method according to claims 5 and 6, comprising determining said trajectory (T) in dependence of:
- the position of at least one opening (8) in the one or more than one wall (2) of said container (1), and comprises determining said trajectory (T) for temporarily orienting and holding said container (1) with said opening (8, 8-v) at an uppermost position of said container to allow any air (12) to escape out of said container (1).
8. Method according to one or more than one of the foregoing claims, wherein the step of holding the container (1) by the manipulator (9) comprises the step of supporting said container (1) by a carriage (14) that is moveable along a guide (17).
9. Method according to claim 8, wherein the step of arranging the pickling and/or passivation liquid (10) inside the container (1) comprises the step of guiding said container (1) in and out of the bath (13) by moving said carriage (14) along the guide (17).
10. Method according to one or more than one of the foregoing claims, comprising the step of manipulating the container (1) along the pre-determined trajectory (T) having a three-dimensional shape.
11. Method according to one or more than one of the foregoing claims, comprising the step of manipulating the container (1) along the pre-determined trajectory (T) with an articulated arm (18) of said manipulator (9).
12. Manipulator (9) of or for a method of pickling and/or passivating at least an inside of a container (1) according to any of the foregoing claims, said manipulator (9) comprising:
- an articulated arm 18 and/or a guide (17) configured to guide at least one carriage (14); and
 - a controller (19) configured to control the manipulator (9) to manipulate the container (1) along a pre-determined trajectory (T) to thereby successively:
- distribute the pickling and/or passivation liquid (10) inside said container (1); and
 - drain the pickling and/or passivation liquid (10) out of said container (1),

characterized in that said controller (19) is configured to control the manipulator (9) according to the pre-determined trajectory (T) that is determined in dependence of a position of at least one opening (8)

in one or more than one wall (2) of said container (1), wherein said at least one opening (8) is selected for allowing a fluid to leave said container (1).

- 13.** Manipulator (9) according to claim 12, comprising both the guide (17) and at least one carriage (14) and the articulated arm (18), wherein the at least one carriage (14) comprises the articulated arm (18).

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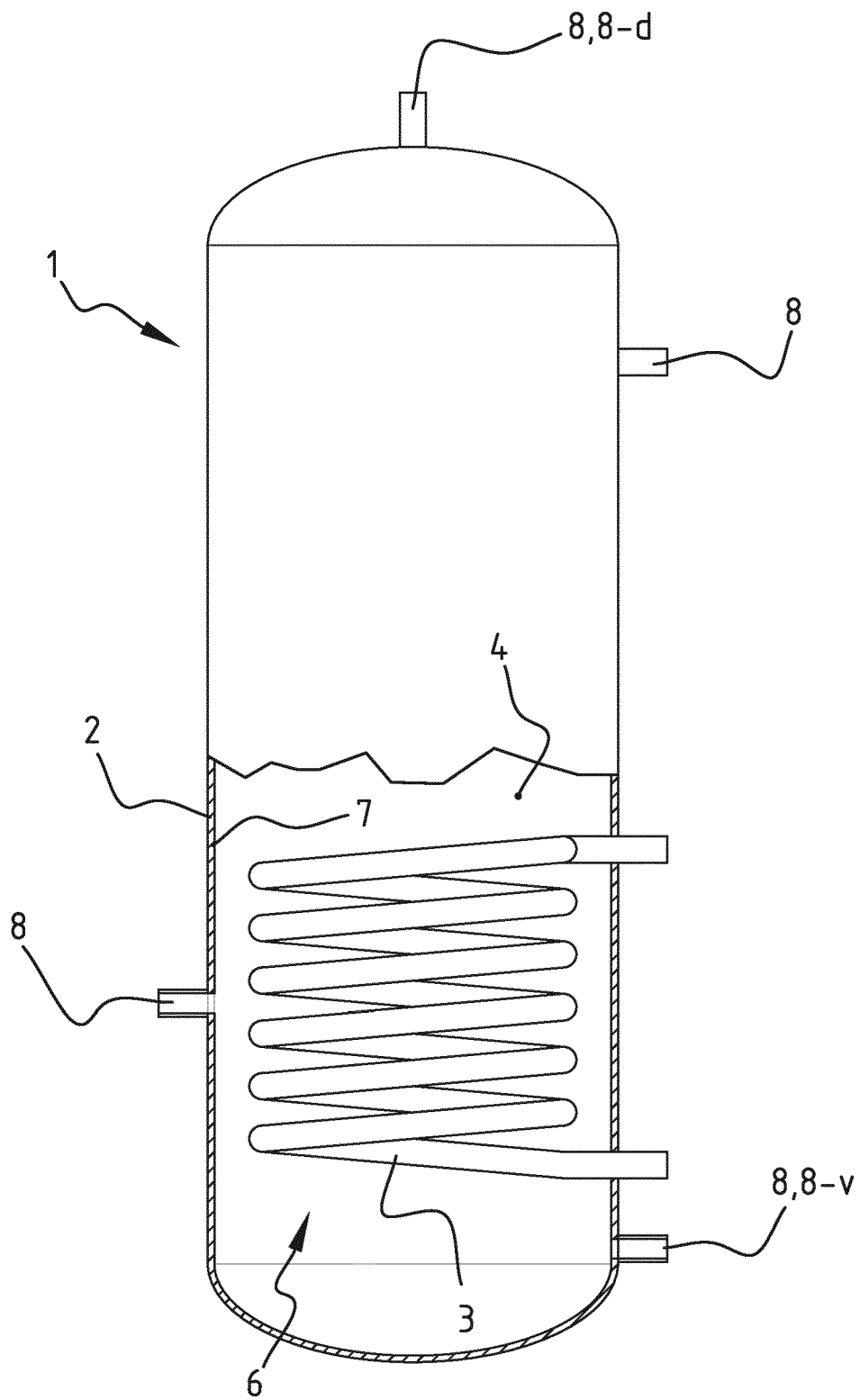


FIG. 1

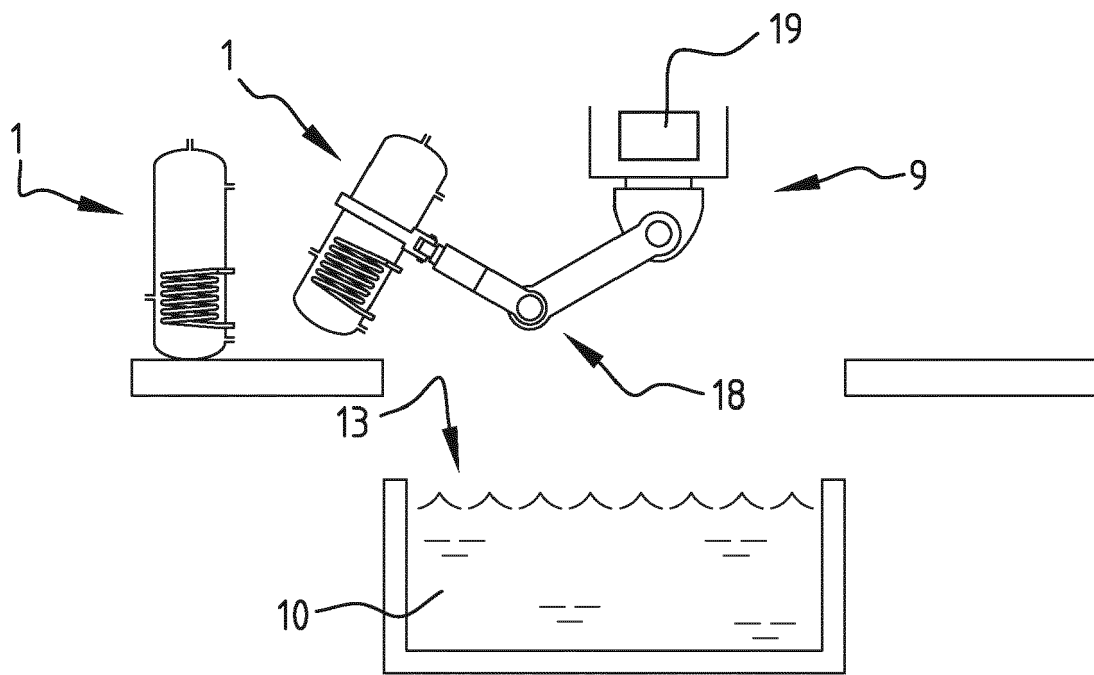


FIG. 2

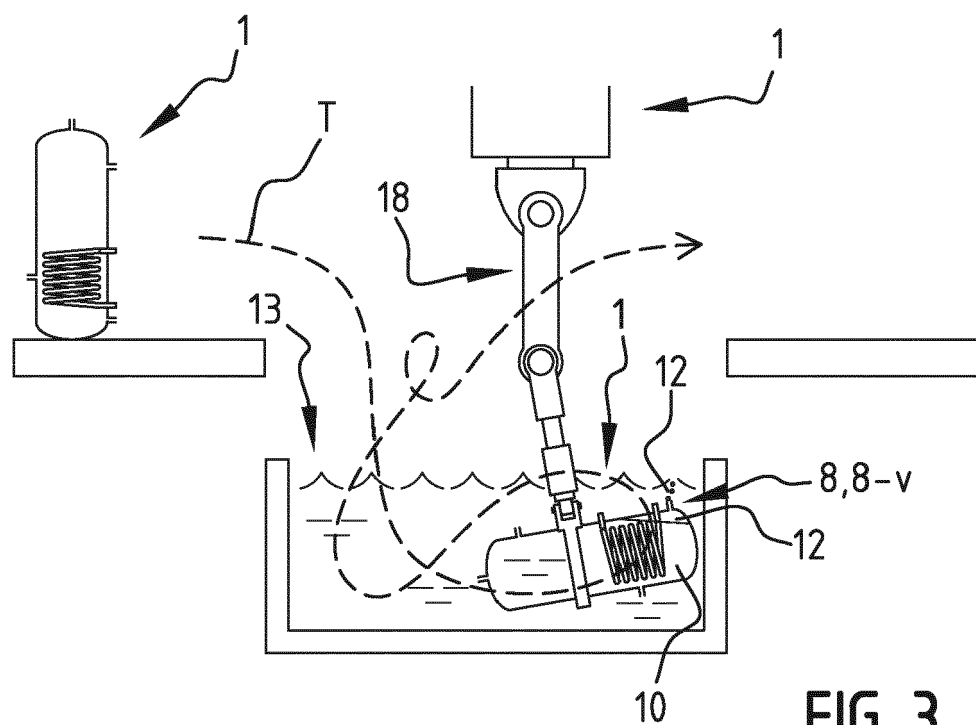


FIG. 3

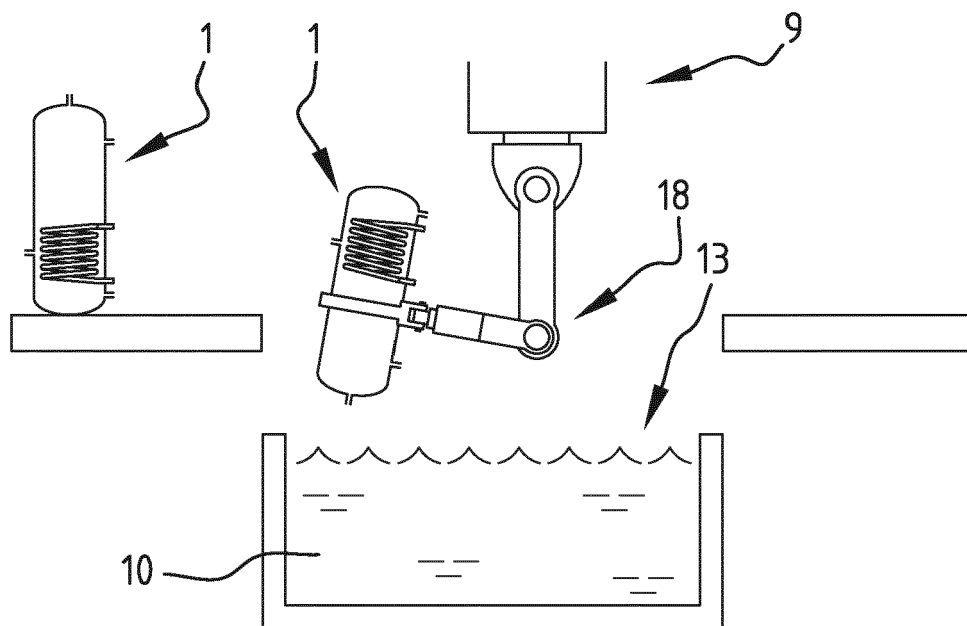


FIG. 4

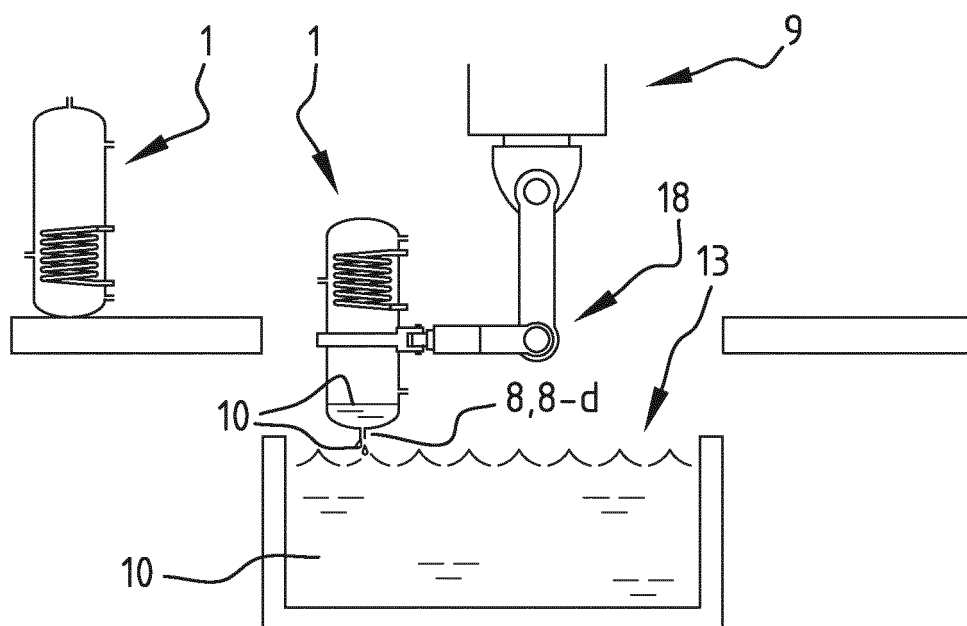


FIG. 5

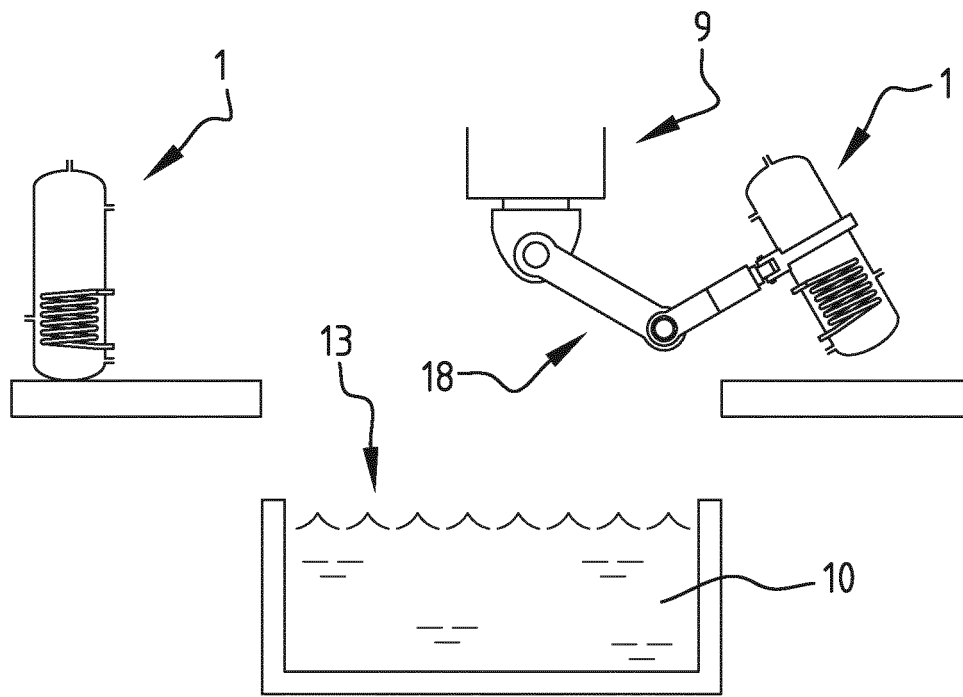


FIG. 6

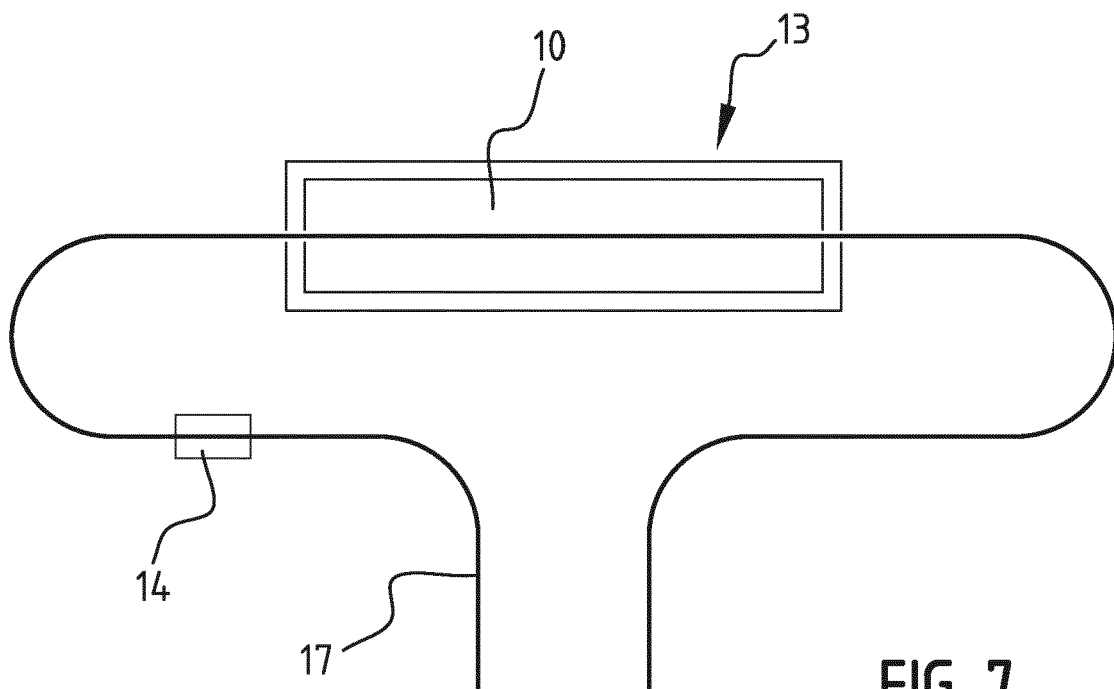
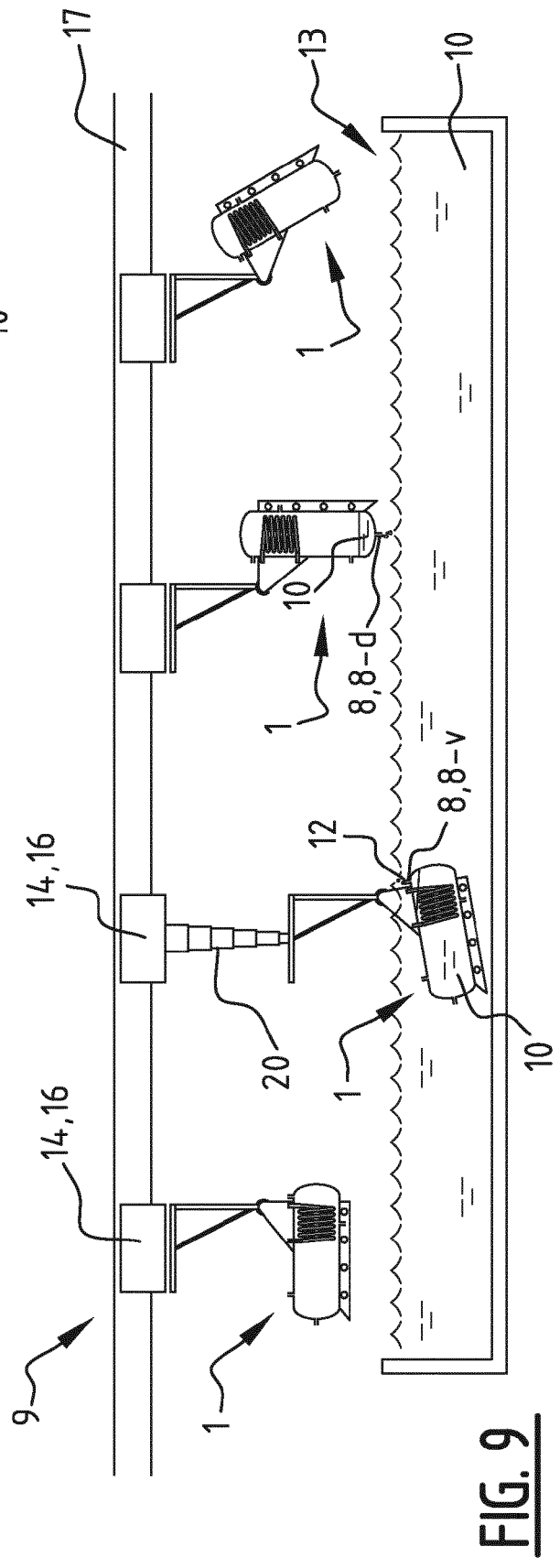
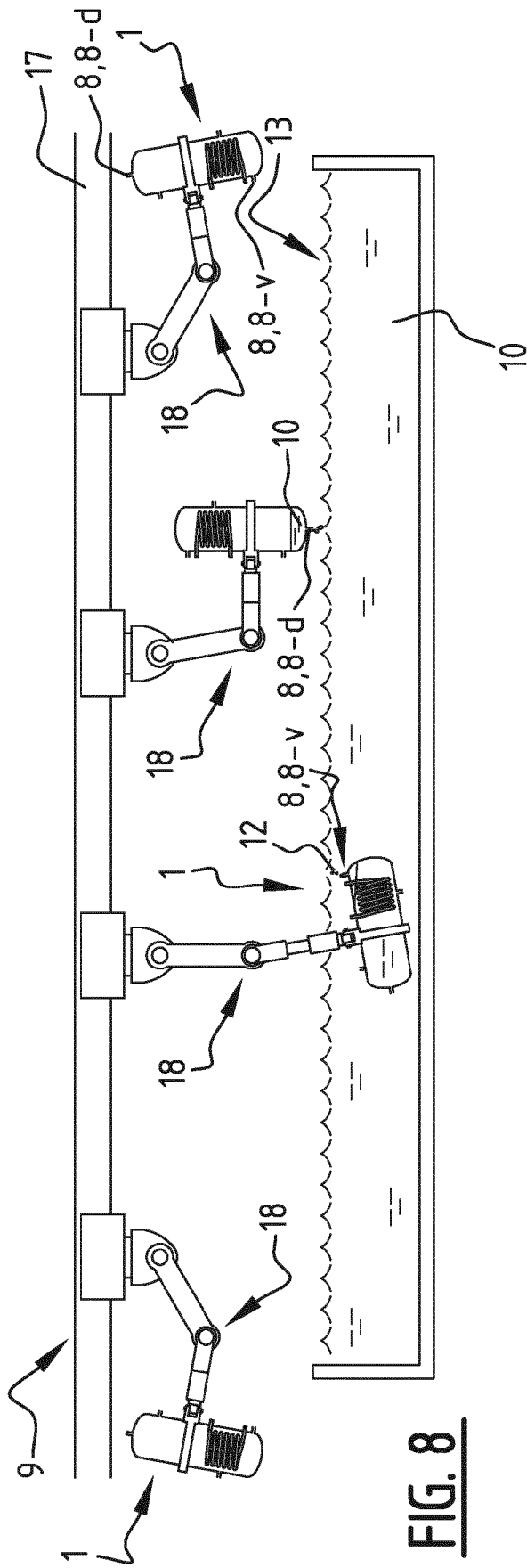


FIG. 7



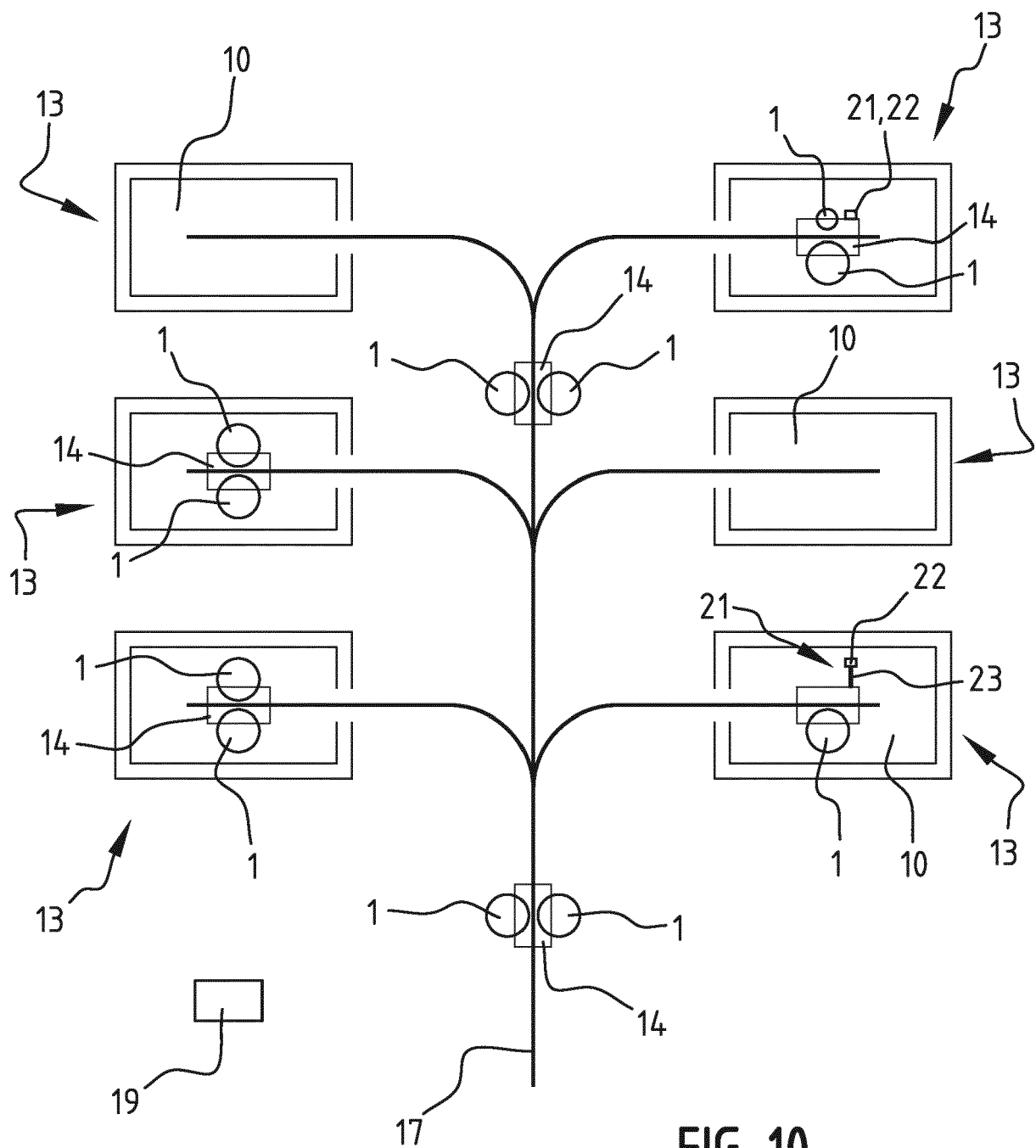


FIG. 10



EUROPEAN SEARCH REPORT

 Application Number
 EP 21 17 1626

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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