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(54) Heat exchanger with integrated cleaning and diagnostic system

(57) The invention concerns a heat exchanger with an integrated cleaning and diagnostic system. It comprises, inside a body or housing with entrance and exit passages of a first fluid, a number of tubes (14) spaced on a parallel, passing crossways in a number of finned plates (15) and connected to each other for the circulation of a second fluid. The finned plates (15), in the spaces between the tubes, are crossed by holes (20) aligned on axes parallel to said tubes and coincident to the access openings (21) provided in a first front plate. The cleaning and diagnostic system comprises at least a cleaning nozzle (12) that can be inserted from time to time into said aligned holes (20) and equipped at least for forced delivery of jets of air, water or steam to clean the internal surfaces of said exchanger.

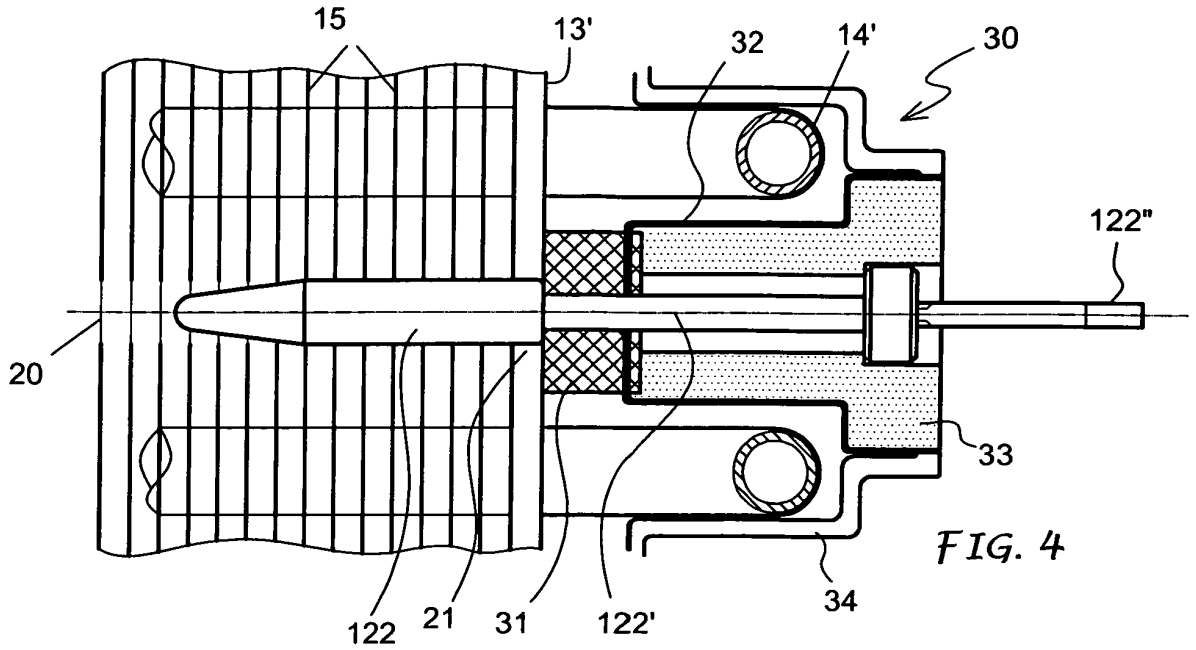

FIG. 4

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Description

Field of the Invention

[0001] This invention concerns the heat exchanger field, and in particular systems set up for the recovery and/or transformation of thermal energy of a fluid into another mechanical or electric energy.

State of technique

[0002] In such systems thermal exchangers are usually used for a direct or indirect exchange of heat between a heated fluid and a work fluid or be heated ort to be evaporated.

[0003] These heat exchangers are usually comprised of smooth or finned tubes placed alongside each other and assembled in a somewhat closed group in a housing, so that they are covered by the heating fluid and the fluid to be heated flows through them, or vice versa. This is the case, for example, in systems designed to recover the heat content of combustion fumes out flowing from internal combustion motors or from other sources, for the heating of a work fluid in the field of a Rankine cycle with a turbine for the production of mechanical or electric energy. However, in addition to the fact that the finned tubes are difficult and costly to produce, when fumes from any source flow through similar heat exchangers, their tubes and in particular their fins are subject to soot deposits and solid particles of different types, which in the long run tangibly reduce the yield of the heat exchanger. In this case to restore the full efficiency of an exchanger the housing must be opened, the tubes and relative fins accessed in order to clean them to repair the exchanger, operations that obviously can only be carried out when the system is stopped with consequent time, production and economic loss.

Objectives and summary of the invention

[0004] One objective of the invention is however to create the conditions to avoid to aforementioned drawbacks of the exchangers of the known technique and to facilitate cleaning and washing all the internal surfaces of a heat exchanger without basically having to open the housing and with the exchanger stopped or functioning.

[0005] Another objective of the invention is to propose an innovative heat exchanger designed without having to depend on the traditional finned tubes.

[0006] A further objective of the invention is to provide a heat exchanger with an integrated multifunction system that enables it both to carry out rapid internal cleaning with efficient removal of deposits and diagnostic interventions by measuring the temperatures and/or the collection of samples of fluid circulating between the tubes to check for possible leaking of other fluid from the tubes.

[0007] The above objectives and implicit advantages deriving from them are achieved, in compliance with this invention, by a heat exchanger comprising a number of parallel spaced tubes, inserted and passing crossways through a number of closely spaced shared fins, and where said fins are crossed by holes aligned on parallel axes to the tubes and in each of said holes can be inserted from time to time a nozzle which can move in different directions, equipped at least for the forced supply of jets of air, water or vapour to clean the internal surfaces of said exchanger.

[0008] Furthermore and advantageously, the nozzle can be provided and used to carry out added or auxiliary functions always remaining within the sphere of the heat exchanger, useful in the control and to improve the correct management of the latter.

Brief description of the drawings

[0009] Greater details of the invention will however become evident from the following description made in reference to the attached indicative and not limiting drawings, in which;

Fig. 1 shows an example of a heat exchanger according to the invention;
Fig. 2 shows, in a schematic form, the view of a part of the internal structure of the heat exchanger in Fig. 1 in association with a nozzle;
Fig. 3 shows a partial cross section of the heat exchanger;
Fig. 4 shows a way of closing the openings in a wall of the housing used to insert the cleaning nozzle;
Fig. 5 shows a way of guiding the cleaning nozzle towards the holes in the plates or fins of the heat exchanger;
Fig. 6 shows a way of blocking the openings in a wall at the back of the body or housing of the heat exchanger;
Fig. 7 shows the view of a nozzle complete with heat sensor;
Fig. 8 shows a heat exchanger made up of a number of tube packs;
Fig. 9 shows a variation in the configuration of the nozzle introduction holes; and
Fig.10 shows a cross section in line with a hole in Fig. 9 to introduce a nozzle associated with a brush.

Detailed Description of the invention

[0010] In said drawings, the reference number 11 generically indicates a heat exchanger and 12 a nozzle provided at least for the internal cleaning and washing of the exchanger.

[0011] The heat exchanger 11 comprises internally a body or housing 13, a tube nest consisting in a number of smooth tubes 14, positioned in parallel according to a square or rectangular matrix, inserted crossways in a number of plates 15. The tubes 14 are in communication by means of connecting curves 14' or collectors. The

plates 15 are spaced in parallel and form heat exchange fins in common for all the tubes. Said plates or fins 15 are connected to the tubes so as to guarantee an efficient heat exchange by conduction between fin and tube. For this purpose each tube 14 may be forced inside the holes provided in the fins 15, or the fins themselves may be brazed or welded to the tubes according to the technique used in the finned pack heat exchanger industry.

[0012] The body or housing 13 will be provided with entrance 16 and exit 17 passages, according to the arrows in Fig. 1, for a flow of a heating fluid, designed to flow through the tube nest and lap against the fins. In particular the heating fluid may be the discharge gas of internal combustion engines fed by vegetable oil, biodiesel, Diesel fuel or something similar, or the effluent fumes from biomass combustion plants or the like. The tube nest 14 will in turn have an entrance and exit 17, 19 for a fluid to be heated coming from a respective circuit - not shown.

[0013] The free sides of the exchanger can be insulated, and in particular one of its front sides can be formed by at least a first plate or wall 13' with a hinged camouflaged door 113, possibly insulated (Fig. 3).

[0014] The plates or fins 15, in their parts between the tubes, are provided with holes 20 aligned on parallel axes to the tubes 14 and coinciding with openings 21 provided in the front plate or wall 13' of the exchanger. For the internal sealing of the exchanger when operating, each of these openings 21 can be closed by a cover or plug 22 removable to enable access to the holes 20 they are lined up to.

[0015] For example, the cover 22 can be fixed to the front plate or wall by magnetic member to facilitate both the application and removal using an automatic manipulator without having to rely on mechanical fixing means which would prove more difficult to assemble and disassemble.

[0016] As regards to the nozzle 12, it will be connected to a control device numbered generically as 112 and configured, dimensioned and movable in order to be able to be inserted into the aligned holes 20 of the plates or fins 15 through the front openings 21 after their plugs 22 have been removed, Furthermore the nozzle 12 is provided for delivery of strong jets of washing fluid, such as air, water or steam against the internal surfaces of the exchanger for efficient cleaning, and because of this it will be provided with radial orifices 23 connectable to an air, water or steam source under pressure.

[0017] It should be noted that for each access opening 21 in the front wall 13' of the exchanger housing, a closing plug 122 can be provided with a rod 122' ending in a gripper tang 122" and associated with a guide and centring support 30 (Fig.4). This includes, for example, a plug 31 resting against the front wall 13' around the opening 21, a cup 32 containing a filling material 33, which the stem 122' of the plug passes and moves in, and an external sleeve 34, which holds the cup and that can be bedded on the curves 14' connecting the tubes 14.

[0018] For its use, the nozzle 12 can be assembled on a means of handling-not shown- susceptible to movements in at least three orthogonal directions according to the arrows in Fig.2, so that the nozzle 12 can be moved and positioned in line with each opening 21 in the plate or front wall 13' of the exchanger and consequently inserted and moved in the coincident holes 20 of the plates or fins 15 for washing the internal surfaces.

[0019] As shown in Fig. 5, the housing 13 of the exchanger can also be provided with a second plate or wall 113' at a distance from the front plate or wall 13' with openings 21 for the insertion of the nozzle 12. In this case, a guide sleeve 35 can be fixed to the two parallel plates or walls 13', 113", in line with each opening 21, that extends until it emerges from the front of a third plate 113", where it is closed by a plug 36. So, between the second and third plate some insulating material can be inserted so that the external plate 113" of the three remains basically cold and, after removing the plug 36, and the nozzle 12 carried by the handling means can be fitted into the sleeve 35 and guided towards the corresponding opening 21. The third plate 113" can be rigid or even flexible and/or have holes larger than the diameter of the guide sleeves so as not to interfere with the latter and compensate the thermal expansions.

[0020] Furthermore and worthy of note is the fact that two or more nozzles operating in parallel and according to a fixed and conveniently managed movement programme can be mounted on the handling means. In addition, the one or each nozzle 12 can incorporate a vibration generator, for example a compressed are type, able to increase efficiency. Furthermore, the one or each nozzle 12 can act also as a support for a heat sensor 24 that enables measuring of the temperature inside the exchanger in order to better control the operating phase.

[0021] Preferably, the heat sensor 24 is positioned at the end of a rod 25 that extends from the free end of the nozzle 12 as shown in Fig. 7. In this case, given the overall length of the nozzle complete with heat sensor, it is preferable for the back wall 13" of the housing 13 opposite the one with the opening 21 to insert the nozzle 12 is spaced from the fins of the tube nest so as to enable the insertion and use of the nozzle for all the depth of the heat exchanger without limitations due to the presence of the heat sensor. On the contrary, the heat sensor (Fig. 3) may be able to retract inside the feed tube of the cleaning fluid (compressed air, steam, etc.) so as to enter into the tube when the nozzle reaches the back wall 13" of the exchanger.

[0022] As an alternative, and as shown in Fig. 6, also the back wall 13" of the body or housing 13 can be provided with exit openings 37 coincident with the holes 20 in the plates or fins 15 and each closed by a magnetic type plug 38 such as to remain attached to the housing in a removable form. In this way the nozzle 12 can come into contact with the plug 38 at the end of the work stroke and move it away from the opening so that it can emerge from said back wall. The magnetic plug will however re-

main attached to the nozzle and when the latter retracts, it will move into the position to close the opening 37 attaching itself once more to the back wall 13" of the body or housing 13.

[0023] Worthy also of attention is the fact that the nozzle, instead of being connected to a source of fluid under pressure, can be connected to an aspirator to be used when inserted into the holes 20 of the finned plates 15, also as a probe to collect samples of fluid from inside the exchanger and be able, by analysing the samples, to detect and spot possible leaks of fluid to be heated using the tubes it is circulating in. It should be pointed out however that changes in details can be carried out to the above described system without by this moving outside the objectof this invention.

[0024] For example, when the heating fluid is particularly hot, it will be worthwhile dividing the exchanger into several winged tube nests so as to avoid the fins warping due to heat dilation, making sure that the holes 20 receiving the nozzle 12 maintain the same step, that is the same distance between centres, even near the contiguous sides of the adjacent nests as shown in Fig. 8.

[0025] Furthermore, even if the holes 20 in the drawing are circular shaped, both those the holes 20 in the plates and fins 15 can be of a different shape in order to insert the nozzle, for example elliptic or however shaped in order to enable the use of one nozzle in particular and only according to a set direction. In addition, the nozzle can also be associated with a rotating brush 26 so as to be able to carry out mechanical cleaning of the surfaces of the exchanger as shown by the trace 26' in Fig. 9. In this case, the holes 20' in the plates or fins 15 can have one shape and be turned alternatively through about 90° as shown in the same Fig. 9 and possibly have their edges bent 20" as shown in Fig. 10 to facilitate access and movement forwards of the nozzle with brush.

[0026] To be noted that the same system described beforehand could be used also in other fields. For example, an application in the field of refrigerators consists in the making of finned pack condensers according to the invention, in which the refrigerant condenses inside the tubes, whereas ambient air flows over the finned side. In this application the system would keep the finned side clean, avoiding periodical washing of the pack and having to carry out diagnosis as described above.

Claims

1. Heat exchanger with an integrated cleaning and diagnostic system, **characterised by** the fact that said exchanger comprises, inside a body or housing (13) with entrance and exit passages of a first fluid, a number of tubes (14) spaced parallel to each other passing crossways in a number of plates or fins (15) densely spaced and connected to each other for the circulation of a second fluid, **characterised by** the fact that said plates and fins (15) in the spaces between the tubes (14) are crossed by holes (20) aligned on parallel axes to said tubes and coincident with access openings (21) provided in a first plate or front wall (13') of said body or housing, and by the fact that said cleaning and diagnostic system comprises at least a cleaning nozzle (12) which can be inserted from time to time into said aligned holes (20) and designed at least for forces delivery of jets of air, water or steam to clean the internal surfaces of said exchanger.

2. Heat exchanger according to claim 1, wherein the access openings to the aligned holes (20) of the plates or fins (15) are each closed by a plug (22, 122), said plug being attached in a removable way to said plate or front wall of the body or housing.

3. Heat exchanger according to claim 2, wherein said plug (122) is associated with a guide and centring support (30) with respect to the respective access opening (21), said support comprising a plug (31) designed to rest against the plate or front wall (13') of the exchanger around the access opening (21), a cup (32) containing a filling material into which a rod holding the plug extends, and an external sleeve (34), holding the cup and which bedded on or placed between the tubes on the plate or front wall side.

4. Heat exchanger according to claims 1, 2 or 3, wherein the cleaning nozzle (12) is assembled on means of support susceptible to movements in several orthogonal directions to position it selectively in line with the access openings (21) and holes (20) of said plates or fins (15).

5. Heat exchanger according to claim 1, wherein the body or housing (13) comprises at least two plates or front walls (13', 113') spaced in parallel holding a sleeve (35) in line with each of said access openings (21) and acting as a guide means for the nozzle (12), said sleeve extending freely through a possible third rigid or flexible plate or wall (113") and being closed by a terminal plug (36).

6. Heat exchanger according to any of the previous claims, wherein the body or housing (13) has a rear wall (13") with exit openings (37) coincident with the holes in the plates or fins (15) and each closed by a plug (38), in particular a magnetic type, said plug being removed by the nozzle (12) at the end of its work stroke and repositioned in correspondence with the respective opening when the nozzle moves back towards the access opening (21).

7. Heat exchanger according to any of the previous claims, wherein said supporting means are designed to hold two or more nozzles and controlled by a management programme.

8. Heat exchanger according to any of the previous claims, wherein said cleaning nozzle (12) incorporates a vibration generator, this vibration generator possibly being the compressed air type.

9. Heat exchanger according to any of the previous claims, wherein said cleaning nozzle (12) forms a support for a heat sensor (24) suitable for reading the temperature inside the exchanger.

10. Heat exchanger with integrated cleaning and diagnostic system according to claim 6, wherein said heat sensor (24) is at the end of a rod (25) protruding from the point of said nozzle, said rod being retractable.

11. Heat exchanger according to any of the previous claims, wherein said nozzle is associated with a rotating brush.

12. Heat exchanger according to any of the previous claims, wherein the tubes and relative plates or fins are subdivided into several packs positioned side by side.

13. Heat exchanger according to any of the previous claims, wherein the holes used to insert the nozzle into said plates or fins have the same distance between the centres even near the contiguous sides of the adjacent packs.

14. Heat exchanger according to any of the previous claims, wherein the holes (20') used to insert the nozzle into said plates or fins have a shape which is not circular, possible with bent back edges when the nozzle is associated with a brush.

15. Heat exchanger according to claim 14, wherein said holes (20') used to insert the nozzle into said plates or fins are positioned alternately turned through about 90°.

16. Heat exchanger according to any of the previous claims, wherein said nozzle can be connected to an aspirator group to be used as a probe to collect samples of first fluid circulating in the heat exchanger through the holes of the plates or fins.

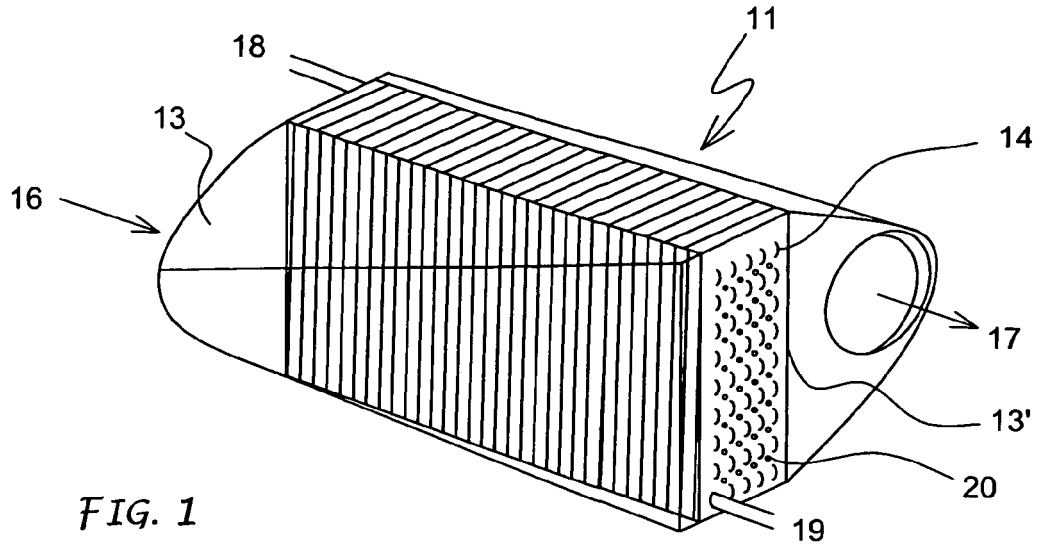

FIG. 1

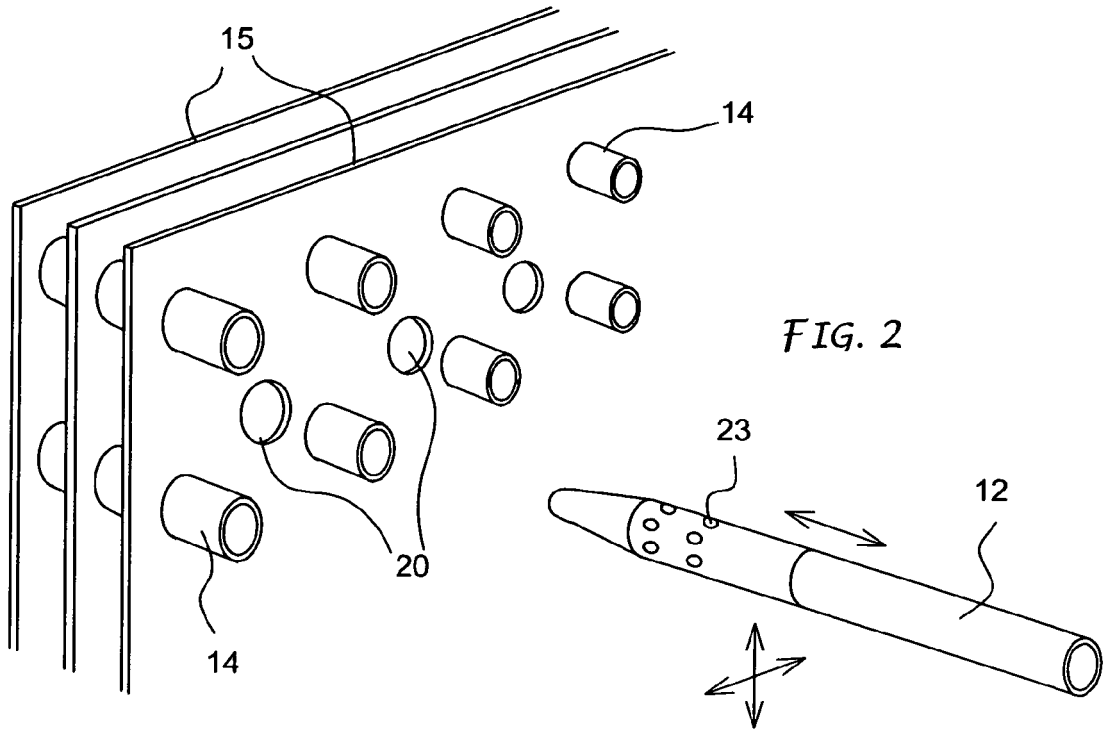

FIG. 2

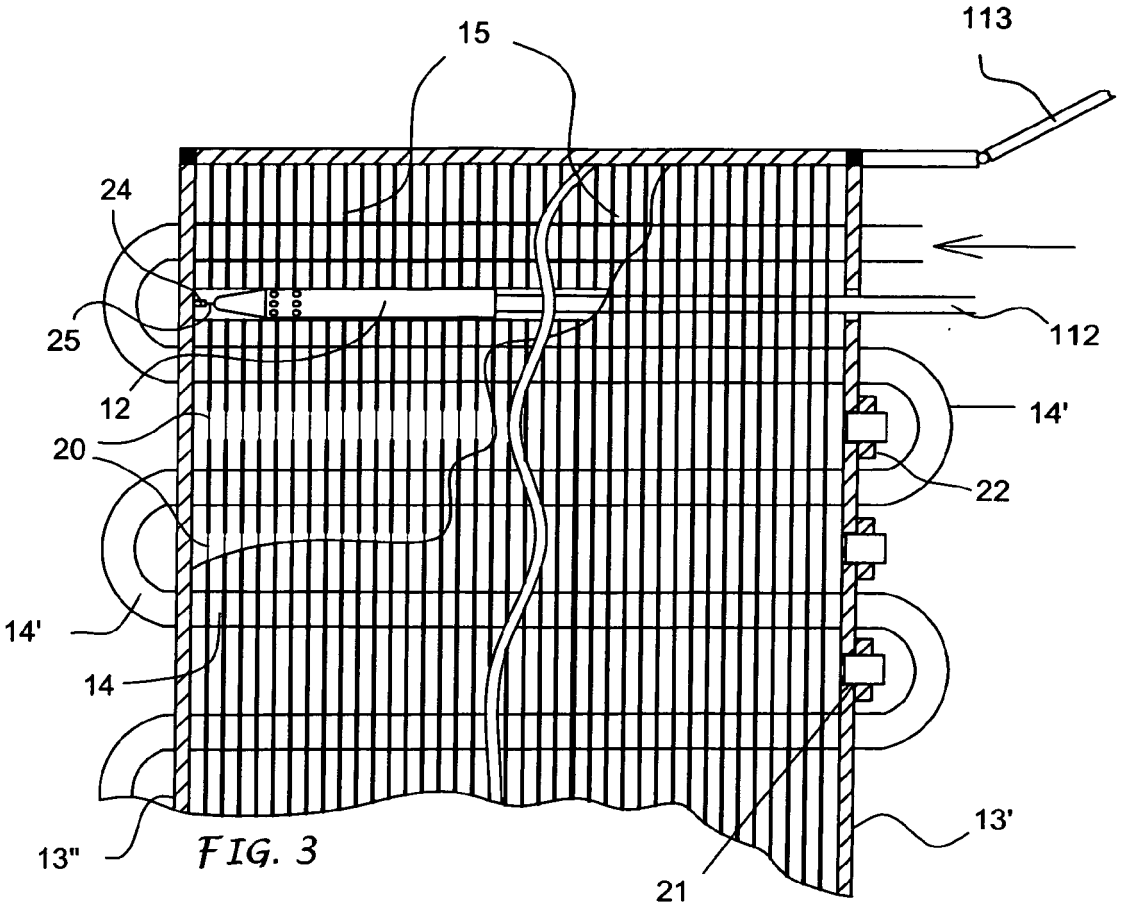
15
113
24
25
12
20
14'
14
13"
112
14'
22
13'
21

FIG. 3

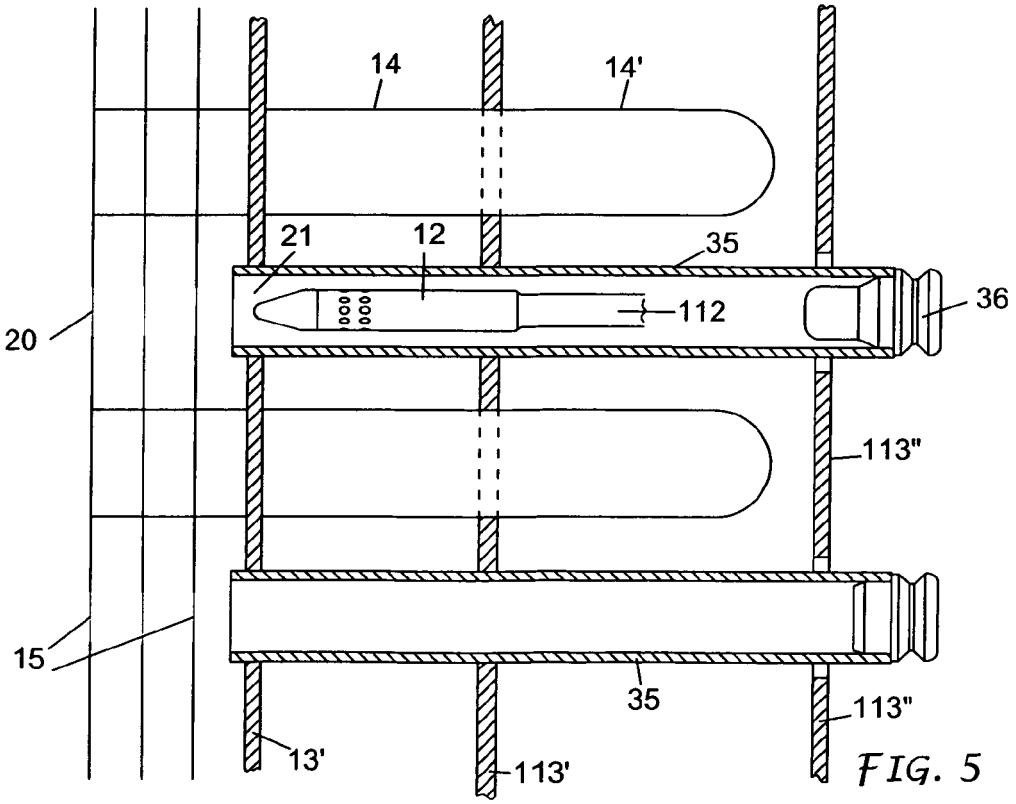
14
14'
21
12
35
36
112
20
113"
15
35
113"
13'
113'

FIG. 5

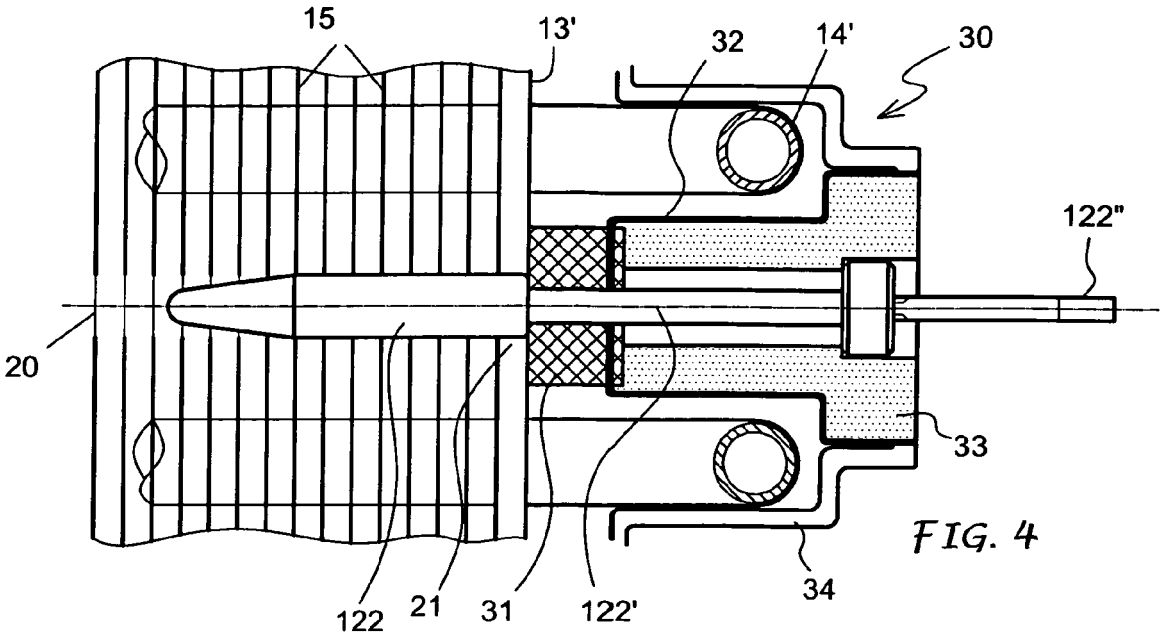

FIG. 4

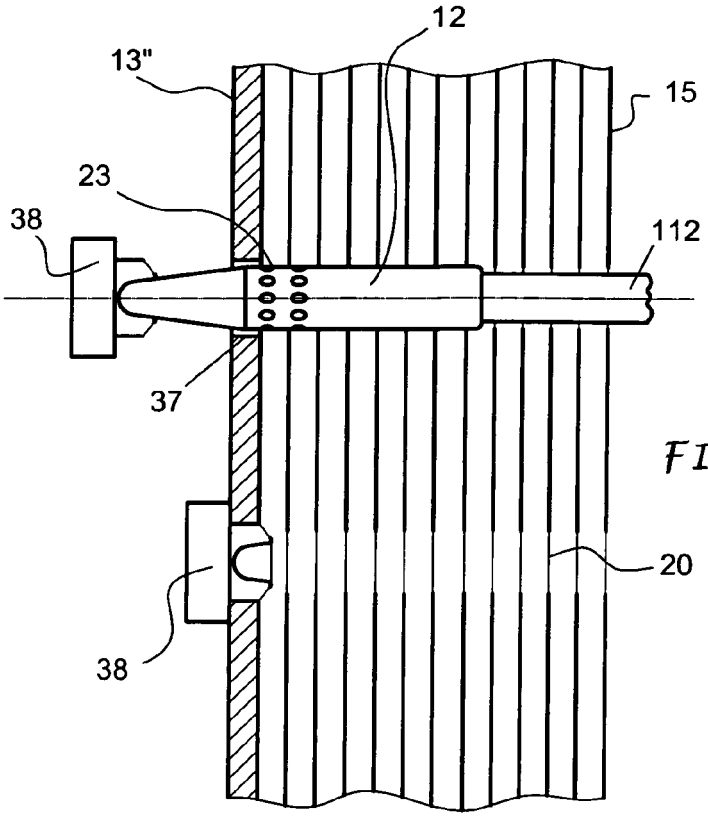

FIG. 6

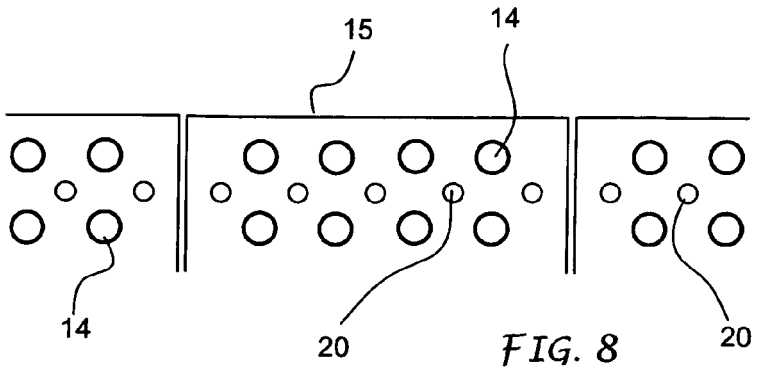

FIG. 8

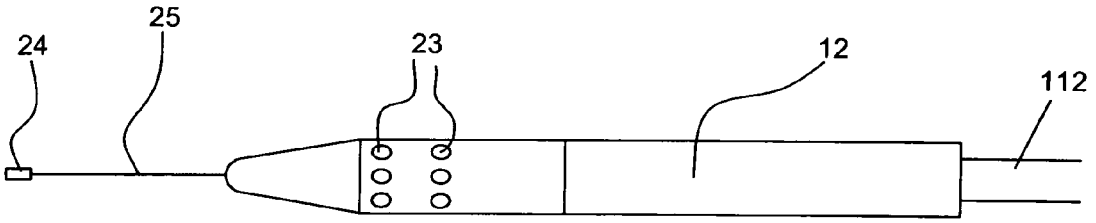

FIG. 7

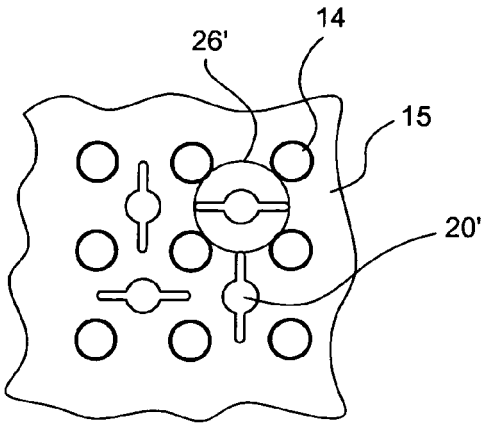

FIG. 9

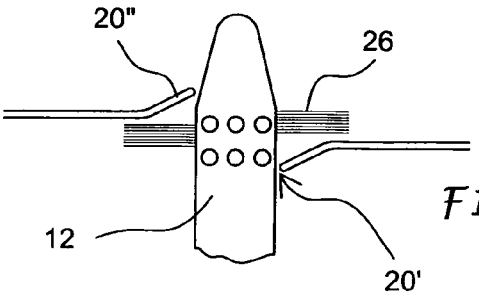

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 07 42 5794

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

F28G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 April 2008	Mellado Ramirez, J

CATEGORY OF CITED DOCUMENTS

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