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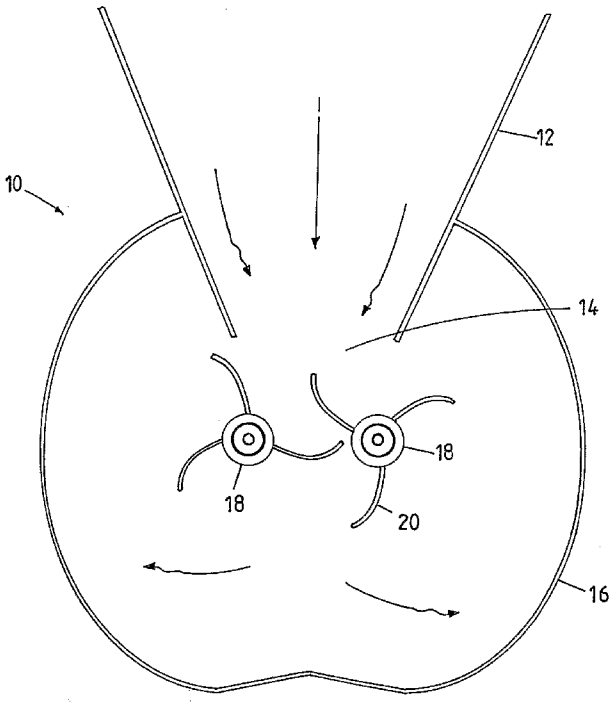
(54) Title: CROSS-AXIS WIND TURBINE ENERGY CONVERTER

(57) Abstract: The invention relates to a wind energy converter apparatus (10) which comprises an incoming wind guide (12), a cross-axis wind turbine (18), a wind containing region (16) and a wind outlet (24). Preferably, means is provided for cooling the wind air to enhance precipitation of moisture from the wind air in the apparatus.



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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.

TITLE

CROSS-AXIS WIND TURBINE ENERGY CONVERTER

FIELD OF THE INVENTION

The present invention relates to a wind energy converter apparatus.

BACKGROUND TO THE INVENTION

Many known wind turbines require axial alignment with the direction of the wind.

Cross-axis turbines are also known, where the turbine axis is perpendicular to the wind direction. With such an arrangement, the turbine is able to operate equally well regardless of wind direction. Cross-axis turbines may be arranged vertically, horizontally or at an incline. Cross-axis turbines may also be arranged in a bank, to increase power output and/or to alter the properties of wind passing through.

Wind turbines are known for extracting kinetic energy from wind and converting to mechanical or electrical energy. It is also proposed that wind turbines may be used as part of an apparatus for condensing water from air.

The present invention attempts to provide a wind energy converter which is advantageous in at least some applications in comparison to known wind turbines.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention there is provided a wind energy converter apparatus characterised by comprising an incoming wind guide, at least one cross-axis wind turbine, a wind containing region and a wind outlet, wherein incoming

wind air is directed through the guide to the wind turbine and then into the wind containing region, the air subsequently travelling through the wind outlet to leave the apparatus.

Preferably, the wind containing region is cooled, for instance such that moisture in the air can be precipitated in the wind containing region. More preferably, the blades of the turbine are refrigerated to assist in the cooling of the air.

Also preferably, the wind outlet is vertically displaced from the turbine.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a plan view of a wind energy converter in accordance with a first embodiment of the present invention;

Figure 2 is a plan view of a wind energy converter in accordance with a second embodiment of the present invention;

Figure 3 is a partial cross sectional view of a wind energy converter in accordance with the present invention;

Figure 4 is a plan view of a wind energy converter in accordance with a third embodiment of the present invention;

Figure 5 is a plan view of a wind energy converter in accordance with a fourth embodiment of the present invention;

Figure 6 is a plan view of a wind energy converter in accordance with a fifth embodiment of the present invention;

Figure 7 is a plan view of a wind energy converter in accordance with a sixth embodiment of the present invention;

Figure 7a is a side elevation of the apparatus of Figure 7;

Figure 8 is a plan view of a wind energy converter in accordance with a seventh embodiment of the present invention;

Figure 9 is a cross sectional schematic view of a first embodiment of a turbine used within the present invention;

Figure 10 is a cross sectional schematic view of a the turbine of Figure 9 with a screw compressor;

Figure 11 is a cross sectional schematic view of a the turbine of Figure 9 with a flexible compression chamber;

Figure 12 is a schematic cross-sectional view of a pair of turbines such as that of Figure 9;

Figure 13 is a schematic cross-sectional view of the turbines of Figure 12 linked with a further pair of non-cooled turbines;

Figure 14 is a schematic cross-sectional view of an alternative embodiment of a pair of turbines used in the present invention;

Figure 15 is a schematic cross-sectional view of another alternative turbine for use in the present invention;

Figure 16 is a schematic plan view of a first alternative vane arrangement for use in the present invention;

Figure 17 is a schematic plan view of a second alternative vane arrangement for use in the present invention; and

Figure 18 is a schematic plan view of a third alternative vane arrangement for use in the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the Figures, there is shown in Figures 1 and 2 a wind energy converter apparatus 10. The wind energy converter apparatus 10 has a substantially V-shaped incoming wind guide 12, which acts to direct incoming air into a mouth 14 of a bulbous shaped wind containing region 16.

Two wind turbines 18 are located at the mouth 14 of the wind containing region 16. The turbines 18 are contra-rotating, vertical-axis turbines.

In the embodiment of Figure 1, each turbine 18 has 3 curved blades 20. The blades 20 each have a radius of curvature slightly less than that of the turbine 18. The blades are curved in a direction so as to be propelled by wind directed between the two turbines 18, and to provide minimal resistance at the lee side of each turbine. The blades 20 are arranged such that the nominal line of intersection of the blades is offset from the turbine axis in a windward direction. This assists some incoming wind to spill inwardly of the blades 20.

In the alternative embodiment of Figure 2, the blades 20 are straight blades mounted at an angle about a central cylinder. The blades are aligned such that the cylinders defined by the sweep of the blades 20 about the two turbines 18 are tangential, meeting at a central line 22. Figure 2 also shows further four-blade turbine sections which may be used.

The wind energy converter apparatus 10 is shown in partial cross section in Figure 3. The wind containing region 16 has a wind outlet 24 at a lower end thereof. The wind

outlet 24 is vertically displaced below the turbines 18. In another embodiment (not shown), the wind containing region 16 has upper and lower wind outlets 24, vertically displaced above and below the turbines 18. Preferably, the wind containing region 16 has a rear wall 17 which is cooled by suitable means.

Preferably, the rear wall 17 has a hydrophobic, non-wettable coating such that water droplets condensing on the surface have a high contact angle and readily drain down to a collecting duct. A suitable surface is that described by Zhiguang Goo et al in the Journal of the American Chemical Society, 2005, Vol 127, Pages 1570-1571. Further, surfaces with a water repellent surface similar to a lotus leaf are also suitable.

Desirably the axial length of the turbines 18 is large compared to their diameter. Preferably the axial length of the turbines 18 is two to three times their diameter. This design provides a high rotation rate and at the same time exposes a large proportion of the air to the surface of the turbine blades.

It will be appreciated that numerous other configurations of turbines 18 within the wind containing region 18 may be used.

In the embodiment of Figure 3, the wind energy converter 10 is geared to a mechanically driven device 25 such as a generator or compressor. The gearing is such that a high revolution rate is generated in the device 25.

Figure 4 shows an embodiment of the present invention wherein each of the two turbines 18 are formed from a pair of vertical axles 24, with blades 20 being mounted on chains 26 mounted on wheels located adjacent the top and bottom of the axles 24. The axles 24 are offset such that the two turbines 18 are in a V-shaped configuration.

Figure 5 shows a further embodiment of the present invention similar to that shown in Figure 4. In the embodiment of Figure 5, each turbine 18 has a refrigerating plate 28

extending between the axles 24. In this embodiment, the turbine blades 20 are mounted on chains or belts 29, thus allowing air to pass through the turbine 18 and over the refrigerating plate 28. The refrigerating plate also assists to divert wind from the blades 20 returning upwind.

Figure 6 shows a further embodiment of the invention. In the embodiment of Figure 6, the wind energy converter has three pairs of incoming wind guides 12, each directing wind to a set of two contra-rotating turbines 18. The six turbines 18 all feed air in turn to a single wind containing region 16.

Figure 6a shows a variation of the embodiment of Figure 6. In this embodiment the apparatus comprises a condensation tunnel 19. Air from two centre turbines 18 leads into the tunnel 19. There are four outside turbines 18 which are used for power only. The turbines 18 drive a refrigeration compressor by means of a common shaft such as by gears. The tunnel 19 may be in the form of a wind vane to keep the turbines 18 facing the wind.

Additional photovoltaic powered refrigeration may be desirable to produce very cold spots in the tunnel 19.

The condensation tunnel 19 contains tubes 21 which are refrigerated by the refrigeration compressor discussed above.

The two centre turbines 18 may have refrigerated blades.

Figure 7 shows still a further embodiment of the invention. In this embodiment, rather than a single pair of contra-rotating turbines 18 being located at the mouth 14, the wind energy converter has a V-shaped array of turbines 18 extending from the mouth 14 inwardly of the wind containing region 16. The turbines 18 are arranged such that all turbines on one 'arm' of the V-shape rotate in one direction, and all turbines on the

other arm rotate in the other direction. The turbines 18 may or may not be mechanically linked.

In each of the embodiments described above, air is directed via the incoming wind guides 12 through the turbines 18. The turbines 18 act to convert kinetic energy from the air into mechanical energy. This mechanical energy may then be used for suitable purposes, for instance to power a refrigeration cycle. The refrigeration cycle may in turn be used to cool air in the wind containing region 16, for instance by cooling the walls of the wind containing region.

An example of such an arrangement is shown in Figure 8. The wind energy converter 10 of Figure 8 includes two contra-rotating turbines 18 which are arranged to drive a refrigeration compressor (not shown). On the down-wind side of the turbines 18 two vanes 30 extend inwardly of the wind containing region 16. The vanes 30 are refrigerated by means of the compressor. Water contained in the air thus condenses on the vanes 30, and can be recovered by suitable means.

The present invention envisages that refrigeration of the turbine blades 20 will greatly assist in the removal of heat from incoming air. Various means of refrigerating the turbine blades 18 are proposed.

Figure 9 shows a turbine 18 having a compressor 32 at an upper end thereof. The compressor 32 is connected to a circular condenser 34 by means of pipes 37. The condenser 34 is arranged to release heat above the turbine 18 outside the internal air flow. A one-way valve 35 prevents refrigerant from flowing back into the turbines 18. Each of the turbine blades 20 includes a refrigerant flow path 36 passing therethrough. The turbine 18 has a hollow axle 24 through which refrigerant may flow to the ends of flow paths 36 and then up to the compressor 32 so that compressed

refrigerant enters the condenser 34. The compressor 32 and condenser 34 each rotate with the turbine blades 20. As a result, a refrigerant cycle can be hermetically sealed. Further, a pipe 39 leads from the condenser 34 to the turbine blades 20 so as to feed compressed refrigerant into the blades 20 through a constriction. Further, the compressor 32 has a flexible top 41. A track 43 is mounted on the top 41. The track 43 has an uneven profile. Further, a pair of undulant idler wheels 45 are mounted above and in contact with the track 43. The wheels 45 are mounted on a fixed axle 47. As the compressor 32 rotates the top 41 thereof is compressed when the wheels 45 engage with higher portions of the track 43 and expands when the wheels 45 engage with the lower portions of the track 43. In this way the compressor 32 acts to compress refrigerant contained therein before the refrigerant is fed to the condenser 34.

The compressor 32 may be a screw compressor 32 as shown in Figure 10. In the screw compressor of Figure 10, the compressor 32 has an outer condensing coil 38, which is connected via a constrictor 40 into hollow blades 20. The hollow blades 20 each have a refrigerant return path 36 through which refrigerant is returned to the base of the compressor 32. Expanded refrigerant flows from the return path 36 into the beginning of an internal spiralling screw 42. The screw 42 is supported by internal bearings 44, and coupled to a drive gear 46. The drive gear 46 is driven by a satellite gear 48, which in turn is driven by an internal ring gear 50 mounted to the compressor 32. As the turbine 18 rotates, the gearing arrangement causes the screw 42 to rotate at a much greater speed, compressing the refrigerant.

In an alternate embodiment, the compressor 32 may be formed from a flexible compression chamber 52 as shown in Figure 11. The flexible compression chamber

52 is mounted to a rod 54, which in turn is eccentrically mounted to a vertical shaft 56. As the turbine 18 rotates, the eccentric mounting of the rod 54 causes its lower end to move vertically, thus in turn expanding and collapsing the compression chamber 52. The compression chamber 52 thus acts as a bellows for the compression of refrigerant. In the embodiment of Figure 11 the turbine 18 has a flexible compression chamber 52 both above and below, with refrigerant returning to the compression chambers 52 via a hollow axle 24 with one-way valves 35 disposed at either end. The compressed refrigerant is fed to the turbine blades 20 through a constriction.

The flexible compression chamber may also be operated by a push rod 58 eccentrically mounted to a horizontal shaft 60. Such an arrangement is shown in Figure 12. In the embodiment of Figure 12 two turbines 18 are shown mounted to the same horizontal shafts 60, with gears 62 arranged to permit their contra-rotation.

In the embodiment of Figure 13, two further turbines 18 are coupled to the shafts 60. The additional turbines are not refrigerated, and merely act as an additional source of power. It will be appreciated that appropriate wind capture arrangements allow for cooled air to be separated from uncooled air down-stream of the turbines 18.

It will be understood that the use of additional wind turbines for additional power generation can be achieved in many different configurations. In the embodiment of Figure 14, two cross-axis turbines 18 are located along a common axle 24, however only one of the turbines 18 is cooled. In this embodiment, cooling is achieved by use of a scroll compressor 62. The scroll compressor 62 is mounted on a planetary gear arrangement 64 which causes an internal cylindrical element 66 to 'wobble' at a high speed, compressing the refrigerant against an outer wall.

It will be appreciated that various other means of cooling the blades 20 are envisaged, such as the use of a centrifugal compressor, as shown in simple form in Figure 15. It will be appreciated that the arrangement of Figure 15 might have to be altered to induce higher rotational speeds in the compressor portion.

The means for cooling blades may vary in relation to the number of turbines 18 within the wind energy converter 10, and whether or not the turbines 18 are mechanically linked.

It will also be appreciated that various blade arrangements may be used with any of the embodiments described above. One such blade arrangement is shown in plan view in Figure 16. Each of the blades 20 are curved with a relatively large radius of curvature, and are spaced from a central axle 24 so as to allow air to flow through the centre from the downwind blade side of the turbine 18 to the upwind side, thus providing additional power.

Another blade arrangement is shown in Figure 17. The arrangement of Figure 17 includes fixed wind deflectors 70 mounted circumferentially about the turbine 18.

A further blade arrangement is shown in Figure 18. In the arrangement of Figure 18 each turbine 18 comprises two substantially flat blades 20, curved at outer ends. Air passes between the two blades 20, providing power to both down-wind and up-wind portions. The arrangement of Figure 18 shows a plurality of turbines 18 arranged in a bank, with wind guides 12 as described above.

Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention. For instance, further cooling of wind may be powered by the use of additional wind turbines, photo-voltaic cells or other available energy sources. Similarly, further types of compressors may be used,

whether or not this requires the use of rotating seals in order to provide refrigerant to the turbine blades.

CLAIMS

1. A wind energy converter apparatus characterised by comprising an incoming wind guide, at least one cross-axis wind turbine, a wind containing region and a wind outlet, wherein incoming wind air is directed through the guide to the wind turbine and then into the wind containing region, the air subsequently travelling through the wind outlet to leave the apparatus.

2. A wind energy converter apparatus according to claim 1, characterised in that there is provided at least two wind turbines arranged adjacent one another and arranged to counter rotate relative to one another.

3. A wind energy converter apparatus according to claim 1 or 2, characterised in that the wind outlet is vertically displaced from the or each wind turbine.

4. A wind energy converter apparatus according to any one of the preceding claims, characterised in that the or each turbine has an axial length which is larger than a diameter thereof.

5. A wind energy converter apparatus according to any one of the preceding claims, characterised in that the or each turbine is arranged to convert kinetic energy into mechanical energy.

6. A wind energy converter apparatus according to claim 5, characterised in that the mechanical energy is arranged to power a refrigeration cycle which is arranged to cool air in the wind energy converter apparatus.

7. A wind energy converter apparatus according to claim 6, characterised in that there is provided means for cooling the wind air between the incoming wind guide and the wind outlet so as to enhance precipitation of moisture from air in the apparatus.

8. A wind energy converter apparatus according to claim 7, characterised in that the or each wind turbine contains blades which are arranged to be refrigerated to assist in cooling of the air.

9. A wind energy converter apparatus according to any one of claims 6 to 8, characterised in that the apparatus comprises a refrigeration compressor arranged to be operated by the mechanical energy from the wind turbine.

10. A wind energy converter apparatus according to claim 9, characterised in that the compressor is associated with a condenser and means is provided for allowing refrigerant to flow from the compressor to the condenser, and means is provided for circulating refrigerant from the condenser to the or each turbine and returning spent the refrigerant to the compressor.

11. A wind energy converter apparatus according to claim 10, characterised in that a constriction is disposed between the condenser and the or each turbine so that the circulating refrigerant to pass through the constriction to enter the or each turbine.

12. A wind energy converter apparatus according to any one of claims 9 or 12, characterised in that the compressor is arranged to be driven by a gear means which induces faster rotation of the compressor.

13. A wind energy converter apparatus according to any one of claims 9 to 11, characterised in that the compressor comprises a flexible compression chamber and means is provided for applying a compression force to the compression chamber.

14. A wind energy converter apparatus according to any one of the preceding claims, characterised in that the turbine blades are curved.

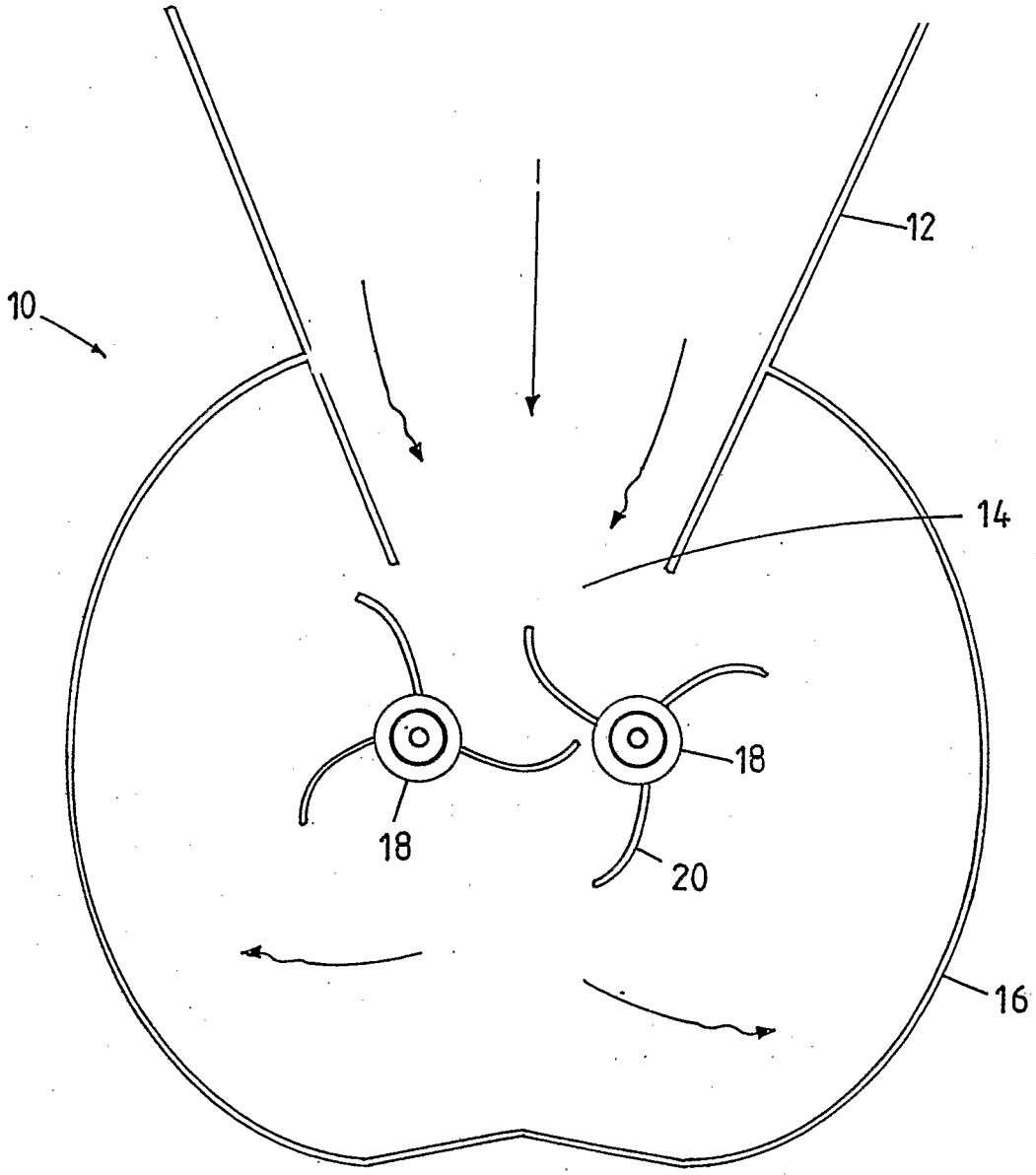


FIG. 1

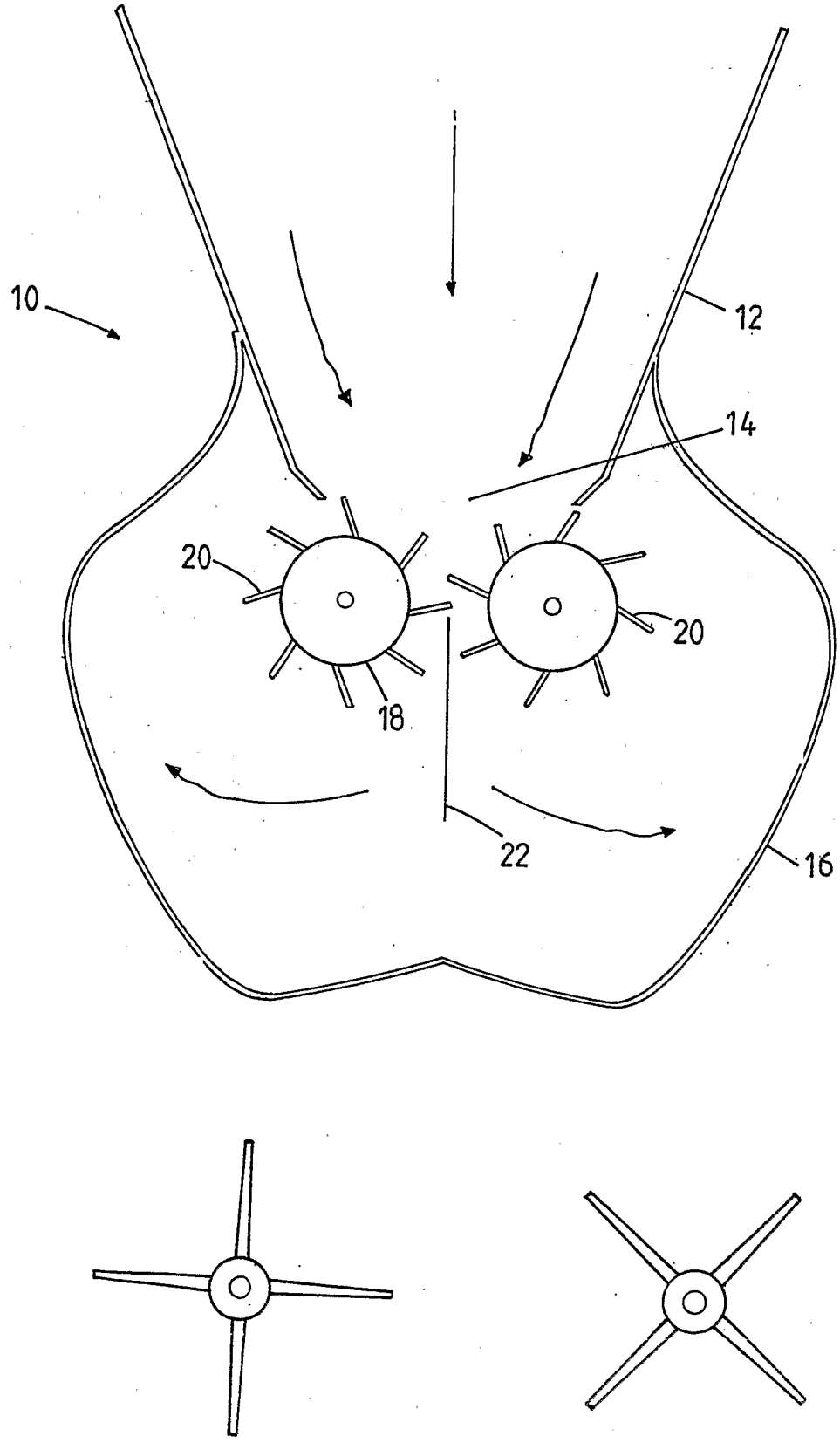


FIG. 2

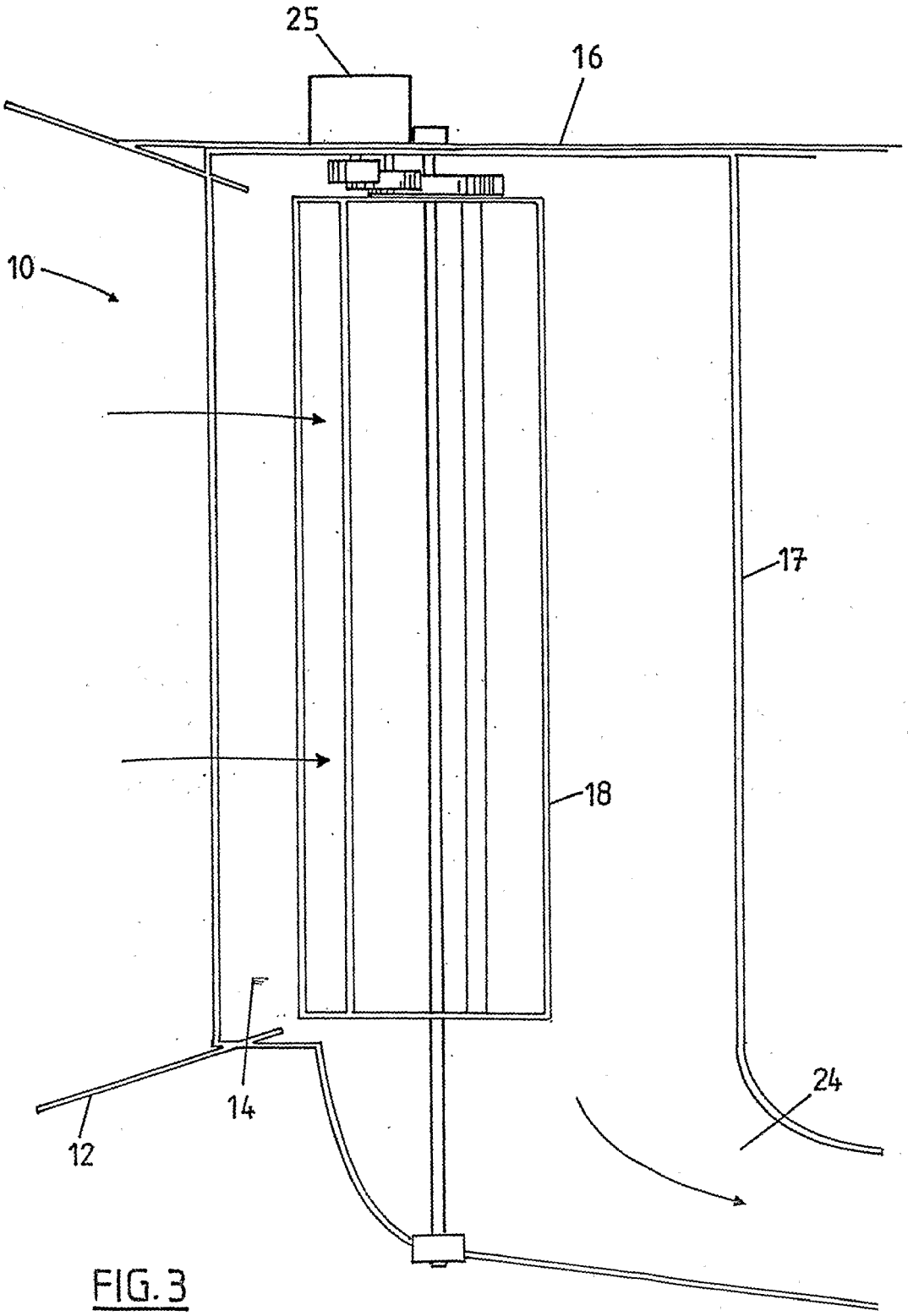


FIG. 3

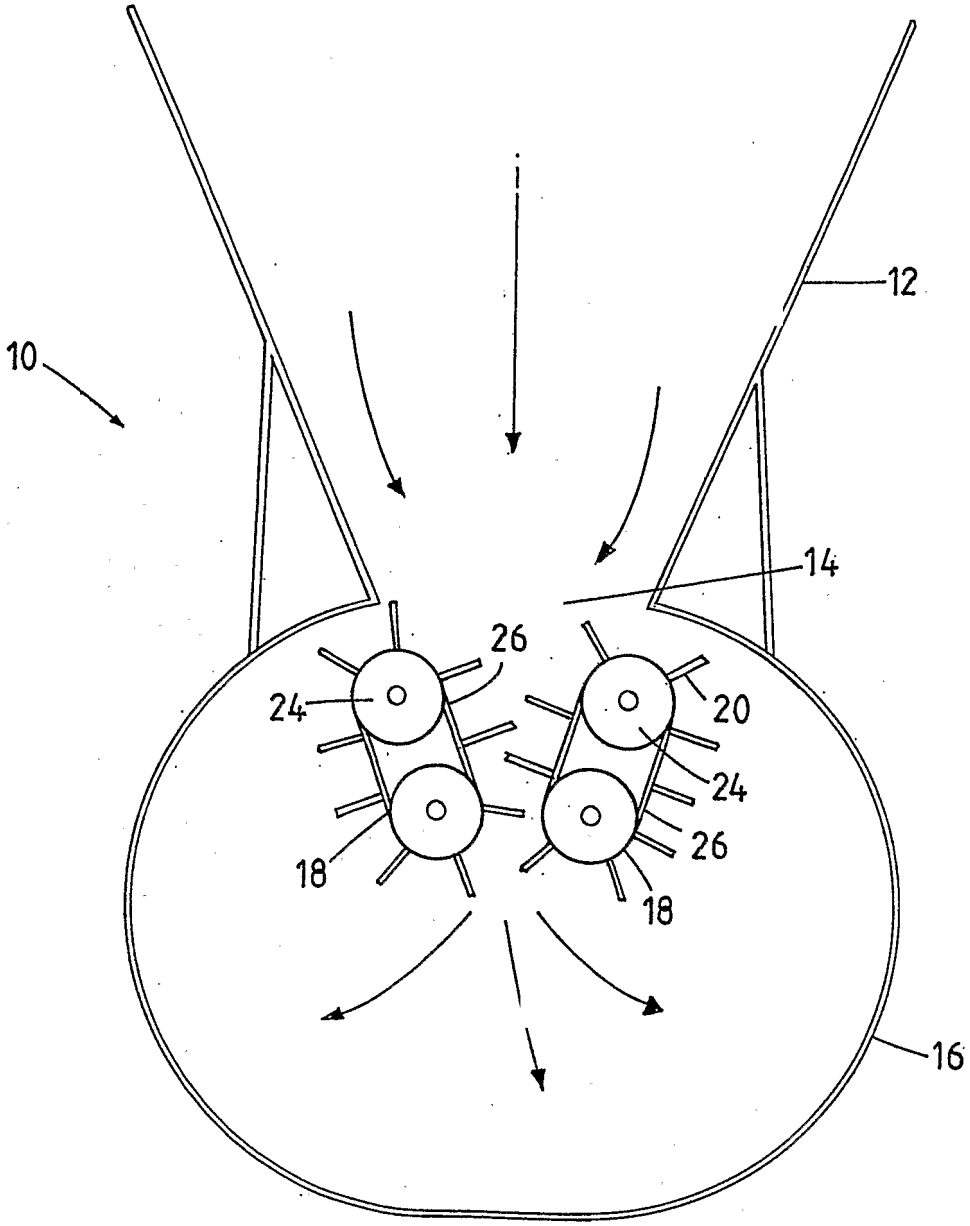


FIG. 4

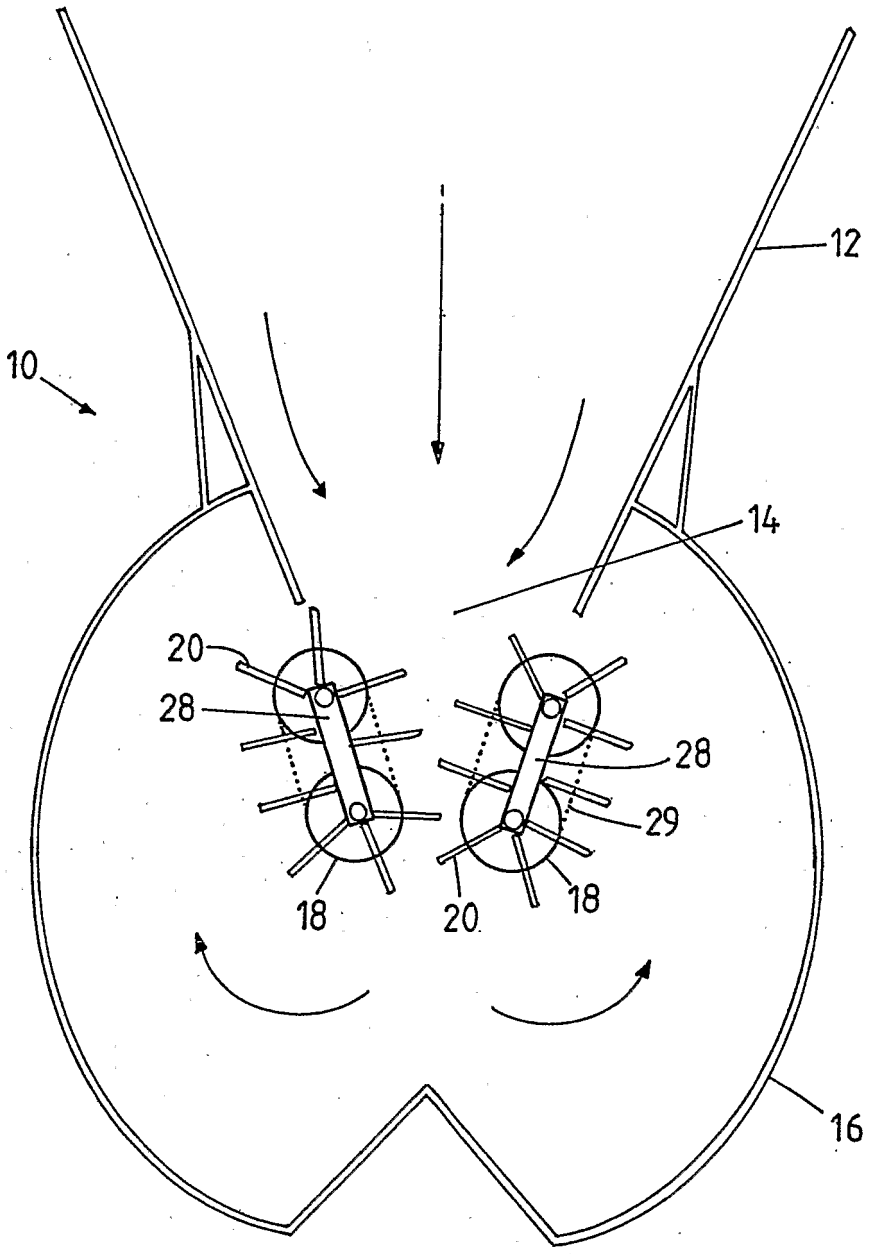


FIG. 5

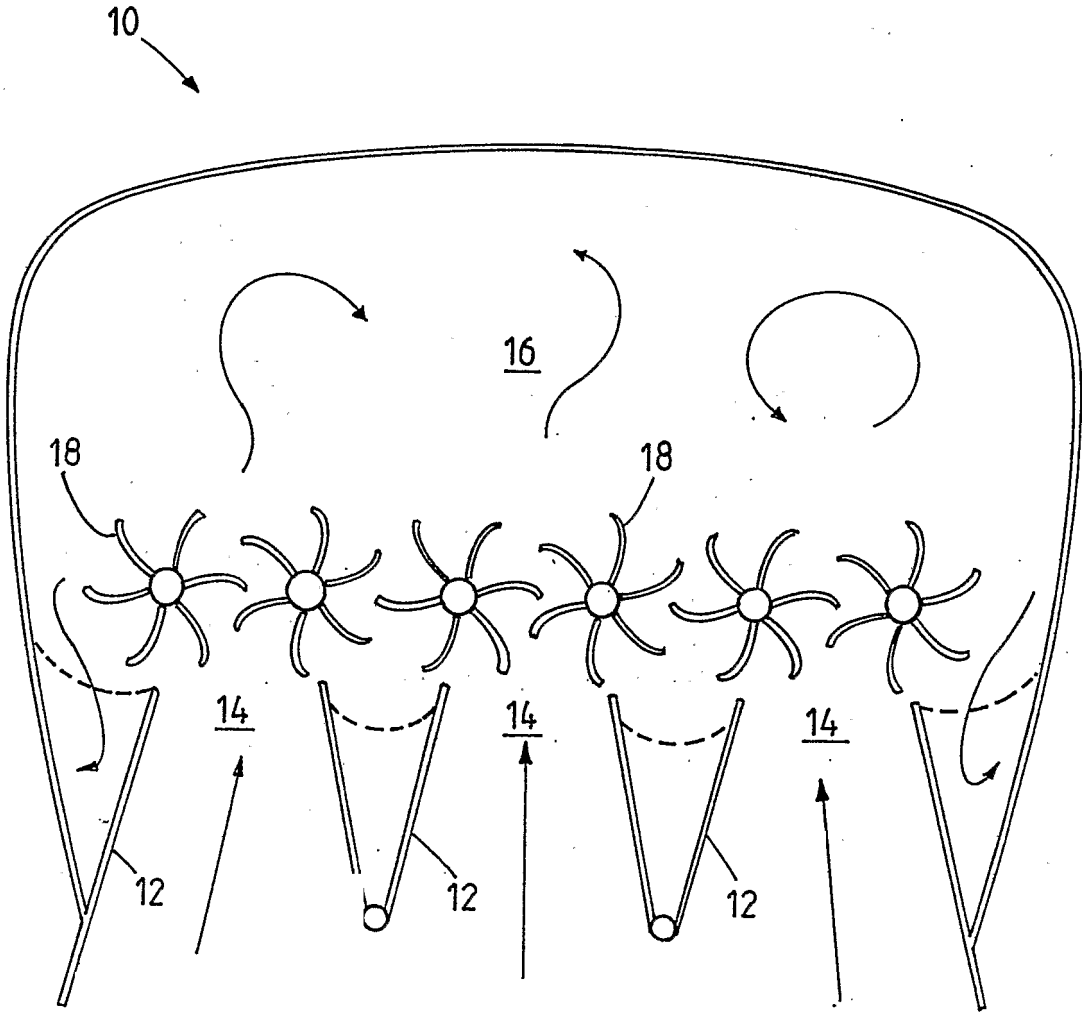


FIG. 6

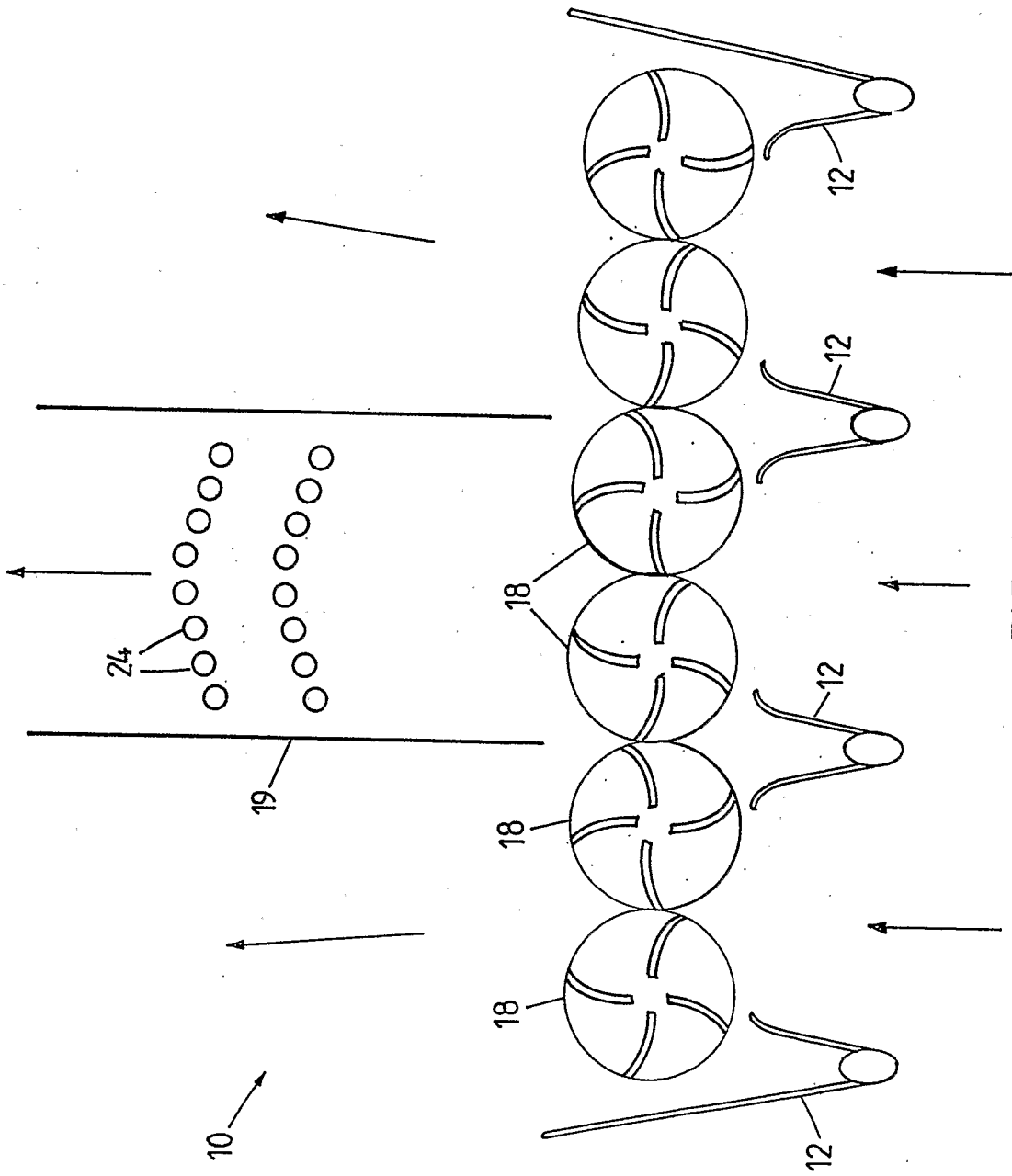
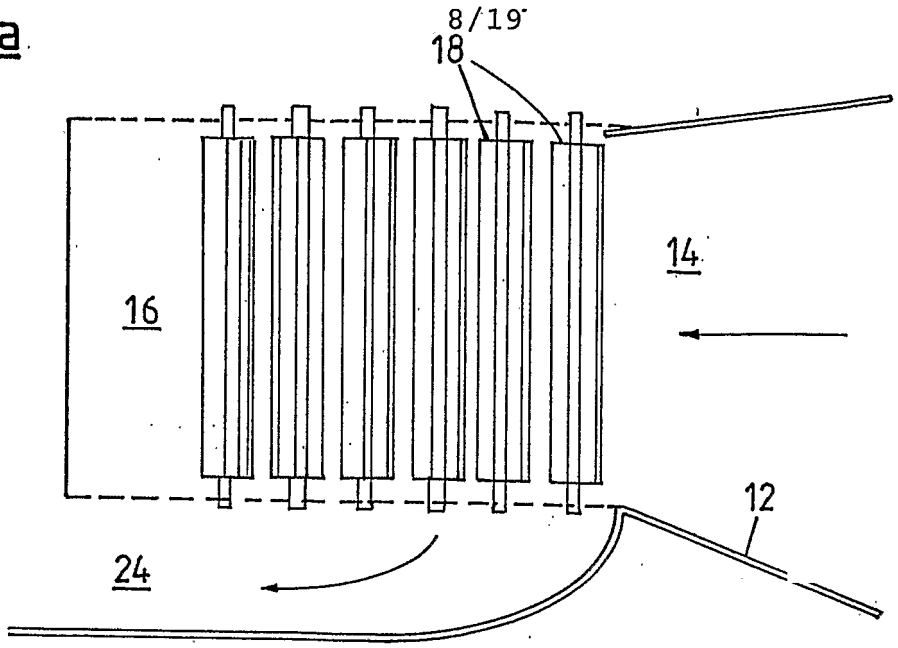


FIG. 6a

FIG.7a



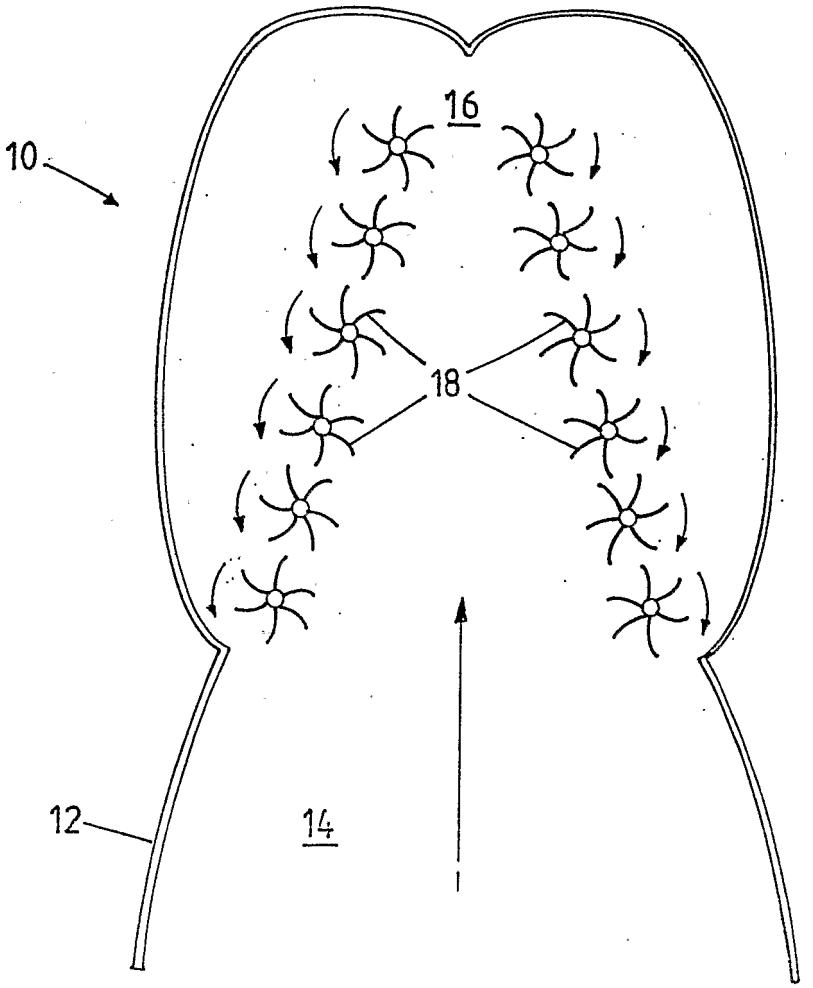


FIG.7

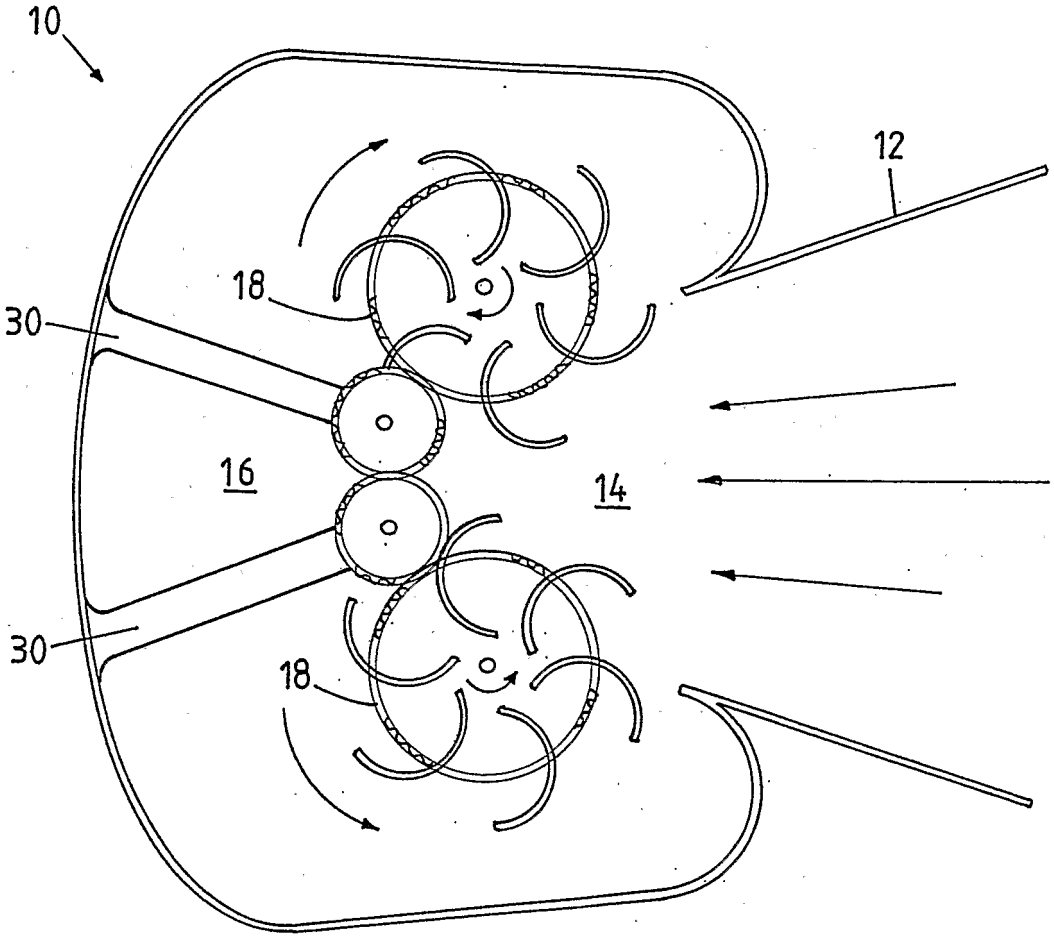


FIG. 8

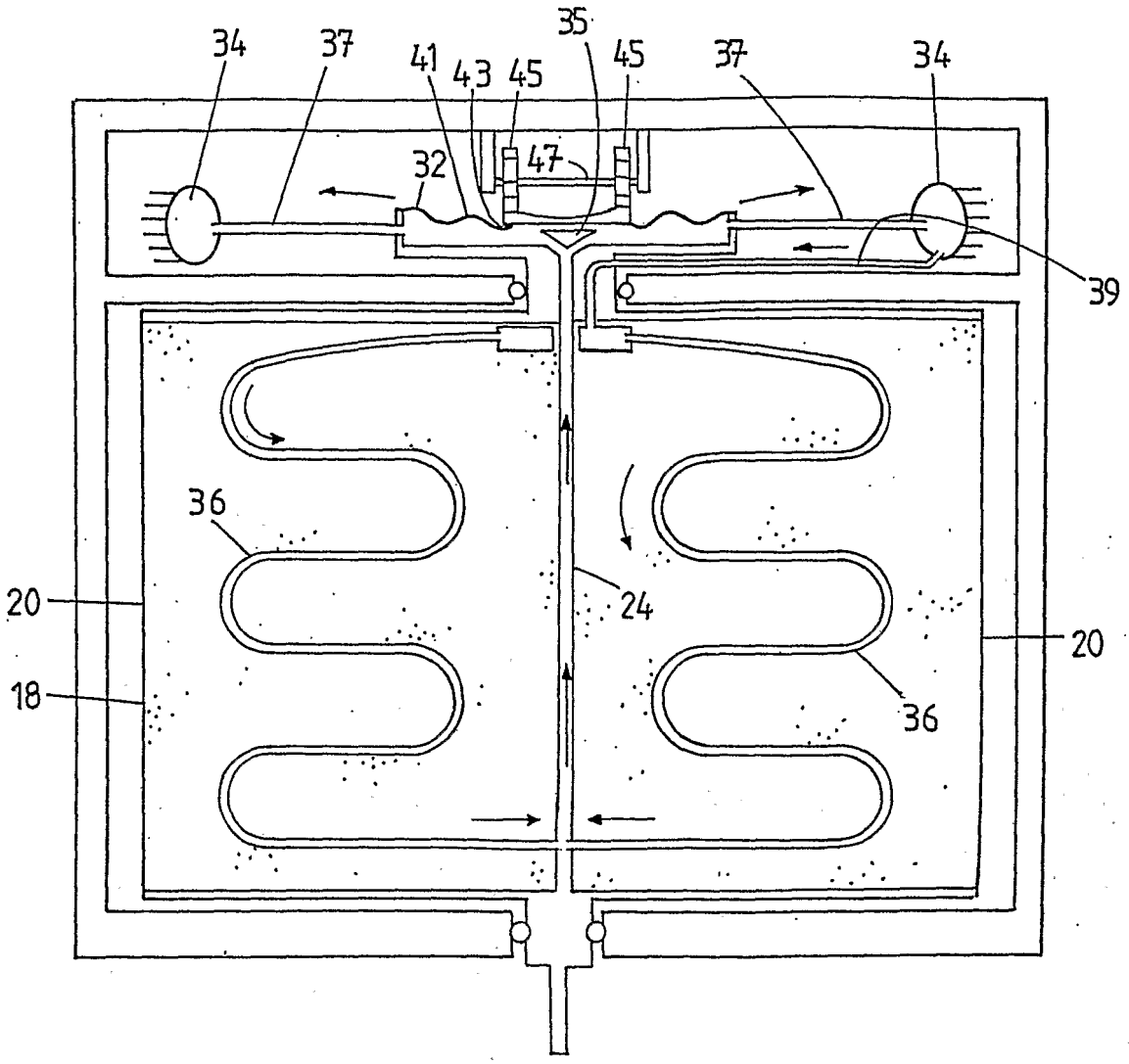


FIG.9

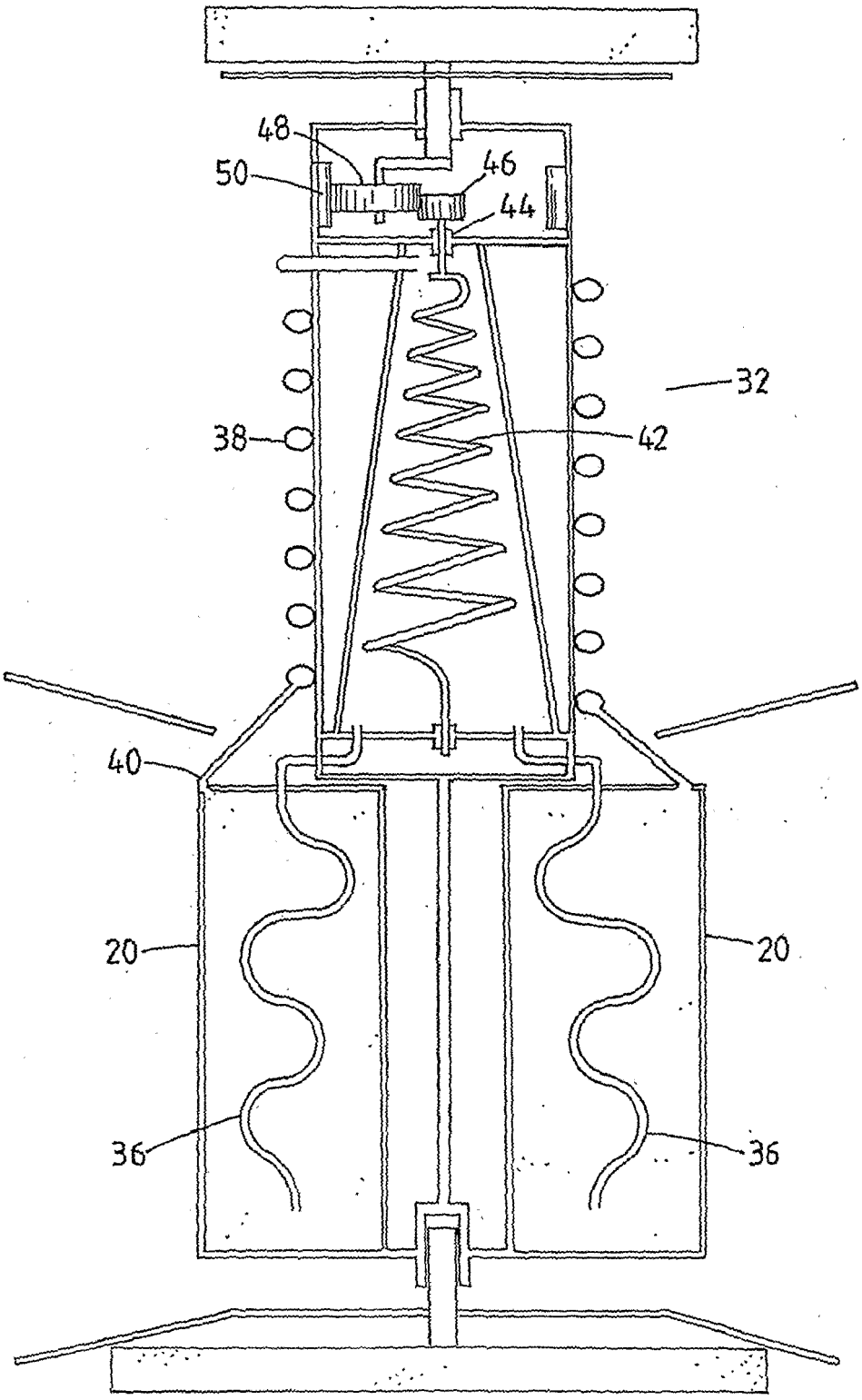


FIG. 10

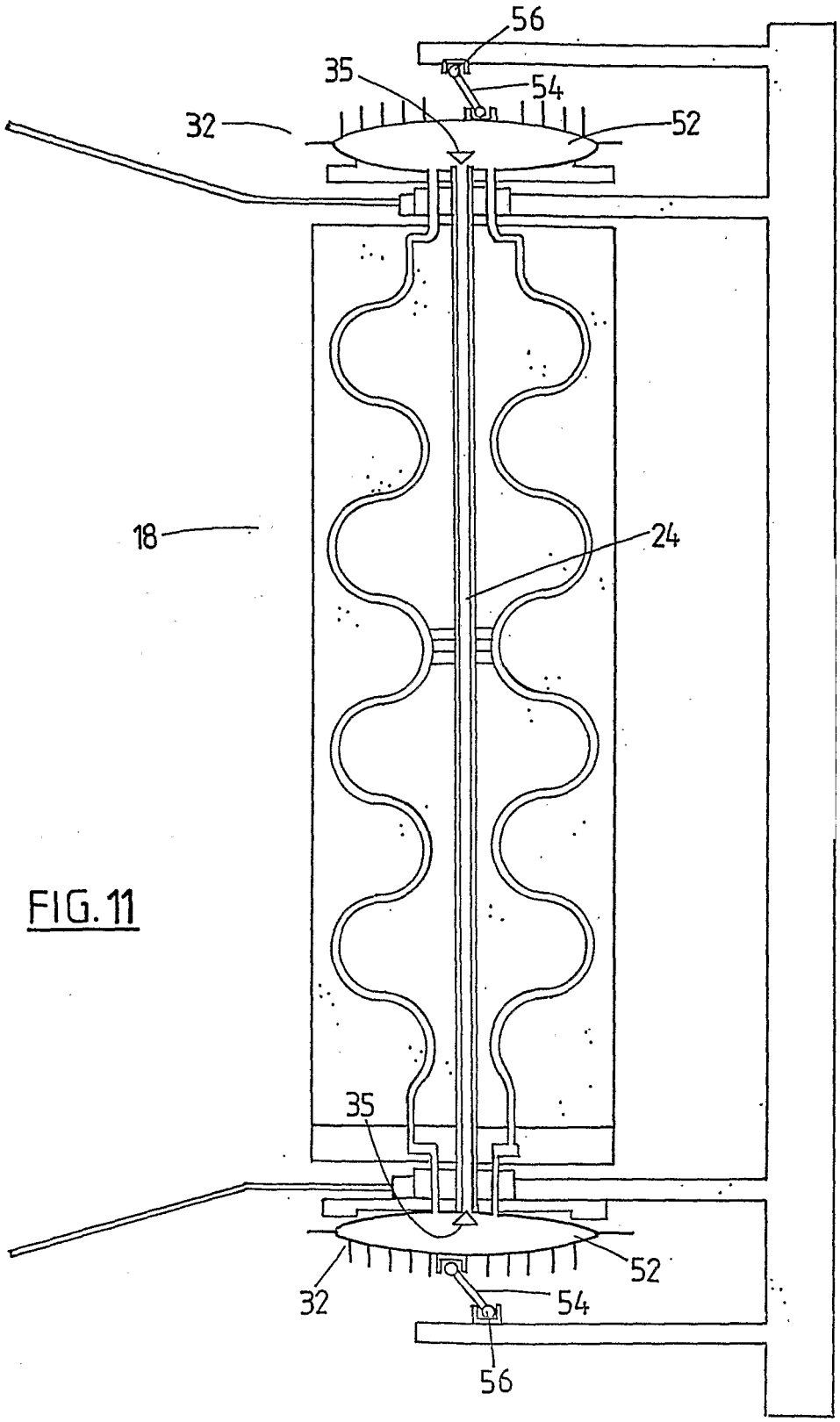
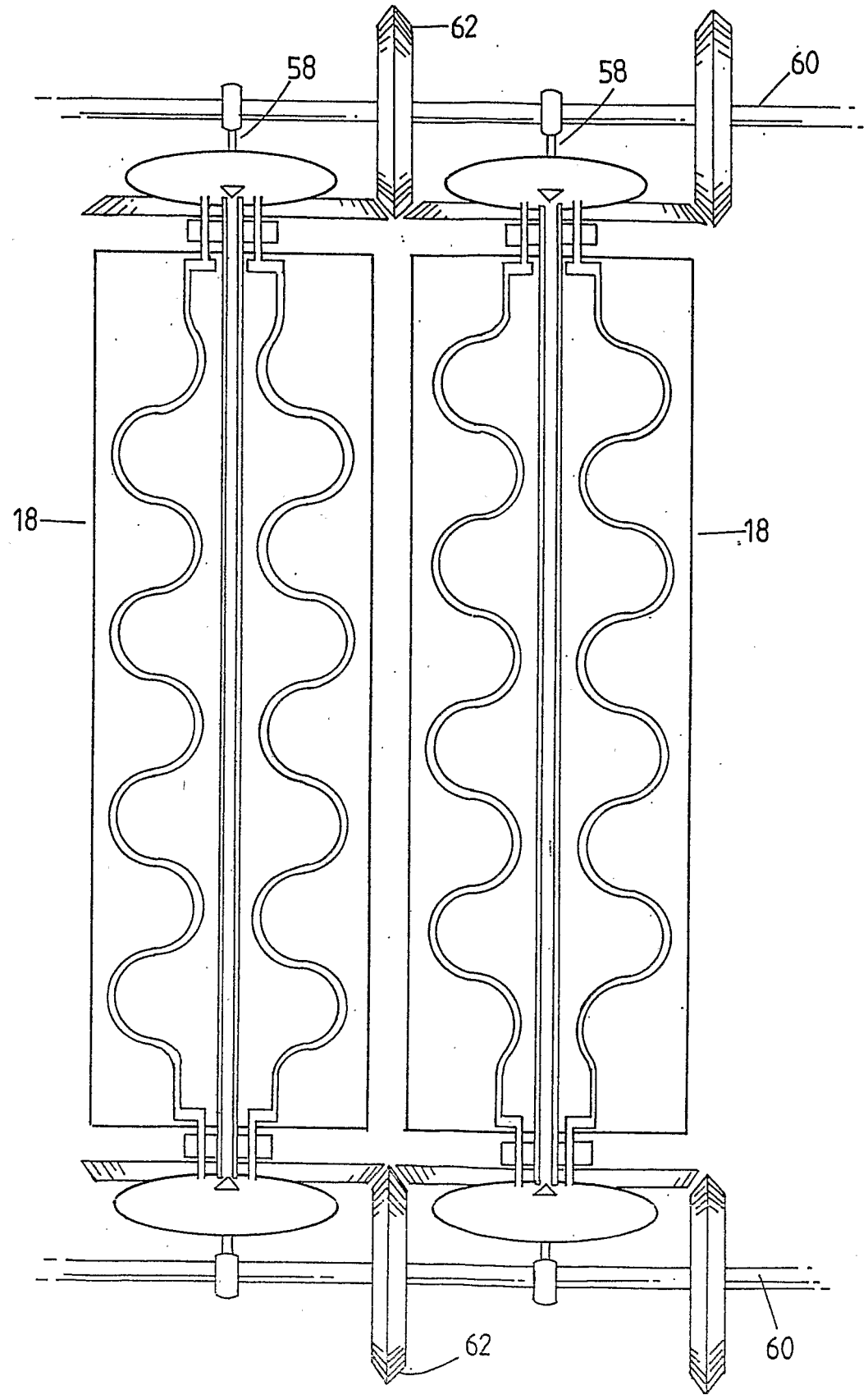


FIG. 11

FIG. 12



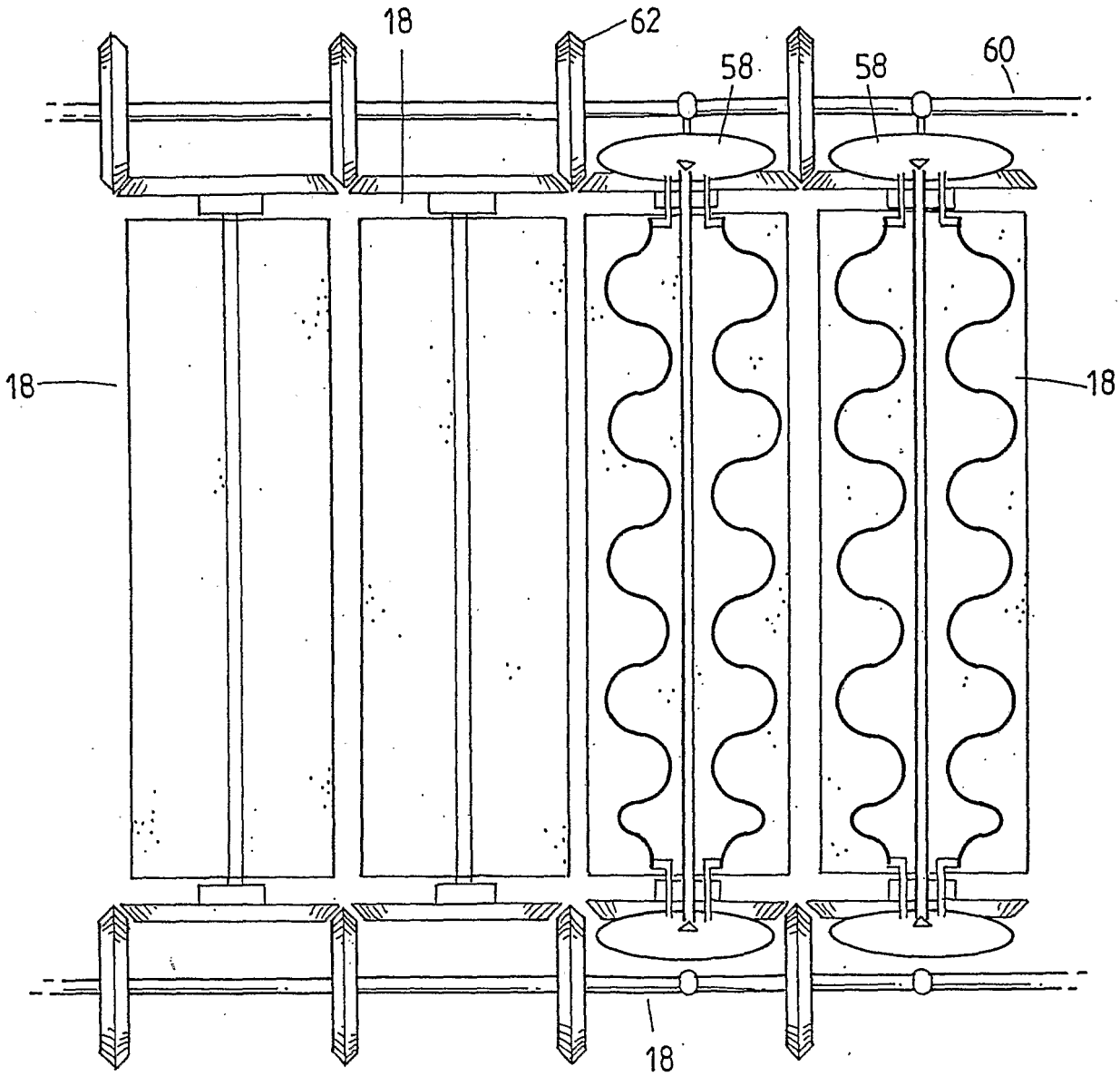


FIG. 13

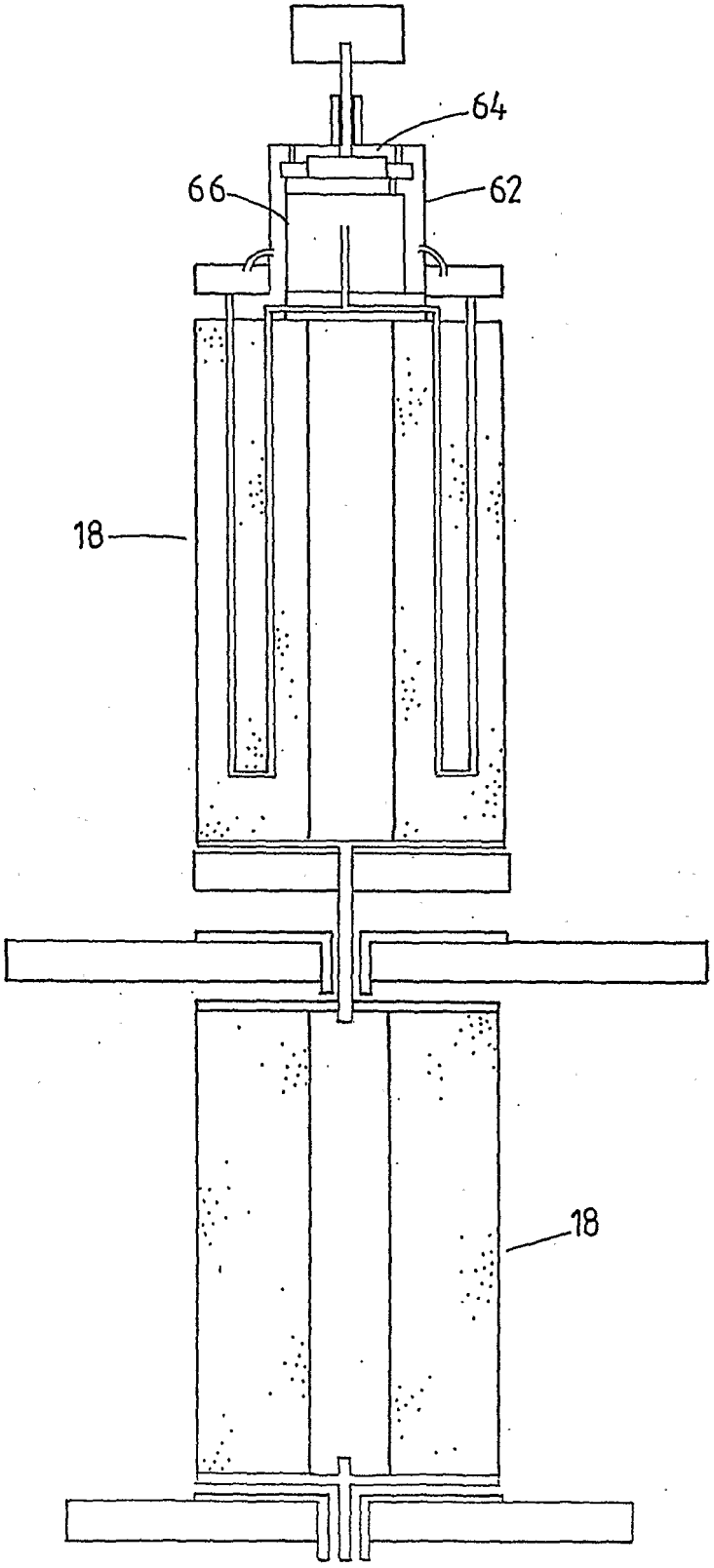


FIG. 14

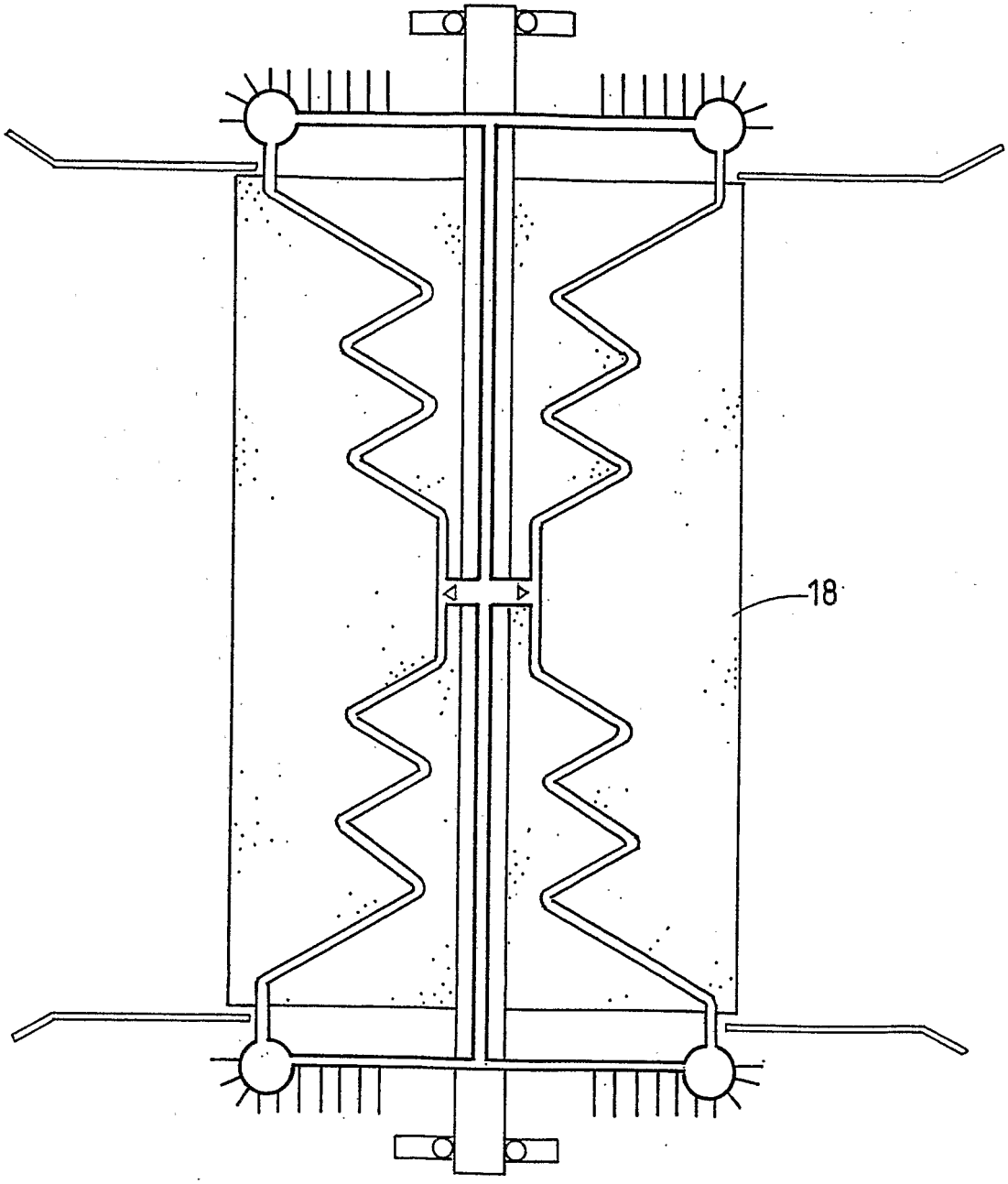


FIG. 15

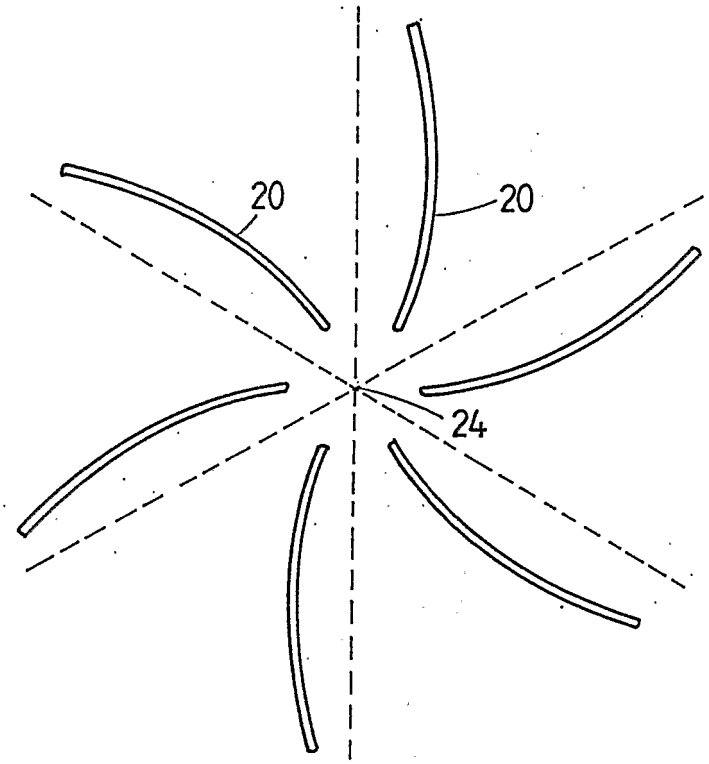


FIG.16

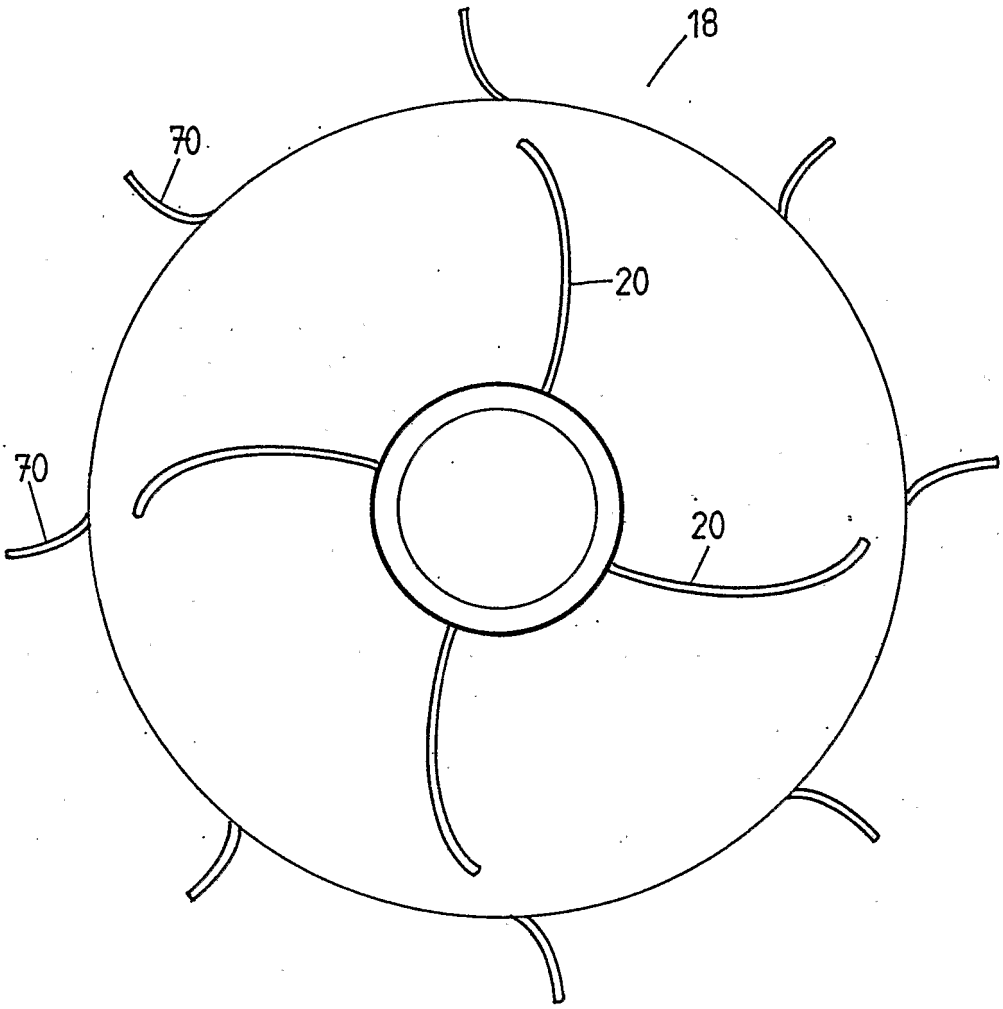


FIG. 17

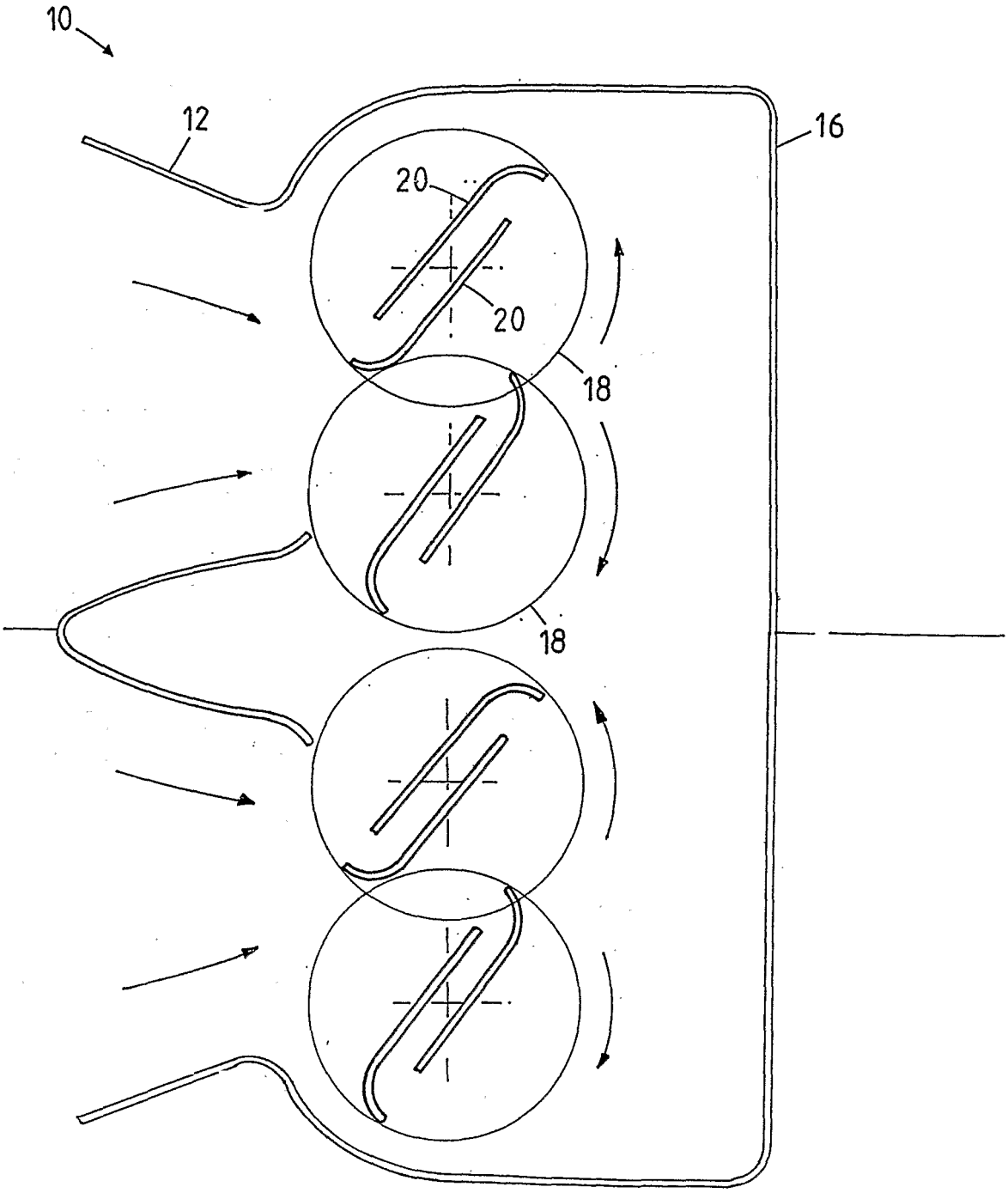


FIG.18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2006/001900

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

F03D 3/00 (2006.01) ***F03D 3/02*** (2006.01) ***F25B 27/00*** (2006.01)
B01D 5/00 (2006.01) ***F03D 3/04*** (2006.01)

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)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
PAIS: IPC F03D1/00, F03D3/00, B01D5/00, F03D3/04

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: F03D3/IC, F03D9/IC, B01D5/IC, F25B27/IC AND KEYWORDS WIND, AIR, ENERGY, GUIDE, TUNNEL, LEAD, DIRECT, SHROUD, CHANNEL, CHUTE, WATER, MOISTURE, CHILL, REFRIGERATE, COMPRESSOR AND LIKE TERMS.
USPTO AND ESP@CE KEYWORDS: F03D,REFRIG*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No..
X	US 4433552 A (SMITH) 28 February 1984 Whole document	1,3-7,9,12
P, Y	WO 2006/017888 A1 (WATER UNLIMITED) 23 February 2006 Whole document	1, 3, 5-14
X	US 5729981 (MARKUS et al.) 24 March 1998 Whole document	1-5
Y	Whole document	6-14

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
13 February 2007	06 MARCH 2007
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **D.R. LUM** Telephone No : (02) 6283 2544

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2006/001900

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2003/064852 A1 ((WIND HARVEST COMPANY) 07 August 2003 Abstract, Figs. 1 to 6	1-14
A	US 6308521 B1 (EYLMAN) 30 October 2001 Whole document	1-14
A	FR 2833044 A1 (PARENT M H N) 06 June 2003 Whole document	1-14
A	WO 2004/109102 A1 (INTEC POWER SYSTEMS LIMITED) 16 December 2004 Figs. 4 to 7; page 7, line 10 to page 13 line 1.	1, 5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2006/001900

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4433552						
WO	2006017888						
US	5729981	AU	78067/94	DE	4334457	EP	0722354
		WO	9510342				
WO	03064852	BR	0307217	CA	2512189	CN	1643250
		EP	1478848	MX	PA04007141	US	6784566
		US	2002105190				
US	6308521						
FR	2833044						
WO	2004109102	AU	2004245741	AU	2004245742	CA	2528265
		CA	2528266	CN	1798924	EP	1642027
		EP	1642028	GB	2402976	KR	2006003561
		KR	2006005269	US	2007018462	WO	2004109103

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX