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(54) Title: APPARATUS FOR CATALYSING A REACTION IN A FLUID MATERIAL

(57) Abstract: Apparatus (10) for catalysing a reaction in a fluid material comprises an impeller (12) to impel the fluid material. The impeller (12) has a plurality of impeller members (18) comprising a photocatalytic material. The apparatus (12) further includes irradiation means (14) to irradiate the impeller members (18) with electromagnetic radiation to allow the plastic catalytic material to catalyse the reaction.



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Apparatus for Catalysing a Reaction in a Fluid Material

This invention relates to apparatus for catalysing reactions in fluid
5 materials.

In many buildings for example office buildings, it is necessary to provide adequate air quality and thermal comfort for building occupants. Air entering a building is contaminated with pollutants. It is necessary to ensure that the air
10 entering the building is clean and that all of these pollutants are removed. The pollutants may include such things as cigarette smoke, traffic fumes, and harmful bio-materials such as bacteria. Generally, such pollutants are removed by the use of scrubbing devices.

15 According to one aspect of this invention there is provided apparatus for catalysing a reaction in a fluid material, the apparatus comprising an impeller to impel the fluid material, the impeller having a plurality of impeller members comprising a photocatalytic material, and the apparatus further including irradiation means to irradiate the impeller members with electromagnetic
20 radiation to allow the photocatalytic material to catalyse the reaction.

Preferably, the impeller is a rotary impeller which may comprise a rotary shaft. The impeller members are desirably provided on the shaft. The impeller members may extend outwardly from the shaft, preferably radially outwardly
25 therefrom.

Each impeller member may comprise a flexible elongate member which may be coated with said photocatalytic material. Each elongate member may comprise a filament. The impeller may comprise a mop fan.

30

The apparatus may further include drive means to rotatably drive the impeller. Preferably, the drive means is drivingly connected to the shaft to effect said rotary motion of the impeller.

The irradiation means may comprise a source of electromagnetic radiation. Alternatively, the irradiation means may comprise means for allowing external electromagnetic radiation, for example solar radiation, to irradiate the
5 impeller members.

Where the irradiation means comprises a source of electromagnetic radiation, the irradiation means may comprise a source of ultraviolet light, for example UVA or UVC light. The irradiation means may comprise ultraviolet
10 illumination means, such as an ultraviolet lamp. The lamp may be a fluorescent ultraviolet lamp. In some embodiments, the ultraviolet lamp may comprise a fluorescent ultraviolet tube.

In one embodiment, the source of electromagnetic radiation is arranged
15 externally of the impeller. In another embodiment, the impeller members may comprise fibre optic cables. In this embodiment, the source of electromagnetic radiation may be provided centrally of the impeller, preferably within the shaft.

The apparatus preferably includes a casing to house the impeller and the
20 irradiation mean. The casing may have a reflective internal surface to reflect the electromagnetic radiation onto the impeller members.

The casing preferably includes an inlet to direct the fluid material onto the impeller members. The inlet is conveniently an axially extending inlet, arranged
25 axially of the impeller, preferably generally parallel to the shaft. The casing may further include an outlet to exhaust the fluid material from the apparatus.

The photocatalytic material is preferably a material which is sensitive to ultraviolet light. The photocatalytic material is preferably titanium dioxide.
30

The apparatus is preferably a gas cleaning apparatus. The gas to be cleaned may be air. The apparatus is advantageously suitable for cleaning the gas by catalysing a reaction of matter in the gas, for example pollutants in the

gas. The reaction may be an oxidation reaction.

5 In one embodiment, the apparatus comprises air cleaning apparatus for catalysing a reaction of pollutants carried in the air, for example by oxidising the pollutants. The pollutants may be oxidised to carbon dioxide and water.

A reaction catalysed by the photocatalytic material may be the inactivation of airborne bio-material, for example fungi, spores, viruses and bacteria.

10

According to another aspect of this invention there is provided apparatus for catalysing a reaction in a fluid material, the apparatus comprising a heat exchanger comprising a first conduit for the flow of a first fluid material therethrough, a second conduit for the flow of a second fluid material
15 therethrough, the first and second conduits being arranged in heat exchange relation with each other, wherein the first conduit has a surface comprising a photocatalytic material to catalyse a reaction in the first fluid material, and the apparatus further including irradiation means to irradiate said surface of the first conduit with electromagnetic radiation to allow the photocatalytic material to
20 catalyse the reaction.

In one embodiment, the first and second conduits have respective surfaces comprising said photocatalytic material, and the irradiation means may irradiate said surfaces of the first and second conduits with electromagnetic
25 radiation to allow the photocatalytic material to catalyse the reaction.

In another embodiment only the first conduit comprises a surface comprising said photocatalytic material. In this embodiment, the irradiation means may irradiate only the surfaces of the first conduit.

30

Preferably, the surface of the, or each, conduit is coated with the photocatalytic material.

Preferably, the heat exchanger comprises a plurality of said first conduits and a plurality of said second conduits. Each of said first conduits preferably has a respective surface comprising said photocatalytic material, and each of said
5 surfaces of the first conduits is conveniently coated with the photocatalytic material. In one embodiment, each of the second conduits preferably has a surface comprising said photocatalytic material and each of the surfaces of the second conduits is conveniently coated with the photocatalytic material. In another embodiment, only the first conduits have surfaces comprising said
10 photocatalytic material.

The heat exchanger may be a plate heat exchanger, wherein first and second conduits are formed by at least one planar member, preferably by a plurality of planar members, which may be arranged in generally parallel relation
15 with each other.

The irradiation means may comprise a source of electromagnetic radiation. Alternatively, the irradiation means may comprise means for allowing external electromagnetic radiation, for example solar radiation to irradiate the, or
20 each, surface.

Where the irradiation means comprises a source of electromagnetic radiation, the irradiation may comprise a source of ultraviolet light, for example UVA or UVC light. The irradiation means may comprise an ultraviolet lamp. The
25 lamp may be a fluorescent ultraviolet lamp.

The photocatalytic material is preferably a material which is sensitive to ultraviolet light. The photocatalytic material is preferably titanium dioxide.

30 The heat exchanger is preferably suitable for cleaning a gas. The gas to be cleaned may be air. The heat exchanger is preferably suitable for cleaning the gas by catalysing a reaction of matter in the gas, for example pollutants in the gas. The reaction may be oxidising reaction.

In one embodiment, the heat exchanger is for cleaning air by catalysing a reaction of pollutants carried in the air, for example by oxidising the pollutants. The pollutants may be oxidised to carbon dioxide and water.

5

According to another aspect of this invention, there is provided a heat transfer assembly comprising: a heat exchanger comprising a first conduit for the flow of a first fluid material therethrough, the first conduit having a surface, and the heat exchanger further including a second conduit for the flow of a second
10 fluid material therethrough, the first and second conduits being arranged in heat exchange relation with each other, whereby heat can be transferred between said first and second fluids; an impeller to impel the first fluid material through the first conduit; wherein either or both of the surface of the first conduit and at least part of the impeller comprises a photocatalytic material to catalyse a reaction in
15 the first fluid material; the assembly further including irradiation means to irradiate the photocatalytic material with electro-magnetic radiation to catalyse the reaction.

Preferably, the heat exchanger is a heat exchanger as described above

20

The impeller may include at least one impeller member to impel the fluid as aforesaid. Preferably the impeller includes a plurality of said impeller members to impel the fluid as aforesaid. The, or each, impeller member may comprise said photocatalytic material. The impeller is advantageously an
25 impeller as described above.

The impeller may be a fan for driving air. In the preferred embodiment, the impeller may be a mop fan.

30

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, in which;

Fig. 1 shows a first embodiment of an apparatus for catalysing a reaction

in a fluid material;

Fig. 2 shows a second embodiment of an apparatus for catalysing a
5 reaction in a fluid material;

Fig. 3 shows a third embodiment of an apparatus for catalysing a reaction
in a fluid material;

10 Fig. 3A shows another embodiment of the apparatus shown in Fig. 3;

Fig. 4 shows a sectional side view of the second embodiment of the
apparatus;

15 Fig. 5 shows a sectional view of an impeller member used in the
embodiment shown in Figs. 2 and 4;

Fig. 6 shows a first embodiment of a heat transfer assembly; and

20 Fig. 7 shows a second embodiment of heat transfer assembly.

Referring to Fig. 1, there is shown a first embodiment of an apparatus 10
for catalysing a reaction in a fluid material. The apparatus 10 comprises an
impeller 12, in the form of a mop fan, and a UV lamp 14.

25

The impeller 12 comprises a shaft 16 upon which is mounted a plurality of
radially outwardly extending impeller members in the form of filaments 18. The
shaft 16 is drivingly connected to a motor 20 for rotatably driving the shaft 16 and
the filaments 18 in the direction indicated by the arrow A.

30

The impeller 12 further includes a casing 22 having an axial inlet conduit
24 through which a first fluid to be cleaned, for example air, can be supplied, as
shown by the arrow B. The casing 22 also includes an outlet conduit 26 through

which cleaned air can be exhausted, as shown by arrow C. As can be seen, the casing 22 is generally circular in configuration.

5 The inner surface of the casing 22 is coated with a reflective material to reflect light from the UV lamp 14 onto the filaments 18. The UV lamp is held within the casing 22 and is connected to a supply of electricity (not shown). Each of the filaments 18 is formed of a flexible plastics material, and each filament 18 is coated with a photocatalyst in the form of titanium dioxide.

10 In operation, the motor 20 is switched on to rotate the shaft 16 in the direction of the arrow A which, in turn, causes corresponding rotation of the filaments 18. The UV lamp 14 is switched on, to bathe the filaments in UV light. The UV light can be UVA and/or germicidal UVC light.

15 Air, which is contaminated with pollutants, passes through the inlet pipe 24 to the filaments 18 of the impeller 12.

20 The pollutants in the air fed via the inlet conduit 24 react with water and oxygen in the air on the filaments 18. The reaction is catalysed by the titanium dioxide photocatalyst coating, and results in the pollutants breaking down to form generally harmless materials which can easily be dealt with, for example with carbon dioxide and water. The cleaned air is then exhausted via the outlet conduit 26.

25 A modification of the apparatus shown in Fig. 1 is shown in Figs. 2 and 4, which includes many of the same the features as the apparatus shown in Fig. 1, and these have been designated with the same reference numerals.

30 The apparatus shown in Figs. 2 and 4 differs from that shown in Fig. 1 in that the UV lamp 14 is omitted, and the shaft 16 is replaced by a hollow transparent rotatable tubular member 116. An ultraviolet fluorescent tube 114 is mounted axially within the tubular member 116. Also, the filaments 18 are

replaced by fibre optic filaments 118.

5 The tubular member 116 is connected to the motor 20 to be rotatably driven thereby. The ultraviolet fluorescent tube 114 is connected to a supply of electricity via the motor 20. In operation, the motor 20 is switched on which causes the impeller 12 to rotate and also lights the fluorescent tube 114. Fig. 5 shows a section of one of the fibre optic filaments 11A which is coated with a coating 120 of titanium dioxide. When the ultraviolet fluorescent tube 114 is
10 switched on, light is directed down the fibre optic filament in the directions as shown by the arrow D. As the light is reflected off the inner surface of the optical fibre 118, the titanium dioxide photocatalyst coating 120 is activated by the ultraviolet light enabling the above described reaction to take place.

15 Referring to Fig. 3 there is shown a heat exchanger 60 comprising a plurality of generally rectangular plates 62 arranged in a parallel array, and connected by a plurality of first wall members 64 along a first pair of opposite edges 65 of the plate 62. The plates 62 are also connected by a plurality of second wall members 66 along a second pair of opposite edges 67 of the plates
20 62. The first and second wall members 64, 66 alternate with each other to define a plurality of first and second conduits 68, 70. The plurality of first conduits 68 are for the flow of a first fluid, such as air, through the heat exchanger 60, and the plurality of second conduits 70 are for the flow of a second fluid, such as air, through the heat exchanger 60. The first and second conduits 68, 70 are
25 arranged in heat exchange relation with each other via the plates 67, but are physically isolated from one another so that fluid flowing through the first conduits 68 cannot pass across into air flowing through the second conduits 70.

Each of the first and second conduits 64, 66 comprises respective heat
30 exchange surfaces 72, 73. The surfaces 72 of the first conduits 68 are coated with a photocatalytic material, for example titanium dioxide. An ultraviolet lamp 74 is provided to illuminate the surfaces 72 of the first conduits 68. Thus any pollutants in the air passing through the first conduits 68 will react on the titanium

dioxide photocatalyst to form harmless products, in the same way as described above. If desired, the surfaces 73 of the second conduits 70 can also be coated with a photocatalyst such as titanium dioxide, and a suitable ultraviolet lamp 76
5 may be provided to illuminate the surface, 73 of the second conduits 70. Thus, if air entering the second conduits 70 is contaminated with pollutants these can be converted into harmless reaction products.

In one embodiment, shown in Fig. 3A, the heat exchanger 60 may be
10 housed within a housing 80 to provide a heat exchange assembly 100. The housing 80 has a first inlet 82 for the inlet of the first fluid into the first conduits 68, and a first outlet 84 for the outlet of the first fluid. The housing 80 also defines a second inlet 86 opposite the first inlet 82 for the inlet into the second conduits 70 of the second fluid, and a second outlet 88 for the second fluid.

15 An ultraviolet lamp 74 is provided within the housing 80 for illuminating the surfaces of the first conduits 68 with ultraviolet light to perform the same function as described above with reference to Fig. 3. A further ultraviolet lamp 76 may also be provided, if desired, within the housing 80 for illuminating the surfaces of
20 the second conduits 70 with ultraviolet light.

The plates 62 of the heat exchanger shown in Figs 3 and 3A are of a rectangular configuration. The plates 62 can be of any other suitable configuration, for example hexagonal, circular or the like.

25 Also, the direction of the air flowing through the first and second conduits of the heat exchanger 60 is a cross-flow direction. The heat exchanger 60 can be modified so that the flow of air through the first and second conduits 68, 70 is a counter-flow direction, i.e. flowing in opposite directions, or in a parallel flow
30 direction i.e. flowing in the same direction

Referring to Figs. 6 and 7, there is shown two embodiments of heat transfer apparatus 200. In Fig. 6, the apparatus 200 comprises a heat

exchanger 202 and first and second impellers or fans 204, 206.

5 The heat exchanger 202 and the first and second impellers 204, 206 are enclosed within a casing 208 having a first inlet 210 for a first fluid, a first outlet 212 for the first fluid, a second outlet 214 for the second fluid, and a second outlet 216 for the second fluid. The first fluid may originate as cold, contaminated air from outside a building and the second fluid may originate as warm air from inside the building

10

The first and second impellers 204, 206 may be generally in the form of mop fans i.e. similar to the impellers 10 described above in connection with Fig. 1 or 2. However, only the first impeller 204, is provided with flexible members coated with a photocatalyst, such as titanium dioxide. In the embodiment shown in Fig. 6, the first impeller 204 is in the form of an impeller 10 as shown in Fig. 2. Thus, the impeller 10 comprises flexible outwardly extending filaments 118 in the form of optical fibres. The filaments are mounted on an axially hollow, rotatable tubular member having an ultraviolet fluorescent tube axially mounted therein to illuminate the optical fibres with ultraviolet light.

20

The heat exchanger 202 is similar in construction to the heat exchanger 50 shown in Fig. 3 but the surfaces 72, 73 of the first and second conduits 68, 70 therefore are not coated with a photocatalyst. Thus, an ultraviolet lamp is not required to illuminate the surfaces of the conduits.

25

In use, cold contaminated air from outside a building enters the heat transfer apparatus 200 via the first inlet 210, as shown by the arrow E. The air passes through the first conduits 68 of the heat exchanger 202. At the same time, warm air from inside the building passes into the second inlet 216 as shown by the arrow F. This air passes through the second impeller 204 to be driven thereby out of its air exit 218 thereof to the heat exchanger 202. The air from the second impeller 206 passes through the second conduits 70 of the heat exchanger 202.

30

The first and second conduits 68, 70 are arranged in heat exchange relation with each other, so that heat is transferred from the air passing through the second conduit 70 to the air passing through the first conduits 68. As a result, the air passing through the first conduits 68 is warmed and the air passing through the second conduits 70 is cooled.

The air from the first conduits 68, then enters the first impeller 204 via its air entrance 220. The first impeller 204 is provided with a titanium dioxide coated on the fibre optic filaments thereof. The ultraviolet tube in the hollow tubular member supporting the tube is switched on which causes the catalytic reaction of the pollutants in the air, thereby cleaning the air. The warmed, cleaned air then exits from the first impeller 204 and the apparatus 200 via the first outlet 212 as shown by the arrow G.

The air passing through the second conduits 70 of the heat exchanger 202 exits from the apparatus 202 via the second outlet 214, as shown by the arrow H.

The embodiment shown in Fig. 7 is generally the same as that shown in Fig. 1, but differs therefrom in that the first impeller 204 possesses filaments 18 of a flexible plastics material, i.e. not optical fibres, and does not possess any ultraviolet fluorescent tube. Instead the heat exchange surfaces 72 of the first conduits 68 of the heat exchanger 202 are coated with titanium dioxide, in the same way as described above with reference to Fig. 3.

An ultraviolet lamp 222 is provided to bathe the surfaces 72 of the first conduit 68 with ultraviolet light to effect the aforesaid photocatalytic reaction.

Other than these differences the heat transfer apparatus 200 shown in Fig. 7 operates the same way in the embodiment described with regard to Fig. 6.

In a modification of the apparatus shown in Figs. 6 and 7, the heat exchanger 202 could have the surfaces 72 of the first conduits 68 coated with

titanium dioxide as well as the first impeller 204 having fibre optic filaments 118 coated with titanium dioxide. In such a modification, the apparatus would include the ultraviolet lamp 222, as well as the fluorescent tube 118 in the hollow shaft of the first impeller 204. In other embodiments the heat exchange surfaces 72, 73 of the first and second conduits could be coated with titanium dioxide. In such an embodiment, suitable ultraviolet lamps are provided to provide ultraviolet illumination of the first and second conduits.

10 The embodiments shown in Figs. 6 and 7 are configured for the removal of pollutants from air taken from outside the building. In a modification of these embodiments, air taken from inside the building could also be cleaned by the apparatus shown in Figs. 6 and 7. This would allow the air to be recycled, if desired.

15 In these modifications, either the surfaces 73 of the second conduits are coated with the photocatalytic material, such as titanium dioxide, or the filaments, 118 of the second impeller 206 are coated with the photocatalytic material. Suitable ultraviolet lighting arrangements such as a lamp on a table are provided to illuminate either the surfaces of the conduits 70, 73 or the filaments 118 of the second impeller 206.

25 In a further modification, all of the surfaces 72, 73 of the first and second conduits 68, 70 are coated with the photocatalytic material. Also, the filaments 118 of both of the first and second impellers 204, 206 are coated with the photocatalytic material. Suitable ultraviolet illuminating means, which may be as described above, is provided to illuminate the surfaces 72, 73 of the first and second conduits 68, 70 and the filaments 118 of the first and second conduits 204, 206. This modification ensures thorough cleaning of the air passing through the apparatus in both directions.

30 In Figs 6 and 7, the first impeller 204 is provided downstream of the first conduits 68 of the heat exchange 202, whereas the second impeller 206 is

provided upstream of the second conduits 70 of the heat exchange 2020.

5 In a modification, the positions of the first and second impellers 204 206 and of the heat exchanger 202 are reversed. In this modification, therefore, the first impeller 204, is provided upstream of the first conduits 70 of the heat exchanger 2020, and the second impeller 206 is provided downstream of the second conduits 70 of the heat exchanger 202.

10 Various modifications can be varied within the scope of the invention. For example, the titanium dioxide could be replaced by another suitable photocatalyst.

15 Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims:-

1. Apparatus for catalysing a reaction in a fluid material, the apparatus
5 comprising an impeller to impel the fluid material, the impeller having a plurality
of impeller members comprising a photocatalytic material, and the apparatus
further including irradiation means to irradiate the impeller members with
electromagnetic radiation to allow the photocatalytic material to catalyse the
reaction.
- 10 2. Apparatus according to claim 1, wherein the impeller is a rotary impeller
comprising a rotary shaft, the impeller members extending outwardly from the
shaft.
- 15 3. Apparatus according to claim 2, wherein the impeller members extend
radially outwardly from the shaft.
4. Apparatus according to claim 1, 2 or 3, wherein the apparatus further
comprises drive means to rotatably drive the impeller.
- 20 5. Apparatus according to claim 4 when dependent upon claim 2 or 3,
wherein the drive means is drivingly connected to the shaft to effect said rotary
motion of the impeller.
- 25 6. Apparatus according to any preceding claim, wherein each impeller
member comprises a flexible elongate member coated with said photocatalytic
material.
7. Apparatus according to any preceding claim, wherein each elongate
30 member comprises a filament.
8. Apparatus according to any preceding claim, wherein the irradiation
means comprises a source of electromagnetic radiation.

9. Apparatus according to any of claims 1 to 7, wherein the irradiation means comprises means for allowing external electromagnetic radiation to irradiate the impeller members.

5

10. Apparatus according to claim 8, wherein the irradiation means comprises a source of ultraviolet light.

10

11. Apparatus according to any of claims 1 to 8 or 10, wherein the source of electromagnetic radiation is arranged externally of the impeller.

12. Apparatus according to any of claims 1 to 8 or 10, wherein the impeller members comprise fibre optic cables, and the source of electromagnetic radiation is provided within the impeller.

15

13. Apparatus according to any preceding claim, wherein the apparatus includes a casing to house the impeller and the irradiation means, the casing having a reflective internal surface to reflect the electromagnetic radiation onto the impeller members.

20

14. Apparatus according to claim 13, wherein the casing includes an inlet to direct the fluid material onto the impeller members, and an outlet to exhaust the fluid material from the apparatus.

25

15. Apparatus according to claim 14, wherein the inlet is an axially extending inlet, arranged axially of the impeller.

16. Apparatus according to any preceding claim, wherein the photocatalytic material comprises titanium dioxide.

30

17. Apparatus according to any preceding claim, wherein the apparatus is a gas cleaning apparatus.

18. Apparatus for catalysing a reaction in a fluid material, the apparatus comprising a heat exchanger comprising a first conduit for the flow of a first fluid material therethrough, a second conduit for the flow of a second fluid material therethrough, the first and second conduits being arranged in heat exchange relation with each other, wherein the first conduit has a surface comprising a photocatalytic material to catalyse a reaction in the first fluid material, and the apparatus further including irradiation means to irradiate said surface of the first conduit with electromagnetic radiation to allow the photocatalytic material to catalyse the reaction.

19. Apparatus according to claim 18, wherein the first and second conduits have respective surfaces comprising said photocatalytic material, and the irradiation means can irradiate said surfaces of the first and second conduits with electromagnetic radiation to allow the photocatalytic material to catalyse the reaction.

20. Apparatus according to claim 18, wherein only the first conduit comprises a surface comprising said photocatalytic material, and the irradiation means can irradiate only the surfaces of the first conduit.

21. Apparatus according to claim 18, 19 or 20, wherein the surface of the, or each, conduit is coated with the photocatalytic material.

22. Apparatus according to any of claims 18 to 21, wherein the heat exchanger comprises a plurality of said first conduits and a plurality of said second conduits, each of said first conduits having a respective surface comprising said photocatalytic material.

23. Apparatus according to claim 22, wherein each of said surfaces of the first conduits is coated with the photocatalytic material.

24. Apparatus according to any of claims 18 to 23, wherein each of the

second conduits preferably has a surface comprising said photocatalytic material.

5 25. Apparatus according to claim 24, wherein each of the surfaces of the second conduits is coated with the photocatalytic material.

26. Apparatus according to any of claims 18 to 25, wherein the heat exchanger comprises a plate heat exchanger, wherein first and second conduits
10 are formed by at least one planar member.

27. Apparatus according to any of claims 18 to 26, wherein the first and second conduits are formed by a plurality of planar members, each being arranged in generally parallel relation with each other.
15

28. Apparatus according to any of claims 18 to 27, wherein the irradiation means comprises a source of electromagnetic radiation.

29. Apparatus according to any of claims 18 to 27, wherein the irradiation means comprises means for allowing external electromagnetic radiation to
20 irradiate the, or each, surface.

30. Apparatus according to claim 28, wherein the irradiation means comprises a source of ultraviolet light.
25

31. Apparatus according to any of claims 18 to 30, wherein the photocatalytic material comprises titanium dioxide.

32. Apparatus according to any of claims 18 to 31, wherein the heat
30 exchanger is suitable for cleaning a gas.

33. A heat transfer assembly comprising: a heat exchanger comprising a first conduit for the flow of a first fluid material therethrough, the first conduit having a

surface, and the heat exchanger further including a second conduit for the flow of a second fluid material therethrough, the first and second conduits being arranged in heat exchange relation with each other, whereby heat can be transferred between said first and second fluids; an impeller to impel the first fluid material through the first conduit; wherein either or both of the surface of the first conduit and at least part of the impeller comprises a photocatalytic material to catalyse a reaction in the first fluid material; the assembly further including irradiation means to irradiate the photocatalytic material with electro-magnetic radiation to catalyse the reaction.

34. A heat transfer assembly according to claim 33, wherein the heat exchanger comprises a plurality of said first conduits and a plurality of said second conduits, each of said first conduits having a respective surface comprising said photocatalytic material.

35. A heat transfer assembly according to claim 34, wherein each of said surfaces of the first conduits is coated with the photocatalytic material.

36. A heat transfer assembly according to claim 33, 34 or 35, wherein each of the second conduits preferably has a surface comprising said photocatalytic material.

37. A heat transfer assembly according to claim 36, wherein each of the surfaces of the second conduits is coated with the photocatalytic material.

38. A heat transfer assembly according to any of claims 33 to 37, wherein the heat exchanger comprises a plate heat exchanger, wherein first and second conduits are formed by at least one planar member.

39. A heat transfer assembly according to claims 33 to 38, wherein the first and second conduits are formed by a plurality of planar members, each being

arranged in generally parallel relation with each other.

40. A heat transfer assembly according to any of claims 33 to 39, wherein the
5 impeller comprises at least one impeller member to impel the fluid as aforesaid.

41. A heat transfer assembly according to claim 40, wherein the, or each,
impeller member comprises said photocatalytic material.

10 42. A heat transfer assembly according to claim 40 or 41, wherein the impeller
is a rotary impeller comprising a rotary shaft, the impeller members extending
outwardly from the shaft.

43. A heat transfer assembly according to any of claims 40 to 42, wherein the
15 apparatus further include drive means to rotatably drive the impeller.

44. A heat transfer assembly according to claim 43 when dependent upon
claim 42, wherein the drive means is drivingly connected to the shaft to effect
said rotary motion of the impeller.

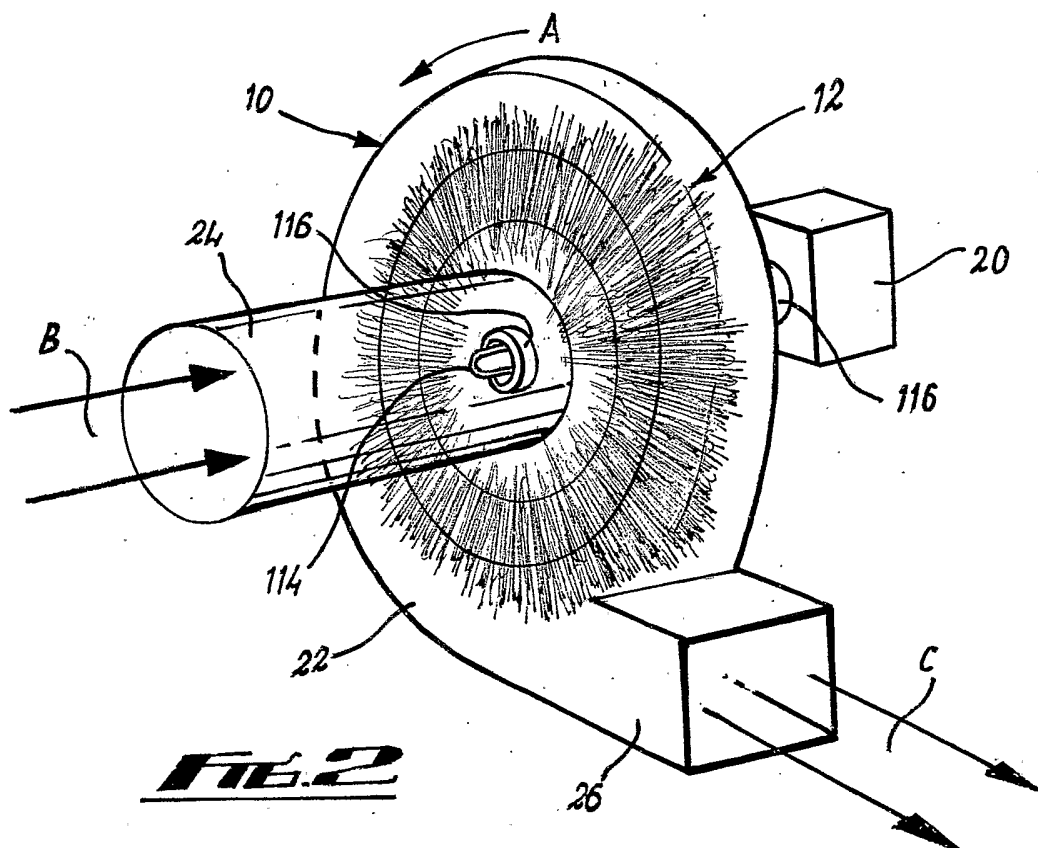
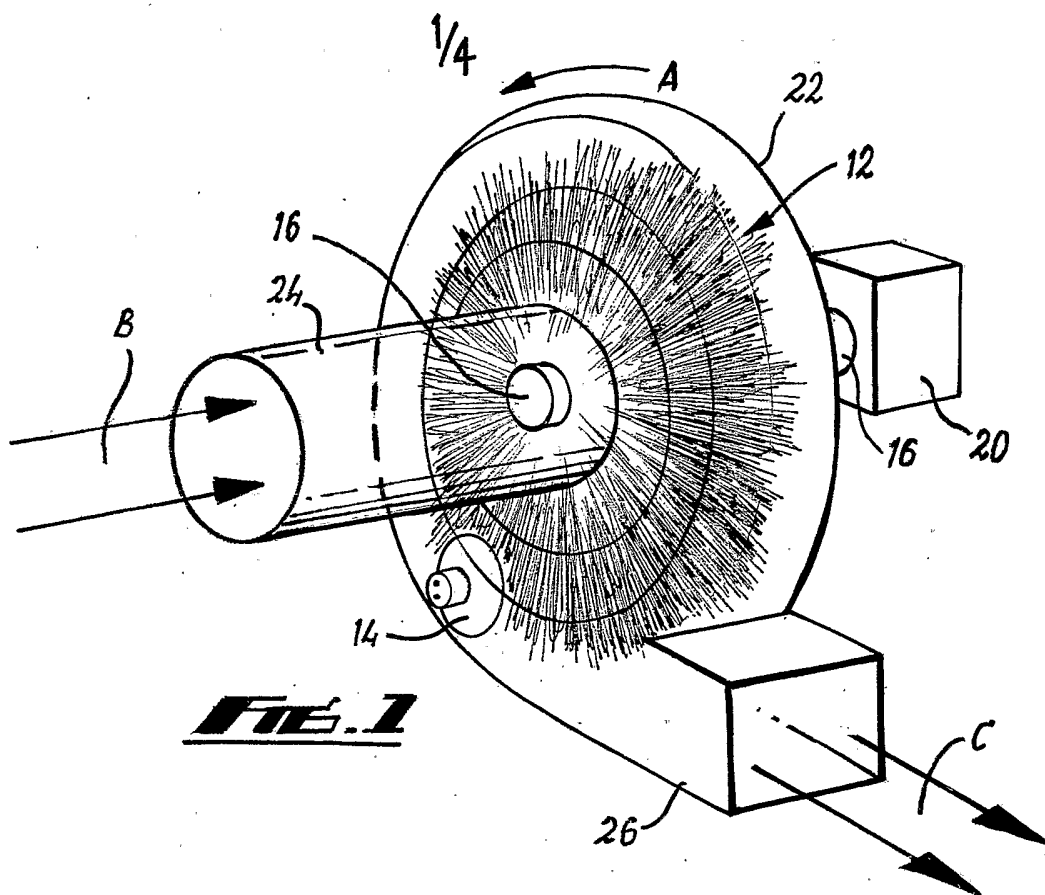
20 45. A heat transfer assembly according to any of claims 40 to 44, wherein
each impeller member comprises a flexible elongate member coated with said
photocatalytic material.

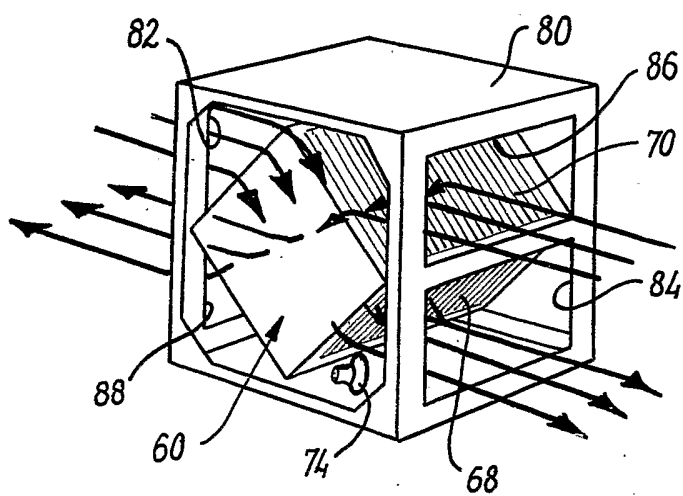
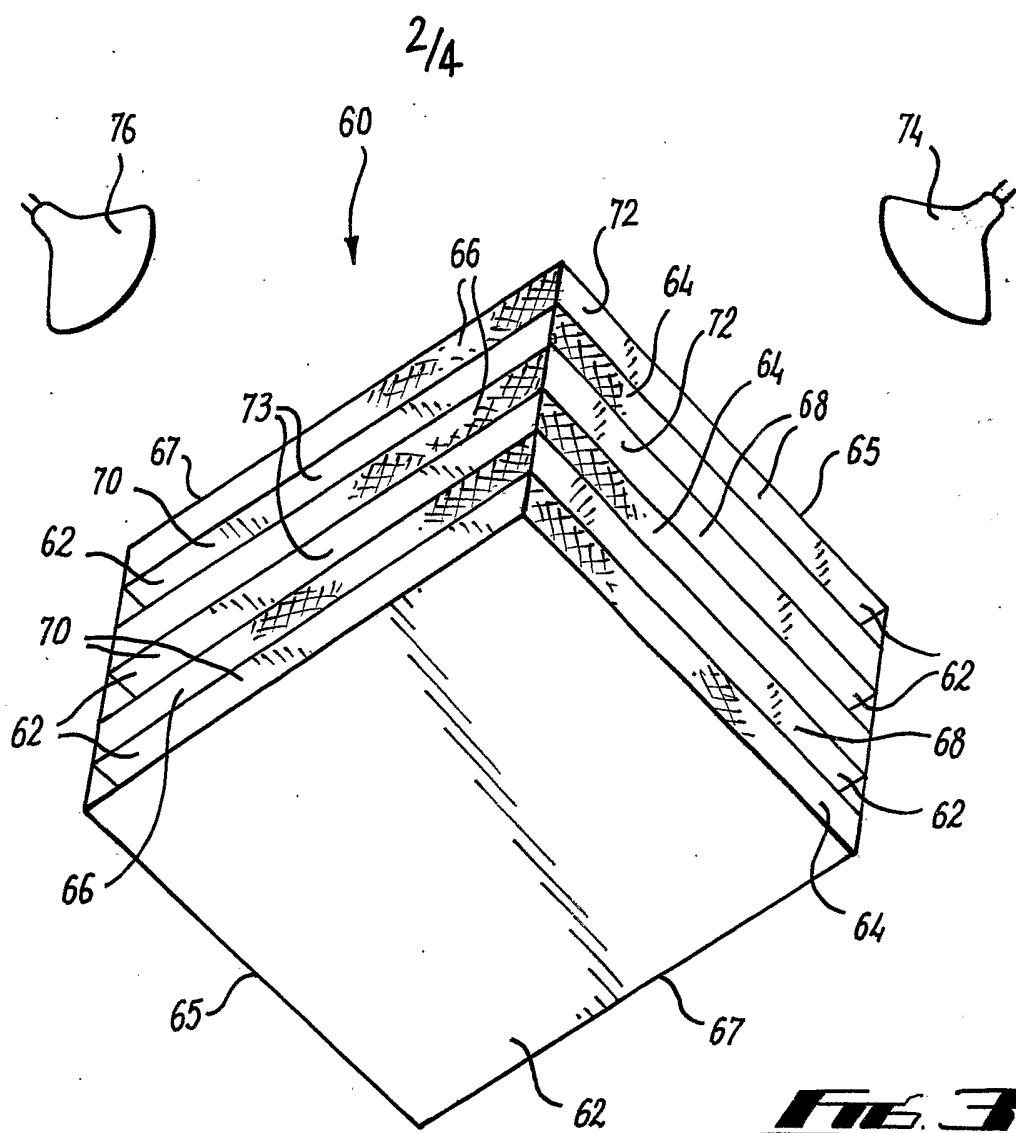
25 46. A heat transfer assembly according to any of claims 40 to 45, wherein
each elongate member comprises a filament.

47. Apparatus substantially as herein described with reference to Figs. 1, 2
and 4 of the accompanying drawings.

30 48. Apparatus substantially as herein described with reference to Figs. 3 and
3A of the accompanying drawings.

49. A heat transfer assembly substantially as herein described with reference to Figs. 6 and 7 of the accompanying drawings.
- 5 50. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.





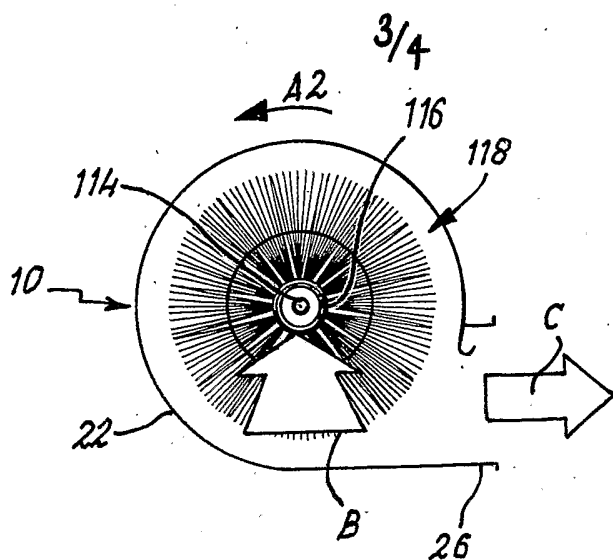


FIG. 4

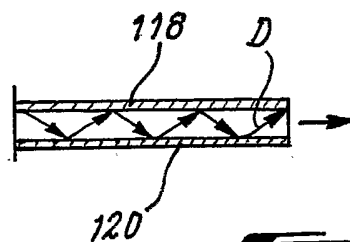


FIG. 5

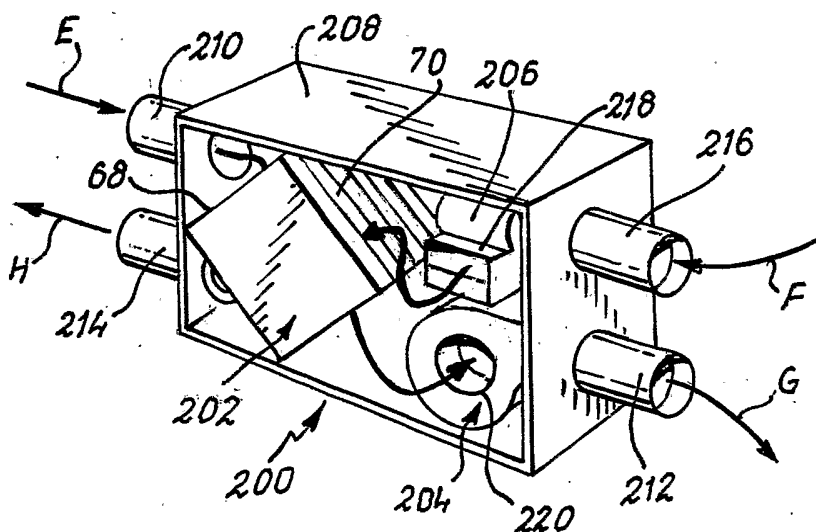
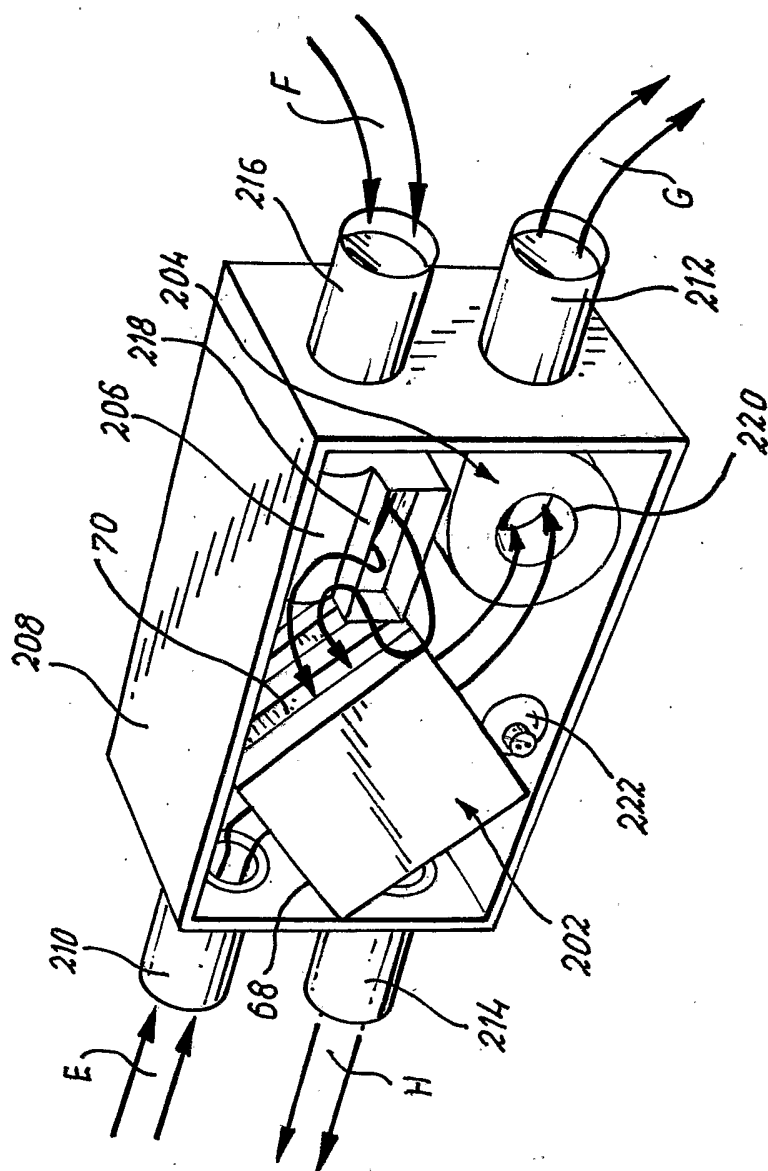


FIG. 6

$\frac{4}{4}$ 

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