(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 August 2001 (16.08.2001)

PCT

(10) International Publication Number
WO 01/59385 A1

(51) International Patent Classification[7]: F28F 1/06, F28D 7/12, A23C 3/033

(21) International Application Number: PCT/SE01/00239

(22) International Filing Date: 8 February 2001 (08.02.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0000398-8 8 February 2000 (08.02.2000) SE
0002120-4 6 June 2000 (06.06.2000) SE

(71) Applicant *(for all designated States except US)*: **HACKMAN WEDHOLMS AB** [SE/SE]; P.O. Box 1002, S-611 29 Nyköping (SE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **HOLST, Jan** [SE/SE]; Hackman Wedholms AB, P.O. Box 1002, S-611 29 Nyköping (SE).

(74) Agent: **FRÖDERBERG, Oskar**; Dr Ludwig Brann Patentbyrå AB, P.O. Box 17192, S-104 62 Stockholm (SE).

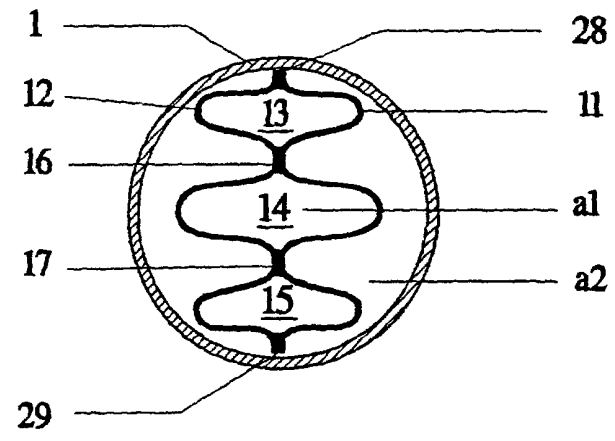
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A HEAT EXCHANGER AND USE THEREOF



(57) Abstract: A heat-exchanger comprising a tube (1) for conducting a first medium that is to be cooled, tubular body (7) arranged inside the tube (1) for the purpose of conducting a cooling medium therein. The tubular body (7) comprises a first and a second elongated sheet (11,12), extending in parallel inside the tube (1), said sheets (11,12) being connected to each other along the opposite longitudinal edges of each sheet respectively, and the sheets (11,12) are connected to each other along a first and second seam (16,17), said first and second seam (16,17) extending generally in parallel to said edges,said sheets, first and second edges and first and second seams delimiting three parallel channels (13,14,15) in the length direction of the sheets (11,12).

WO 01/59385 A1

A heat exchanger and use thereof.

TECHNICAL FIELD

The present invention relates to a heat-exchanger comprising
- a tube for conducting a first medium that is to be cooled, and
- a tubular body arranged inside the tube for the purpose of conducting a cooling medium therein.

Although aimed for use in many different applications, the invention particularly relates to heat exchangers for cooling any kind of liquid, also including solid particles. It is particularly suitable for use in the food industry, and, more precisely, the milk industry, for the purpose of cooling milk. Accordingly, by way of example, the invention will be described with reference to such applications.

BACKGROUND OF THE INVENTION

Heat exchangers, such as pipe coolers, are often provided with flanges for the purpose of increasing the heat transferring surface and in order to increase the convection between the tube and the medium that is to be cooled.

In heat exchangers, particularly tubular evaporators, for the purpose of cooling food, such as milk, the tubular bodies used for conducting a cooling medium or the milk and for effecting the heat exchange between the milk and the cooling medium have plane surfaces in order to cope with the hygienic requirements. Accordingly, the heat exchange will suffer from the relatively small contact surface thereby achieved.

THE OBJECT OF THE INVENTION

It is one object of the present invention to present a heat exchanger of the type initially defined that promotes an efficient cooling of a liquid while simultaneously being of such an uncomplicated design that unhygienic conditions due to unsatisfying convection during, for example, the cooling of milk are avoided. The heat exchanger shall be of such uncomplicated design that production thereof in materials normally used for handling food, such as milk, is possible at a relatively low cost, and such that the reliability thereof is promoted. The heat exchanger shall have such a design that a high pressure of the cooling medium in the tubular body can be tolerated without the need of excessive wall thickness of the tubular body.

There is another object of the invention to present a heat exchanger that is easy to assemble and disassemble for the purpose of inspection and maintenance.

There is a further object of the invention to permit uncomplicated continual cleaning of separate parts of the heat exchanger, in particular such parts that are supposed to be in contact with the medium that is to be cooled, such as milk.

There is a further object of the invention to present a heat exchanger that will make it possible to efficiently cool milk on its way in a tube system to a tank, already before the milk has reached the tank.

BRIEF DESCRIPTION OF THE INVENTION

The main object of the invention is achieved by means of the initially defined heat exchanger, which is characterised in that

- the tubular body comprises a first and a second elongated sheet, extending in parallel inside the tube,
- said sheets being connected to each other along the opposite longitudinal edges of each sheet respectively, and in that
- the sheets are connected to each other along a first and second seam,
- said first and second seam extending generally in parallel to said edges,
- said sheets, first and second edges and first and second seams delimiting three parallel channels in the length direction of the sheets.

Thanks to the inventive design a large heat conducting area between the liquid to be cooled and the cooling medium is achieved. The tubular shape of the channels contributes to a high pressure resistance of the tubular body.

Preferably, the distance between the first seam and the first edge is generally equal to the distance between the second seam and the second edge.

The volumes of the channels increase from the opposite edges of the sheets to the centre channel or channels, i.e. the distance between the first and second seam is larger than the distance between each seam respectively and its adjacent edge. Thereby, the cross section of the tubular body is perfectly adapted to the condition in which the tube surrounding it has a generally oval or, as preferred, circular cross section.

At opposite end regions of the elongated sheets the seams end and the channels go over into one single channel. Preferably, the single

channel has a circular cross section, which is easy to fasten to other components by means of, for example, welding.

The total volume for receiving the cooling medium inside the channels is generally equal to the volume between the tubular body and the tube for receiving the medium to be cooled.

The maximum width of the tubular body should be generally equal to the inner diameter of the tube. Thereby, optimum advantage is taken of the surrounding tube for given inner diameter thereof.

Preferably, the tubular body enters into the tube via and end wall thereof and extends to an opposite end of the tube.

The tubular body is closed in one end thereof and that there is arranged an pipe that extends inside one of the channels and opens in a region adjacent said end, said pipe being arranged for the purpose of conducting the cooling medium to said end and letting it out into the tubular body. Thereby, the cooling medium can be conducted to said end of the tubular body in a liquid state before it flows out into the channels in order to receive heat from the medium that is to be cooled and that flows outside the tubular body. The cooling medium can move in an opposite direction (in relation to its direction in the pipe) in the channels while, at the same time, taking up heat and, possibly, evaporating.

Preferably, an inlet for the pipe into the tubular body and an outlet for the cooling medium from the tubular body are arranged in the same end region of the tubular body.

It is advantageous if the tube comprises an inlet for the medium to be cooled at one end thereof and an outlet for said medium at an opposite end thereof.

According to one preferred embodiment, the tube comprises a first and a second part that are connected to each other via a joint that can be released for the purpose of separating the two parts, and the tubular body is connected to the first tube part. Thereby, a very uncomplicated disassembly of the heat exchanger is permitted. Inspection of the result of a cleaning of the surfaces that are in contact with the liquid that is to be cooled becomes very uncomplicated thanks to this feature. The joint, which for example can be a screw joint or a bayonet coupling, is released and the tubular body is pulled out of the second tube part by means of the first tube part. Preferably, the first tube part is substantially shorter than the second tube part.

According to a preferred embodiment he cross section of the tubular body is generally constant along the part thereof comprising said channels. Thereby, cleaning of the outer surface of the tubular body and the inner surface of the tube, i.e. the surfaces delimiting the channel in which the liquid to be cooled is flowing , can be accomplished by flushing a cleaning agent through said channel, without any excessive pressure loss and with a good result.

Preferably, the heat exchanger comprises a plurality of tubes arranged in series, a tubular body for conducting a cooling medium being arranged in each tube. Thereby, a system comprising a plurality of inventive tubes and tubular bodies is provided for a stepwise cooling of any medium. The pipes and tubular bodies of a set of individual tubes in such a system should be branches from common circuit in which the cooling medium is continuously

circulated and cooled, for example by means of a compressor/inter-cooler arrangement.

According to a preferred embodiment of the invention, the medium to be cooled inside the tube or tubes comprises food, in particular milk. The heat exchanger is then connected to a milk tank for the purpose of pre-cooling milk that is to be gathered in said tank.

In particular for the purpose of achieving a hygienic handling of food products that are to be cooled, in particular milk, the tube and the tubular body are made of stainless steel. It should be understood that the design of the tubular body as disclosed above promotes efficient production thereof by using sheets of stainless steel that are welded together along their edges. Also the seams are achieved by means of welding together the sheets. Preferably, the sheets are compression moulded to their final shape before being welded together.

The invention also relates to the use of the inventive heat exchanger in a system for gathering and storing milk.

Further advantages and features of the present invention are found in the following detailed description and in the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will now be described by way of example with reference to the appended drawing, on which:

Fig. 1 is a schematic cross section of one embodiment of the inventive heat exchanger,

Fig. 2 is a side view of a tubular body according to one embodiment of the invention,

Fig. 3 is a view from above of the tubular body shown in fig. 2,

Fig. 4 is a view corresponding to section IV-IV in fig. 3,

Fig. 5 is a view corresponding to section V-V in fig. 3,

Fig. 6 is a view of the cross section of a tubular body according to figs. 2-5 and a surrounding tube,

Fig. 7 is a cross section of a set of individual heat exchangers connected in series, and

Fig. 8 is an overall view showing a system for handling and storing milk.

DETAILED DESCRIPTION OF THE INVENTION

In fig. 1 there is shown an embodiment of a heat exchanger according to the invention. The heat exchanger is particularly adapted to the pre-cooling of milk, including milk containing solid particles, before the latter is stored in a tank for storage and or further distribution.

The heat exchanger comprises a tube 1 preferably made of stainless steel and provided with an inlet 2 and an outlet 3 for the milk that is to be cooled while flowing through the tube 1. The tube 1 has a generally circular cross-section. It is preferably made of stainless steel but may, as an alternative be made of a suitable polymer. It comprises a first part 4 and a second part 5 connected to each other

via a joint 6. The joint may be any kind of releasable joint for joining tube ends, for example screw joint, a clamp or a bayonet coupling. The first part 4 comprises one of the inlet 2 or the outlet 3, while the second part 5 comprises the other one of the inlet 2 or outlet 3. The first tube part 4 is also connected to a tubular body 7, which has a length that generally corresponds to the length of the tube 1 and extends inside the tube 1. The first tube part 4 and the tubular body 7 may be arranged as one single body.

The tubular body 7 enters the tube 1 via and opening at one end thereof, more precisely the end of the first part 4. It comprises an inlet 8, via which a pipe 9 penetrates and extends into the tubular body 7. It also comprises an outlet 10 arranged adjacent to the inlet 2/oulet 3 of the first tube part 4. The tubular body 7 has the task of conducting a cooling medium, and the heat from the milk is transferred to the cooling medium via the wall of the tubular body 7. Preferably, the tubular body 7 is made of stainless steel. The cooling medium enters the body 7 via the inlet 9 and exits it via the outlet 10.

The cooling medium enters the body 7 via the pipe 9. The pipe 9 has a length inside the body 7 that corresponds to the length of the latter. The pipe 9 guides the cooling medium from the inlet end of the body 7 to the opposite, closed end thereof.

The tubular body 7 comprises a first and second elongated sheet 11,12 made of stainless steel and connected to each other along opposite edges 28,29 thereof. With reference to figs. 2-5 it is noted that the sheets 11,12 of the tubular body 7 have a supplementary shape such that, when fixed to each other, they define three separate channels 13,14,15 along a major part of the length of the body 7. The channels are formed thanks to the sheets being provided with an

ondular or wave-shaped cross section and seams 16,17, preferably welds, being provided along contact lines between the sheets 11,12 in the length direction thereof. At the opposite end regions of the tubular body 7, or more precisely of the sheets 11,12, the ondular or wave-shaped cross section of each of the sheets 11,12 is modulated and the sheets are narrowed, going over into a semi-circular cross section. Thereby, at the ends of the tubular body 7 the latter comprises only one channel 18, that channel 18 having a generally circular cross-section, such as shown in fig. 5. At its inner end the tubular body 7 is closed by and end wall 19, for example a plug or disc welded to the end of the sheets 11,12.

The pipe 9, preferably made of copper, could extend through any one of the channels 13,14,15 but preferably extends through the central channel 14 of the tubular body 7 and ends adjacent to the end wall 19 thereof, as shown in fig. 1.

As can be seen in fig 6, the maximum width of the tubular body 7 is generally equal to the inner diameter of the tube 1. The central channel 14 has a larger cross section than the adjacent outer channels 13,15. The total cross section area a1 of the channels 13,14,15 is generally equal to the cross section area a2 remaining between the tube 1 and the tubular body 7. Accordingly, the same applies to the volumes inside the channels 13,14,15 and the between the tubular body 7 and the tube 1.

In fig. 7 there is shown an example of a set of individual heat exchangers according to the invention connected in series for the purpose of achieving a stepwise cooling of milk that passes through the set of exchangers via inlets 2 and outlets 3 in the tubes 1.

In fig. 8 there is shown a system for conducting milk from a milking machine 20 to a tank 21 for the further distribution thereof. Two sets of heat exchangers 22,23 are indicated in the system, both sets being arranged downstream the milking machine 20 and upstream the tank 21 as seen in the milk flow direction. To each set heat exchangers there is connected circuit including a compressor 24 and a condenser 25 for cooling the cooling medium that is cycled through the set of heat exchangers.

To the outside of the tank 21 there is connected a cooling element 26, here connected to the same cooling circuit as one of the set of heat exchangers 22,23. Thanks to the inventive heat exchangers, an efficient cooling of the milk is already obtained before the milk enters the tank 21. A conventional stirrer 27 in the tank is also indicated. If no pre-cooling of the milk is performed, cooling of the milk inside the tank should not be initiated before the stirrer 27 is wet by the milk.

The preferred cooling medium is a halogen compound, such as freon. The tubular body 7 is designed as to stand the saturation pressure (here 19 bar) of the cooling medium, for example in the case of fire or the like, when the heat exchanger is subjected to extreme temperatures. The combination of the specific shape, wall thickness and material (preferably stainless steel) of the tubular body 7 contributes to the achievement of this objective.

It should be understood that a plurality of alternative embodiments will be obvious for a man skilled in the art, however without going beyond the scope of the present invention such as defined in the accompanying claims supported by the description and the accompanying drawings.

PATENT CLAIMS

1. A heat-exchanger comprising
- a tube (1) for conducting a first medium that is to be cooled
- a tubular body (7) arranged inside the tube (1) for the purpose of conducting a cooling medium therein,
characterised in that
- the tubular body (7) comprises a first and a second elongated sheet (11,12), extending in parallel inside the tube (1),
- said sheets (11,12)being connected to each other along the opposite longitudinal edges (28,29) of each sheet (11,12) respectively, and in that
- the sheets (11,12) are connected to each other along a first and second seam (16,17),
- said first and second seam (16,17) extending generally in parallel to said edges (28,29),
- said sheets (11,12), first and second edges (28,29) and first and second seams (16,17)delimiting three parallel channels (13,14,15) in the length direction of the sheets (11,12).

2. A heat exchanger according to claim 1, **characterised in** that the distance between the first seam (16) and the first edge (28) is generally equal to the distance between the second seam (17)and the second edge (29).

3. A heat exchanger according to claim 1 or 2, **characterised in** that volumes of the channels (13,14,15) increase from the opposite edges (28,29) of the sheets (11,12) to the centre channel or channels (14).

4. A heat exchanger according to any one of claims 1-3, **characterised in** that the seams (16,17)end and the channels

(13,14,15) go over into one single channel in opposite end regions of the elongated sheets.

5. A heat exchanger according to any one of claims 1-4, **characterised in** that the total volume for receiving the cooling medium inside the channels (13,14,15) is generally equal to the volume between the tubular body (7) and the tube (1) for receiving the medium to be cooled.

6. A heat exchanger according to any one of claims 1-5, **characterised in** that the maximum width of the tubular body (7) is generally equal to the inner diameter of the tube (1).

7. A heat exchanger according to any one of claims 1-6, **characterised in** that the tubular body (7) enters into the tube (1) via and end wall thereof and extends to an opposite end of the tube (1).

8. A heat exchanger according to any one of claims 1-7, **characterised in** that the tubular body (7) is closed in one end thereof and that there is arranged an pipe (9) that extends inside one of the channels (13,14,15) and opens in a region adjacent said end, said pipe (9) being arranged for the purpose of conducting the cooling medium to said end and letting it out into the tubular body (7).

9. A heat exchanger according to claim 8, **characterised in** that an inlet (8) for the pipe (9) into the tubular body (7) and an outlet (10) for the cooling medium from the tubular body (7) are arranged in the same end region of the tubular body (7).

10. A heat exchanger according to any one of claims 1-9, **characterised in** that the tube comprises an inlet (2) for the medium

to be cooled at one end thereof and an outlet (3) for said medium at an opposite end thereof.

11. A heat exchanger according to any one of claims 1-10, **characterised in** that the tube (1) comprises a first and a second part (4,5) that are connected to each other via a joint (6) that can be released for the purpose of separating the two parts (4,5), and in that the tubular body (7) is connected to the first tube part (4).

12. A set of heat exchangers according to any one of claims 1-11, **characterised in** that it comprises a plurality of tubes (1) arranged in series, a tubular body (7) for conducting a cooling medium being arranged in each tube (1).

13. A heat exchanger according to any one of claims 1-12, **characterised in** that the medium to be cooled inside the tube (1) or tubes comprises food, in particular milk.

14. A heat exchanger according to any one of claims 1-13, **characterised in** that the heat exchanger is connected to a milk tank (21) for the purpose of pre-cooling milk that is to be gathered in said tank (21).

15. A heat exchanger according to any one of claims 1-14 **characterised in** that the tube (1) and the tubular body (7) are made of stainless steel.

16. A heat exchanger according to any one of claims 1-15, **characterised in** that the cross section of the tubular body (7) is generally constant along the part thereof comprising said channels (13,14,15).

17. Use of a heat exchanger according to any one of claims 1-16 in a system for gathering and storing milk.

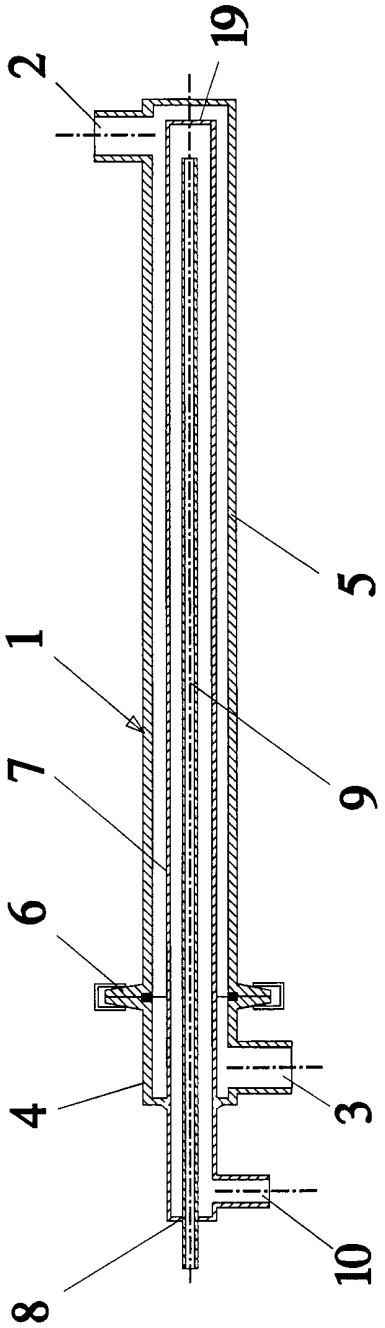


Fig. 1

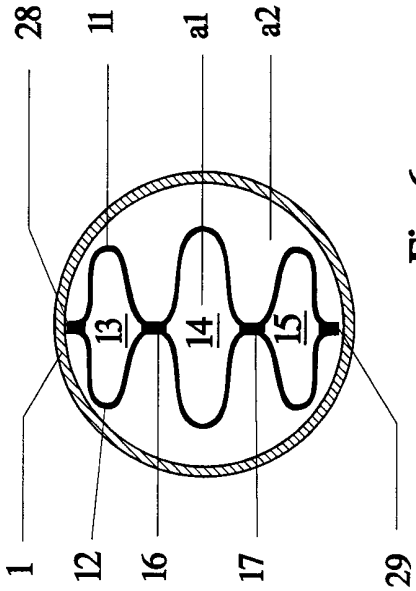


Fig 6

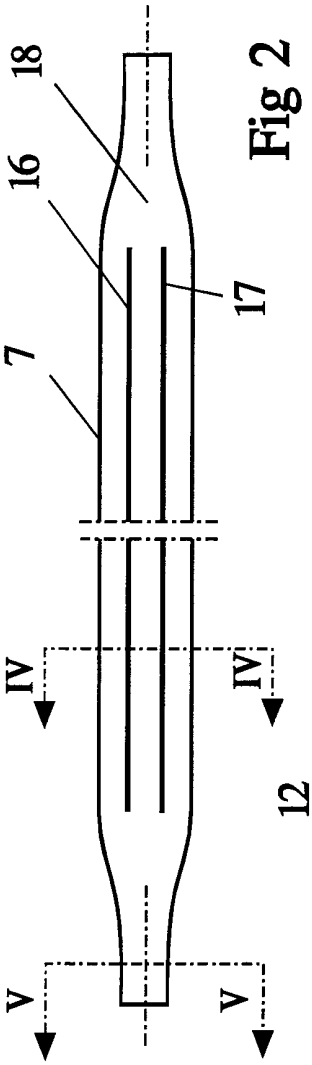


Fig 2

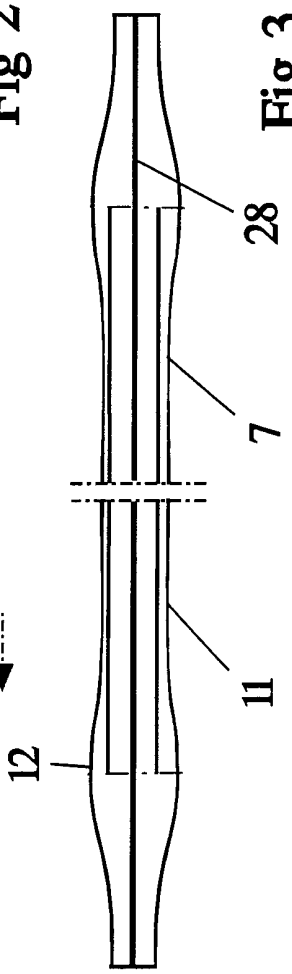


Fig 3

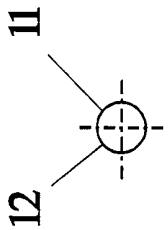


Fig 5

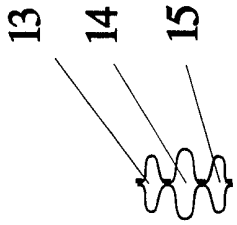


Fig 4

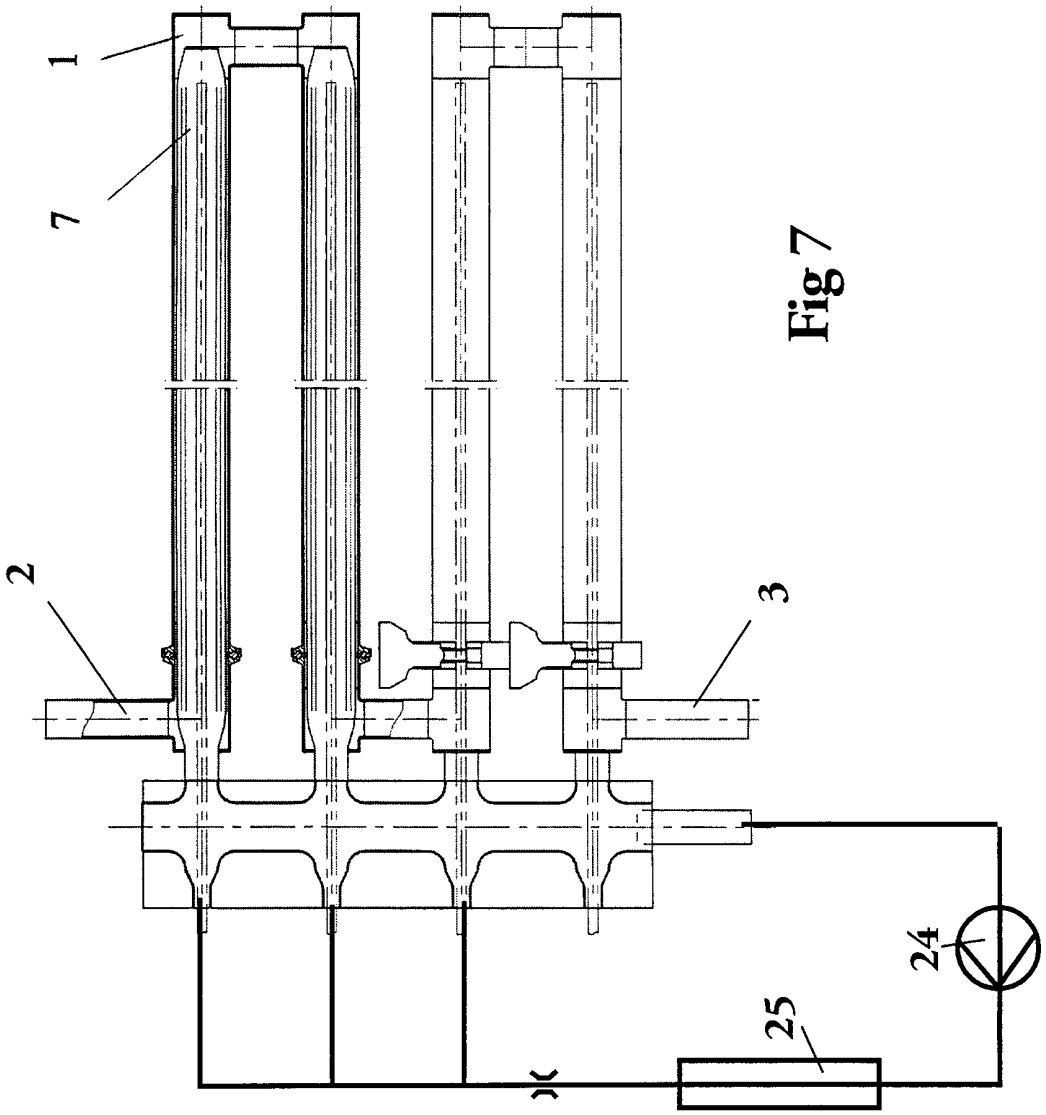


Fig 7

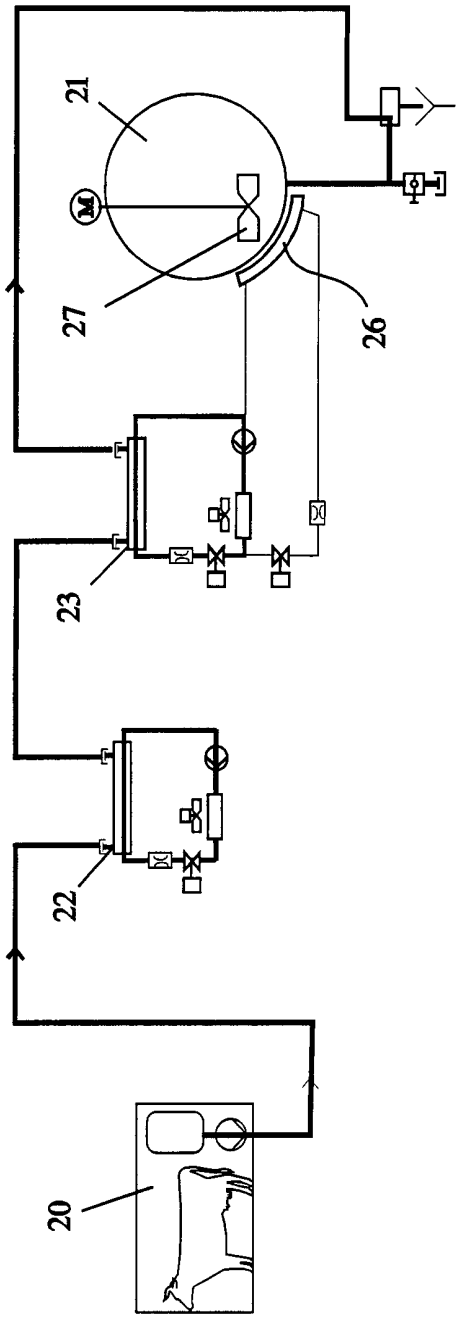


Fig 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/00239

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F28F 1/06, F28D 7/12, A23C 3/033
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F28D, F28F, A23C, F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE 424772 B (PERTINEX AB), 9 August 1982 (09.08.82) --	
A	DE 814159 A (OTTO H. HARTMANN), 20 Sept 1951 (20.09.51) --	
A	DE 839806 A (OTTO H. HARTMANN), 26 May 1952 (26.05.52) --	
A	DE 786832 A (FERLAY ET AL), 10 Sept 1935 (10.09.35) --	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 2001	06 -06- 2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Annette Riedel / JA A Telephone No. +46 8 782 25 00

Form PCT ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/00239

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	BE 682415 A (BLOOM ENGINEERING COMPANY), 12 December 1966 (12.12.66) -- GB 1146740 A (ASSOCIATED ELECTRICAL INDUSTRIES LIMITED), 26 March 1969 (26.03.69) -- EP 0153966 A1 (WILLIAMSON, WILLIAM RODGER), 11 Sept 1985 (11.09.85) -- --------	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SE 01/00239

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
SE 424772 B	09/08/82	AU 7411181 A	02/03/82
		BE 889732 A	16/11/81
		CA 1167653 A	22/05/84
		CH 649370 A	15/05/85
		DE 3152231 T	13/01/83
		DK 132882 A	24/03/82
		FI 71835 B,C	31/10/86
		FI 820972 A	19/03/82
		FR 2487488 A,B	29/01/82
		GB 2102552 A,B	02/02/83
		JP 57501141 T	01/07/82
		NL 8120274 T	01/11/82
		NO 151869 B,C	11/03/85
		NO 820978 A	24/03/82
		SE 8005384 A	26/01/82
		WO 8200511 A	18/02/82
		YU 180981 A	29/02/84
DE 814159 A	20/09/51	NONE	
DE 839806 A	26/05/52	NONE	
DE 786832 A	10/09/35	NONE	
BE 682415 A	12/12/66	FR 1482762 A	04/09/67
		LU 51302 A	10/08/66
		NL 6608126 A	12/12/66
GB 1146740 A	26/03/69	DE 1613520 A	17/09/70
EP 0153966 A1	11/09/85	NONE	