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(71) Applicant: **OY Hydrocell Ltd**
04430 Järvenpää (FI)

(72) Inventors:
- **Juslenius, Pasi**
  04420 Järvenpää (FI)
- **Gasik, Michail**
  00900 Helsinki (FI)
- **Lampinen, Markku**
  02130 Espoo (FI)
- **Rauhala, Keijo**
  20300 Turku (FI)
- **Anttila, Tomi**
  00760 Helsinki (FI)

(74) Representative: **Pirhonen, Kari Lennart**
Patenttitoimisto Kari Pirhonen Oy,
P.O. Box 71
20101 Turku (FI)

(54) Heat exchanger

(57) Heat exchanger (30), comprising a thermopositive core part (31) and thermopositive heat transfer elements (32), which are wires, bristles, fibers, strips or equivalent, preferably copper wires or carbon fibers. The heat transfer wires are squeezed between tubes or rods twisted about each other.

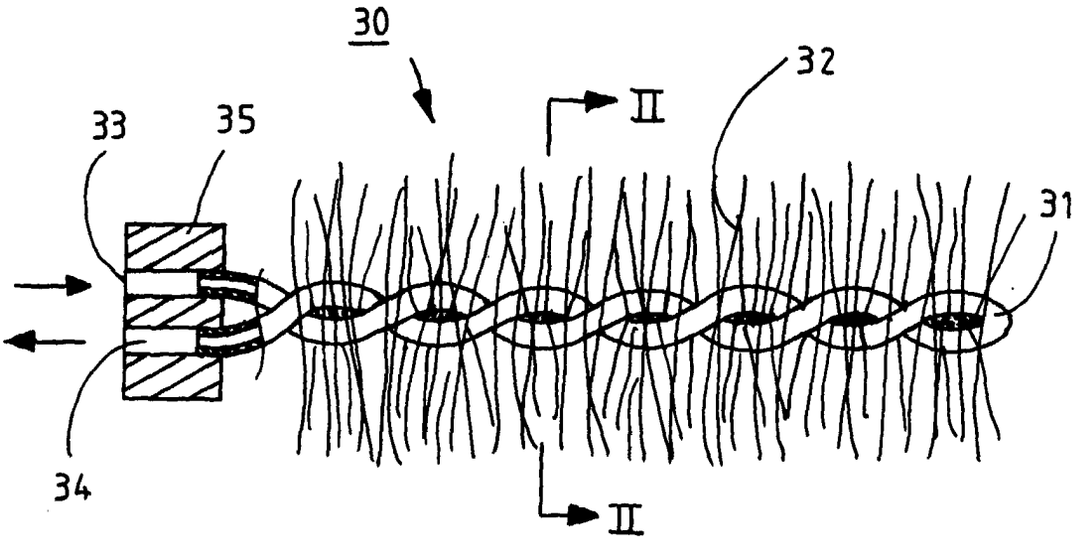

FIG. 1

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Description

SUBJECT OF THE INVENTION

[0001] The present invention relates to a heat exchanger consisting of a thermopositive core part and thermopositive heat transfer elements, in which heat exchanger

- the heat transfer elements are thin and elongated objects, such as wires, bristles, fibers, strips or equivalent,
- the core part comprises at least two compression surfaces or pieces with a compression gap between them where the heat transfer elements are squeezed so as to allow conduction of heat from the compression surfaces or pieces to the heat transfer elements or vice versa,
- the heat transfer elements are so mounted in the compression gap that at least part of the length of the thin wires, bristles, fibers, strips or equivalent of the heat transfer elements remains outside the compression gap.

PRIOR ART

[0002] In thermal engineering, many types of heat exchanger are known, which can be used e.g. for the heating or cooling of liquids, gases, powders or solid objects and also for the vaporization of liquids and condensation of vapors. An example of the cooling of solid objects is the cooling of electronic components.

[0003] The heat transfer elements of a heat exchanger are generally metallic parts which are so shaped that they allow a maximal capacity and efficiency of heat transfer from a heating medium to a medium to be heated or from a medium to be cooled to a cooling medium. The heat transfer surfaces of the heat transfer elements are usually shaped as e.g. a planar, grooved or spicular surfaces. The commonest solutions consist of laminated radiators, finned tubular radiators, or finned tubular radiators having fins cleaved into a spicular form. Generally, however, fairly simple forms are adopted because of the cost, but in this case it is difficult to obtain a large heat delivery surface especially in the gas carrying section as it also involves a large pressure drop. Thus it has been found that designing the shape of e.g. heat transfer fins or equivalent is not a very simple task if the aim is to produce a really efficient heat exchanger, vaporizer or condenser in which the pressure drop especially in the gas or steam carrying section is sufficiently small.

OBJECT OF THE INVENTION

[0004] The object of the invention is to achieve a new heat exchanger that does not have the disadvantages described above and is substantially more efficient than prior-art heat exchangers.

FEATURES CHARACTERISTIC OF THE INVENTION

[0005] The heat exchanger of the invention is characterized in that

- the core part of the heat exchanger comprises at least one helical elongated body, such as a spiral tube or a rod bent like a helical spring, or two or more bodies, such as tubes or rods, twisted about each other,
- and that the heat transfer elements of the heat exchanger, such as wires, bristles, fibers, strips or equivalent, are squeezed between the helices of the helical body or between the bodies twisted about each other.

[0006] By using a plurality of thin wires, bristles, fibers or strips arranged in contact with the compression surfaces or pieces of the core part of the heat exchanger, a large heat delivery surface and a good heat transfer efficiency are achieved. Still, a sufficient space for a gas or steam flow is left between the wires so that the pressure drop of the flow remains small.

EMBODIMENTS OF THE DEVICE OF THE INVENTION

[0007] A preferred embodiment of the device of the invention is characterized in that

- the core part of the heat exchanger comprises
  - one helical tube or one rod bent like a helical spring, or
  - one tube or rod bent over, in which the two tube or rod portions placed against each other have been twisted about each other, or
  - two or more tubes or rods placed against each other and twisted about each other,
- and that opposite ends of the heat transfer elements, such as wires, bristles, fibers, strips or equivalent, extend in opposite directions from the compression gap between the helices of the core part bodies or between the bodies or parts thereof twisted about each other, on both sides of the compression gap.

[0008] The heat transfer elements of the heat exchanger, such as wires, bristles, fibers, strips or equivalent, are directed radially in different directions from the compression surfaces or pieces of the core part. By using radial wires, bristles, fibers or strips, a uniform heat flow in different directions from the core part is achieved.

[0009] A second preferred embodiment of the device of the invention is characterized in that

- the heat transfer elements of the heat exchanger,

such as wires, bristles, fibers, strips or equivalent, are squeezed by their midpoint in the compression gap between the core part portions twisted about each other or between parts thereof,
- and that the ends of the heat transfer elements diverging radially in different directions from the compression gap of the core part are of equal length so that the heat exchanger has a mainly circular cross-sectional form.

[0010] A third preferred embodiment of the device of the invention is characterized in that

- the core part of the heat exchanger comprises a bent-over elongated body, such as tube or rod, in which the two parts bent against each other have been twisted about each other,
- and that the heat transfer elements, such as wires, bristles, fibers, strips or equivalent, are squeezed in the compression gap between the two parts of the elongated body twisted about each other.

[0011] A fourth preferred embodiment of the device of the invention is characterized in that

- the core part of the heat exchanger comprises a bent-over tube whose two parts placed against each other have been twisted about each other,
- that the heat transfer elements, such as wires, bristles, fibers, strips or equivalent, are squeezed in the compression gap between the two parts of the bent-over tube twisted about each other,
- and that an outlet for a heat transfer medium, such as a liquid, vaporized liquid, condensable vapor or a flowing gas, is located at the same end of the heat exchanger as the supply opening for the medium.

[0012] A fifth preferred embodiment of the device of the invention is characterized in that two or more heat exchangers formed from helical tube are connected in parallel in the same space so that the inlet orifices of the heat exchangers for the supply of a heat transfer medium are connected together and similarly the medium outlet orifices of the heat exchangers are connected together.

[0013] A sixth preferred embodiment of the device of the invention is characterized in that one or more heat exchangers formed from helical tube are implemented as a separate unit having a preferably circular cross-section and so designed that it can be easily mounted in and removed from its place of installation, which preferably is a ventilation duct of circular cross-section.

[0014] A seventh preferred embodiment of the device of the invention is characterized in that the heat transfer wires placed in the compression gap between the tubes or tube portions of the heat exchanger twisted about each other are at least partially immersed in a liquid to be vaporized.

[0015] An eighth embodiment of the device of the invention is characterized in that the heat transfer wires placed in the compression gap between the tubes or tube portions of the heat exchanger twisted about each other are at least partially located in a vapor space where condensation of vapor occurs on the surface of the heat transfer wires.

[0016] According to a yet another preferred embodiment of the invention, the heat transfer wires squeezed between the tubes or tube portions twisted about each other are copper wires, aluminum wires or carbon fibers. Copper wires may also be shaped e.g. by flattening their ends into a flat shape.

EXAMPLES OF EMBODIMENTS

[0017] In the following, the invention will be described by the aid of examples, referring to the attached drawings, wherein

LIST OF FIGURES

[0018]

Fig. 1 presents a side view of a heat exchanger according to the invention.
Fig. 2 presents a section of Fig. 1, taken along line II-II.
Fig. 3 presents a side view of a partially sectioned heat exchanger according to the invention, mounted in a ventilation duct or steam conduit.
Fig. 4 presents a section of Fig. 3, taken along line IV-IV.
Fig. 5 presents a partially sectioned side view of the heat exchanger in Fig. 3, placed in powder.
Fig. 6 presents a partially sectioned side view of two heat exchangers as presented in Fig. 1, connected together and placed in a transverse duct.
Fig. 7 corresponds to Fig. 3 and presents a heat exchanger according to the invention, mounted in an air duct or vapor conduit.
Fig. 8 presents a diagrammatic cross-section of a unit consisting of seven heat exchangers.
Fig. 9 presents a perspective view of a heat exchanger unit placed in an air duct.
Fig. 10 presents a section of Fig. 9, taken along line X-X.
Fig. 11 presents a side view of a ventilation duct and a heat exchanger unit as shown in Fig. 9 designed to be mounted in it.
Fig. 12 corresponds to Fig. 11 and presents the heat exchanger unit installed in the ventilation duct.
Fig. 13 presents a heat exchanger according to an embodiment of the invention in side view.
Fig. 14 presents a sectioned side view of a vaporizer

according to the invention.

Fig. 15 presents a heat exchanger according to the invention in side view.

Fig. 16 presents a section of Fig. 15, taken along line XIV-XIV.

Fig. 17 corresponds to Fig. 16 and presents a second embodiment.

Fig. 18 presents a partially sectioned side view of a heat exchanger according to an embodiment of the invention.

Fig. 19 presents a section of Fig. 18, taken along line XXVII-XXVII.

Fig. 20 presents a partially sectioned side view of a heat exchanger according to an embodiment of the invention.

Fig. 21 corresponds to Fig. 2 and presents a cross-section of a heat exchanger according to yet another embodiment.

DESCRIPTION OF THE FIGURES

[0019] Fig. 1 presents a heat exchanger 30 having a core part 31 consisting of a metal tube which has been first bent over, whereupon the two tube portions bent against each other have been twisted about each other. When the tube portions are being twisted about each other, the heat transfer wires 32 are left squeezed between the portions of the helical tube 31 being tightened against each other. In Fig. 1, to clarify the structure of the heat exchanger, only a relatively small number of heat transfer wires 32 are shown between the two parts of the tube 31 twisted about each other, but in practice the heat exchanger may have a very dense array of a large number of wires. Connected to the ends of the helical tube 31 of the heat exchanger 30 is a connection piece 35 comprising an inlet orifice 33 and an outlet orifice 34 for a heat transfer medium, such as a liquid.

[0020] In all the embodiments described below, the medium used on the side of the heat transfer wires may be a liquid, a vaporizable liquid, a condensable vapor or a flowing gas, usually air. In embodiments comprising a helical tube, the medium flowing inside the tube may be a gas, a condensable vapor, a vaporizable liquid or a heat carrier liquid, usually water.

[0021] Fig. 2 presents a cross-section of a heat exchanger 30, showing that the heat transfer wires 32 are squeezed between the two parts of a helical tube 31. The wires 32 are directed radially away from the gap between the helical tubes 31.

[0022] In Fig. 3, a heat exchanger 30 is mounted in an air duct 36 where an air current is flowing. Via the heat transfer wires 32 and a liquid supplied into the helical tube 31, heat can be transferred from the liquid to the air flowing in the duct 36 or vice versa. The medium supplied into the helical tube 31 may also be a vaporizable liquid, e.g. a vaporizable refrigerant in a refrigerator application. A heat exchanger 30 as illustrated in Fig. 3 may also be mounted in a steam conduit, where steam will condense on the surface of the wires 32.

[0023] Fig. 4 presents a cross-section of the heat exchanger 30 in Fig. 3. It can be seen from the figure that the heat transfer wires 32 mainly fill the duct 36 completely. The wires 32 are so thin that their air drag in the duct 36 is insignificant. Still, the total area of the wires 32 is so large that they produce efficient heat transfer.

[0024] Fig. 5 illustrates another way of using a heat exchanger 30. In this case, the heat exchanger 30 is placed e.g. in metal hydride powder 37. Heat transfer wires 32 and helical tubes 13 perform effectively also when heat is to be transferred into or from powder.

[0025] Fig. 6 presents two heat exchangers 30a and 30b connected together so that the heat carrier liquid is supplied into both heat exchangers 30a and 30b via a common inlet channel 33. Correspondingly, the heat exchangers 30a and 30b also have a common outlet channel 34. By combining a number of heat exchangers 30 in this way, it is possible to achieve a sufficiently efficient unit which can be used e.g. as a cooler in a motor vehicle. In this Fig. 6, as in the figures illustrating the other examples of the embodiments of the invention, a relatively small number of heat transfer wires 32 are shown to visualize the structure more clearly. In actual heat exchangers, however, it is preferable to have a large number of heat transfer wires 32. As the wires 32 have a low air drag, they can fill the air flow duct 36 around the heat exchangers 30a and 30b completely.

[0026] Fig. 7 presents a heat exchanger 30 placed in a duct 36 and comprising two separate tubes 31a and 31b twisted about each other. The adjacent ends of both helical tubes 31a and 31b at each end of the heat exchanger 30 are connected both to an inlet channel 33 and to an outlet channel 34. Thus, the heat carrier liquid flows in the same direction in both helical tubes 31a and 31b. As the air in the duct 36 flows in the opposite direction relative to the liquid flow, the result is a heat exchanger 30 functioning in a new way on the countercurrent principle known in itself. The medium fed into the helical tube 31 may also be a vaporizable liquid, e. g. a vaporizable refrigerant in a cooling application. The duct 36 may also carry a steam flow, in which case the heat exchanger functions as a condenser as steam condenses on the wires 32.

[0027] Fig. 8 presents a diagrammatic cross-section of a heat exchanger unit 40 comprising seven heat exchangers 30 according to the invention mounted in a duct 36. As shown in the figure, the heat transfer wires 32 of each heat exchanger 30 partially intermesh with corresponding heat transfer wires 32 of adjacent heat exchangers 30. In this way, the duct 36 is so densely filled with heat transfer wires 32 that a good efficiency of the heat exchanger unit 40 is achieved.

[0028] Fig. 9 presents a heat exchanger unit 40 designed to be placed in a service door of a ventilation duct and comprising seven heat exchangers 30 grouped in the manner illustrated by Fig. 8. For the sake of clarity, Fig. 9 only shows some of the heat exchangers 30. For

those heat exchangers that are not shown in Fig. 9, only the ends of the liquid supply pipes are depicted, to which the ends of the heat exchangers are connected.

[0029] The heat exchanger unit 40 of Fig. 9 is provided with a support plate 41 of semicircular cross-section and flanges 42a and 42b comprised in it. Placed at each end of the heat exchanger unit 40 is a ring 43, 44. Ring 43 is an inlet ring supplying a heat transfer medium into all heat exchangers 30 in the heat exchanger unit 40. Correspondingly, ring 44 at the opposite end of the heat exchanger unit 40 is an outlet ring common to all the heat exchangers 30.

[0030] As shown in the cross-sectional diagram in Fig. 10, the heat transfer medium is passed via the ring f to all the heat exchangers 30 in the heat exchanger unit 40.

[0031] The following figures 11 and 12 show how the flanges 42a and 42b of the heat exchanger unit 40 can be fitted to corresponding flanges of a ventilation duct, with the support plate 41 forming part of the ventilation duct.

[0032] Fig. 11 presents a ventilation duct 50 and a heat exchanger unit 40 designed to be fitted in it. The ventilation duct 50 is provided with a service door opening 51 located in its lower surface and having a size corresponding to the support plate 41. The heat exchanger unit 40 is mounted by placing its mounting flanges 42 against mounting flanges 52 provided at the edges of the service door opening 51.

[0033] Fig. 12 presents the heat exchanger unit 40 installed in the service door opening of the ventilation duct 50. The heat exchangers 30 now fill the entire cross-sectional area of the ventilation duct 50. Fig. 12 shows in a diagrammatic form the topmost and bottommost heat exchangers in the duct 50 to visualize the placement of the heat exchangers in the ventilation duct 50. After the heat exchanger unit 40 has been mounted in position, the mounting flanges 42 of the support plate 41 of the heat exchanger unit 40 fastened to the mounting flanges 52 of the service door opening and the pipes for a heat transfer medium connected to both the inlet 33 and the outlet 34, the heat exchanger unit 40 will be ready for use.

[0034] Fig. 13 presents an embodiment of the heat exchanger 30 in which the heat transfer wires 32 are squeezed between the spirals of a single helical tube 31.

[0035] Fig. 14 presents a vaporizer 60 comprising a heat exchanger 30 placed in a chamber 61 and immersed in vaporizable liquid 62 in the chamber 61. Part of the heat transfer wires 32 of the heat exchanger 30 is inside the vaporizable liquid 62 and part of them is above the liquid surface, in the air space of the chamber 61.

[0036] Fig. 15 presents a heat exchanger 30 comprising several elements 31 twisted about each other. The elements 31 may be rods, such as e.g. four rods, or two rods bent over against each other as shown in Fig. 16. In this case, heat transfer occurs by conduction via the rods 31.

[0037] The elements 31 in Fig. 16 may also consist of tubes, as shown in the cross-sectional view in Fig. 17, in which case heat transfer occurs by the agency of a medium, such as a liquid, flowing through the tubes 31.

[0038] Fig. 18 and 19 present a heat exchanger 30 designed for the cooling of electronic components. In this case, the core part 31 of the heat exchanger 30 and the cooling plate 47 attached to it can be mounted on top of a heat developing component 48, such as e.g. a microprocessor.

[0039] Fig. 20 likewise presents an embodiment of the heat exchanger 30 in which the cooling plate 47 has been pressed e.g. onto an electronic component 48 to be cooled. In this embodiment, the helical tubes 31 of the heat exchanger 30 are mounted in an upright position.

[0040] Fig. 21 presents a cross-sectional view of an embodiment of the heat exchanger 30 consisting of a combination of nested heat exchangers. Placed inside the helical tubes 31a and 31b of the main heat exchanger 30 are corresponding heat exchangers 30a and 30b having core parts 31a and 31b of thin metal wire. Using such an arrangement, the internal heat transfer in the helical tubes 31a and 31b of the main heat exchanger 30 can be made more effective.

LIST OF REFERENCE NUMBERS

[0041]

30	heat exchanger
31	core part (tube, rod)
32	heat transfer elements (wires)
33	inlet orifice
34	outlet orifice
35	connection piece
36	channel
37	powder
40	heat exchanger unit
41	support plate
42	flange
43	inlet ring
44	outlet ring
47	cooling plate
48	component
50	ventilation duct
51	opening
52	flange

Claims

1. Heat exchanger (30), which comprises a thermopositive core part (31) and thermopositive heat transfer elements (32), and in which heat exchanger

   - the heat transfer elements (32) are thin and elongated objects, such as wires, bristles, fib-

ers, strips or equivalent,

- the core part (31) comprises at least two compression surfaces or pieces with a compression gap between them where the heat transfer elements (32) are squeezed so as to allow conduction of heat from the compression surfaces or pieces to the heat transfer elements or vice versa,
- the heat transfer elements (32) are so mounted in the compression gap between the compression surfaces or pieces that at least part of the length of the thin wires, bristles, fibers, strips or equivalent of the heat transfer elements remains outside the compression gap,

characterized in that

- the core part (31) of the heat exchanger (30) comprises at least one helical elongated body, such as a spiral tube or a rod bent like a helical spring, or two or more bodies, such as tubes or rods, twisted about each other,
- and that the heat transfer elements (32) of the heat exchanger (30), such as wires, bristles, fibers, strips or equivalent, are squeezed between the helices of the helical body or between the bodies twisted about each other.

2. Heat exchanger (30) as defined in claim 1, **characterized in that**

- the core part (30) of the heat exchanger (30) comprises
  - one helical tube or one rod bent like a helical spring, or
  - one tube or rod bent over, in which the two tube or rod portions placed against each other have been twisted about each other, or
  - two or more tubes or rods (31a, 31b) placed against each other and twisted about each other,
- and that opposite ends of the heat transfer elements (32), such as wires, bristles, fibers, strips or equivalent, extend in opposite directions from the compression gap between the helices of the core part (31) or between the bodies or parts thereof twisted about each other, on both sides of the compression gap.

3. Heat exchanger (30) as defined in claim 1 or 2, **characterized in that**

- the heat transfer elements (32) of the heat exchanger (30), such as wires, bristles, fibers, strips or equivalent, are squeezed by their midpoint in the compression gap between the bodies of the core part (31) twisted about each other or between parts thereof,
- and that the ends of the heat transfer elements (32) diverging radially in different directions from the compression gap of the core part (31) are of equal length so that the heat exchanger (30) has a mainly circular cross-sectional form.

4. Heat exchanger (30) as defined in claim 1, 2 or 3, **characterized in that**

- the core part (31) of the heat exchanger (30) comprises a bent-over elongated body, such as tube or rod, in which the two parts bent against each other have been twisted about each other,
- and that the heat transfer elements (32), such as wires, bristles, fibers, strips or equivalent, are squeezed in the compression gap between the two parts of the elongated body (31) twisted about each other.

5. Heat exchanger (30) as defined in any one of claims 1 - 4, **characterized in that**

- the core part (31) of the heat exchanger (30) comprises a bent-over tube whose two parts placed against each other have been twisted about each other,
- that the heat transfer elements (32), such as wires, bristles, fibers, strips or equivalent, are squeezed in the compression gap between the two parts of the bent-over tube twisted about each other,
- and that an outlet (34) for a heat transfer medium, such as a liquid, vaporized liquid, condensable vapor or a flowing gas, is located at the same end of the heat exchanger as the inlet (33) for the medium.

6. Heat exchanger (30) as defined in any one of claims 1 - 5, **characterized in that** two or more heat exchangers (30a, 30b) formed from helical tube are connected in parallel in the same space so that the inlet orifices (33) of the heat exchangers for the supply of a heat transfer medium are connected together and similarly the outlet orifices (34) of the heat exchangers are connected together.

7. Heat exchanger (30) as defined in any one of claims 1 - 6, **characterized in that** one or more heat exchangers (30) formed from helical tube are implemented as a separate unit (40) of preferably circular cross-section and so designed that it can be easily mounted in and removed from its place of installation (50), which preferably is a ventilation duct of circular cross-section.

8. Heat exchanger (30) as defined in any one of claims 1 - 7, **characterized in that** the heat transfer wires (32) placed in the compression gap between the tubes (31) or tube portions of the heat exchanger (30) twisted about each other are at least partially immersed in a liquid (62) to be vaporized.

9. Heat exchanger (30) as defined in any one of claims 1 - 8, **characterized in that** the heat transfer wires (32) placed in the compression gap between the tubes (31) or tube portions of the heat exchanger (30) twisted about each other are at least partially located in a vapor space where condensation of vapor occurs on the surface of the heat transfer wires.

10. Heat exchanger (30) as defined in any one of claims 1 - 9, **characterized in that** the heat transfer wires (32) squeezed between the tubes (31) or tube portions of the heat exchanger (30) twisted about each other are copper wires, aluminum wires or carbon fibers.

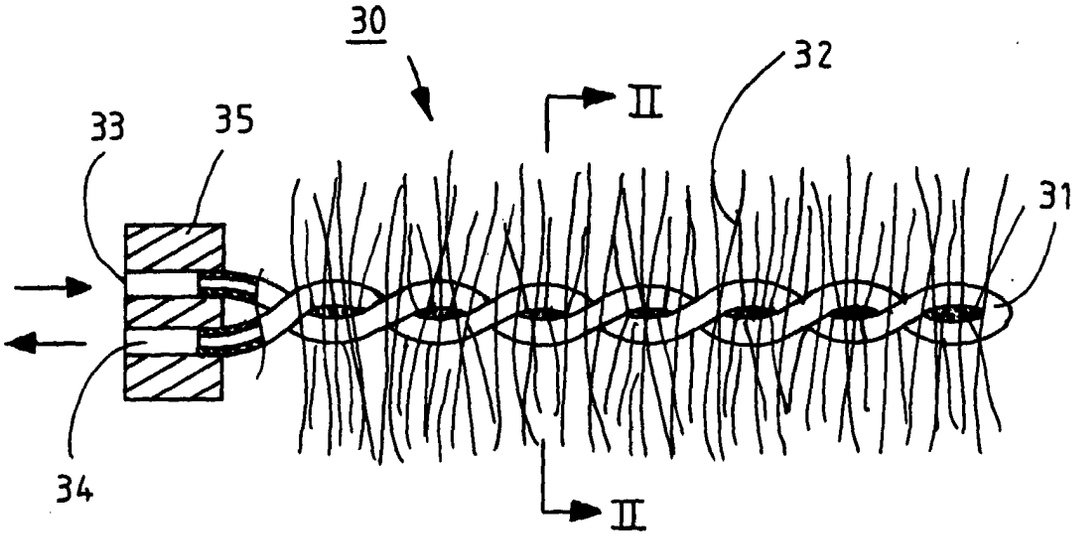

FIG. 1

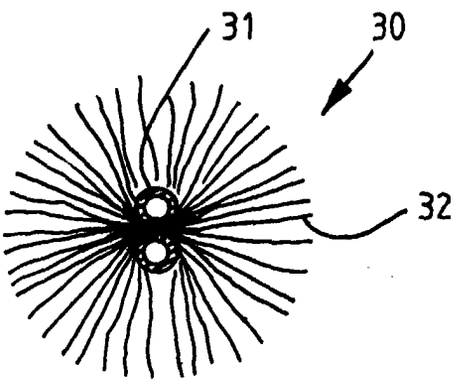

FIG. 2

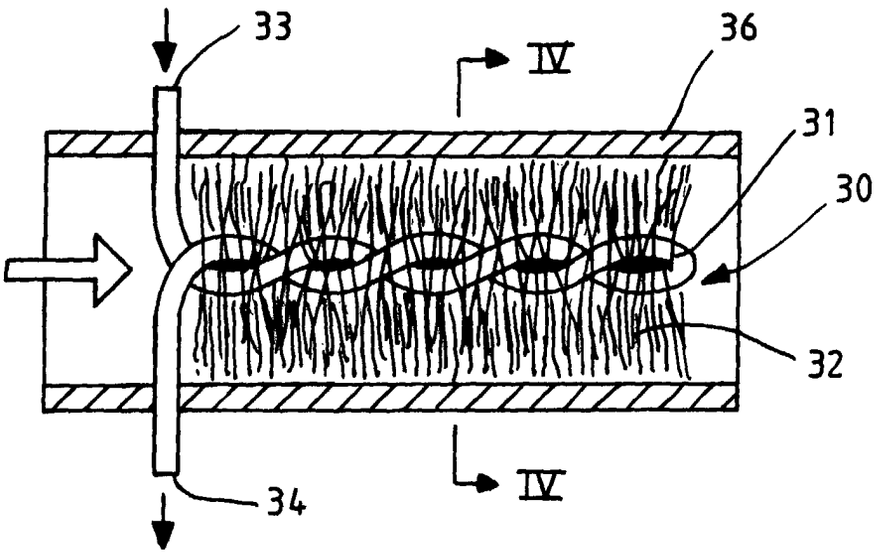

FIG. 3

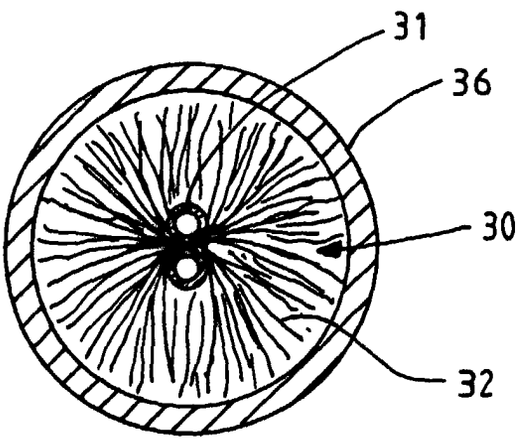

FIG. 4

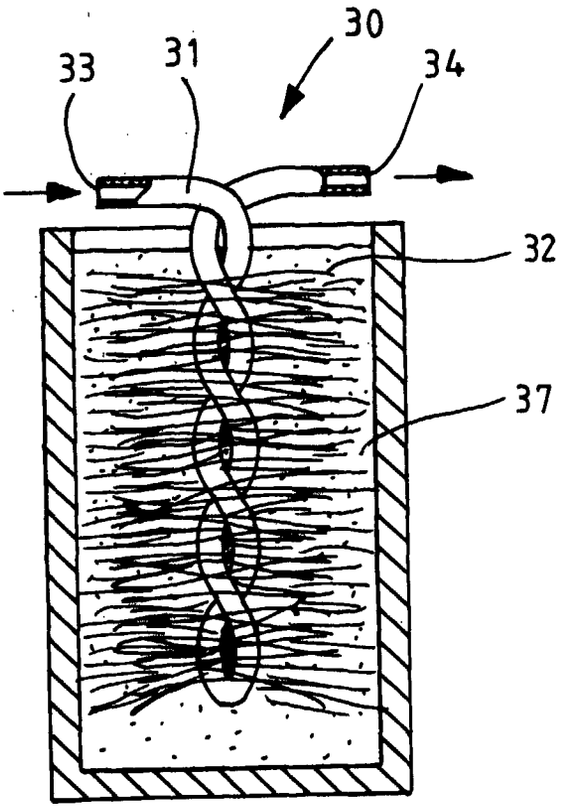

FIG. 5

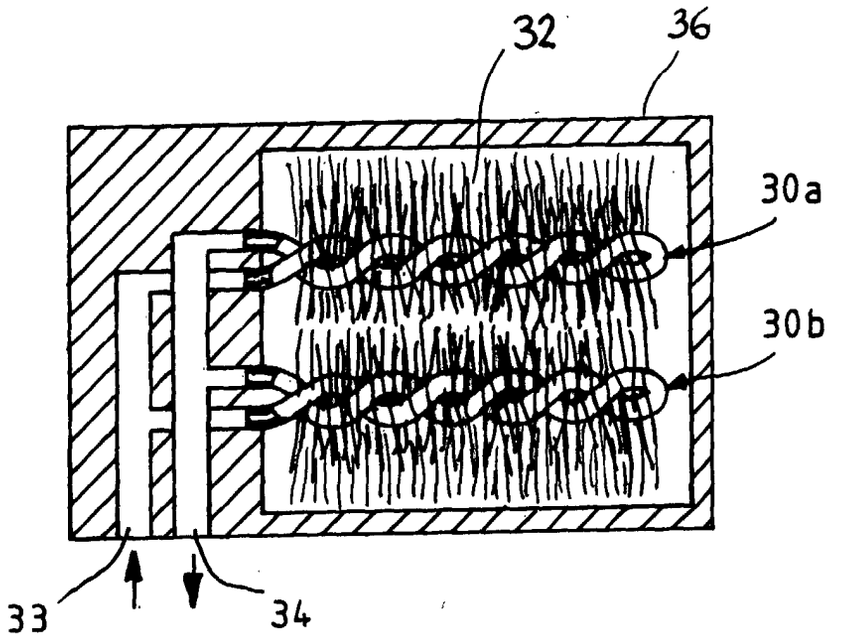

FIG. 6

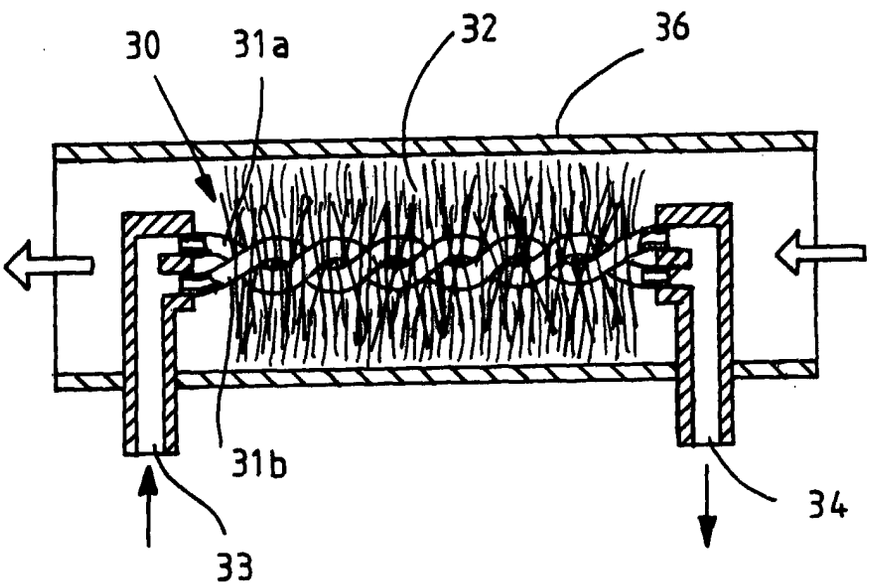

FIG. 7

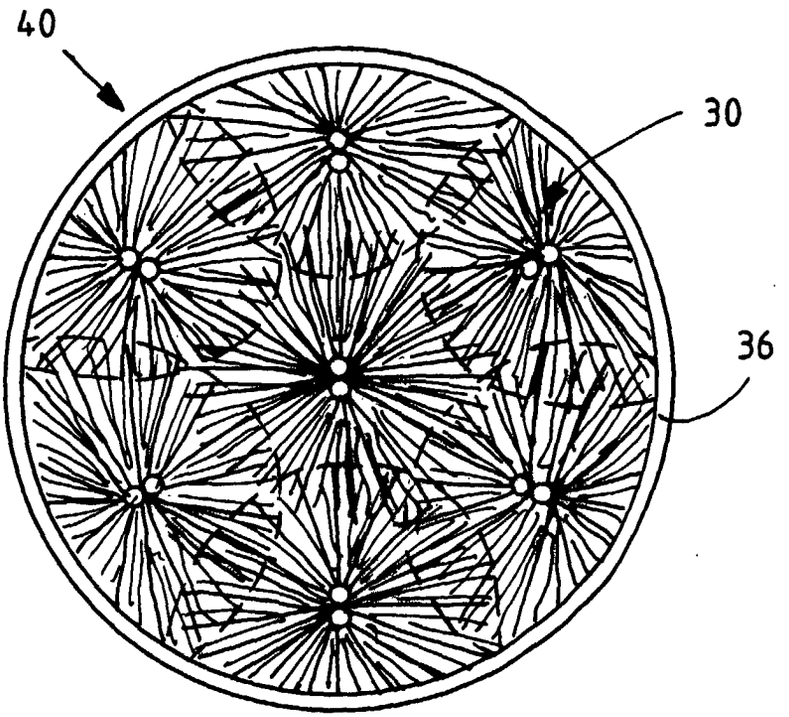

FIG. 8

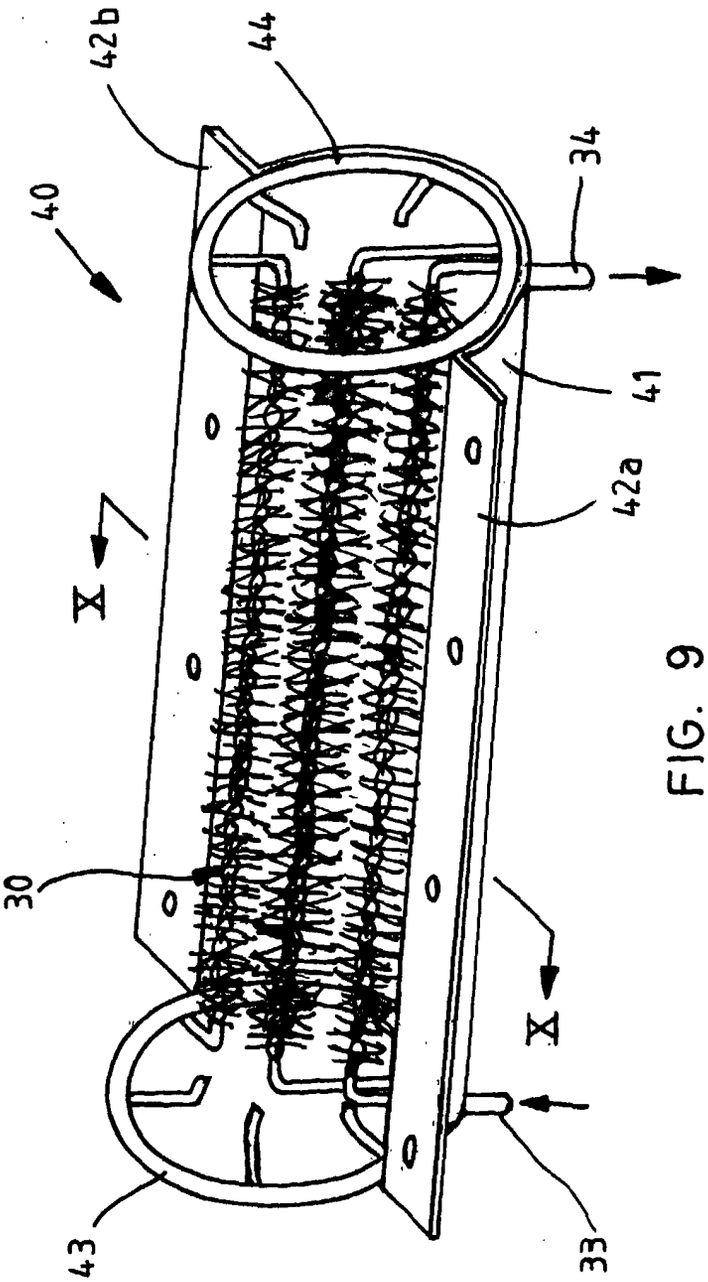

FIG. 9

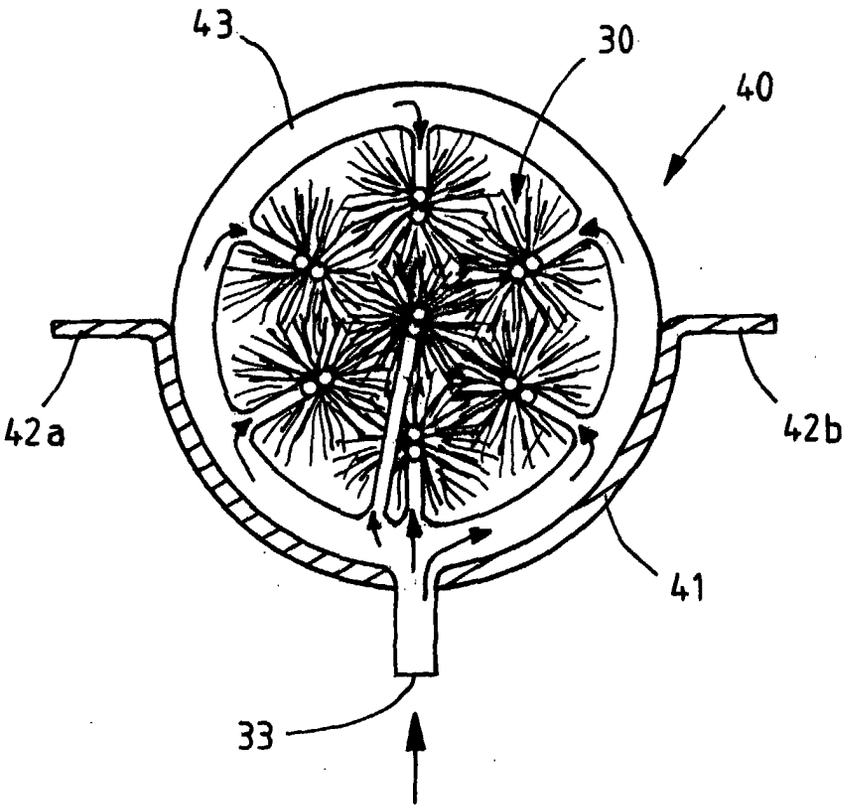

FIG. 10

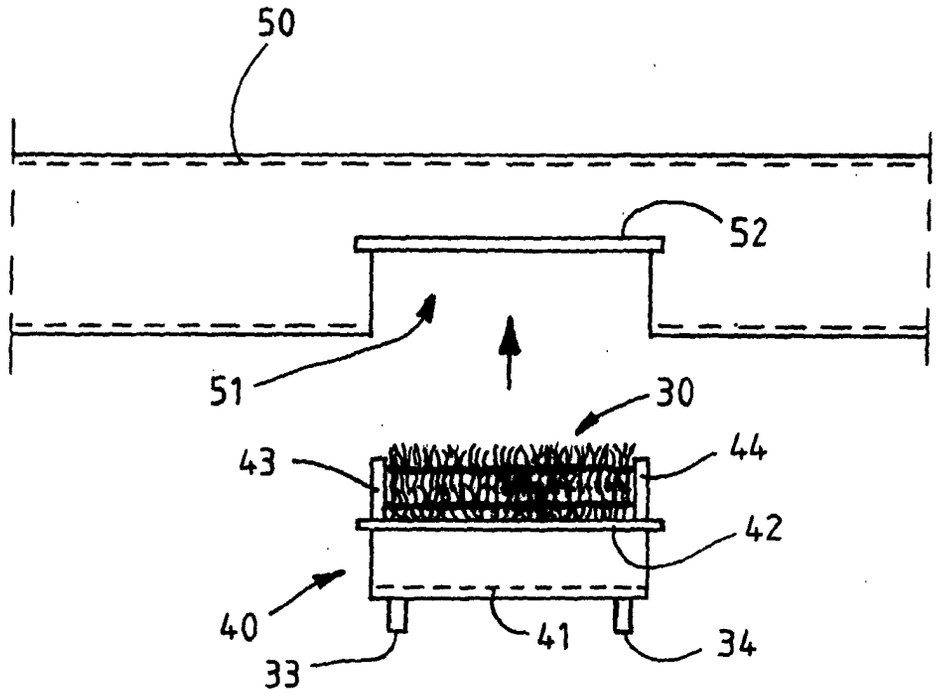

FIG. 11

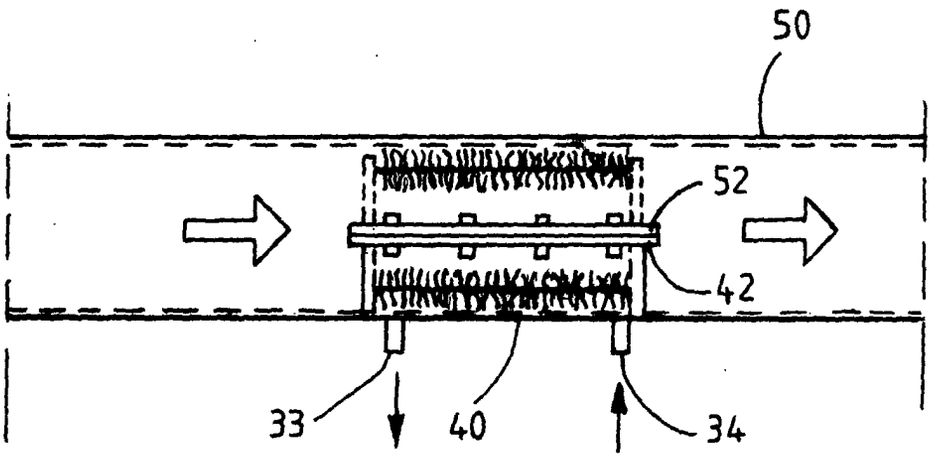

FIG. 12

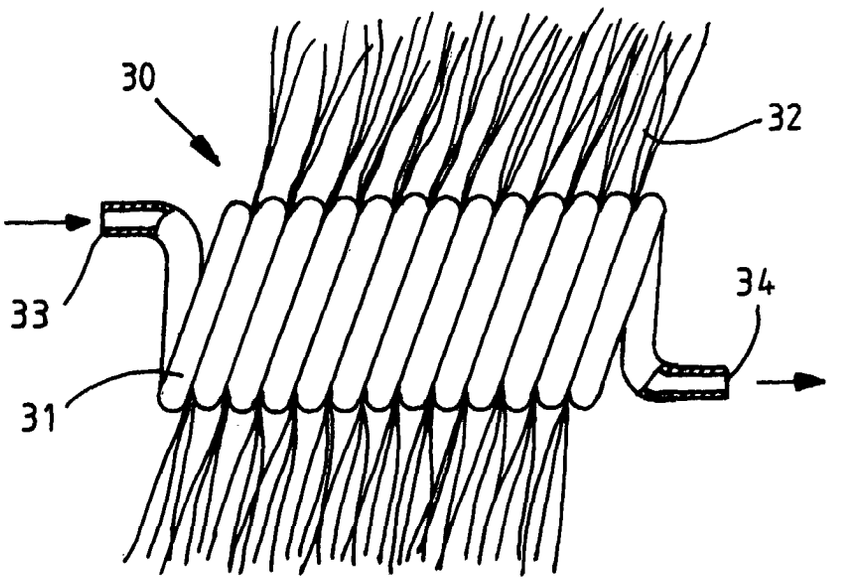

FIG. 13

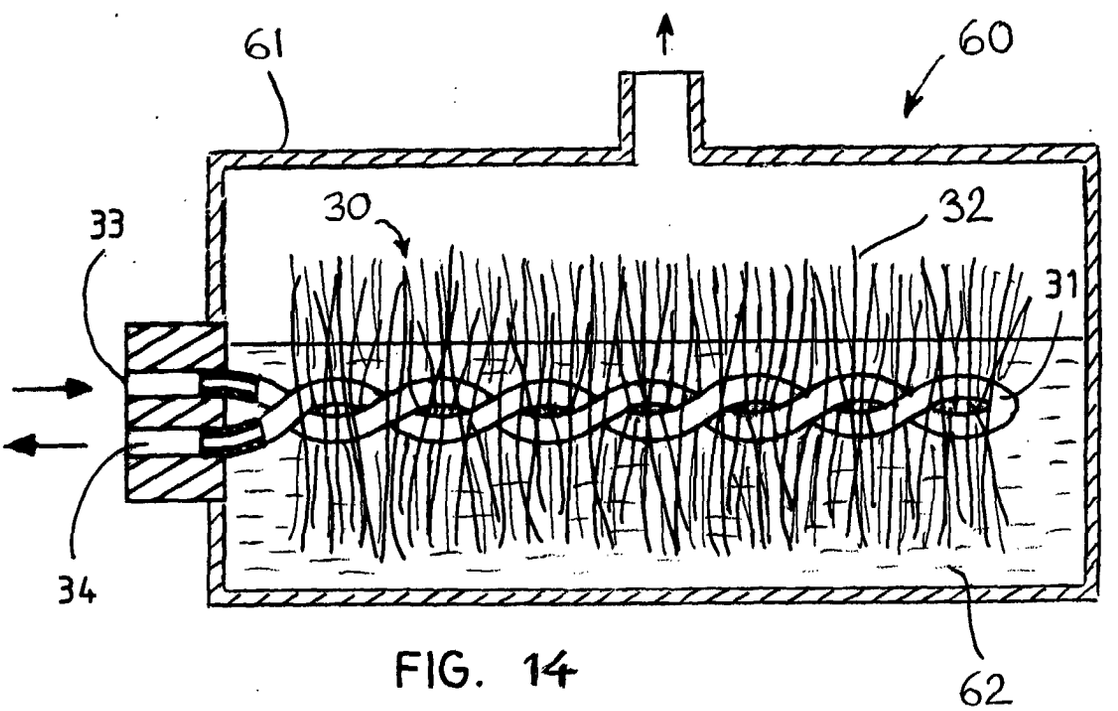

FIG. 14

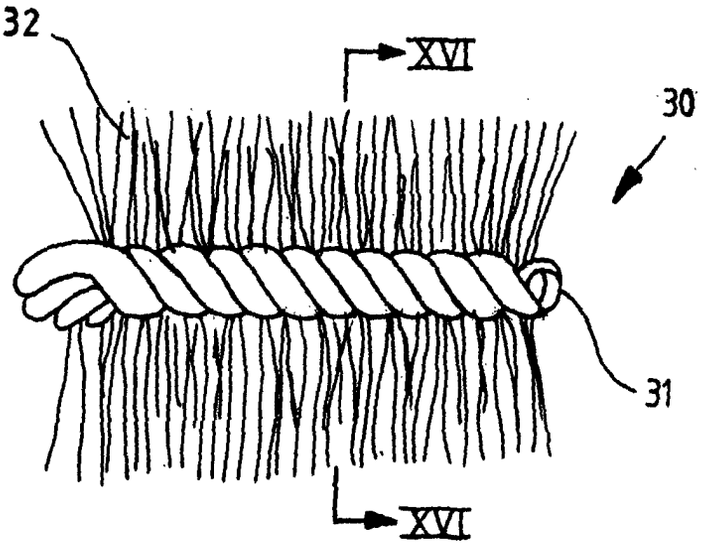

FIG. 15

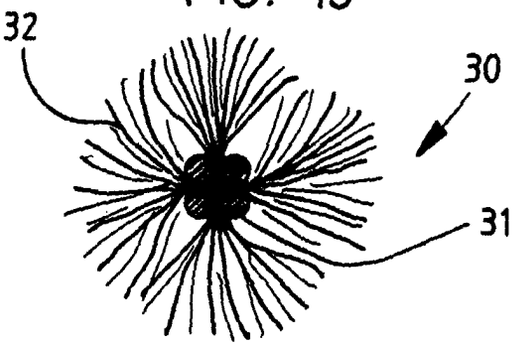

FIG. 16

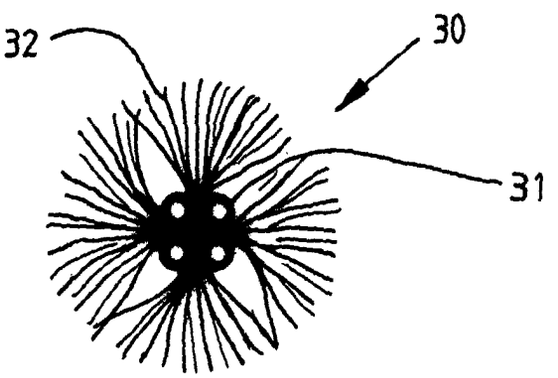

FIG. 17

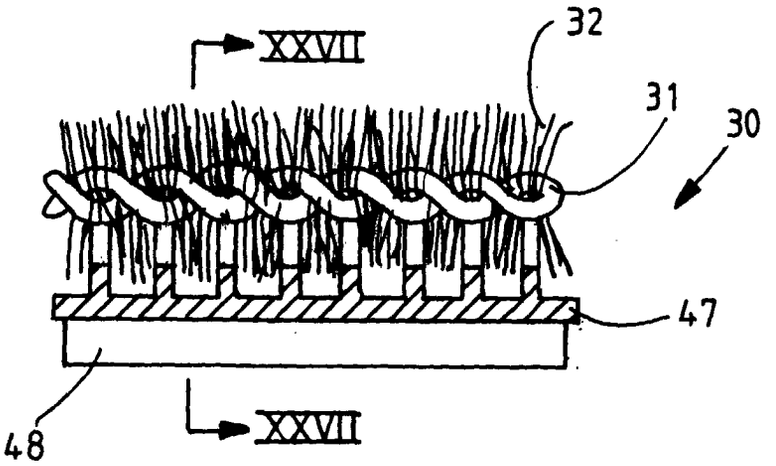

FIG. 18

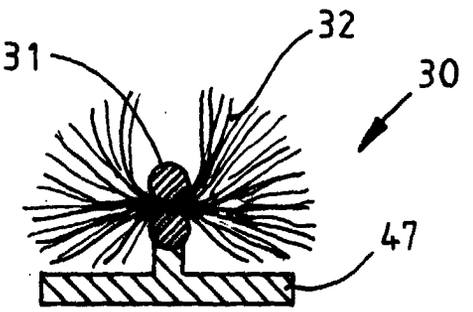

FIG. 19

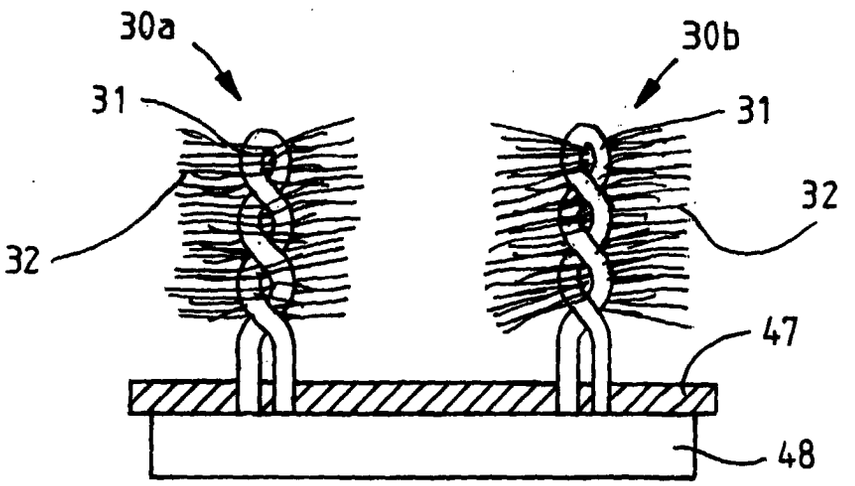

FIG. 20

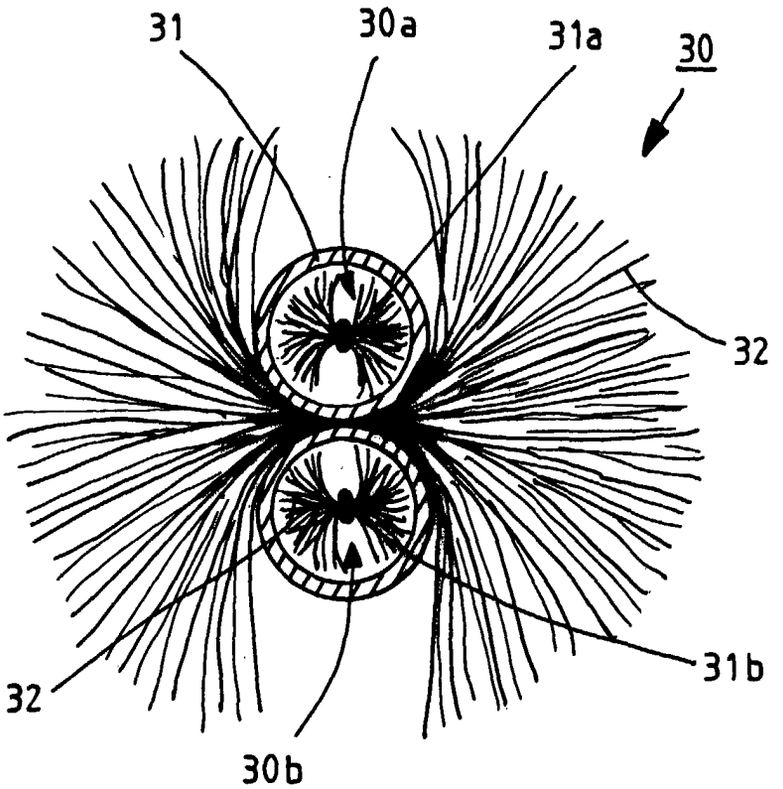

FIG. 21