

EUROPEAN PATENT APPLICATION

Application number: 89100247.9

Int. Cl.4: **F28B 1/06** , **F28B 9/00** ,
F28B 11/00 , **F28F 27/00**

Date of filing: 09.01.89

Priority: 12.01.88 IT 1904788

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Date of publication of application:
19.07.89 Bulletin 89/29

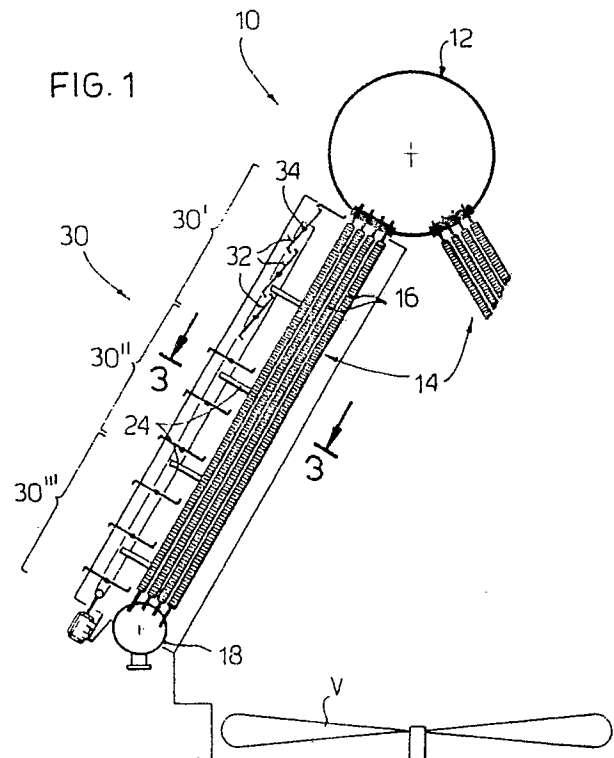
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Designated Contracting States:
BE CH DE FR GB LI NL

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A process and system for protection against freezing of large air-cooled steam condensers.

According to the invention, the heat exchange surface of exchanger tube bundles (14) of a condenser is partially or totally insulated, preventing heat exchange with external air. In case of partial insulation, the part of the tubes nearest to the steam header (12) is insulated. The insulation is provided by means of rotary fins (32) which can be tightly sealed or by means of removable panels (132), or flexible screens (232), or with combined systems.



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A PROCESS AND SYSTEM FOR PROTECTION AGAINST FREEZING OF LARGE AIR-COOLED STEAM CONDENSERS

The present invention refers to the field of large air-cooled steam condensers, as those provided, for example, in power plants. These generally comprise one or more bundles of exchanger tubes, usually finned, which branch off from a steam header and are arranged in various ways, for example vertically or horizontally or like "a roof" (like an A) in a lateral view, each bundle ending, at its end opposite to the steam header, in a condensate header. The condenser is usually sized on the basis of the maximum steam flow rate and for functioning with summer air, usually according to the equation:

$$Q = A \times \Delta T \times K$$

wherein

Q is the heat per hour to be exchanged, Kcal/h

A is the exchange surface sq m

ΔT is the thermal head or temperature differential (or the average logarithmic temperature) between the steam and the environment air

K is the total heat exchange coefficient, the most important variable of which is the air speed.

During winter, the condenser works in unfavourable conditions, both because it has a reduced steam capacity, part of the steam being directed to other uses, and because of the severity of the external conditions.

Such large condensers are therefore frequently damaged on the inside because the condensate water freezes. These serious damages deriving from freezing are due to the low temperature of the winter environment air, to cold winds and to an inadequate designing of the condenser, which can determine the formation of pockets in which part of the condensate is held, which is therefore exposed to freezing to a larger extent.

The protection of the condenser from freezing therefore is a problem which at present is widely studied.

In order to remove the disadvantage mentioned above one or more of the solutions listed below are presently provided:

a) The insides of the tube bundles are designed and the heads are made in such a way to try to avoid the stagnation of steam between the rows of tubes or between the tube bundles; such stagnation entraps incondensable matter which is inevitably present (USA patents No. 3968836 and No. 4129180).

b) Variable speed or multi-speed ventilators are used to control the speed of cooling air through the bundles of the finned exchanger tubes according to the temperature of the air itself.

c) Mechanical blinds or shutters are used which are installed above the tube bundles to control the air flow rate in relation to the temperature requirements of the steam condenser. All the bars or plates of these blinds are connected to a single control lever, so that they move together to reduce the air flow rate through the total width and the total length of the bundle.

d) Insulating valves (of the throttle type) are used, which are mounted on the header which feed steam to the bundles, in order to exclude 25%, 50%, etc. of the tubes of the steam condenser, thus concentrating all the steam to be condensed in a reduced number of tubes of the condenser itself.

e) Windscreen walls are used which are raised along the periphery of the steam condenser, having the aim of reducing the effect of the impact of the wind which influences, in a considerable way, the heat exchange from the bundles to the air.

f) Windscreen skirts are used extended downwards with respect to the bundles, which form a screen against the disturbing effect of the wind to the recycled hot air.

g) Hot air recycling chambers and cold air mixing ducts are used, with mechanical blinds which control the relative flows (UK-A-2 086 559, DE-A-1 936 137).

h) Preheaters for the cold environment air are used which are fed with steam having a higher thermal content or with electric preheaters.

All these systems however have a high operating cost and furthermore are unreliable, in as much as they don't always obtain the hoped results. In particular, they are not able to completely eliminate the stagnation of steam within the tube bundles and the steam trapped therefore remains exposed to freezing, with dangerous damages both to the exchanger tubes and to the heads.

The system d) which is provided with big valves is rarely used both because it is expensive and because it has big upkeep problems and therefore high costs. There are also disadvantages of operation caused by the freezing of the valve heads and by leakage at their seats.

The blind control systems c), although they drastically reduce the heat exchange capacity of a condenser, they nevertheless produce the following disadvantages: even when the blinds are almost completely closed, the cold winter air continues to pass through the heat exchange bundle and laps the entire length of the tubes, This means that, under certain thermal conditions, the steam can be

completely condensed, for example, in the first half of the tubes. The so formed condensed steam runs along the second half of the tubes, which is lapped by cold air and therefore can freeze. Furthermore a good control of air speed would impose, especially in winter, very low air speeds, while the cold wind reaches the condenser at much higher speeds. Gusts of wind from 15 to 80 km/h are not rare. The final result is that the wind, reaching with this speed the thermal exchange surfaces of the bundles of the condenser, cause effects about 100 times superior (for example 80 km/h) to those which would be desirable to obtain by controlling the speed of the air moved by the ventilators (for example 0,9 km/h).

Let's examine the example of a steam turbine which discharges at a pressure of 0,2 ata (i.e. under vacuum state) corresponding to a steam temperature of 60 ° C. Supposing that the environment air design temperature is 30 ° C, the thermal head ΔT (or the average logarithmic temperature) will be proportional to $60-30 = 30$ ° C.

Let's assume that the system is installed in a place having the minimum winter temperature equal to -30 ° C. At said winter extreme temperature the thermal head is proportional to $60-(-30) = 90$ ° C; this means that the condenser surface which is designed for the least favourable air condition (in summer) exceeds, in winter, of $90/30$, i.e. of 300%. It appears that the means used at present, which are directed only to the control of the air flow rate by means of one of the systems mentioned at pages 2 and 3, do not prevent from freezing. Above all, the least expensive systems described at points b) and c), separately or jointly, do not achieve said purpose, since the winter air at -30 ° C, however having a low flow rate, when reaching the finned tubes of the end row in their entire length, can cause the condensate to freeze.

The risk of freezing increases with the wind, which passes through the bars of the usual blinds (which, as known, are closed all together, in a modular way) and causes effects of heat exchange up to 100 times superior than what is necessary.

The problem of the service stability of the system is further increased by the natural draught which takes place due to the so-called "chimney effect" of the air chamber and the ring of the ventilator. The natural draught is desirable in as much as it reduces the operating costs (less electrical power to the ventilators); however this draught becomes unstable because of the continuous disturbance caused by the wind. The low air speeds required, which work together with the natural draught, are therefore very susceptible to the disturbing effect of the gusts of wind. These instabilities of the movement of the air cause an undesired instability of the discharge pressures of the steam

turbines.

A further known solution (i) consists in screening (against these gusts of wind) the air-cooled bundles of the condensers providing en walls, blinds, etc. up to completely enclose the condenser in order to eliminate the effect of the wind and to preheat the environment air by mixing it with the recycled hot air (UK-A-2 086 559, DE-A-1 936 137). Even this solution is very expensive and, the more it is efficient against the wind, the higher is the installation cost.

The aim of this application is to carry out a good protection against the freezing in air-cooled steam condensers. A further aim is to reach such protection at low costs and nevertheless in an effective way.

An object of this invention is a protection process for tube bundles of an air-cooled steam condenser against an excessive cooling, characterized in that, instead of reducing the air flow rate as in the previous systems, the heat exchange surface or area of the tube bundle/s is reduced by means of a total or partial external insulation of said surface.

According to a further feature, the surface of the single bundle is insulated starting from the end next to the steam header.

A steam cooling system, comprising a steam header and at least one bundle of exchanger tubes extended from said heater to a condensate header, is also an object of the invention, characterized in that it comprises a means for airtightly screening or insulating the surface of the header, said system being selectively operable at successive intervals along the length of the tubes.

The screening means can be made of blinds or shutters having two positions, i.e. open/closed, or of removable panels, or even of roller shutters, or finally of any other means apt to the aim.

The new process and the new system provide a reliable protection of the steam cooling structures against freezing and furthermore have a low cost.

Some exemplary embodiments of the system and the process will be described later with reference to the attached drawings in which:

figure 1 is a schematic view of a steam condenser, as seen from a plan at right angles to the axis of the steam header and provided with an insulating means; one bundle of tubes is completely illustrated, another is shown broken-away;

figure 2 is a broken-away view from the left of figure 1;

figure 3 is a section along line 3-3 in figure 1, enlarged with respect to this;

figure 4 is a view similar to that of figure 1, but shows a bundle of tubes in a condition completely insulated from external air;

figure 5 shows, in a view similar to that of figure 1, a modified embodiment of the steam condenser. in a condition in which part of the surface of a tube bundle is insulated;

figure 6 is a left end view with respect to figure 5;

figure 7 is a view, similar to that of figure 1, of a further modified embodiment of the system, shown in a condition in which part of the surface of a bundle is insulated;

figure 8 is a left hand view with respect to figure 7;

figure 9 shows a further modified embodiment of the system, in a condition in which part of the surface of the tube bundle is insulated;

figure 10 is a left hand view with respect to figure 9;

figure 11 shows, in a view similar to that of figure 1, a condenser system with a combined insulation system for the surface of the tubes.

An air-cooled steam condenser is indicated as a whole with 10 and comprises a steam header, 12, to which the ends of several bundles 14 of generally finned heat exchanger tubes 16 are connected. The other end of each tube of each bundle 14 connects with a condensate header tube, 18. The bundles, in the examples illustrated in the figures, are arranged like a roof, or like an A; they could however have any other arrangement whatsoever.

Each bundle of tubes is supported by means of a structure or frame 20 which can be seen in figure 3, having a substantially rectangular shape in plan view and generally comprising a couple of lateral channel sections, 22, with solid walls, which enclose the tubes along two opposite sides of the rectangle, and spaced, transversal elements 24, placed along the other opposite sides of the rectangle. This assembly, per se known, leaves the bundle of tubes exposed to the passage of air through the structure walls defined by the elements 24. A flow of air is determined and controlled by means of the ventilator V.

According to this invention, on the external and/or internal side of each support structure 20 supporting a bundle of tubes, a screening or insulating assembly 30 is provided, which can be selectively closed section by section, for example against said support structure, so as to substantially prevent the air to circulate in said sections where the screening assembly is closed. The assembly 30 is made up, as shown in figures 1, 2, of oscillating fins or blinds 32, each pivoted on an intermediate axis 34, so that it can be rotated between an open position, as seen for the lower fins in figure 1, and the tightly closed position, as seen in the upper fins in figure 1. In the illustrated

example, the axes 34 are transversal to tubes 16. The fins are preferably organized in sections, for example three sections as in figure 1, indicated with 30', 30'', 30'''. According to weather conditions, one, two, or three sections of fins will be closed by means of motor 36, starting from the one closest to the steam header; for example, in figure 1 only section 30', nearest to the header 12, is shown closed; air circulation is therefore avoided between the tubes 16 in their part which is screened by closed fins 32. In other words, the surface of the tubes which is exposed to the heat exchange is reduced only to the sections 30'' and 30'''. It will be noted that, in this way, the steam travels hot inside the part of tubes nearest the steam header, substantially without any heat exchange with the outside; then, in the successive part, it starts to give off heat to the outside and condenses only near the condensate header 18. The risk of the condensate freezing in the finned tubes is thus avoided.

In figure 4 the same system or plant 10 can be seen, in which all sections 30', 30'', 30''' of the fins have been closed, for particularly unfavourable weather conditions, so as to completely insulate the tubes from the outside (exchange area equal to zero). It should be noted that the fins 32 could be placed also on the structure wall facing the ventilator.

In figures 5 and 6 a modified embodiment 110 of the system is illustrated, in which the insulation assembly for insulating the finned tubes from the outside, is made of a structure comprising I-section beams 138, extended between the walls 22 of the structure which encloses the tubes, and furthermore comprises curtain panels 132 which are assembled between the beams 138. The other elements of the condenser illustrated in figures 5 and 6 are identical to the similar elements described for the first embodiment and have the same reference numbers. According to the environment conditions, the curtain panels 132 relating only to the first section 130' or also panels relative to the second section 130'' or also panels relative to the third section 130''' will be assembled (so insulating the corresponding section/s and preventing air from circulating in it). Instead of the entire area of the tubes, an area reduced by 1/3 or 2/3 or even no area is exposed to the heat exchange. Also in this case the panels may be placed also on the other structure wall.

A third embodiment 210 of the steam condensing system is illustrated in figures 7 and 8, in which the elements similar to the embodiment of figures 1, 2 and 3 have the same reference numbers and will not be described in detail. The system of figures 7 and 8 is provided with an insulating system 230 made up of a folding screen 232, unwound from a roll 234 by means of a motor

means 235. The part of the folding screen which is unwound from the roll is positioned against the crosspieces 236 extending between walls 22 and encloses the corresponding tube sections, i.e. does not let the air pass through a corresponding part of tubes 18. With this system it is possible to continuously vary the length of the finned tubes of the condenser which must be insulated from the outside. Even in this case the screen 232 could be placed also on the side facing the ventilator, besides on the one opposite the ventilator.

The system 310 illustrated in figures 9 and 10 comprises a bundle of exchanger tubes 14, a steam header 12 and a condensate header 18 as described with reference to figures 1 to 3 and having the same reference numbers. The insulation system 330, in this case, is formed of a series of blades 332 which can be lowered like a shutter starting from a store 334, so as not to let the air pass for selected part of the bundle of tubes 14.

In figure 11, finally, a system 410 is illustrated, comprising the parts relating to the exchanger tubes, to the steam header, to the condensate header, identical to everything described with reference to figures 1 to 3, and equipped with a mixed insulation system, partly made of removable panels 432 and partly of a flexible screen 433 unwound by means of motor 435 from a roll 434, placed at intermediate height on the finned exchanger tubes.

Possible other insulation systems of exchanger tubes made of combinations of the systems illustrated here and equivalent to them are comprised in the field of invention.

Claims

1. A process for protecting an air-cooled steam condensation system against freezing, said system comprising bundles (14) of exchanger tubes (16) extending between a steam header (12) and a condensate header (18), characterized in that at least partial thermal insulation or screening of the exchange surface or area of the bundle tubes is provided, thus making the air circulation in the screened part substantially equal to zero.

2. A process according to claim 1, characterized in that the insulation is provided starting from the end of the tubes (16) next to the steam header (12).

3. A process according to claim 1, characterized in that said insulation or screening is provided tightly closed at least on the side of each tube bundle facing outwards.

4. A system for the condensation of steam by air circulation, comprising a steam header (12), at least one bundle (14) of exchanger tubes (16) extended from said header to a condensate header

(18), a supporting structure (20) for said exchanger tubes comprising supporting walls (22), characterized in that it comprises a screening assembly (30) extended on at least one face of the supporting structure, said assembly being tightly closable selectively section by section, so as to selectively reduce the exchange area.

5. A system according to claim 4, said structure (22) comprising solid lateral walls (22), characterized in that said assembly (30) comprises hinged fins (32) which are pivotable between an open position, in which air is allowed to pass around said tubes, and a tightly closed position on said supporting structure, in which air is not allowed to pass.

6. A system according to claim 5, characterized in that said fins (32) are arranged in sections and each section can be closed in sequence starting from the section nearest to the steam header.

7. A system according to claim 4, characterized in that the screening assembly (30) comprises removable panels (132) collaborating with crosspieces or beams (138) extending between the lateral walls (22) of the tubes to insulate the bundle of tubes section by section.

8. A system according to claim 4, characterized in that the screening assembly (210) comprises a flexible screen (232) wound in a roll (234) and which can be unwound therefrom along supporting crosspieces (236) extending between the lateral walls (22) of the tube bundle.

9. A system according to claim 4, characterized in that the screening assembly (310) comprises interconnected plates (332) forming a shutter which can be lowered along the tube bundle starting from a storing space (334) for said plates.

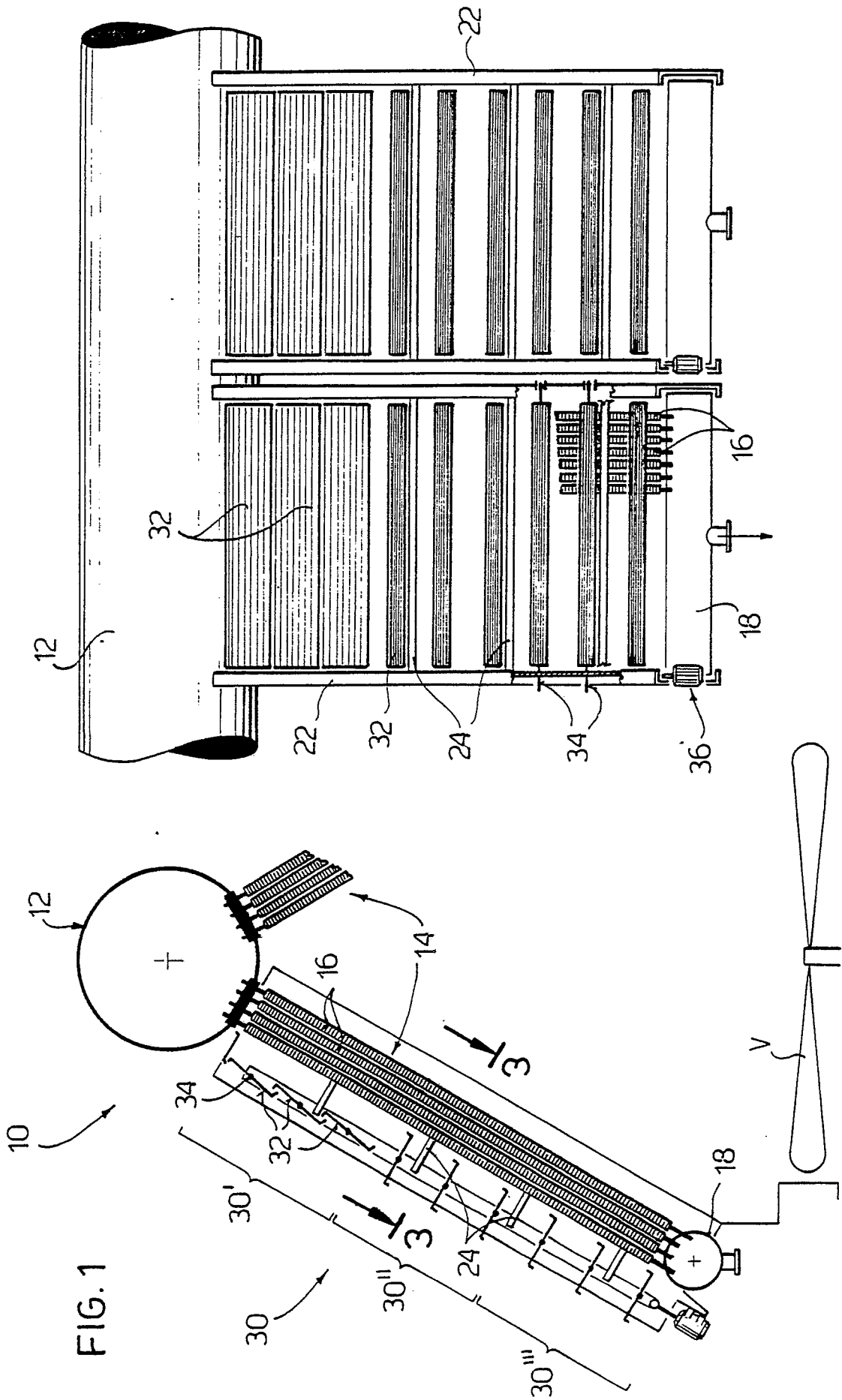


FIG. 2

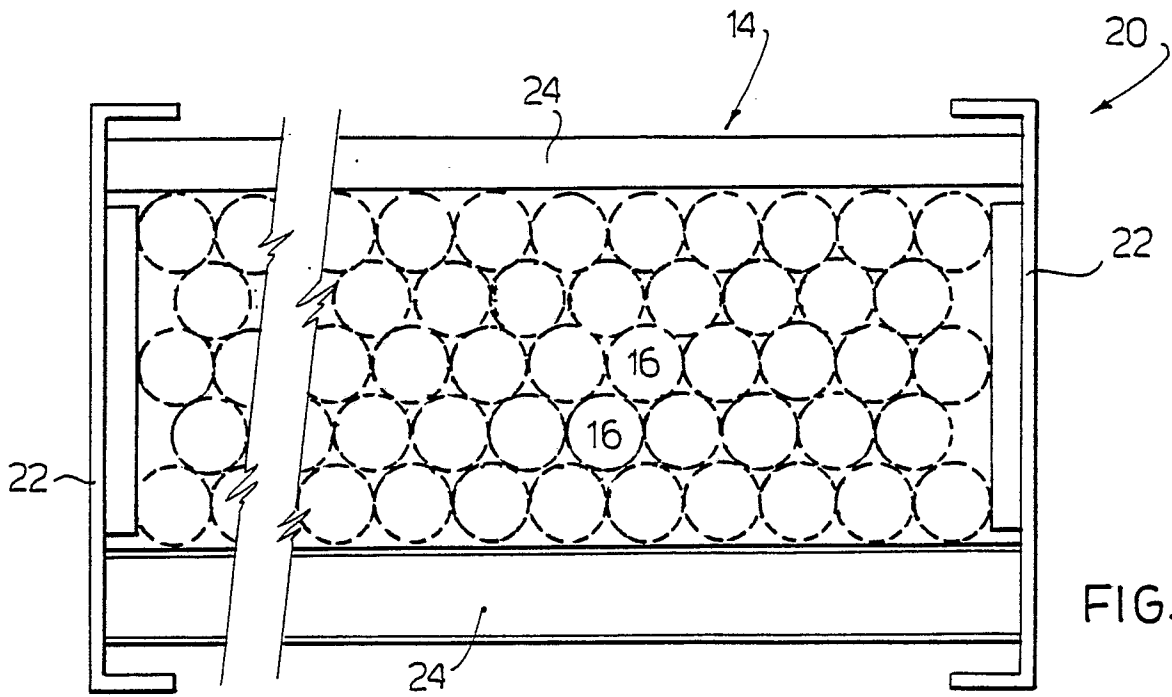


FIG. 3

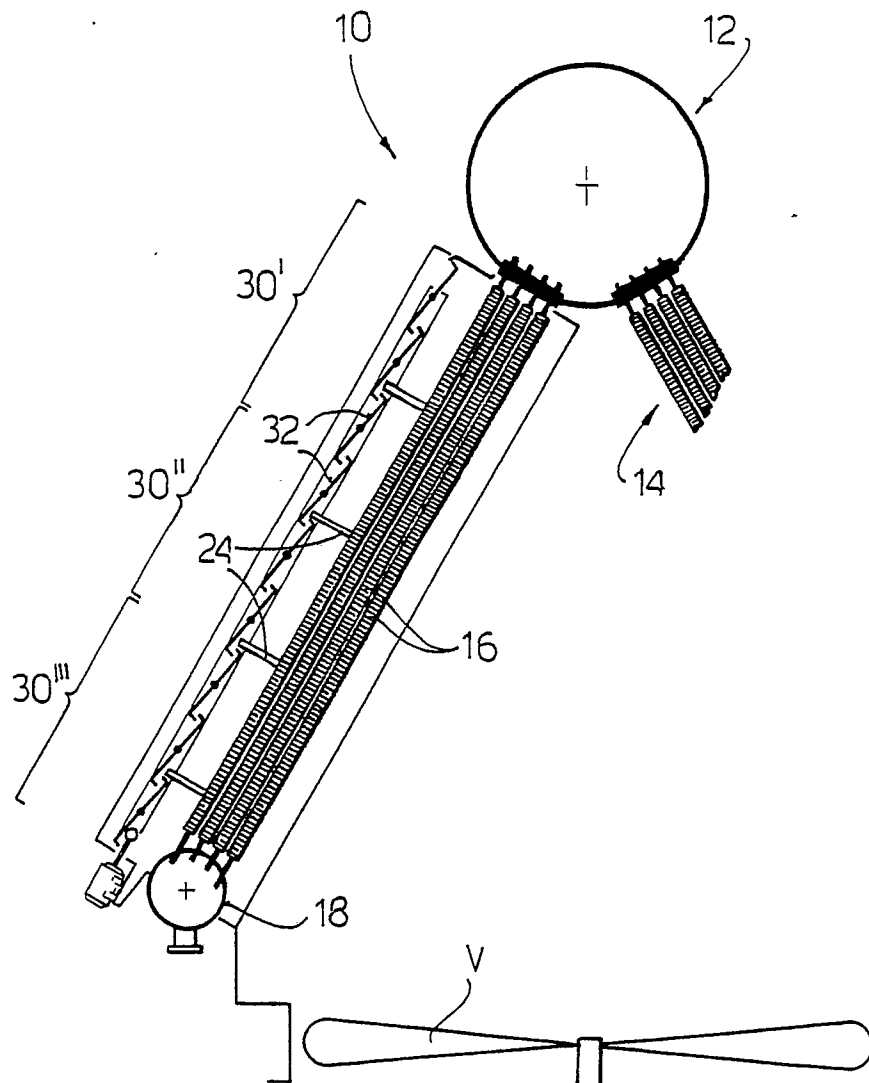


FIG. 4

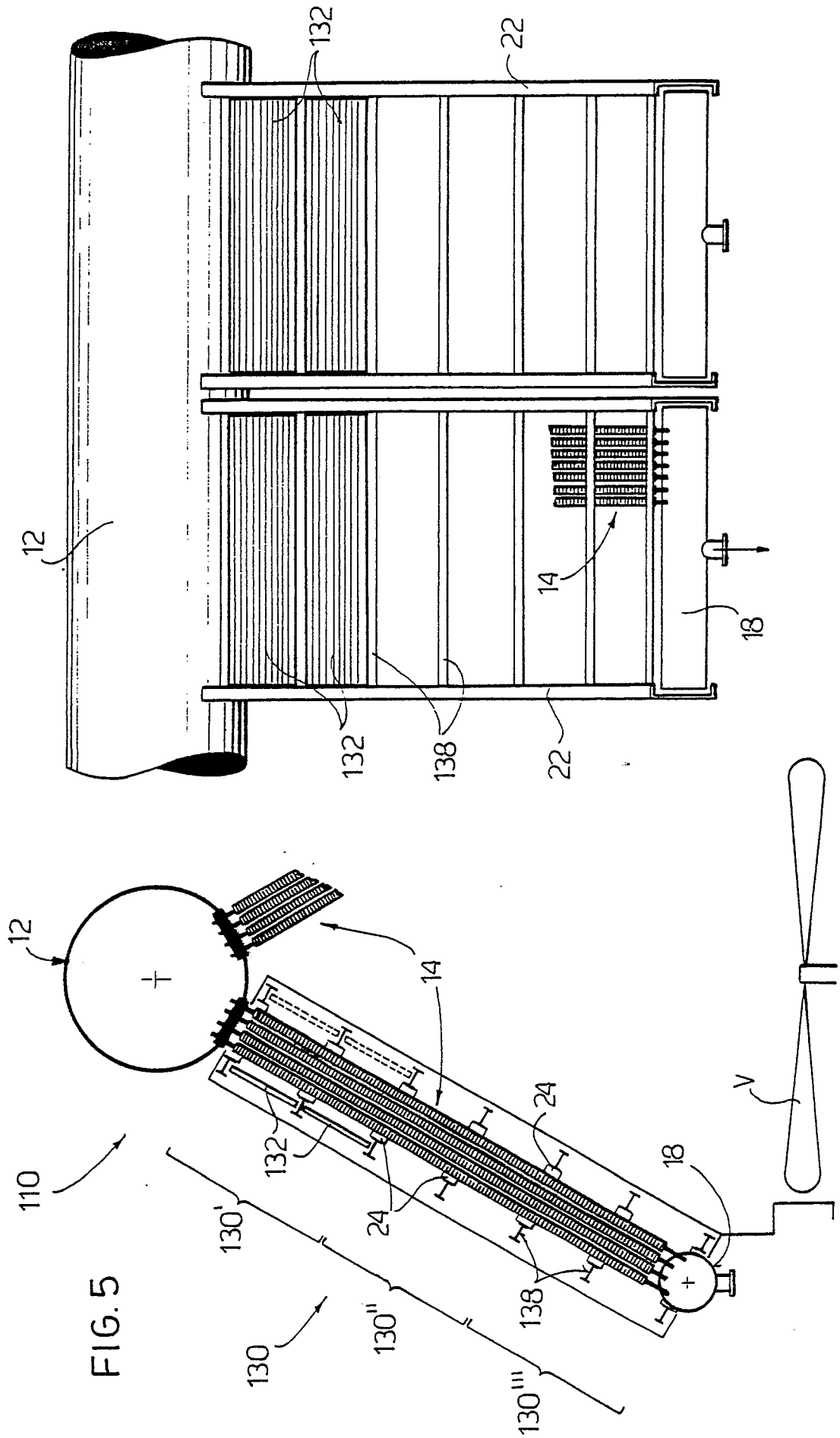


FIG. 5

FIG. 6

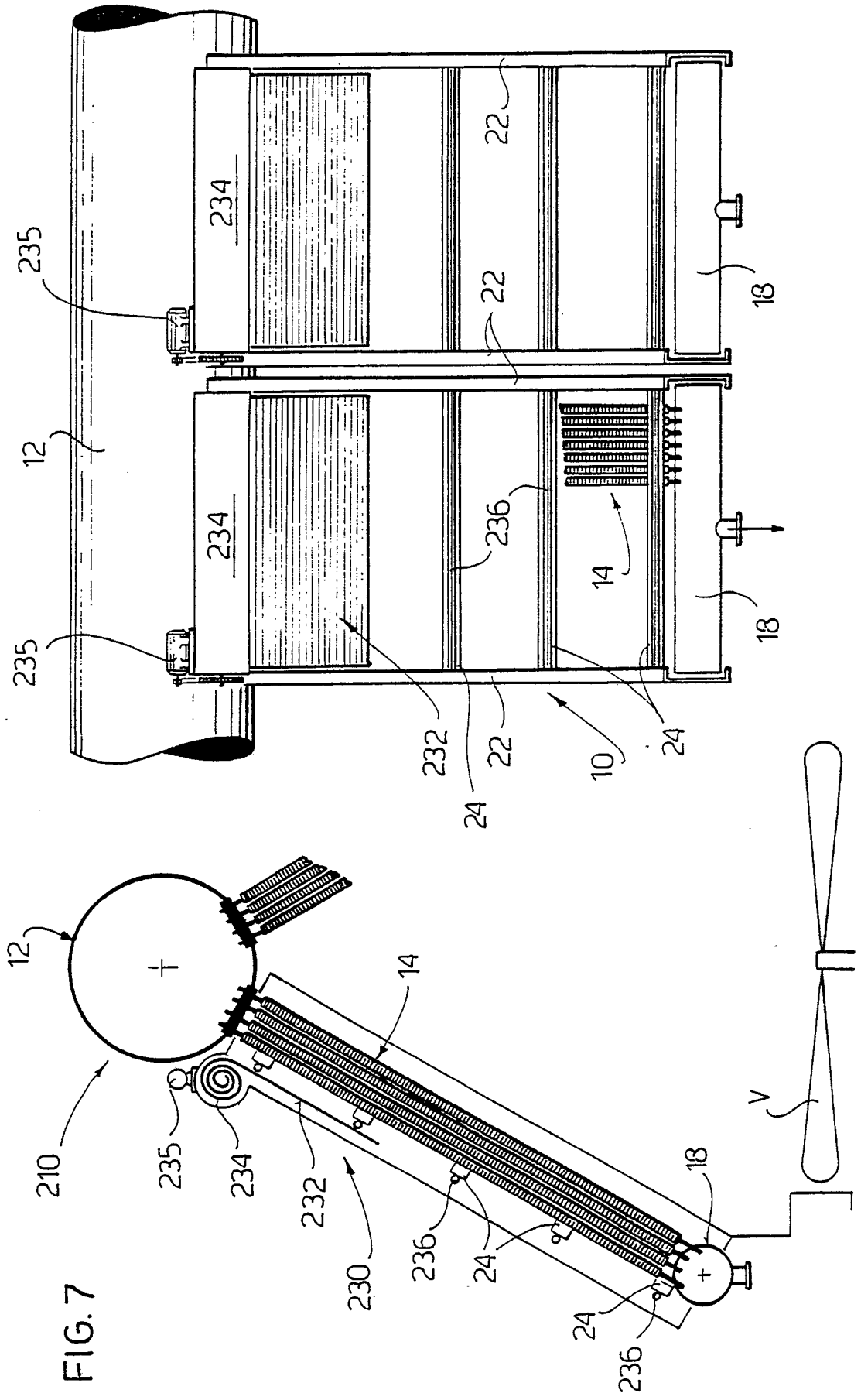


FIG. 7

FIG. 8

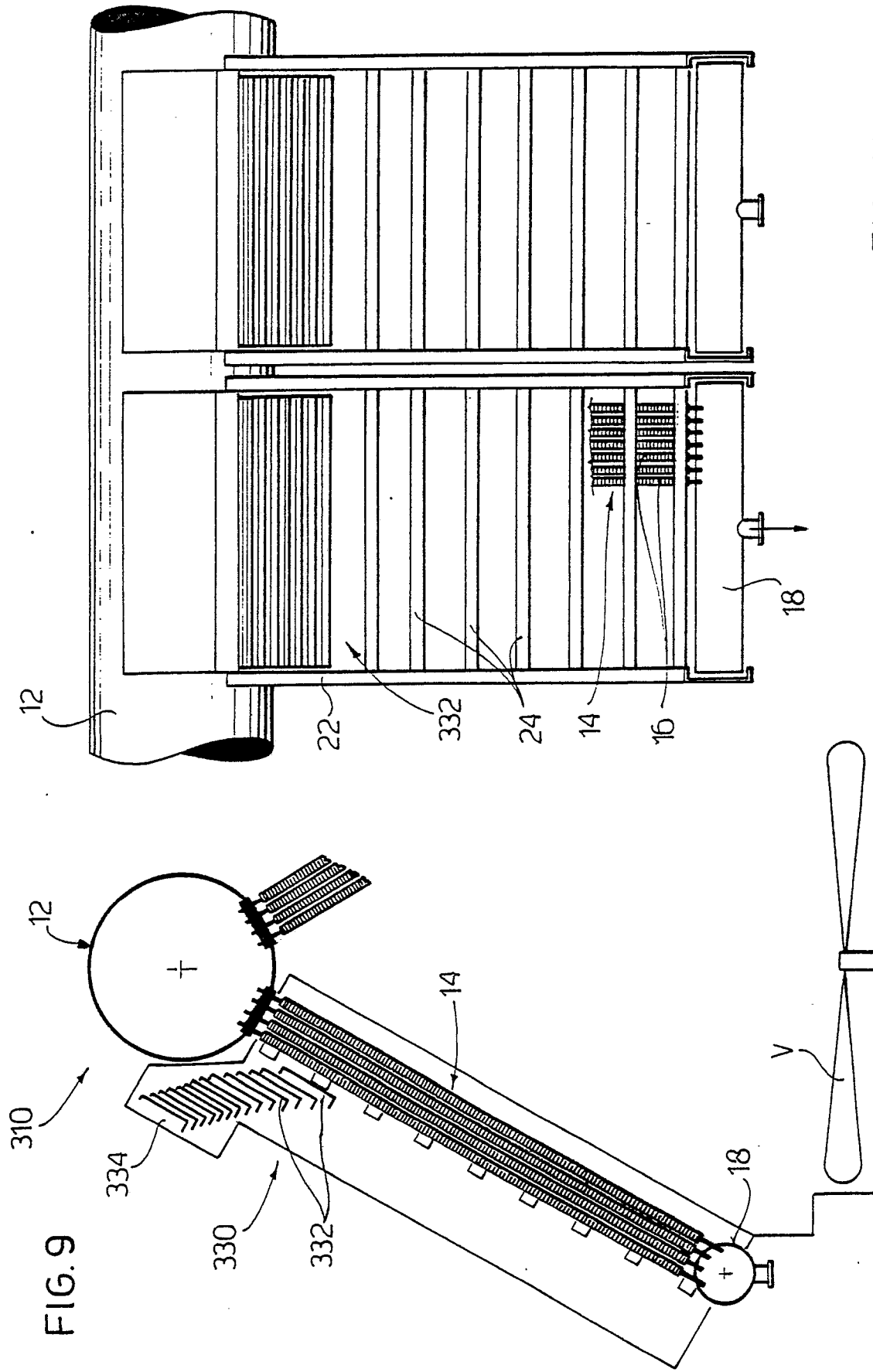


FIG. 9

FIG. 10

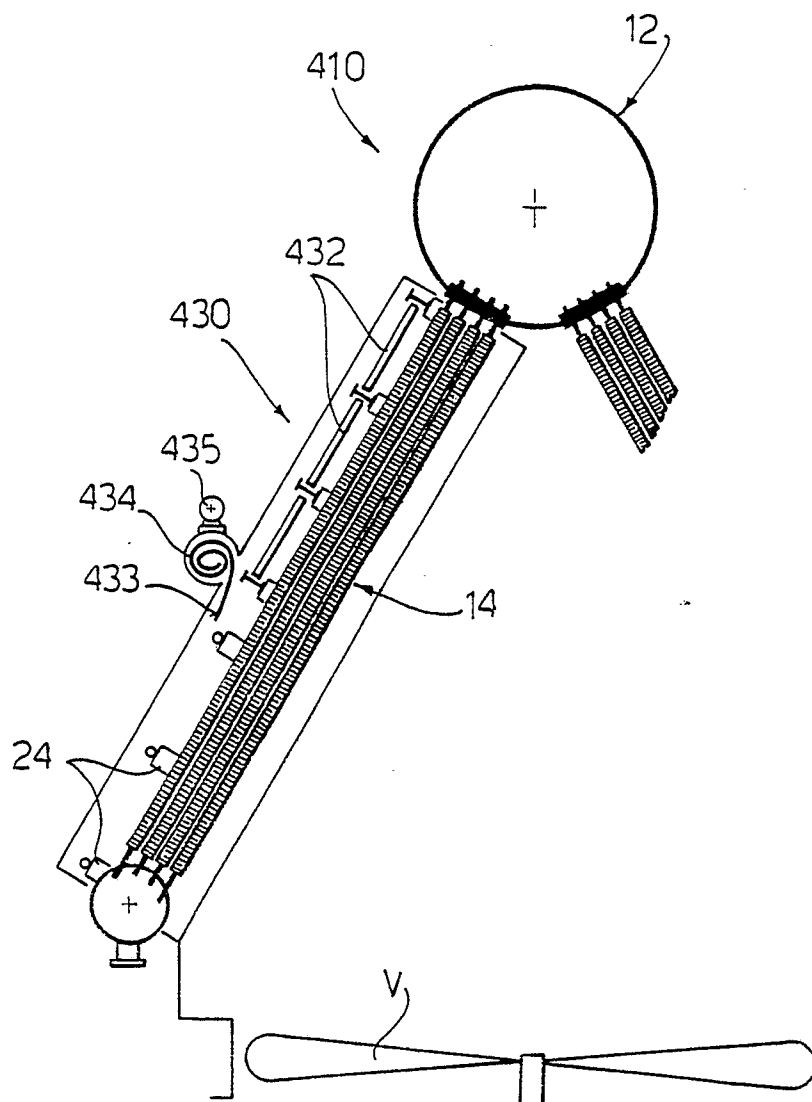


FIG. 11



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,Y	GB-A-2 086 559 (SVENSKA FLÄKTFABRIKEN) * Abstract; claims 1,8; figures 1-4 * ---	1-6,8	F 28 B 1/06 F 28 B 9/00
D,Y	DE-A-1 936 137 (KRAFTWERK UNION) * Page 7, lines 1-12; claims 4,6; figures 2,3 * ---	1-6,8	F 28 B 11/00 F 28 F 27/00
A	FR-A-2 237 153 (RESEARCH-COTTRELL) * Page 7, lines 16-30; figures 4,5 * ---	7,9	
A	DE-A-1 601 120 (APPARATEBAU ROTHEMÜHLE, BRANDT & KRTITZLER) ---	7,9	
A	FR-A-2 360 059 (CHAUSSON) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 28 B F 28 C F 28 F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 06-04-1989	Examiner HOERNELL, L.H.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			