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(54) **APPARATUS AND METHOD FOR COOLING OF AIR**

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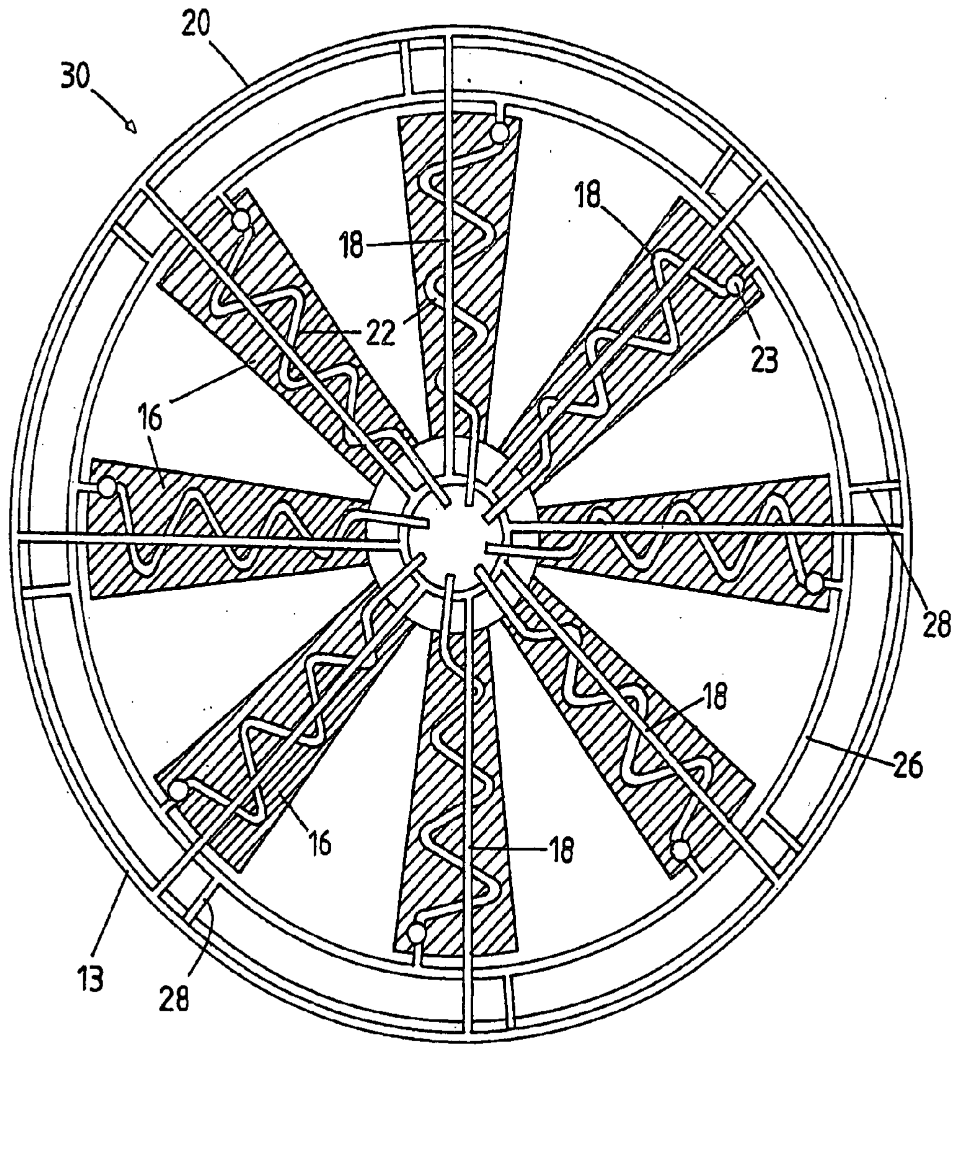
(52) **U.S. Cl.** **62/93**; 62/404; 62/426; 62/401; 62/498

(57) **ABSTRACT**

A wind turbine apparatus for cooling of air having a wind turbine axially connected to a refrigeration compressor arranged to compress refrigerant, at least one tube for conducting compressed refrigerant centrifugally outwards, a construction for causing the compressed refrigerant to lose pressure so as to cool fades of the wind turbine, and a conduit for returning spent refrigerant centripetally to the compressor.



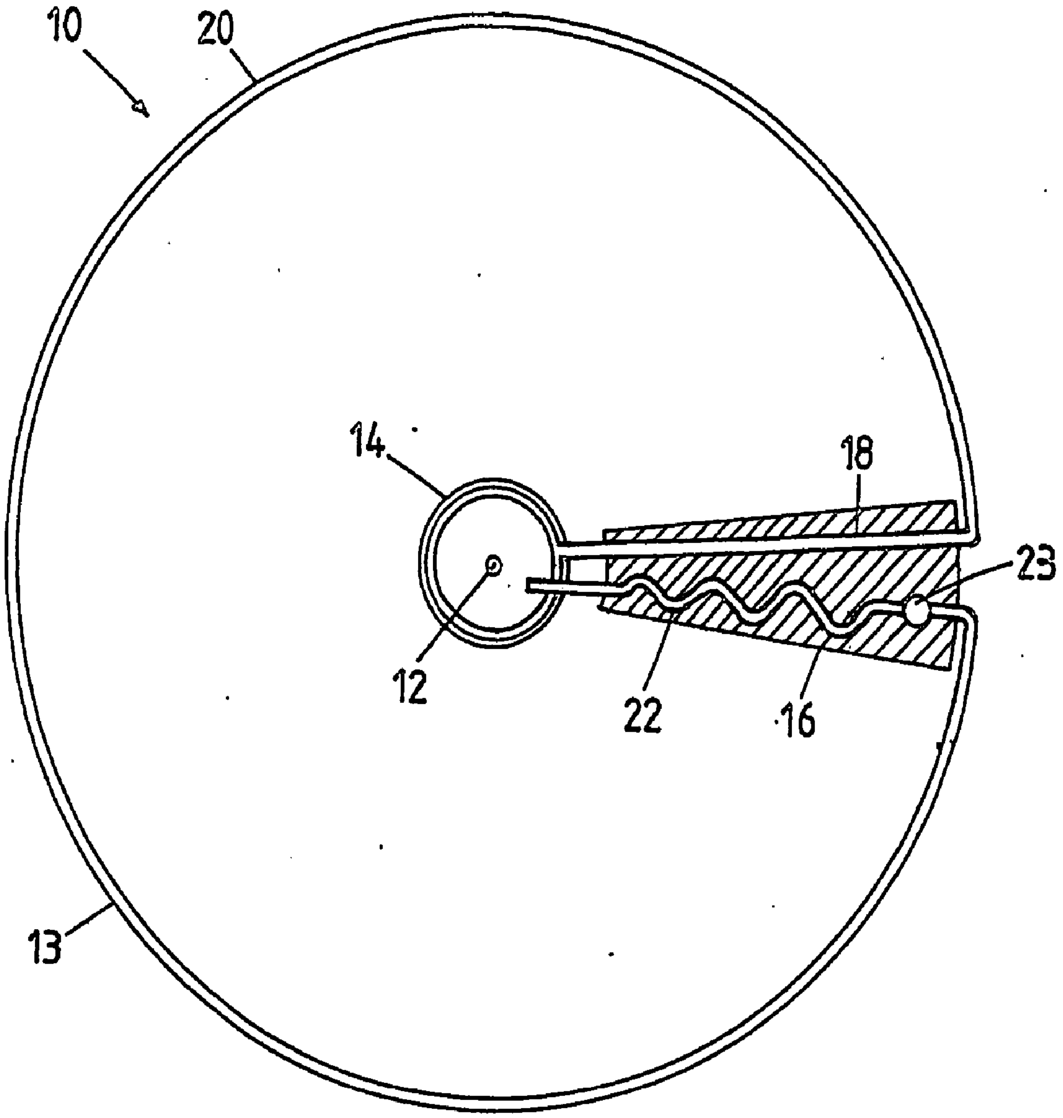


FIG. 1

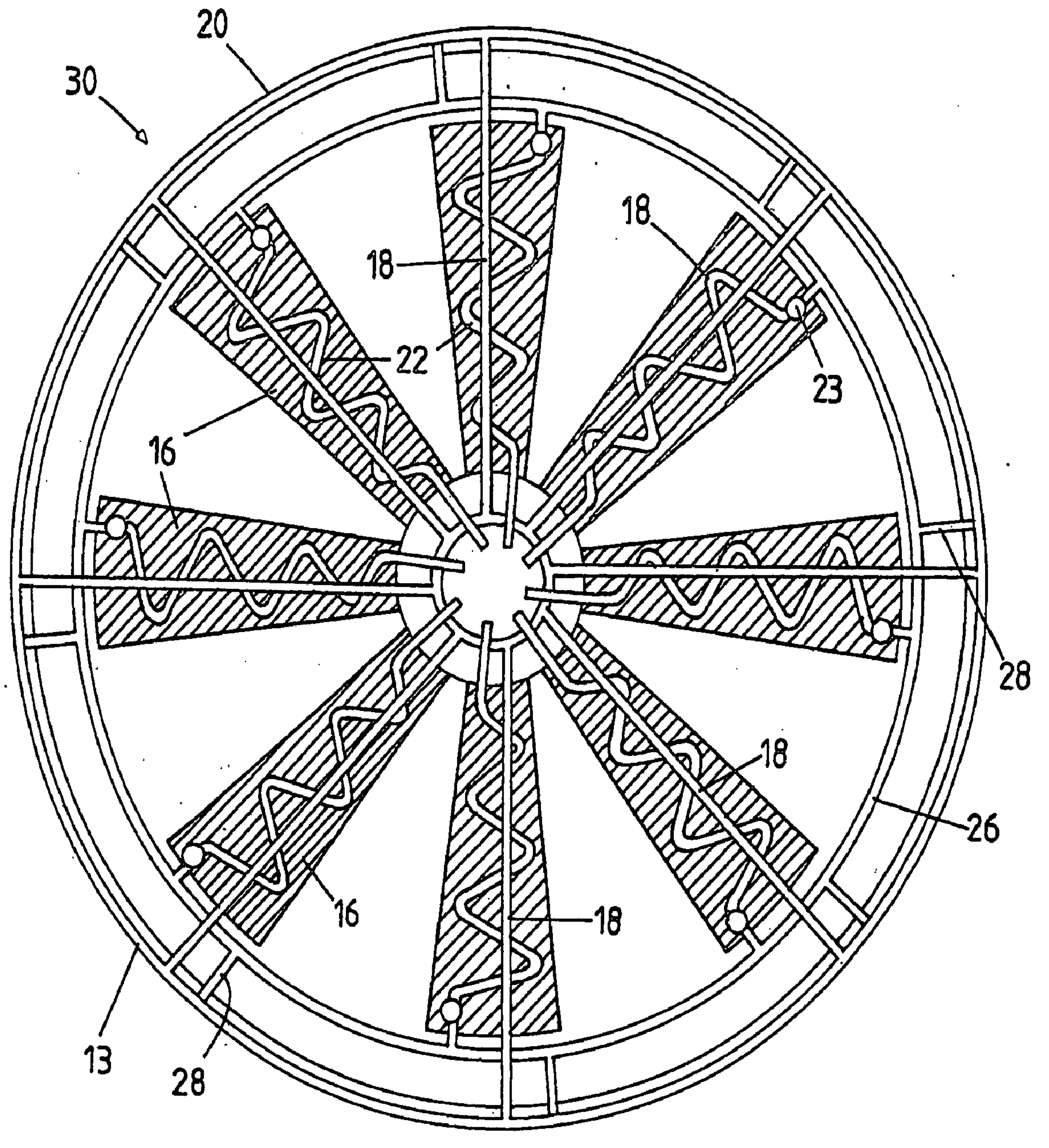


FIG. 2

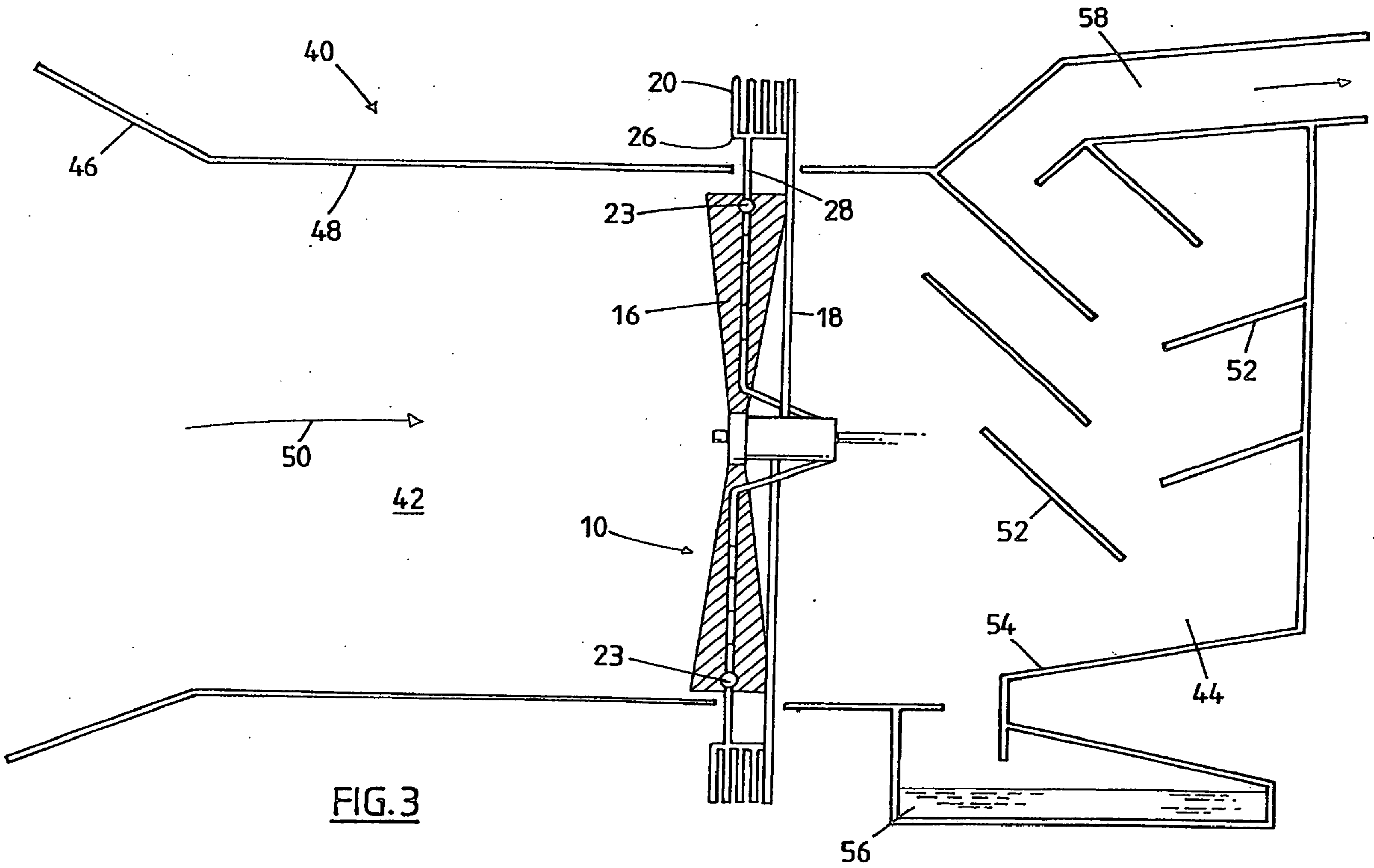


FIG.3

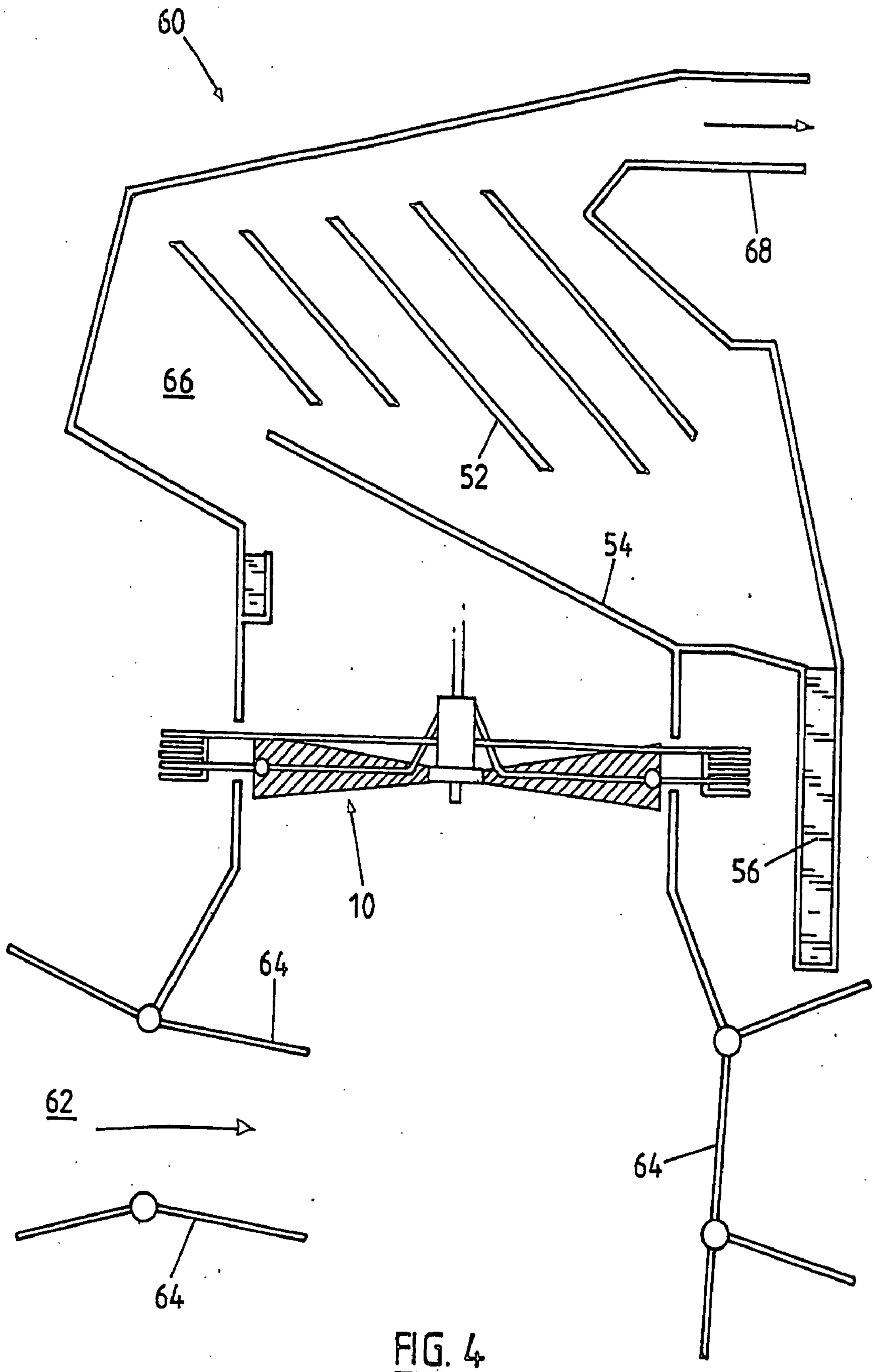
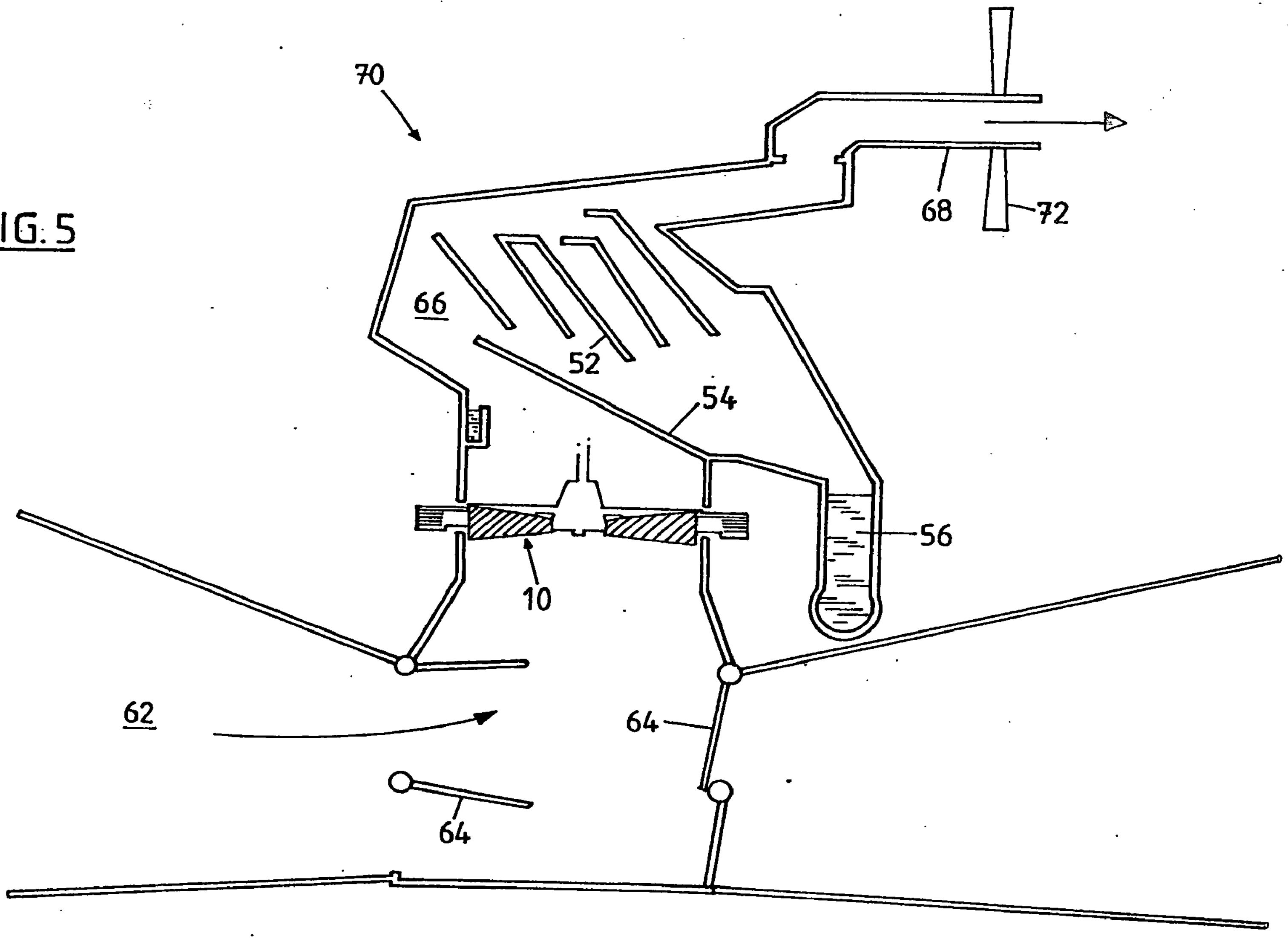


FIG. 4

FIG. 5



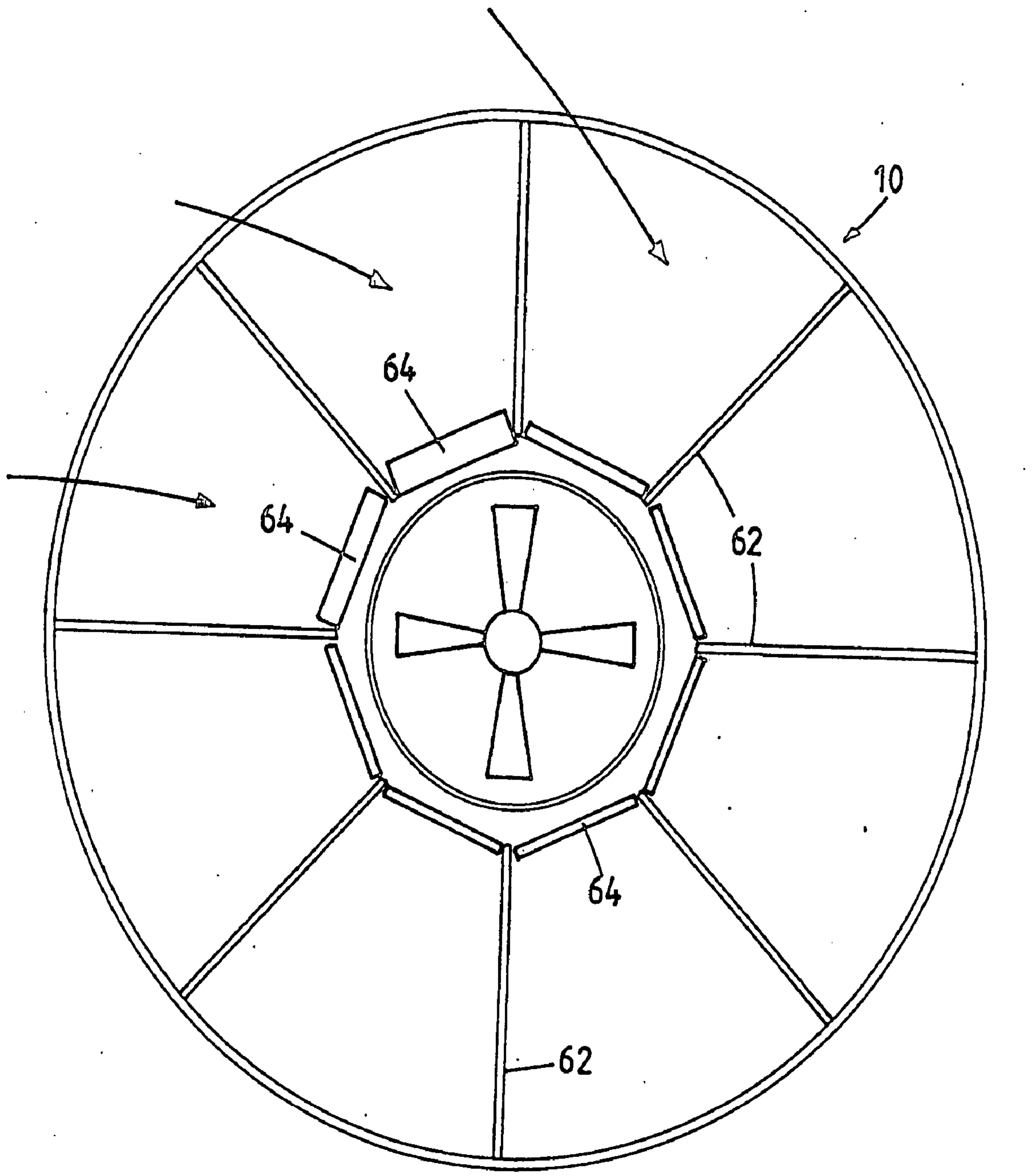


FIG.6

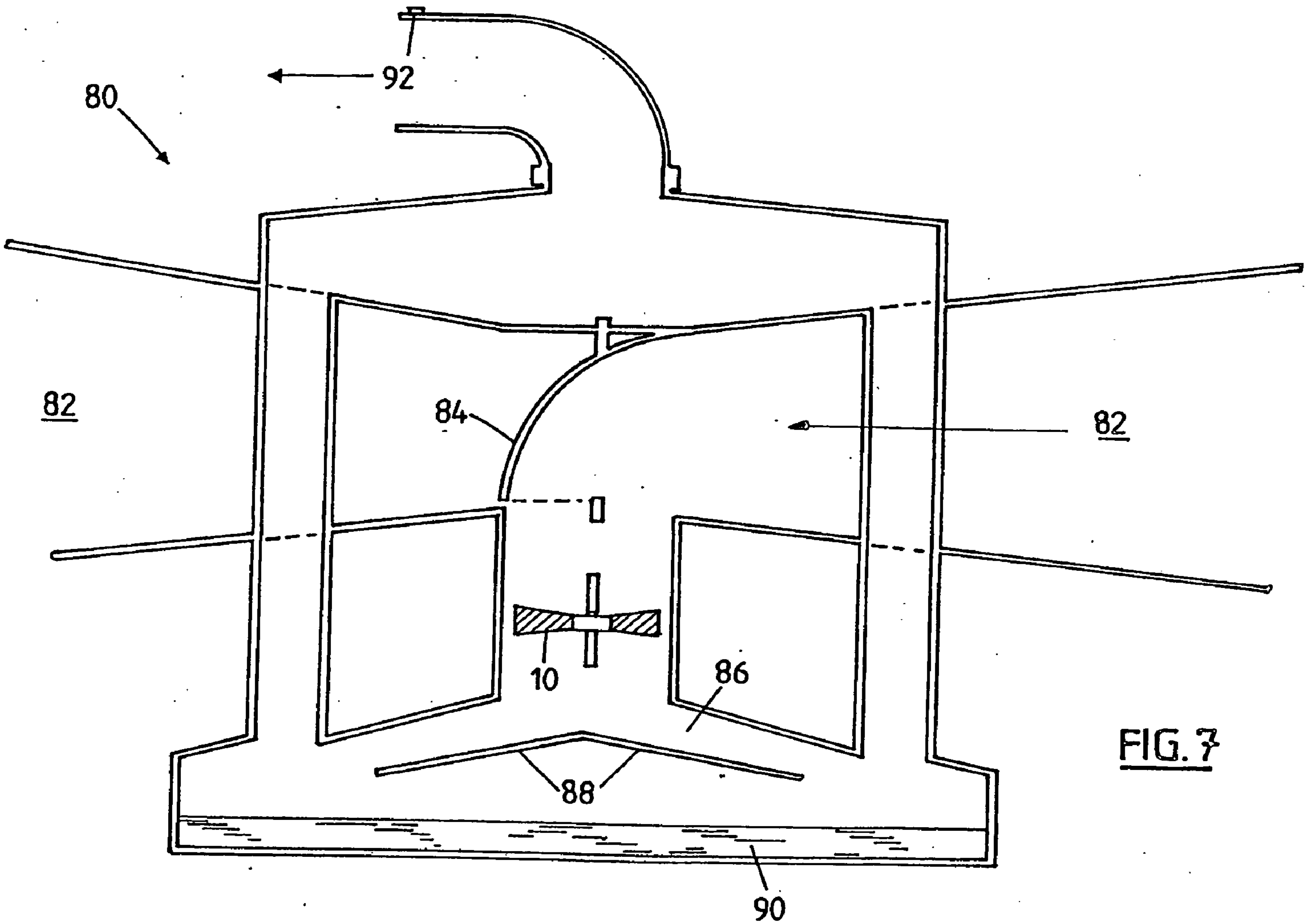


FIG. 7

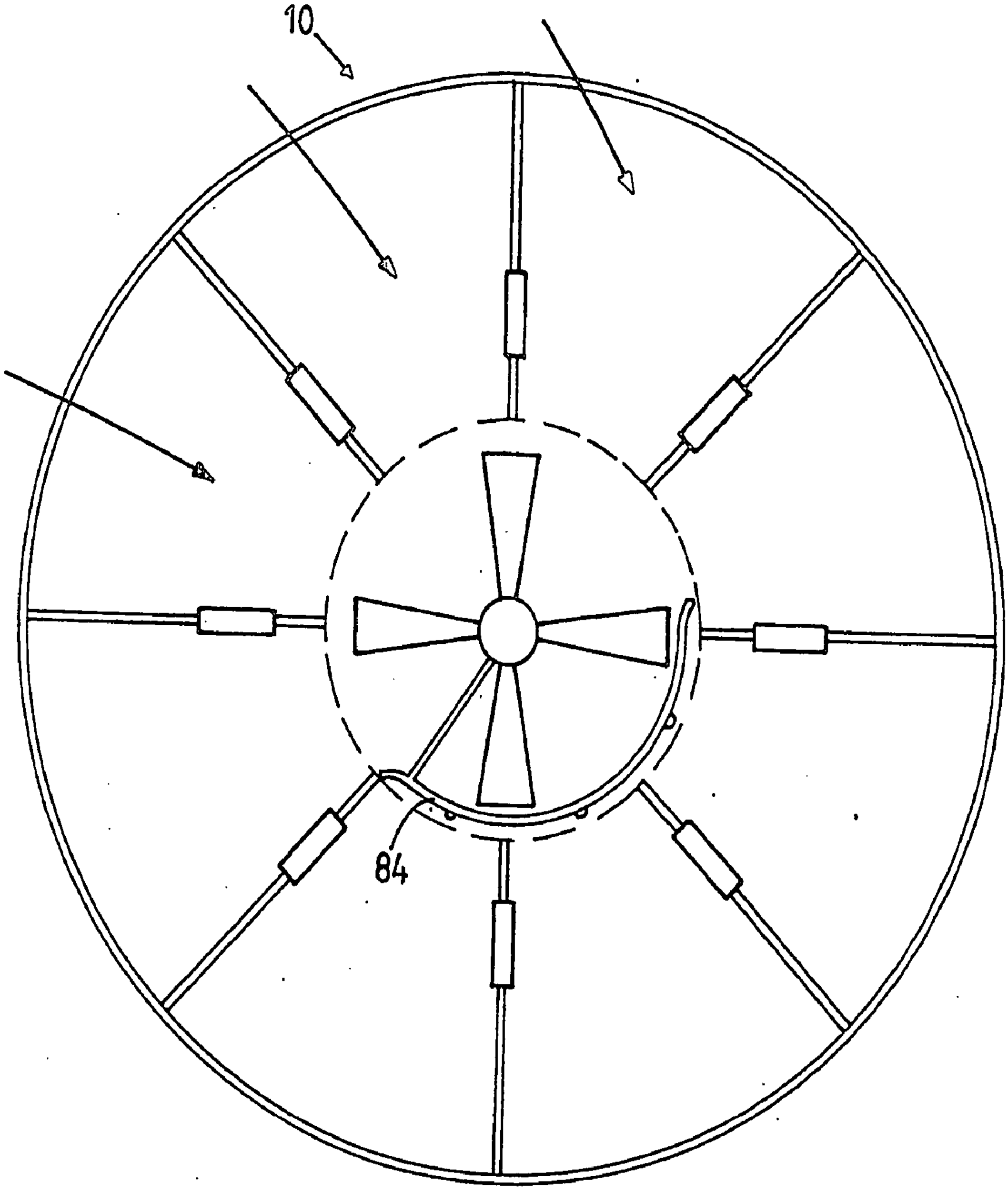


FIG. 8

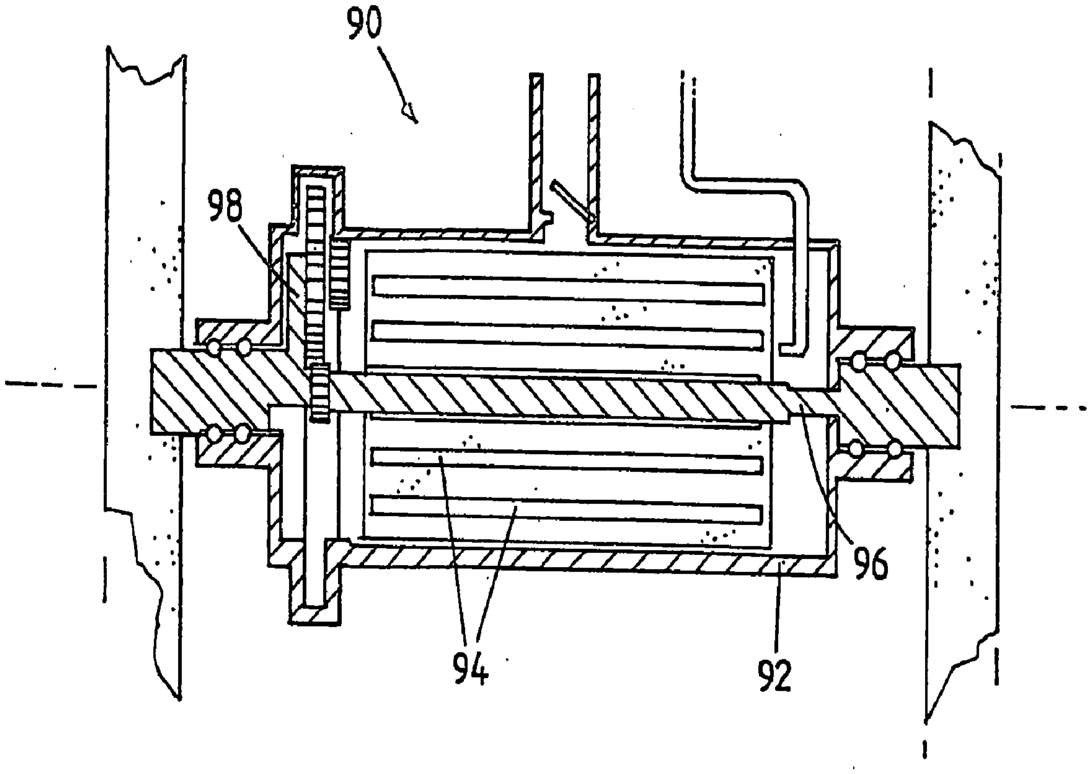


FIG. 9

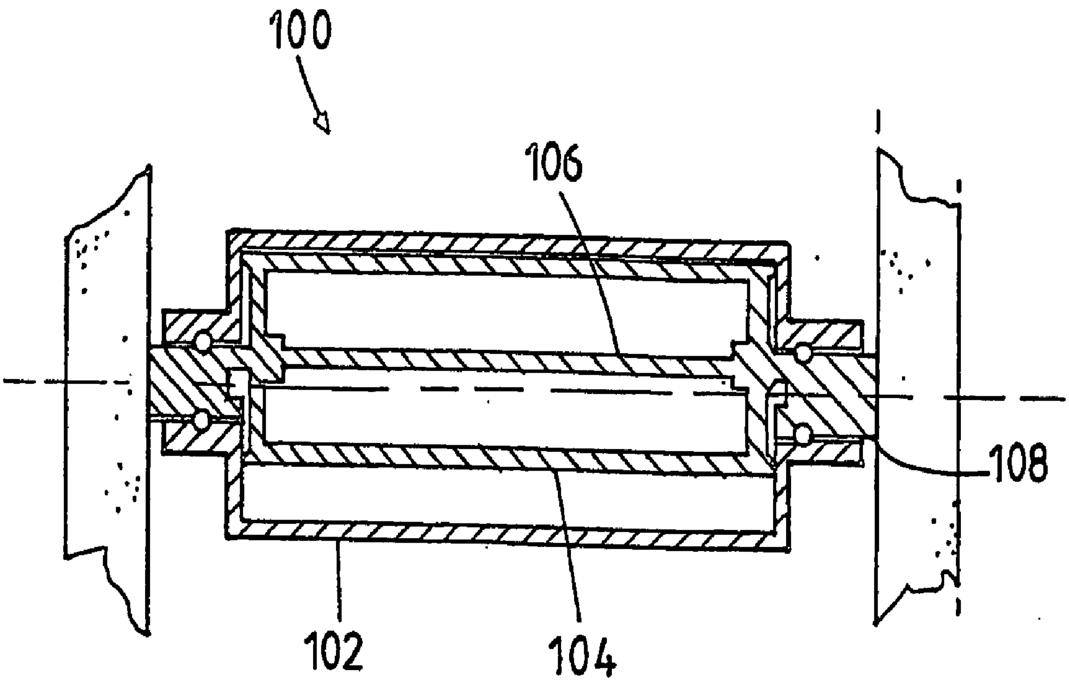


FIG. 10

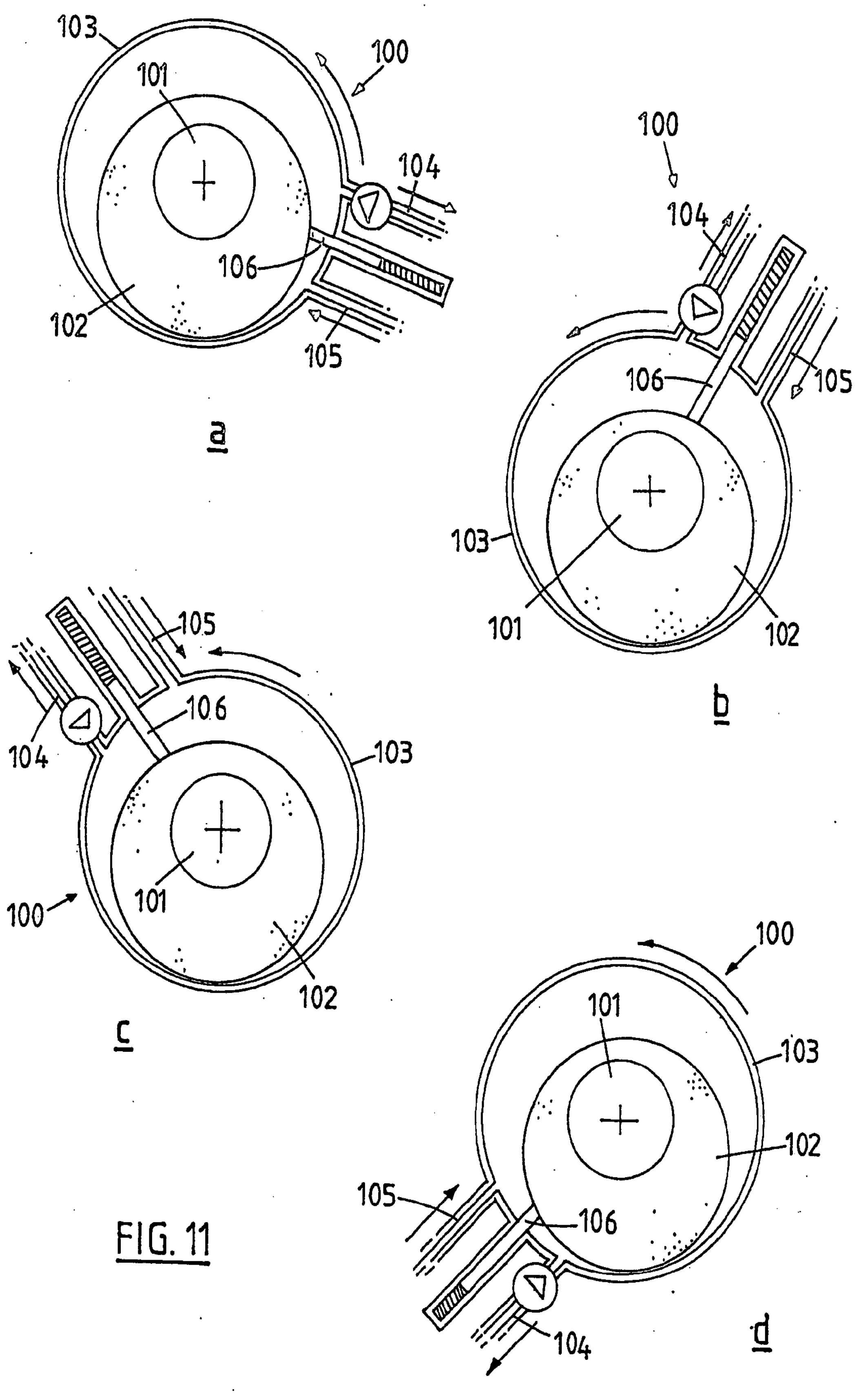

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FIG. 11

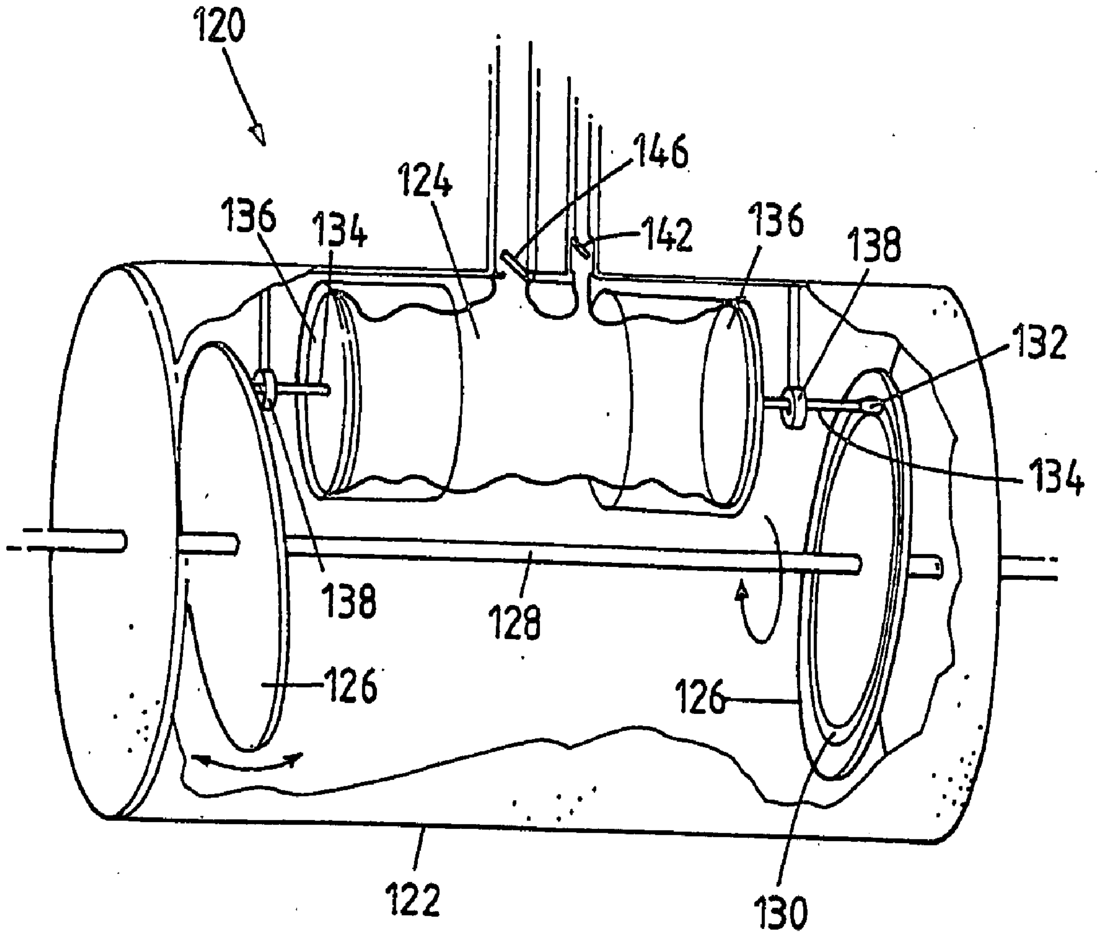

FIG. 12

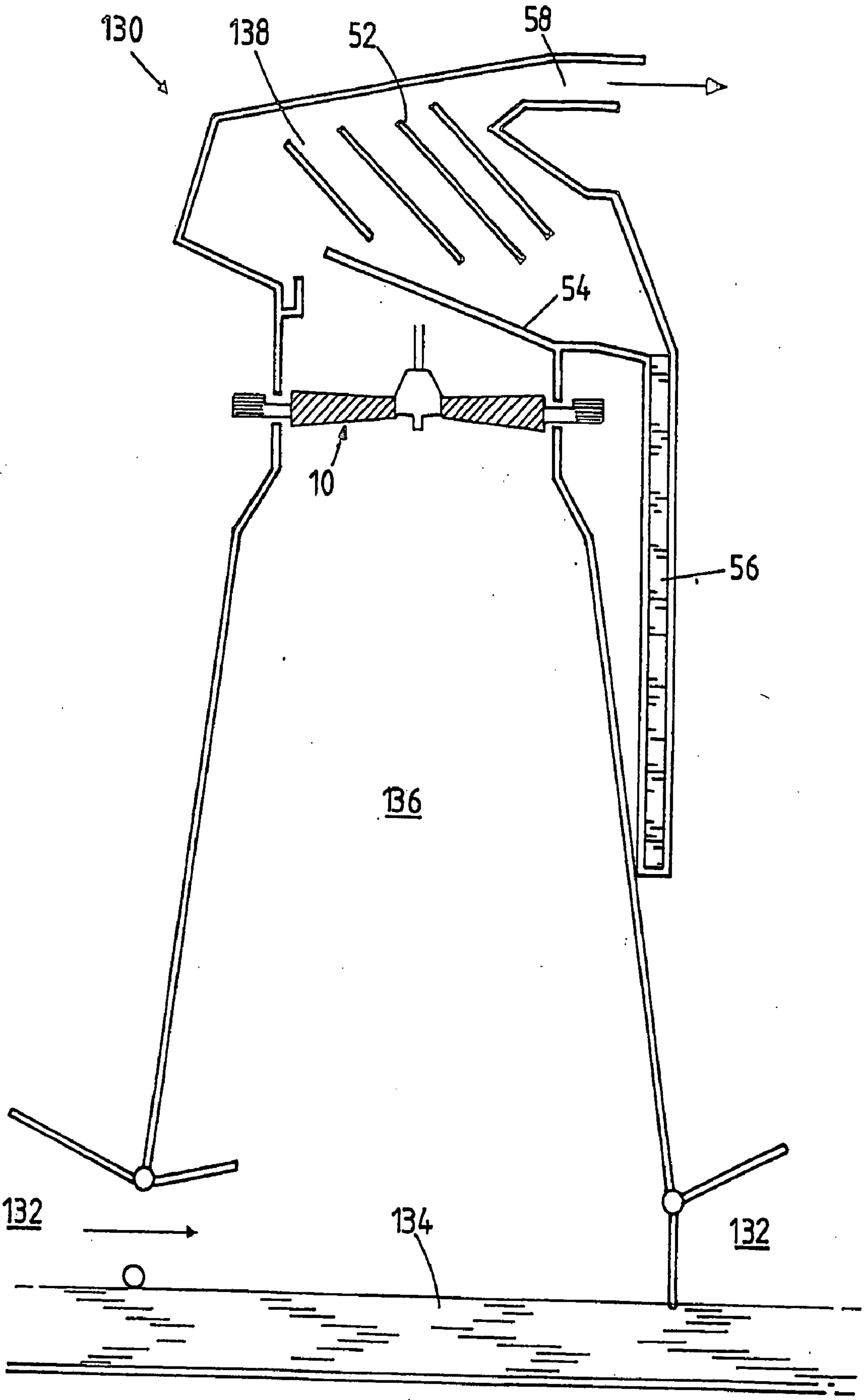

FIG. 13

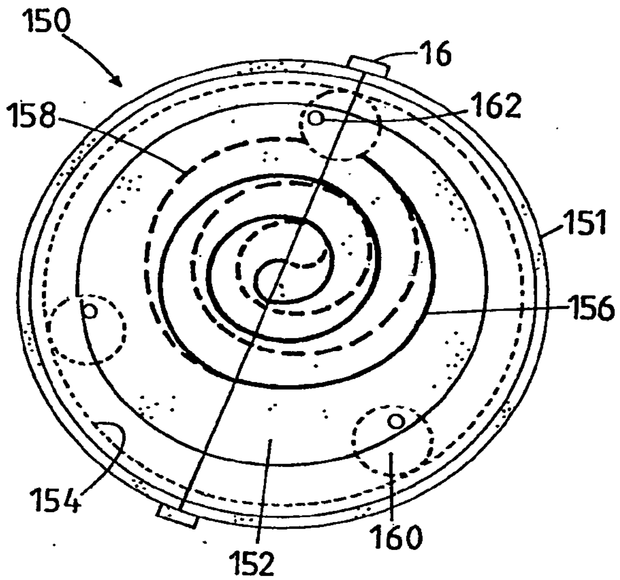

FIG.14a

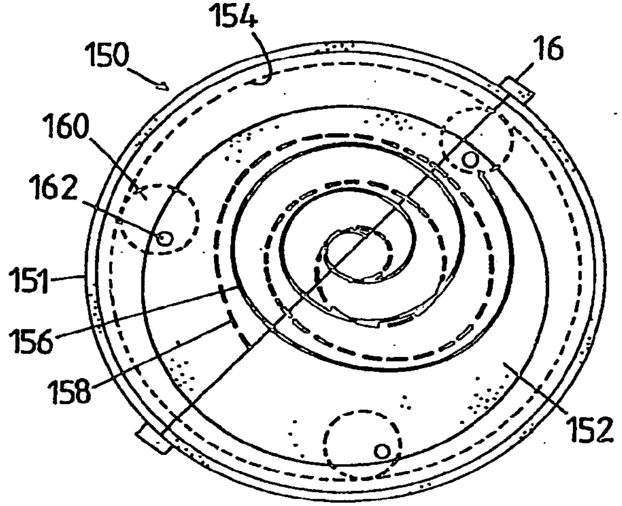

FIG.14b

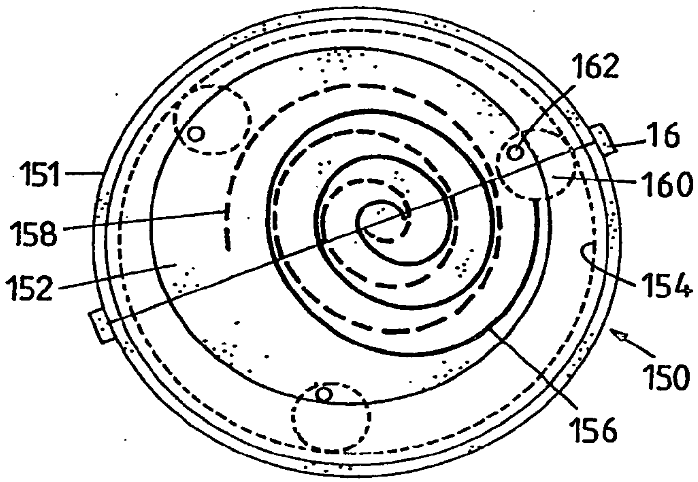

FIG.14c

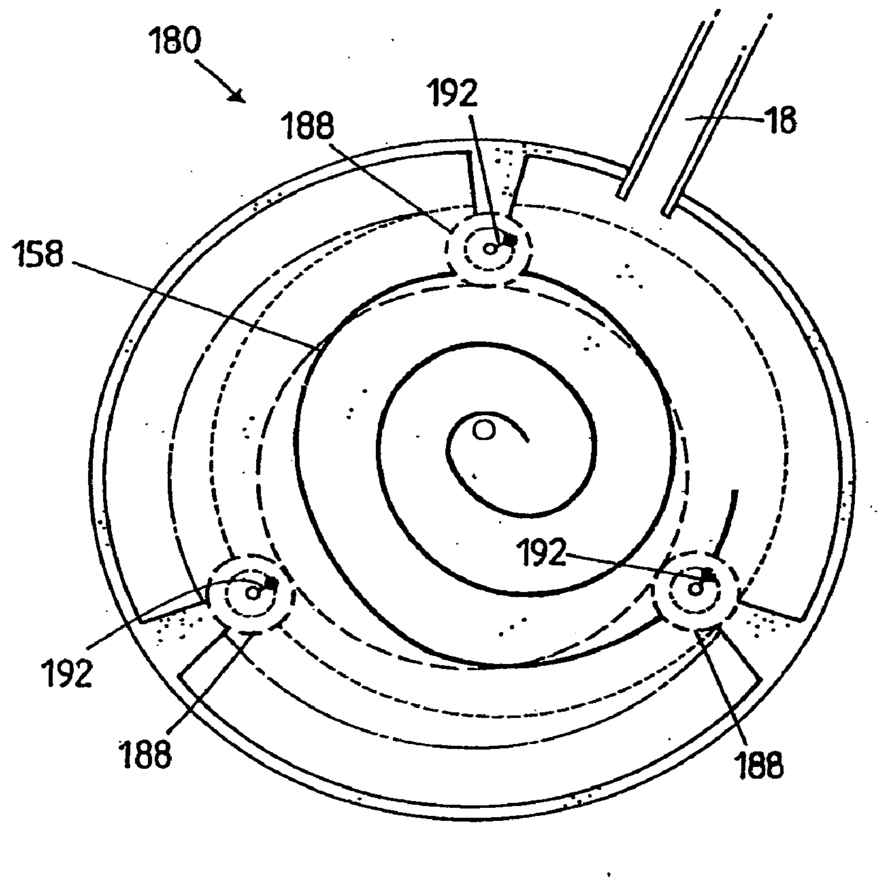

FIG.15a

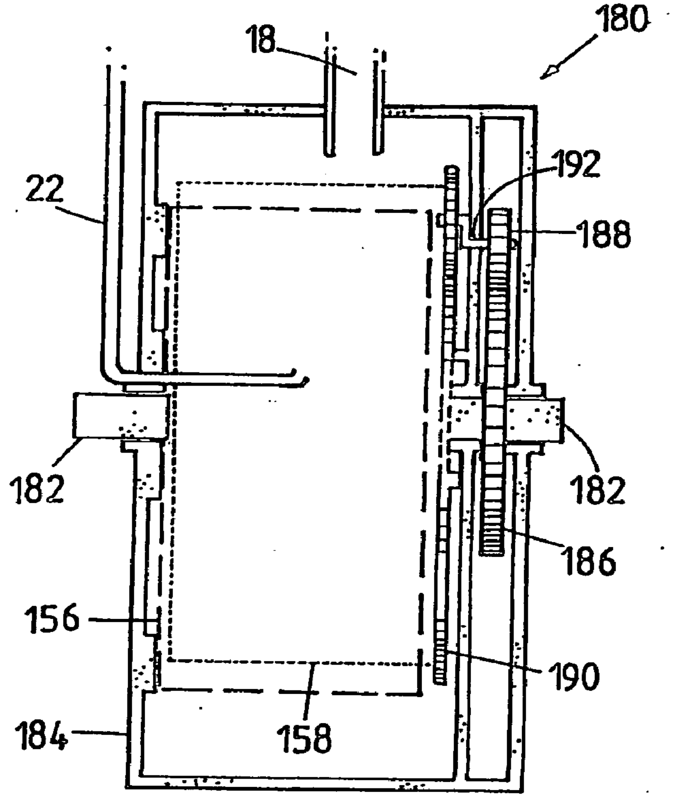

FIG. 15b

APPARATUS AND METHOD FOR COOLING OF AIR

FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus and method for cooling air.

SUMMARY OF THE INVENTION

[0002] In accordance with one aspect of the present invention there is provided a wind turbine apparatus for cooling of air characterised by comprising a wind turbine axially connected to a refrigeration compressor arranged to compress refrigerant, means for conducting compressed refrigerant centrifugally outwards, means for causing the compressed refrigerant to lose pressure so as to cool blades of the wind turbine, and means for returning spent refrigerant centripetally to the compressor.

[0003] In accordance with a further aspect of the present invention there is provided a method of condensing water from ambient air, which comprises driving, by means of ambient wind, a wind turbine apparatus in accordance with the present invention mounted in a duct by ambient wind so as to cause blades of the wind turbine to be cooled and to thereby cool ambient wind air passing through the duct and the wind turbine, and causing water vapour in the ambient wind air to condense to form liquid water, and collecting the liquid water.

[0004] In accordance with a yet further aspect of the present invention there is provided a wind turbine having at least one blade mounted to a compressor housing mounted on a shaft for axial rotation relative to the shaft, and means for conducting compressed refrigerant outward centrifugally and means for returning the refrigerant centripetally through the or each blade with loss of pressure and change of phase from liquid to gas so as to cool the or each blade.

DESCRIPTION OF THE DRAWINGS

[0005] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

[0006] FIG. **1** is a schematic plan view of a wind turbine of the present invention showing a single turbine blade;

[0007] FIG. **2** is a further schematic plan view similar to FIG. **1** showing a plurality of turbine blades;

[0008] FIG. **3** is a schematic side elevation of a first embodiment of an apparatus to convey air in accordance with the present invention;

[0009] FIG. **4** is a view similar to FIG. **3** showing a second embodiment of an apparatus of the present invention;

[0010] FIG. **5** is a side elevation of a third embodiment of an apparatus of the present invention;

[0011] FIG. **6** is a plan view of a further embodiment of a wind turbine of the present invention as used in the third embodiment of apparatus illustrated in FIG. **5**;

[0012] FIG. **7** is a side elevation of a fourth embodiment of an apparatus of the present invention;

[0013] FIG. **8** is a plan view of a yet further embodiment of a wind turbine of the present invention used in the fourth embodiment of apparatus illustrated in FIG. **7**;

[0014] FIG. **9** is a schematic side elevation of a compressor used in the air cooling apparatus of the present invention;

[0015] FIG. **10** is a schematic side-elevation of a further embodiment of a compressor used in the air cooling apparatus of the present invention;

[0016] FIGS. **11***a, b, c* and *d* are various views of the compressor of FIG. **10**;

[0017] FIG. **12** is a schematic side elevation of a yet further embodiment of a compressor used in the air cooling apparatus of the present invention;

[0018] FIG. **13** is a view similar to FIG. **3** showing a fifth embodiment of an apparatus of the present invention;

[0019] FIGS. **14**A, **14**B and **14**C show schematically a scroll refrigerant compressor useful in the present invention in various positions;

[0020] FIG. **15**A is a plan view of an alternative form of scroll compressor useful in the present invention; and

[0021] FIG. **15**B is a side view of the scroll compressor of FIG. **15**A.

DESCRIPTION OF THE INVENTION

[0022] In FIG. **1** of the accompanying drawings, there is shown a wind turbine apparatus **10** comprising a central shaft **12** having a compressor **13** comprising a housing **14** mounted thereabout. The compressor housing **14** is arranged to rotate axially relative to the shaft **12**. Further, a plurality of turbine blades **16** (only one of which is shown) are mounted to the compressor housing **14**. As shown, a tube **18** extends outwardly from the housing **14** to a peripheral cooling coil **20**. A convoluted pipe **22** extends from the cooling coil **20** back to the housing **14**. There is a constriction **23** at a part in the pipe **22** adjacent the cooling coil **20**.

[0023] In use, the turbine blade **16** is caused to rotate axially about the shaft **12** by the kinetic energy of ambient wind air. Rotation of the blade **16** causes rotation of the compressor housing **14** and refrigerant in the compressor housing **14** to be compressed so as to undergo a phase change from gas to liquid. The compressed liquid refrigerant flows outwardly driven by the compressor and assisted by centrifugal force along the tube **18** to the cooling coil **20** which acts as a manifold.

[0024] As shown, the refrigerant has to travel almost in a complete circle to reach the pipe **22**. This enables the compressed refrigerant to be cooled during its residence in the cooling coil **20**.

[0025] The refrigerant leaves the cooling coil **20** through the constriction **23** which leads into the pipe **22**. At this point the refrigerant undergoes a rapid loss of pressure and thus evaporates back to the gaseous phase and causes the blade **16** to be cooled. The spent refrigerant then passes centripetally back to the housing **14** on a low pressure line of the compressor **13**.

[0026] The cooling of the blade **16** causes ambient wind air to be cooled which has useful effects as will be described.

[0027] In FIG. **2**, there is shown an apparatus **30** similar to that in FIG. **1**. In FIG. **2** there can be seen a plurality of turbine blades **16**, a plurality of tubes **18**, a cooling coil **20** and a plurality of pipes **22**. In this embodiment, the compressed refrigerant passes along the tubes **18** to the cooling coil **20**. From the cooling coil **20** the compressed refrigerant passes through a plurality of short tubes **28** to an inner manifold **26**. From the inner manifold **26** the compressed refrigerant passes through the constrictions **23** into the tubes **22** as described hereinabove. Thus the compressed refrigerant does not enter the tubes **22** directly and therefore is cooled by its residence in the cooling coil **20** and the tubes **28** and the inner manifold **26**.

[0028] In FIG. **3**, there is shown an apparatus **40** which comprises a wind turbine **10**. There is also shown a respective inner manifold **26** adjacent an outer end of each blade **16**. The compressed liquid refrigerant passes initially from the cooling coil **20** to each inner manifold **26** through short tubes **28**. The refrigerant then passes through constrictions **23** into the pipes **22** as described hereinabove.

[0029] Further, there is shown in FIG. **3**, a wind collecting duct **42** and an outlet condensation chamber **44**. The duct **42** includes an outer wide portion **46** and an inner relatively narrow portion **48**. The combination of the wide portion **46** and the narrow portion **48** increases air velocity in the duct **42**.

[0030] Ambient wind air blowing in the direction of an arrow **50** flows through the wind turbine **10** so as to cause the latter to rotate such that the blades **16** are cooled. This causes the air temperature to fall below the condensation point or dew point and water vapour to condense from the ambient air to form liquid water. This is enhanced by the presence of baffles **52** which impede the flow of air and induce liquid water to collect thereon. The liquid water flows from the baffles **52** onto a sloping floor portion **54** from which the liquid water flows into a collection trough **56**. The cooled air from which water has been removed is exhausted through an upper outlet **58**. As can be seen in FIG. **3**, the coil **20** is located externally of the duct **42** so that heat lost from the compressed refrigerant is dispersed into the ambient air rather than inside the duct **42**.

[0031] In FIG. **4**, there is shown an apparatus **60** similar to that in FIG. **3**, except that an inlet **62** is lowermost and is provided with flaps **64**. In this case, the flaps **64** are only opened, as shown, on the windward side of the apparatus **60**. Wind air flows upwardly through the turbine **10** and then through a condensation chamber **66** to exhaust through a top vent **68**. Once again liquid water collects on baffles **52** and then flows along a sloping floor **54** to collect in a trough **56**.

[0032] In FIG. **5**, there is shown an apparatus **70** similar to that in FIG. **4**, except that the exhaust vent **68** is provided with an additional wind turbine **72** to reduce pressure in the exhaust vent **68** and enhance removal of exhaust air. Power obtained from the wind turbine is available for any useful purpose.

[0033] In FIG. **6**, there is shown a wind turbine **10** having wind guides **62** with flaps **64** between adjacent pairs of wind guides **62**. The flaps **64** are arranged to be opened as shown by the wider oblong shape when the flaps face in the direction of the ambient wind.

[0034] In FIG. **7**, there is shown an alternative form of the apparatus of the present invention

[0035] In this Figure there is shown an apparatus **80** having a funnel **82** at an intermediate level and a downwardly directed deviation device **84**. The device **84** is arranged to pivot about a substantially vertical axis so as to orientate itself, in use, into a position which is most effective in directing the ambient wind air through a wind turbine **10**. Cooled air can then enter a condensation chamber **86** below the wind turbine **10** and deposit moisture on baffles **88**. The deposited moisture can then flow into a collection trough **90**. The cooled air depleted of moisture can then pass upwardly to an upper vent **92**.

[0036] In FIG. **8**, there is shown a wind turbine **10** similar to that shown in FIG. **7**. As shown, the device **84** faces the incoming ambient wind. The wind air is directed into the wind turbine **10**.

[0037] In FIG. **9**, there is shown a preferred form of compressor **90** of the present invention. The compressor **90** has a central rotating cylindrical hub or housing **92** on which is mounted the blades **16** and refrigerant carrying tubes of the wind turbine **10** as described herein. The compressor **90** includes compressor blades **94** mounted on a drive shaft **96**. The blades **94** are arranged to be driven at high speed by a gear train **98** fitted to an inner wall of the hub **92**. Used refrigerant returning centripetally to the compressor **90** as described above is recompressed and sent out centrifugally as described above.

[0038] In FIG. **10** there is shown an alternative form of compressor **100** mounted within a cylindrical hub or housing **102**. In this embodiment refrigerant is displaced by a roller **104** mounted eccentrically on a shaft **106** relative to a main shaft **108** of the compressor **100**.

[0039] As shown in FIGS. **11***a*, **11***b*, **11***c* and **11***d*, the compressor **100** operates as follows. The compressor **100** comprises a central shaft **101** having an eccentric **102** mounted thereon. A rotatable housing **103** is mounted about the eccentric **102**. A tube **104** leads away from the housing **103** and a pipe **105** leads into the housing **103**. A spring biased vane **106** extends through a wall of the housing **103** and contacts an outer surface of the eccentric **102**. Rotation of the housing **103** causes refrigerant contained therein to be compressed and exited through the tube **104**. Similarly, used refrigerant returns to the housing **103** through the pipe **105**. This is facilitated by the vane **106** which is spring biased into engagement with the outer surface of the eccentric **102**.

[0040] In FIG. **12** there is shown a further alternative form of compressor **120** mounted within a cylindrical hub **122**. In this embodiment refrigerant is contained in an elastic chamber **124**. The chamber **124** is alternately contracted and expanded. This is done by eccentric discs **126** fixedly mounted on a central shaft **128**. Each disc **126** has a circular channel **130** formed on an inner side thereof A slidable bearing **132** is mounted in each channel **130**. A respective rod **134** extends from each bearing **132** to a respective end plate **136** of the chamber **124**. Each rod **134** is constrained by a circular guide member **138**.

[0041] In use, a hub **122** rotates axially about the shaft **128** and the chamber **124** rotates with the hub **122**. This movement causes the bearings **132** to slide in the channels **130** and the rods **134** to reciprocate correspondingly in the guide member **138**. In this way the chamber **124** is expanded and retracted so alternately compressing and driving out compressed refrigerant through a one way valve **140** and allowing ingress of used refrigerant through a one way valve **142**.

[0042] In FIG. **13**, there is shown a wind turbine apparatus **130** which is similar to that shown in FIGS. **4** and **5**. In this embodiment, wind funnels **132** are arranged to direct ambient wind air over a water surface **134**. The water may be brackish or fresh water. The wind air then passes upwardly through an upright tube **136** (or a sloping duct on a hillside) to pass through a wind turbine **10** and thence a condensation chamber **138** having baffles **52** and a sloping floor **54** from which water flows into a collection trough **56**. Exhaust air is vented through an outlet **58**. Absolute humidity of air entering the apparatus **130** increases and the density of the air is therefore lowered. Thus, flow of air due to the wind is augmented by convection as the wet air rises to the wind turbine **10**.

[0043] It is also envisaged that the refrigeration compressor used in the apparatus of the present inventions could be in the form of a scroll compressor.

[0044] This embodiment of the present invention is illustrated in FIGS. **14**A, **14**B and **14**C of the accompanying drawings.

[0045] In FIG. **14** there is shown a scroll compressor **150** having a housing **151** having mounted therein a circular plate **152**. Further, an internal ring gear **154** mounted on a wind turbine axial shaft (not shown) extends around the internal periphery of the housing **151**. Turbine blades **16** are mounted to the housing **151** and cause wind to effect axial rotation of the housing **151** on a fixed shaft (not shown).

[0046] The housing **151** is rotated, in use, by rotation of blades of a wind turbine as described hereinabove.

[0047] As indicated above, the scroll compressor **150** is mounted on a bearing on the fixed axial shaft (not shown). One scroll **156** is attached to the housing **151** whilst another **158** is driven by three planetary gears **160** mounted on the housing **151** disposed at the apex of an equilateral triangle. The gears **160** are driven by the ring gear **154**. The scroll **158** maybe described as a wobbling scroll.

[0048] The gears **160** are asymmetrically connected to the plate **152** by means of respective pivotal connections **162**. In use the housing **151** is axially rotated by the wind turbine. This causes the planetary gears to be turned by engagement with the fixed ring gear **154**. This causes the ring gear **154** to rotate and thereby cause rotation of the planetary gears **160**. Rotation of the planetary gears **160** causes the plate **152** to move in a wobbling motion which causes the scroll **158** to move correspondingly.

[0049] As shown in FIGS. **14**A to **14**C this causes gaps between the two scrolls **156** and **158** to be alternately opened up and closed in a progressive manner. This action leads to compression of refrigerant vapour contained between the scrolls such that the vapour is subjected to increased pressure and is converted-to liquid form.

[0050] As described hereinabove, the compressed liquid refrigerant is thus urged outwardly of the compressor housing **151** through a tube (not shown) by centrifugal-force. Further, as described hereinabove, the spent refrigerant returns through pipes (not shown) to the interior of housing **151** where it enters the gap between the scrolls **156** and **158**.

[0051] In FIGS. **15**A and **15**B there is shown an alternative arrangement of scroll compressor **180** useful in the present invention compared to the scroll compressor of FIG. **14**. Like reference numerals denote like parts. It should be noted in FIG. **15**A that only the scroll **158** is shown.

[0052] In this embodiment there is a central shaft **182** having mounted thereon a housing **184**. The housing is mounted on a bearing on the shaft **182**. The shaft **182** may or may not be continuous. A central gear wheel **186** is fixedly mounted about the shaft **182**. The gear wheel **186** is connected to three planetary gears **188**.

[0053] Further, as can be seen in FIG. **15**B one scroll **156** is fixed to the housing **184** by any suitable means such as an end plate (not shown). The other scroll **158** is mounted on an end plate **190** and is connected to the planetary gears **188** through eccentric pins **192**.

[0054] The shaft **182** and the gear wheel **186** are fixed in position. The housing **184** is arranged to rotate about the shaft **182** as described hereinabove. The planetary gears **188** engage with the gear wheel **186** and are thereby caused to rotate as the housing **184** rotates. This rotation of the planetary gears **188** causes the scroll **158** to move on the plates **190** by means of the pins **192** such that the scroll **158** undergoes a wobbly motion as described hereinabove.

[0055] Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention.

1. A wind turbine apparatus for cooling of air comprising a wind turbine axially connected to a refrigeration compressor arranged to compress refrigerant, means for conducting compressed refrigerant centrifugally outwards, means for causing the compressed refrigerant to lose pressure so as to cool blades of the wind turbine, and means for returning spent refrigerant centripetally to the compressor.

2. An apparatus according to claim 1, wherein the apparatus comprises a central shaft and the refrigeration compressor has a housing which is mounted about the shaft, the compressor housing being arranged to rotate axially relative to the shaft.

3. An apparatus according to claim 2, wherein a plurality of turbine blades are mounted on the housing and extend away therefrom.

4. An apparatus according to claim 3, wherein tube means extends outwardly from the housing and interconnects with a peripheral coil.

5. An apparatus according to claim 4, wherein the coil is disposed externally of the apparatus so as to radiate heat to the ambient air

6. An apparatus according to claim 4 or 5, wherein a respective return pipe extends from the coil through one or more turbine blades, the or each return pipe being provided adjacent the coil with a constriction so as to cause the refrigerant to undergo loss of pressure and the turbine blades to be cooled, the spent refrigerant then returning centripetally back to the housing on a low pressure side of the compressor.

7. An apparatus according to claim 1, wherein there is provided a wind collecting device into which ambient wind air flows, the wind collecting device contains the wind turbine and the ambient wind air causes the wind turbine to rotate so as to cause refrigerant to be compressed by the refrigeration compressor and to flow outwardly under centrifugal force and return centripetally to the refrigeration compressor to cause cooling of the blades so as to cause water vapour in the ambient wind air to condense to form liquid water.

8. An apparatus according to claim 7, wherein the wind collecting device comprises an inlet funnel upstream of the wind turbine and an outlet condensation chamber downstream of the wind turbine, and an intermediate portion narrower than the inlet funnel, the intermediate portion containing the wind turbine.

9. An apparatus according to claim 8, wherein the condensation chamber comprises a baffle to enhance condensation of water from the ambient air.

10. An apparatus according to claim 8 or 9, characterised in that the outlet condensation chamber is provided with means for collecting liquid water condensed from the ambient wind air.

11. An apparatus according to claim 8, wherein the duct is provided with flaps which are arranged to be opened when facing windward.

12. An apparatus according to claim 8, wherein the outlet condensation chamber has an outlet vent provided with an additional wind turbine to reduce pressure in the outlet vent and enhance removal of exhaust air.

13. An apparatus according to claim 8, wherein the wind turbine has adjacent pairs of wind guides with respective flaps therebetween, the flaps being arranged to be opened when facing in the direction of ambient wind.

14. An apparatus according to claim 8, wherein there is provided a deviation device arranged to pivot about a substantially vertical axis so as to orientate itself, in use, into a position which is most effective in directing ambient wind through the wind turbine.

15. An apparatus according to claim 1, wherein the refrigeration compressor has a central rotatable housing having blades provided therein, the refrigeration compressor further comprising compressor blades mounted on a drive shaft, the compressor blades being arranged to be driven by a gear train fitted to an inner wall of the housing.

16. An apparatus according to claim 1, wherein the housing of the refrigeration compressor comprises a housing containing an eccentrically mounted roller.

17. An apparatus according to claim 1, wherein the refrigeration compressor comprises a housing containing an elastic chamber containing refrigerant which elastic chamber is arranged to be alternately contracted and expanded.

18. An apparatus according to claim 1, wherein the refrigeration compressor comprises a housing containing a scroll compressor.

19. A method of condensing water from ambient air which comprises driving, by means of ambient wind, a wind turbine apparatus in accordance with claim 1, mounted in a duct so as to cause blades of the wind turbine to be cooled and to thereby cool ambient wind air passing through the duct and the wind turbine, and causing water vapour in the ambient wind air to condense to form liquid water, and collecting the liquid water.

20. A wind turbine having at least one blade mounted to a refrigeration compressor housing mounted on a shaft for axial rotation relative to the shaft and means for conducting compressed refrigerant centrifugally outward and means for returning the refrigerant centripetally through the or each blade with loss of pressure and change of phase of the refrigerant from liquid to gas so as to cool the or each blade.

* * * * *