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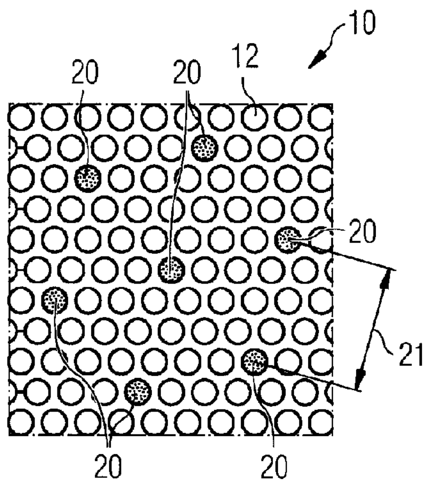


(57) **Abrégé/Abstract:**
The invention relates to a vertical heat exchanger (1) having a heat exchange volume (2) that is bounded at opposite ends by an upper tube plate (3) and a lower tube plate (4) of the heat exchanger (1), and a homogeneous tube bundle (10), wherein the tube bundle (10) has a multiplicity of heat exchanger tubes (12) that are arranged regularly with respect to one another and extends within the heat exchange volume (2) between the lower tube plate (4) and the upper tube plate (3), wherein furthermore the heat exchanger tubes (12) can be flowed through by a first medium and at least one second medium can be arranged in the rest of the heat exchange volume (2), and wherein an exchange of heat can be carried out between the first medium and the second medium.

Abstract

The invention relates to a vertical heat exchanger (1) having a heat exchange volume (2) that is bounded at opposite ends by an upper tube plate (3) and a lower tube plate (4) of the heat exchanger (1), and a homogeneous tube bundle (10), wherein the tube bundle (10) has a multiplicity of heat exchanger tubes (12) that are arranged regularly with respect to one another and extends within the heat exchange volume (2) between the lower tube plate (4) and the upper tube plate (3), wherein furthermore the heat exchanger tubes (12) can be flowed through by a first medium and at least one second medium can be arranged in the rest of the heat exchange volume (2), and wherein an exchange of heat can be carried out between the first medium and the second medium.

Description

Vertical heat exchanger

The present invention relates to a vertical heat exchanger having a heat exchange volume which is delimited at opposing ends by an upper pipe base and a lower pipe base of the heat exchanger, and a homogeneous pipe bundle, wherein the pipe bundle has a large number of heat exchanger pipes which are arranged in a regular manner with respect to each other and extends inside the heat exchange volume between the lower pipe base and the upper pipe base, wherein a first medium can further flow through the heat exchanger pipes and at least one second medium can be arranged in the remaining heat exchange volume, and wherein a heat exchange can be carried out between the first and the at least one second medium.

Heat exchangers are used in modern technology in order to transmit heat between different media. Thus, for example, heat condensers are used as such heat exchangers in power plants in order to transfer thermal energy from water vapor, which is produced in the power plant in most cases as a result of combustion operations, into a heat transfer medium, for example, of a district heating network.

In this instance, there are often used horizontal heat exchangers in which the thermal energy transfer media flow through the heat exchanger in a horizontal direction. However, such horizontal heat exchangers have in this instance a high installation space requirement. In order to avoid this, it is known to also construct heat exchangers as a vertical construction type in which the thermal energy transfer media flow through the heat exchanger in a vertical direction. Such upright heat exchangers also have, for example, the advantage that a control of a heating power can be carried out in particular by flooding the heat exchanger with a condensate.

In particular in this condensate, however, evaporation effects may occur, for example, in the event of a sudden load change, whereby vapor bubbles which may cause damage to the heat exchanger, in particular the heat exchanger pipes used, are produced. In order at the same time to nonetheless be able to ensure a high level of stability of the heat exchanger pipes, known vertical heat exchangers are therefore often provided with complex and cost-intensive grid support constructions since the support walls used in the horizontal heat exchanger for the vapor bubbles occurring during the evaporation effects are not continuous and therefore cannot be used in vertical heat exchangers. Use of a larger pipe division which in this instance in particular involves an increased installation space requirement is also required as a result of these grid support constructions.

An object of the present invention is therefore to at least partially solve the problems described above in heat exchangers. In particular, an object of the invention is to provide a vertical heat exchanger which allows in a simple and in particular cost-effective manner damage to the heat exchanger, in particular a pipe bundle of the heat exchanger as a result of evaporation effects, to be prevented in a manner which is particularly effective and at the same time saves installation space and costs.

The above object is achieved with a vertical heat exchanger as described herein. The object is thus achieved with a vertical heat exchanger having a heat exchange volume which is delimited at opposing ends by an upper pipe base and a lower pipe base of the heat exchanger and a homogeneous pipe bundle, wherein the pipe bundle has a large number of heat exchanger pipes which are arranged in a regular manner with respect to each other and extends inside the heat exchange volume between the lower pipe base and the upper pipe base, wherein a first medium can further flow through the heat exchanger pipes and at least one second medium can be arranged in the remaining heat exchange volume, and wherein a heat exchange can be carried out between the first medium and the at least one second medium. A vertical heat exchanger according to the invention is characterized in that compensation volumes are arranged in the pipe bundle, wherein the compensation volumes within the pipe bundle extend through the heat exchange volume.

The heat exchanger according to the invention is in particular a vertical heat exchanger, that is to say, a flow direction of the first and/or the at least one second medium in the heat exchanger is orientated perpendicularly or, in particular in the case of the second medium, at least substantially perpendicularly, for example, from the bottom to the top. In a particularly preferred manner, a heat exchanger according to the invention may in this instance be constructed as a heat condenser. A vertical heat exchanger according to the invention has to this end in particular a heat exchange volume which, for example, with a cylindrical construction may have a diameter of from 300 mm to several meters and a height of from one to several meters. In this heat exchange volume, a transfer of thermal energy is carried out preferably from at least one second medium, which surrounds the heat exchanger pipes, to the first medium, which flows inside the heat exchanger pipes. In this instance, it is possible to use as the second medium, for example, water vapor, and as the first medium a fluid which is suitable for further transport of the thermal energy. The heat exchanger pipes, which are constructed preferably identically or at least substantially identically and whose number often exceeds several 1000 pipes, are in this instance in particular arranged in a homogeneous pipe bundle. Homogeneous in the context of the invention may in this instance in particular mean that the heat exchanger pipes are arranged in a regular manner with respect to each other, that is to say, that they are arranged at recurring identical intervals with respect to each other. An arrangement of the heat exchanger pipes parallel or at least substantially parallel with each other may also often be provided. One possible such homogeneous arrangement is, for example, a hexagon-symmetrical arrangement. As a result, the tightest possible arrangement of heat exchanger pipes in the pipe bundle can be achieved, whereby the largest possible number of heat exchanger pipes can be arranged in the respective heat exchange space. In this instance, the heat exchanger pipes are in each case also arranged with a spacing with respect to each other in order to enable an arrangement of the at least one second medium in the intermediate spaces which are formed between the heat exchanger pipes of the pipe bundle. Preferably, the heat exchanger pipes are thereby at least partially surrounded by at least one second medium. A particularly good transfer of thermal energy between the first and the at least one second medium can thereby be ensured for all the heat exchanger pipes. The pipe bundle and consequently the heat exchanger pipes extend from the lower pipe base as far as the upper pipe base and consequently in a perpendicular or vertical direction through the entire heat exchanger space. The individual heat exchanger pipes may in this instance extend through the lower pipe base or the upper pipe base or be connected therein in a fluid-communicating manner to form one or more collection lines.

It is significant for the invention that, in a heat exchanger according to the invention, there is provision for compensation volumes to be arranged in the pipe bundle. These compensation volumes are in this instance regions inside the heat exchange volume and in particular also inside the pipe bundle which are not occupied by a heat exchanger pipe and which can consequently be filled by the at least one second medium. They may in this instance preferably be arranged parallel or at least substantially parallel with the heat exchanger pipes. Furthermore, the compensation volumes represent regions which are different from the standard intermediate spaces between the heat exchanger pipes. That is to say, a compensation volume is spatially larger than the intermediate space which is defined by adjacent heat exchanger pipes. The compensation volumes are in particular sized in such a manner that the volume thereof is larger than, in particular more than twice as large as, the volume of an intermediate space which is defined by adjacent heat exchanger pipes. In this instance, these compensation volumes according to the invention are constructed in such a manner that inside the pipe bundle they extend, in particular extend completely, through the heat exchange volume. That is to say, these compensation volumes extend continuously from the lower pipe base as far as the upper pipe base. This affords in particular a significant advantage. When a gaseous and/or vaporous second medium is used, in most cases condensation effects occur in the heat exchange volume. This is even advantageous since a particularly good transfer of thermal energy to the first medium flowing in the heat exchanger pipes is thereby carried out. The condensate which is produced in this case accumulates in the lower portion of the heat exchange volume. Furthermore, via a control or regulation of a filling level of the heat exchange volume with condensate, a particularly simple and effective control of a transfer power of a heat exchanger according to the invention can be provided. In this condensate, in particular, for example, in the event of sudden load changes, evaporation effects may occur. In this instance, vapor bubbles occur in the condensate by means of which a so-called condensate shock can be brought about. As a result of this condensate shock which is produced, for example, as a result of an implosion of these vapor bubbles in the condensate, as a result of the pressure waves which are in this case produced in the condensate, damage in the heat exchanger, in particular to the heat exchanger pipes, may occur. As a result of the compensation volumes provided according to the invention, however, these vapor bubbles in the condensate can rise upward rapidly and in an unimpeded manner. The vapor bubbles thereby reach the surface of the condensate particularly rapidly, whereby an implosion of the vapor bubbles within the condensate can be prevented. A reliable prevention of the damaging procedures which are initiated by this condensate shock can in this manner be reliably prevented by the presence of the compensation volumes which extend through the entire pipe bundle.

Furthermore, with a vertical heat exchanger according to the invention, there may be provision for the pipe bundle to be stabilized inside the heat exchange volume by means of at least one horizontal support wall, wherein the compensation volumes extend through the at least one support wall. As already described above, the heat exchange volume of a heat exchanger according to the invention may extend over a height of over 10 meters. In order to improve a stability of the pipe bundle which is arranged in the heat exchange volume, there may therefore be provided at least one support wall which is arranged horizontally inside the heat exchange volume. Preferably such a support wall extends over an entire inner cross-section of the heat exchange volume. This may be enabled as a result of the fact that, in addition to the heat exchanger pipes of the pipe bundle, the compensation volumes also extend through the at least one support wall. That is to say, the at least one support wall has in the region of the respective compensation volume a vertical, continuous opening. A vapor bubble in the condensate can consequently rise up through the support wall in the condensate and is not stopped by the support wall. In this manner, as a result of the support wall, on the one hand, a high level of stability for the pipe bundle and consequently the entire vertical heat exchanger can be provided without, on the other hand, decreasing the advantages which are provided by the exchange volumes. A vertical heat exchanger according to the invention can consequently be further improved by the use of support walls which are constructed according to the invention. Particularly as a result of this use of support walls, which are mechanically simple and enable a simple assembly, it is also possible to dispense with a use of complex, cost-intensive and complex-to-assemble grid constructions.

In a particularly preferred manner, with a vertical heat exchanger according to the invention there may be provision for at least one of the compensation volumes to correspond or at least substantially correspond to the space of a heat exchanger pipe or a plurality of heat exchanger pipes which are arranged beside each other in the homogeneous pipe bundle. This may be provided in a particularly simple manner by one of the heat exchanger pipes or a group of heat exchanger pipes which are arranged beside each other being omitted or left out when the pipe bundle is formed. A use of the free space which is thereby produced in the pipe bundle as a compensation volume can consequently be carried out in a particularly simple manner. In particular, an introduction of the compensation volumes in the pipe bundle can be enabled in a particularly simple manner since no additional structures have to be provided or present in the pipe bundle.

Furthermore, a vertical heat exchanger according to the invention can be further developed by the at least one horizontal support wall in the region of the compensation volumes being constructed in such a manner that the compensation volumes are expanded at that location, wherein at least one of the compensation volumes corresponds or at least substantially corresponds to the space of a plurality of heat exchanger pipes which are arranged beside each other in the homogeneous pipe bundle. The term "expanded" in the context of the invention may in this instance in particular be understood to mean that a cross-section of the respective compensation volume is increased in the region of the at least one support wall. In this manner, there may be provision for the vapor bubbles which rise in the condensate to be able to climb through the at least one support wall in an even simpler manner and without significant resistance. An influence of a rising movement of the vapor bubbles in the condensate through the at least one support wall can be decreased again, in particular completely prevented. In a compensation volume which corresponds to the space of a plurality of heat exchanger pipes which are arranged beside each other, this expansion can be provided in a particularly simple manner, for example, by removing webs in the support wall which are provided in the support wall for stabilization between the omitted heat exchanger pipes.

Furthermore, a vertical heat exchanger according to the invention may be constructed in such a manner that at least one of the compensation volumes is arranged adjacent to a fixed installation, in particular a tie rod or an evacuation device. Fixed installations are elements which are already present inside the heat exchange volume and which are arranged inside the pipe bundle and which often extend over the entire height of the heat exchange volume from the lower pipe base as far as the upper pipe base. Examples include in this instance tie rods, which improve stability of the heat exchanger over the entire height thereof, or evacuation devices which, for example, can be used for pressure regulation in the heat exchange volumes and/or for removing undesirable media, for example, gases which cannot be condensed. Such fixed installations already represent in this instance interruptions of the homogeneity of the pipe bundle. As a result of an arrangement of at least one of the compensation volumes adjacent to this fixed installation, use can be made of this. For the arrangement of the fixed installation, heat exchanger pipes were already removed from the pipe bundle, wherein often the entire volume which becomes free is not used by the fixed installation. In particular, it is thereby possible, for example, adjacent to such a fixed installation by means of further omission of one or more heat exchanger pipes, for a particularly large compensation volume to be provided in a particularly simple manner.

With a vertical heat exchanger according to the invention, there may also further be provision for at least one of the compensation volumes to be arranged on an edge region of the pipe bundle. An edge region of the pipe bundle also represents, as with the above-described fixed installations, a region in which an arrangement of the heat exchanger pipes has to be adapted to external circumstances. Also at these edge regions, it may be the case here that heat exchanger pipes are consequently omitted without a volume which thereby becomes free being used. As a result of an arrangement of a compensation volume at such a location, for example, by means of recesses in a horizontal support wall, such an increase or arrangement of the compensation volumes on the edge of the pipe bundle can be provided in a particularly simple manner.

Furthermore, a vertical heat exchanger according to the invention may be constructed in such a manner that a spacing between the compensation volumes is limited to a value which corresponds to 15 times, preferably 10 times, in a particularly preferred manner 5 times, a diameter of the heat exchanger pipes. In this manner, it can be ensured in a particularly simple manner that, regardless of the location of the occurrence of a vapor bubble in the pipe bundle, a compensation volume for the vapor bubble to rise without any danger in the condensate is available in the vicinity. A particularly reliable operation of a vertical heat exchanger according to the invention can thereby be enabled.

Alternatively or additionally, with a vertical heat exchanger according to the invention there may be provision for the compensation volumes to be distributed in a uniform manner or at least substantially in a uniform manner in the pipe bundle. In a particularly preferred manner, there may be provision for the uniform distribution of the compensation volumes in the pipe bundle to be adapted to the homogeneous arrangement of the heat exchanger pipes in the pipe bundle or to correspond thereto. It can thereby be ensured in a particularly simple manner that for any location of an occurrence of a vapor bubble inside the pipe bundle, a compensation volume is available in the direct vicinity or at least in close proximity for the vapor bubble to rise in the condensate. A risk of damage to the heat exchanger pipes by a condensate shock can thereby be further reduced.

A vertical heat exchanger according to the invention may also be constructed in such a manner that, close to the upper pipe base on an upper end of the heat exchanger pipes, a wall thickness of the heat exchanger pipes is reinforced, in particular reinforced by a factor of 3 or more, without an inner cross-section of the heat exchanger pipes being reduced or an inner cross-section of the heat exchanger pipes being at least substantially reduced. This embodiment of a vertical heat exchanger according to the invention is particularly advantageous for those fields of use in which a flooding of the heat exchange volume is carried out as far as the vicinity of the upper pipe base or can at least be carried out. In this instance, the vapor bubbles in the condensate often inevitably burst or collapse at the upper ends of the heat exchanger pipes since the vapor bubbles cannot rise any further. As a result of a local reinforcement of a wall thickness of the heat exchanger pipes in this region, in particular by a factor of three or more, damage to the heat exchanger pipes can nonetheless be reduced or even prevented completely. Because of the fact that, as a result of the reinforcement, an inner cross-section of the heat exchanger pipes is not or at least not substantially reduced, a negative influence of a flow of the first medium in the heat exchanger pipes can also be prevented. The reinforcement of the wall thickness is consequently carried out at the outer sides of the heat exchanger pipes.

Preferably, a vertical heat exchanger according to the invention may in this instance be further developed in such a manner that the wall thickness of the heat exchanger pipes is reinforced over a length of more than 50 mm, preferably more than 100 mm. This length is in this instance measured in particular from the upper pipe base in a downward direction. Such a reinforcement of the wall thickness to a length of more than 50 mm, even better more than 100 mm, may in this instance ensure that the upper ends of the heat exchanger pipes are adequately protected from condensate shock, even when the entire or almost the entire heat exchange volume is flooded with condensate.

According to a first alternative development of a vertical heat exchanger according to the invention, there may be provision in this instance for the wall thickness to be reinforced by means of an additional pipe which is arranged axially on the end of the respective heat exchanger pipe and which is in particular welded on. That is to say, as a result of the additional pipe, the respective heat exchanger pipe is extended at the upper end thereof and consequently close to the upper pipe base. The additional pipe bridges in this instance an intermediate space between an upper end of the respective heat exchanger pipe and the upper pipe base. A discharge of the first medium can consequently be prevented. In this instance, the additional pipe may also extend in or through the pipe base. The additional pipe preferably has in this instance a larger wall thickness than the respective heat exchanger pipe. As a result of an appropriate selection of a wall thickness of the additional pipes, an adjustment of the size of the reinforcement of the wall thickness of the respective heat exchanger pipes can be provided. A welding of the additional pipes represents in this instance a particularly secure and durable arrangement of the additional pipes on the respective heat exchanger pipe. According to a second preferred alternative development, with a vertical heat exchanger according to the invention there may be provision for the wall thickness of the respective heat exchanger pipe to be reinforced by a reinforcement pipe which is arranged coaxially with respect to the respective heat exchanger pipe and which radially surrounds it. In this manner, for each heat exchanger pipe which is intended to be protected, only a single additional component has to be provided in order to provide a corresponding reinforcement of the wall thickness of the heat exchanger pipes. In this instance, the reinforcement pipe is arranged at the outer side around the heat exchanger pipe, in particular coaxially, wherein the reinforcement pipe completely encloses and surrounds the heat exchanger pipe. As a result of an appropriate selection of a wall thickness of the reinforcement pipe, the reinforcement of the wall thickness of the heat exchanger pipe is produced automatically. A particularly simple reinforcement of a wall thickness of the heat exchange pipes may be provided in this manner.

Preferably, a vertical heat exchanger according to the invention can be developed in such a manner that the respective reinforcement pipe is secured in a non-positive-locking and/or materially integral manner in and/or on the respective heat exchanger pipe and/or to the pipe bundle and/or to the upper pipe base. Thus, the reinforcement pipes may, for example, be arranged and secured so as to be flush with or recessed in the upper pipe base. Furthermore, for example, a rolling-in of the reinforcement pipes in the upper pipe base can be carried out or, as a result of a hydraulic expansion in the arrangement, the reinforcement pipes can be pressed onto the respective heat exchanger pipes. A welding of the reinforcement pipes to the respective heat exchanger pipe and/or to the upper pipe base is also conceivable. On the whole, as a result of the non-positive-locking and/or materially integral securing, a more secure retention of the reinforcement pipes on the respective heat exchanger pipe can be ensured. An undesirable removal of the reinforcement pipes from the respective position can thereby be prevented. A protection of the heat exchanger pipes from damage, in particular, for example, by a condensate shock, can thereby be provided in a particularly reliable manner.

According to another development of a heat exchanger according to the invention, there may further be provision for an intermediate space between the reinforcement pipe and the respective heat exchanger pipe to be less than 0.5 mm, in particular less than 0.2 mm, preferably 0.0 mm. As a result of a disappearing intermediate space, that is to say, a spacing between an inner face of the reinforcement pipe and an outer face of the respective heat exchanger pipe of 0.0 mm, particularly good protection of the heat exchanger pipe can be provided since no vapor bubble can penetrate between the reinforcement pipe and the heat exchanger pipe. However, since this fit precision cannot always be provided and, furthermore, an assembly of the reinforcement pipes can also thereby be made more difficult, it is often sufficient for adequate protection from condensate shocks for the intermediate space to be small, for example, less than 0.5 mm, preferably less than 0.2 mm. In this instance, these values have been found to be particularly suitable in order, on the one hand, to be able to provide good ease of assembly of the reinforcement pipes and at the same time, on the other hand, to be able to ensure a capability of the reinforcement pipes to protect the respective heat exchanger pipe from condensate shocks.

In a particularly preferred manner, a vertical heat exchanger according to the invention can be developed in such a manner that the intermediate space between the reinforcement pipe and the respective heat exchanger pipe is closed at the lower end of the reinforcement pipe by means of a closure material, in particular a solder and/or a plastics material. As described above, an intermediate space between the reinforcement pipe and the respective heat exchanger pipe cannot always be prevented or is even provided in order, for example, to facilitate an assembly of the reinforcement pipes. In this instance, there is preferably provision for this intermediate space to be closed by means of a closure material at the lower end of the reinforcement pipe, that is to say, at the end of the reinforcement pipe facing away from the upper pipe base. A solder or a plastics material, in particular a capillary-action plastics material, may preferably be used in this instance as a closure material. In this manner, it is possible for the intermediate space between the reinforcement pipe and the respective heat exchanger pipe to be closed at least at the lower end of the reinforcement pipe and consequently to be inaccessible for vapor bubbles rising in the condensate. A penetration of a vapor bubble in this intermediate space can consequently be reliably prevented. All the advantages which have been described above for a disappearing intermediate space consequently also result for an intermediate space which is closed by means of a closure material at the lower end of the reinforcement pipe.

According to one aspect of the present invention, there is provided a vertical heat exchanger having a heat exchange volume which is delimited at opposing ends by an upper pipe base and a lower pipe base of the heat exchanger, and a homogeneous pipe bundle, wherein the pipe bundle has a large number of heat exchanger pipes which are arranged in a regular manner with respect to each other and extends inside the heat exchange volume between the lower pipe base and the upper pipe base, wherein a first medium can further flow through the heat exchanger pipes and at least one second medium can be arranged in the remaining heat exchange volume, and wherein a heat exchange can be carried out between the first medium and the second medium, wherein compensation volumes are arranged in the pipe bundle, wherein the compensation volumes within the pipe bundle extend through the heat exchange volume, wherein the compensation volumes are areas within the tube bundle that are not occupied by a heat exchanger tube and can be filled by the at least one second medium, and at least one of the compensation volumes the space of a heat exchanger tube or a plurality of heat exchanger tubes arranged adjacent to one another in the homogeneous tube bundle corresponds or at least essentially corresponds.

The present invention is further described with reference to the appended drawings. Elements with the same function and operation are given the same reference numerals in each case in Figures 1 to 7. In the schematic drawings:

Figure 1 shows a vertical heat exchanger according to the invention,

Figure 2 shows a first embodiment of compensation volumes inside a pipe bundle,

Figure 3 shows a second embodiment of compensation volumes inside a pipe bundle,

Figure 4 shows a third embodiment of compensation volumes inside a pipe bundle,

Figure 5 shows a fourth embodiment of compensation volumes inside a pipe bundle,

Figure 6 shows an arrangement of a reinforcement pipe on a heat exchanger pipe, and

Figure 7 shows an arrangement of an additional pipe on a heat exchanger pipe.

In Figure 1, a portion of a vertical heat exchanger 1 according to the invention is shown. In this instance, in particular a lower portion of a heat exchange volume 2 is depicted, wherein a lower pipe base 4 forms the lower termination of the heat exchange volume 2. Inside the heat exchange volume 2, there is arranged a homogeneous pipe bundle 10 which has a large number of heat exchanger pipes 12. These heat exchanger pipes 12 are arranged in a regular manner in order to form the homogeneous pipe bundle 10, for example, in a hexagon-symmetrical arrangement. Of this pipe bundle 10 an edge region 11 can be seen. The heat exchanger pipes 12 and consequently the entire pipe bundle 10 extend as far as the upper pipe base 3 (not illustrated) which forms the upper termination of the heat exchange volume 2 of the vertical heat exchanger 1. The heat exchanger pipes 12 extend in this instance through the lower pipe base 4 and the upper pipe base 3 or are combined therein in a fluid-communicating manner to form one or more collection lines. There is further illustrated a support wall 5 which extends horizontally inside the heat exchange volume 2 and which is constructed for stabilization of the heat exchanger pipes 12. There flows inside the heat exchanger pipes 12 a first medium which is warmed, in particular heated, by a second medium which is arranged in the remaining heat exchange volume 2 and consequently surrounds the heat exchanger pipes 12. The second medium can often be present in vapor or gas form. In this instance, a portion of the second medium may also be present as condensate, which accumulates in the lower portion of the heat exchange volume 7. A controlled flooding of the heat exchange volume 2 with this condensate may also be carried out, in particular in order, for example, to control a heating power of the vertical heat exchanger 1 according to the invention. In this instance, for example, in the event of sudden load changes, evaporation effects in the condensate may occur, whereby damage in particular of the heat exchanger pipes 12 can be brought about by means of condensate shocks. In order to prevent this, compensation volumes 20 are arranged in the pipe bundle 10, in this instance on the edge region 11 of the pipe bundle 10. These compensation volumes 20 extend parallel or at least substantially parallel with the heat exchanger pipes 12 through the entire pipe bundle 10, continuously from the lower pipe base 4 as far as the upper pipe base 3 and in particular also through the horizontal support wall 5. In the support wall 5, the compensation volumes 20 may further even be expanded and consequently have a larger cross-section. As a result of this passage of the compensation volumes 20 through the support wall 20, it can be readily used to stabilize the pipe bundle 10, wherein it is thereby possible in particular to dispense with the use of cost-intensive and complex-to-assemble grid constructions. The compensation volumes 20 may also be preferably formed by omitting one or more of the heat exchanger pipes 12 of the pipe bundle 10, whereby in this instance the compensation volumes 20 correspond to a space which these omitted heat exchanger pipes 12 would have taken up in the homogeneous pipe bundle 10. On the whole, as a result of these compensation volumes 20, the vapor bubbles which are produced in the condensate can rise unimpeded as far as a surface of the condensate. There, they can burst without bringing about a condensate shock. A vertical heat exchanger 1 according to the invention with such compensation volumes 20 can consequently be operated with a particularly high level of reliability with respect to an occurrence of condensate shock.

Figures 2, 3, 4 and 5 show different construction possibilities of arrangements of compensation volumes 20 in a homogeneous pipe bundle 10 which itself has a hexagon-symmetrical arrangement of the heat exchanger pipes 12. In each of the embodiments shown, in this instance the respective compensation volumes 20 are formed by means of omission of one or more of the heat exchanger pipes 12 and consequently take up a space which becomes free as a result of this omission in the pipe bundle 10. The heat exchange volume 2 and the remaining entire vertical heat exchanger 1 according to the invention is in each case not illustrated in Figures 2, 3, 4 and 5.

In this instance, it is shown in Figure 2, that already as a result of an omission of an individual heat exchanger pipe 12, a space for a compensation volume 20 can be provided in each case. Furthermore, it can already be seen in Figure 2 that these compensation volumes 20 are preferably also arranged so as to be distributed in a uniform and homogeneous manner in the pipe bundle 10. As a result of compliance with a maximum spacing 21 between the compensation volumes 20 which may, for example, be from 5 to 10 times the diameter of the heat exchanger pipes 12, this can be achieved. In this manner, it can be ensured that, regardless of the location of the occurrence of a vapor bubble in the condensate, the vapor bubble always finds in its vicinity a compensation volume 20 in order to rise in an undisturbed and unimpeded manner.

The embodiment shown in Figure 3 differs from that shown in Figure 2 in particular in that, in place of a single heat exchanger pipe 12, a group of adjacent heat exchanger pipes 12 have been omitted in order to provide a space for the respective compensation volumes 20. In this manner, a larger space for the respective compensation volume 20 can be provided in a particularly simple manner. Also in this embodiment, the compensation volumes 20 are again distributed homogeneously and uniformly in the pipe bundle 10, wherein in this instance, in comparison with Figure 2, a slightly larger spacing 21 between the compensation volumes 20 was selected. All the advantages which have been described with reference to the embodiment shown in Figure 2 can consequently also be provided with the embodiment shown in Figure 3. Furthermore, a fixed installation 6 is shown in the pipe bundle 10. Such a fixed installation 6 may in this instance, for example, be a tie rod or an evacuation device, which may be arranged inside the heat exchange volume 2 of a vertical heat exchanger 1 according to the invention.

Figure 4 shows that an environment of such a fixed installation 6 can also be used as a location for compensation volumes 20. In this instance, use is made of the fact that for the fixed installation 6 heat exchanger pipes 12 have already been omitted from the homogeneous pipe bundle 10. The space which thereby becomes free in the pipe bundle 10 is, however, in most cases not completely filled by the respective fixed installation 6. For example, by means of additional omission of additional heat exchanger pipes 12, as shown in Figure 4, it is consequently possible in a particularly simple manner to provide other additional space for compensation volumes 20.

Figure 5 shows another possible embodiment of compensation volumes 20 in a homogeneous pipe bundle 10 of a vertical heat exchanger 1. In this instance, as illustrated in Figure 5, such compensation volumes 2 may also be provided on an edge region 11 of the homogeneous pipe bundle 10. This also represents in the context of the invention an arrangement inside the pipe bundle 10. Also in this instance, the compensation volumes 20 may take up spaces which correspond to omitted heat exchanger pipes 12. In particular, use can be made of the fact that often the edge region 11 of the pipe bundle 10 does not correspond or is not adapted to the homogeneous distribution of the heat exchanger pipes 12 in the pipe bundle 10, for example, as illustrated with a hexagon-symmetrical arrangement of the heat exchanger pipes 12 in the pipe bundle 10 and a cylindrical heat exchange volume 2 which is indicated in Figure 5 with broken lines. There are thereby automatically produced on the edge region 11 of the homogeneous pipe bundle 10 regions in which no further heat exchanger pipe 12 can be arranged. In these regions, consequently, for example, as a result of an additional omission of heat exchanger pipes 12, compensation volumes 20 can be provided in a particularly simple manner.

Figures 6 and 7 show protective measures which can be taken in a heat exchanger 1 according to the invention in order to protect an upper end of the heat exchanger pipes 12 which is arranged close to the upper pipe base 3, in particular from a condensate shock. This is particularly advantageous in those heat exchangers 1 in which a rising of the condensate as far as the upper pipe base 3 is possible or even desirable. In this instance, vapor bubbles which occur as a result of evaporation effects in the condensate can rise as far as the upper pipe base 3 and will burst and/or implode at that location inside the condensate since it is not possible to rise further through the upper pipe base 3. Damage to the heat exchanger pipes 12 can thereby occur.

Figure 6 shows a first possibility for providing protection for these upper ends of the heat exchanger pipes 12. In this instance, a sectioned illustration through one of the heat exchanger pipes 12 is shown, wherein an adjacent heat exchanger pipe 12 is indicated with broken lines 12. It can additionally be clearly seen in this illustration that the heat exchanger pipes 12 extend through the upper pipe base 12. According to the invention there is now provided a reinforcement pipe 15 which is arranged coaxially around the upper end of the respective heat exchanger pipe 12. A securing of the reinforcement pipe 15 may in this instance be carried out, for example, by means of rolling-in in the upper pipe base 3, a hydraulic expansion when arranged on the respective heat exchanger pipe 12 or welding to the upper pipe base 3 and/or to the respective heat exchanger pipe 12. In this instance, there is preferably provision for the reinforcement pipe 15 to surround the respective heat exchanger pipe 12 in a positive-locking manner. An intermediate space which nonetheless occurs (not illustrated) between the reinforcement pipe 15 and the respective heat exchanger pipe 12 which is preferably smaller than 0.5 mm, particularly preferably smaller than 0.2 mm, may at the lower end of the reinforcement pipe 15 be closed with a suitable closure material 16, for example, a solder or a plastics material. It is thereby reliably possible to prevent a vapor bubble in the condensate from penetrating into this intermediate space. It is thereby possible for a wall thickness 13 of the heat exchanger pipe 12 to be able to be increased locally by a factor of 3 or more without reducing an inner diameter of the respective heat exchanger pipe 12. Damage to the heat exchanger pipes 12 as a result of a condensate shock can consequently reliably be prevented or at least reduced without preventing a throughflow of the first medium into the heat exchanger pipes 12.

Figure 7 shows an additional alternative possibility for overcoming the above-described problem of condensate shocks on the upper end of the heat exchanger pipes 12. In this instance, in place of a surrounding reinforcement pipe 15 (not illustrated) in each case an additional pipe 14 is arranged axially adjacent to an upper end of the respective heat exchanger pipe 12, in particular welded on. The additional pipe 14 bridges in this instance completely an intermediate space between the respective heat exchanger pipe 12 and the upper pipe base 3. The additional pipe 14 has in this instance a larger wall thickness than the respective heat exchanger pipe 12 but without reducing an inner cross-section of the heat exchanger pipe 12, as shown by way of example in the sectioned view. It is also thereby possible to locally increase an effective wall thickness 13 of the heat exchanger pipe 12, in particular to increase it by a factor of 3 or more. A reinforcement of a wall thickness 13 of the heat exchanger pipes 12 which is particularly in accordance with requirements and/or adaptable can be provided in this manner.

CLAIMS:

1. A vertical heat exchanger having a heat exchange volume which is delimited at opposing ends by an upper pipe base and a lower pipe base of the heat exchanger, and a homogeneous pipe bundle, wherein the pipe bundle has a large number of heat exchanger pipes which are arranged in a regular manner with respect to each other and extends inside the heat exchange volume between the lower pipe base and the upper pipe base, wherein a first medium can further flow through the heat exchanger pipes and at least one second medium can be arranged in the remaining heat exchange volume, and wherein a heat exchange can be carried out between the first medium and the second medium,
wherein
compensation volumes are arranged in the pipe bundle, wherein the compensation volumes within the pipe bundle extend through the heat exchange volume, wherein the compensation volumes are areas within the pipe bundle that are not occupied by a heat exchanger pipe and can be filled by the at least one second medium, and at least one of the compensation volumes corresponds to or at least essentially corresponds to a space of a heat exchanger pipe or a plurality of heat exchanger pipes arranged adjacent to one another in the homogeneous pipe bundle.

2. The vertical heat exchanger as claimed in claim 1,
wherein
the pipe bundle is stabilized inside the heat exchange volume by means of at least one horizontal support wall , wherein the

compensation volumes extend through the at least one support wall.

3. The vertical heat exchanger as claimed in claims 1 and 2, wherein
the at least one horizontal support wall in a region of the compensation volumes is constructed in such a manner that the compensation volumes are expanded at that location, wherein at least one of the compensation volumes corresponds or at least substantially corresponds to the space of a plurality of heat exchanger pipes which are arranged beside each other in the homogeneous pipe bundle.

4. The vertical heat exchanger as claimed in any one of claims 1 to 3,
wherein
at least one of the compensation volumes is arranged adjacent to a fixed installation.

5. The vertical heat exchanger as claimed in any one of claims 1 to 4,
wherein
at least one of the compensation volumes is arranged adjacent to a tie rod or an evacuation device.

6. The vertical heat exchanger as claimed in any one of claims 1 to 5,
wherein
at least one of the compensation volumes is arranged on an edge region of the pipe bundle.

7. The vertical heat exchanger as claimed in any one of claims 1 to 6,
wherein
a spacing between the compensation volumes is limited to a value which corresponds to 15 times a diameter of the heat exchanger pipes.

8. The vertical heat exchanger as claimed in any one of claims 1 to 6, wherein a spacing between the compensation volumes is limited to a value which corresponds to 10 times a diameter of the heat exchanger pipes.

9. The vertical heat exchanger as claimed in any one of claims 1 to 6, wherein a spacing between the compensation volumes is limited to a value which corresponds to 5 times a diameter of the heat exchanger pipes.

10. The vertical heat exchanger as claimed in any one of claims 1 to 9,
wherein
the compensation volumes are distributed in a uniform manner or at least substantially in a uniform manner in the pipe bundle.

11. The vertical heat exchanger as claimed in any one of claims 1 to 10,
wherein,
close to the upper pipe base on an upper end of the heat exchanger pipes, a wall thickness of the heat exchanger pipes is reinforced, without an inner cross-section of the heat exchanger pipes being reduced or an inner cross-section of the heat exchanger pipes being at least substantially reduced.

12. The vertical heat exchanger as claimed in claim 11 wherein the wall thickness of the heat exchanger pipes is reinforced by a factor of 3 or more.

13. The vertical heat exchanger as claimed in claim 11, wherein
the wall thickness of the heat exchanger pipes is reinforced over a length of more than 50 mm.

14. The vertical heat exchanger as claimed in claim 11, wherein the wall thickness of the heat exchanger pipes is reinforced over a length of more than 100 mm.

15. The vertical heat exchanger as claimed in any one of claims 11 or 13,
wherein
the wall thickness is reinforced by means of an additional pipe which is arranged axially on the end of the respective heat exchanger pipe.

16. The vertical heat exchanger as claimed in claim 10 or 11, wherein
the wall thickness is reinforced by means of an additional pipe which is arranged axially and welded on the end of the respective heat exchanger pipe.

17. The vertical heat exchanger as claimed in any one of claims 11 to 13,
wherein

the wall thickness of the respective heat exchanger pipe is reinforced by a reinforcement pipe which is arranged coaxially with respect to the respective heat exchanger pipe and which radially surrounds it.

18. The vertical heat exchanger as claimed in claim 17,
wherein
the respective reinforcement pipe is secured in a non-positive-locking manner or a materially integral manner or a positive-locking and materially integral manner:

a) in on the respective heat exchanger pipe;
b) on the respective heat exchange pipe; or
c) to the pipe bundle; or
d) to the upper pipe base; or
e) a combination of two or more of a),b),c) and d).

19. The vertical heat exchanger as claimed in claim 17 or 18,
wherein
an intermediate space between the reinforcement pipe and the respective heat exchanger pipe is less than 0.5 mm.

20. The vertical heat exchanger as claimed in any one of claims 15 to 17,
wherein
an intermediate space between the reinforcement pipe and the respective heat exchanger pipe is less than 0.2 mm.

21. The vertical heat exchanger as claimed in any one of claims 15 or 17,
wherein

an intermediate space between the reinforcement pipe and the respective heat exchanger pipe is 0.0 mm.

22. The vertical heat exchanger as claimed in claim 19, wherein
the intermediate space between the reinforcement pipe and the respective heat exchanger pipe is closed at the lower end of the reinforcement pipe by means of a closure material.

23. The vertical heat exchanger as claimed in claim 19, wherein the closure material is a solder and/or a plastics material.

FIG 1

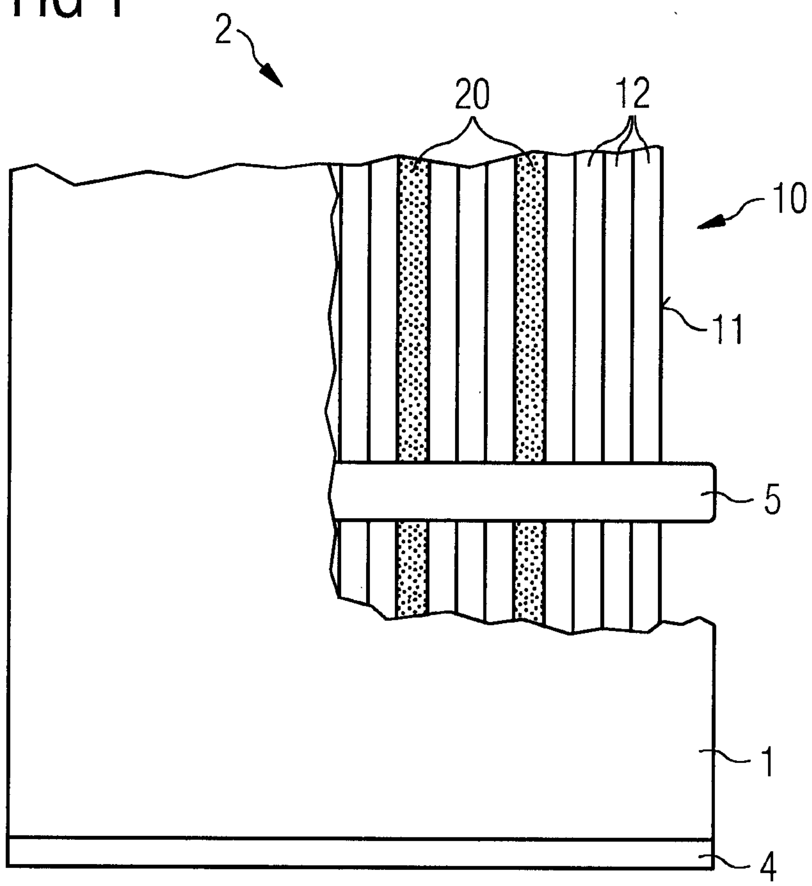


FIG 2

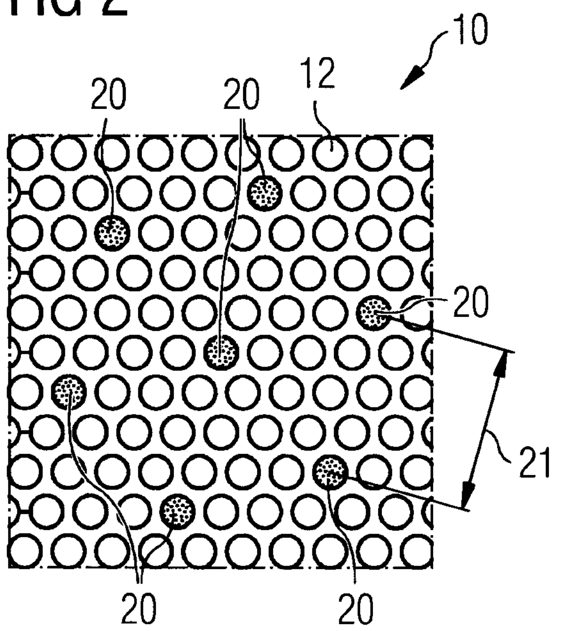


FIG 3

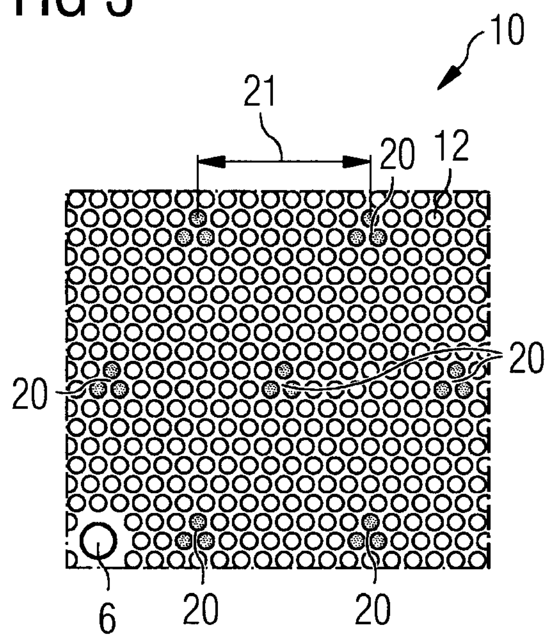


FIG 4

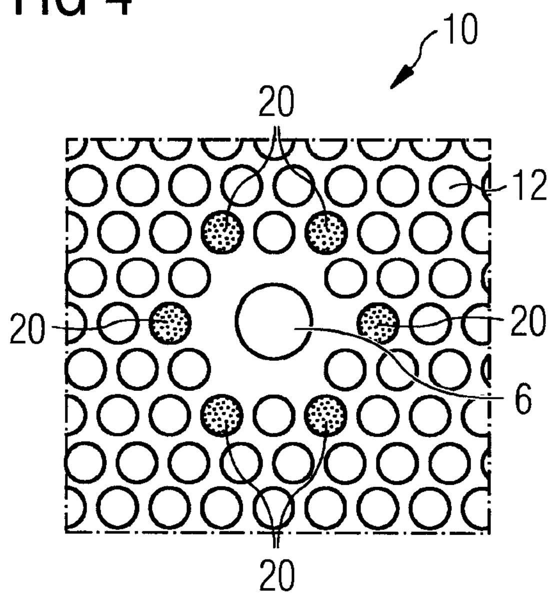


FIG 5

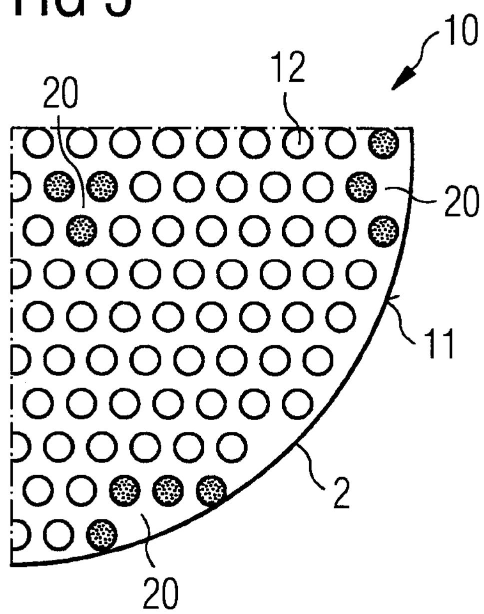


FIG 6

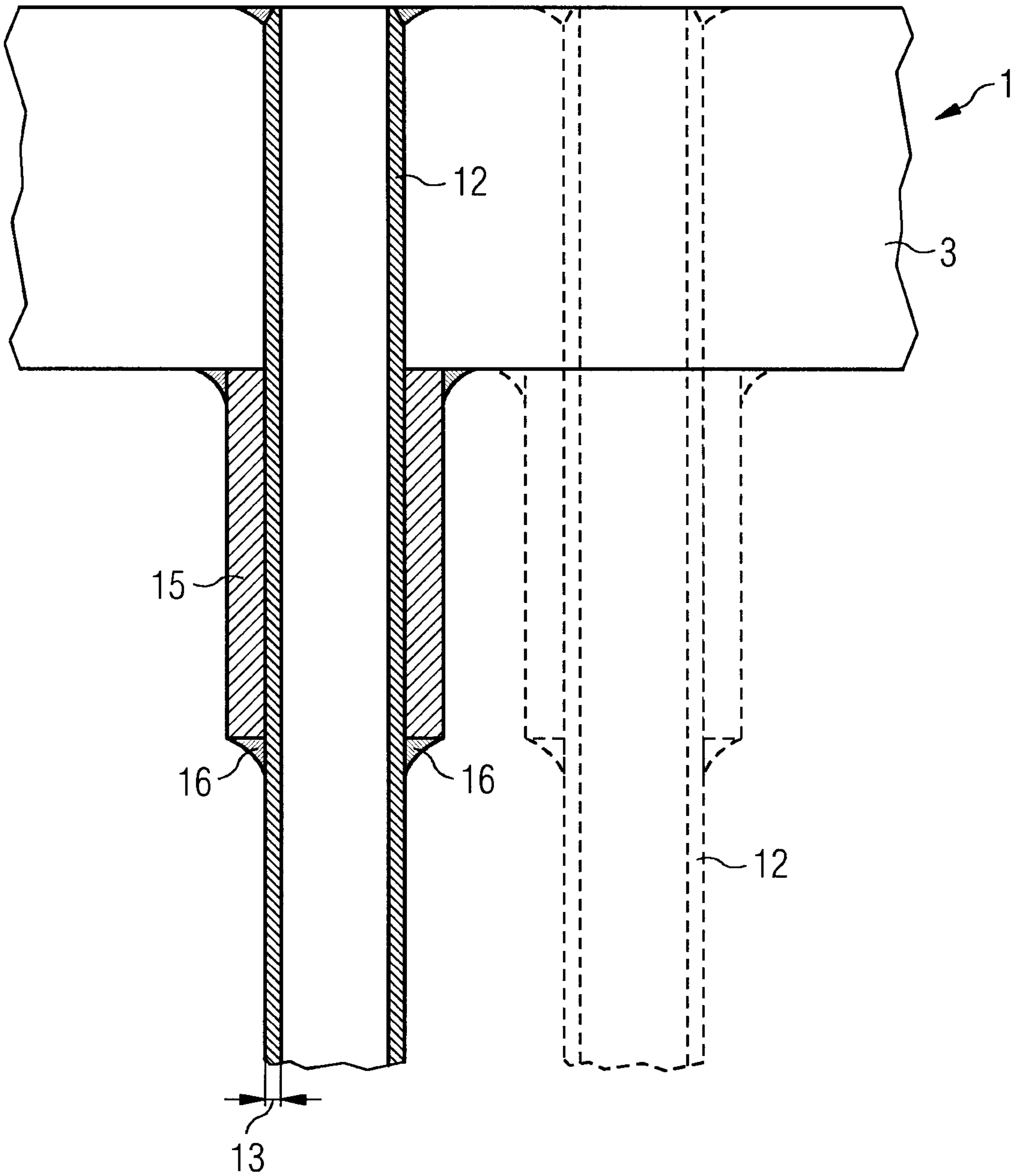
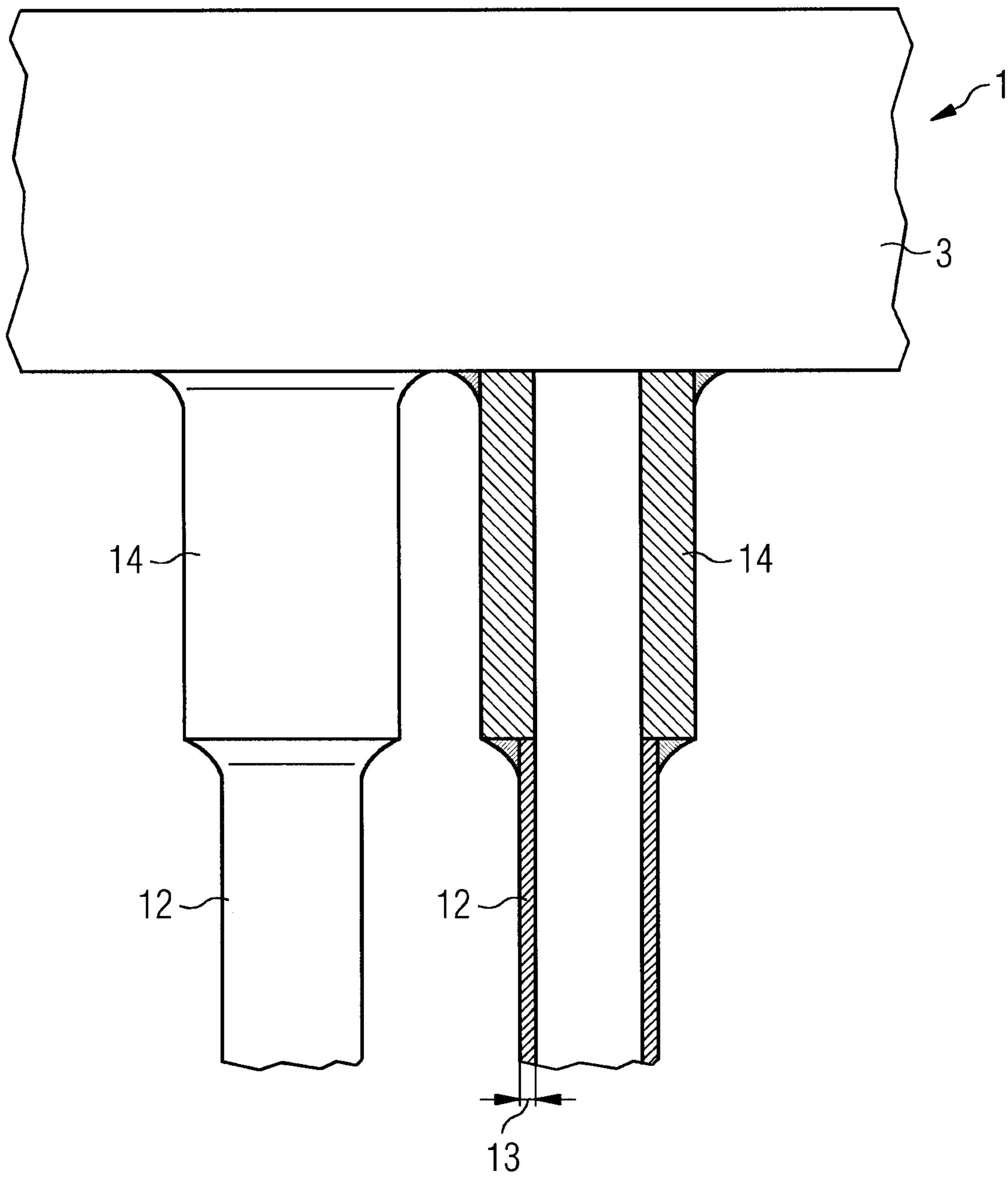
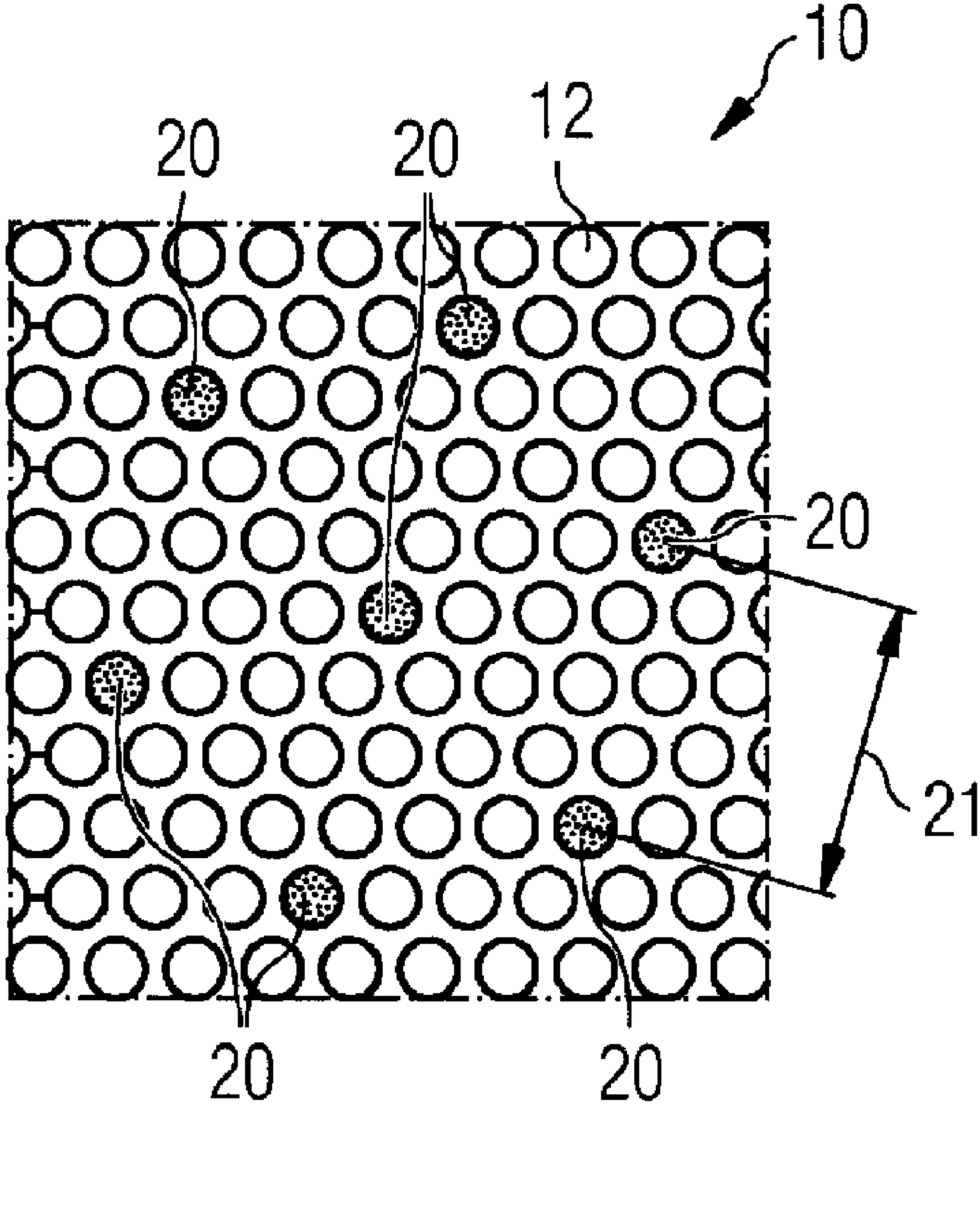


FIG 7





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