

PATENT SPECIFICATION

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(54) FLUID-FLUID CONTACT APPARATUS

(71) We, MASS TRANSFER LIMITED, a British Company of District Bank Chambers, High Street, Newcastle, Staffordshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with fluid-fluid contact apparatus of the packed tower type.

Fluid-fluid contact apparatus of the packed tower type for effecting mutual gas (vapour)/liquid and liquid/liquid contact is well known.

Basically, fluid-fluid contact apparatus of the packed tower type comprises a tower or other structure containing one or more beds of packing elements and having means for introducing the fluids to be brought into contact with each other into said bed. In many applications, the fluids are brought into contact in countercurrent flow, the more dense fluid (i.e. the liquid in the case of gas(vapour)/liquid contact apparatus) flowing downwardly through the packed bed whilst the less dense fluid (i.e. the gas or vapour in the case of gas(vapour)/liquid contact apparatus) flows upwardly through the bed. In other applications (e.g. cross-flow cooling towers) the fluids flows are generally at right angles to each other, for example with a liquid flowing downwardly through the bed whilst a gas or vapour flows across the bed. It is not that necessary that both fluids be forcibly fed to the bed and thus, for example, in the case of a so-called sewage filtration bed, liquid effluent is irrigated onto the surface of a packed bed through which air is allowed to permeate (usually without forced flow) to permit aerobic biological treatment of the effluent. The present invention is concerned with all apparatus in which two different fluids are brought together in a packed bed for some action between them.

A wide variety of packing elements are known for such apparatus, for example, fabricated packings such as Raschig rings, Berl saddles, Intalox saddles and Pall rings. In the case of packing elements such as Raschig rings or Pall rings the beds may be stacked beds, (i.e. beds in which the elements are individually placed in position) or dumped beds, (i.e. beds in which at least a portion of the elements have been dumped *in situ* in the apparatus). In the case of the saddles the beds will almost always be "dumped" beds.

The nature of the packing will of course affect the performance of the apparatus and it is an object of this invention to provide fluid-fluid contact apparatus packed with packing elements leading to improved liquid/liquid or gas(vapour)/liquid contact with the apparatus.

The present invention consists in fluid-fluid contact apparatus comprising a packed bed and means for introducing fluids to said bed for contact therein in which at least a part of the bed is a dumped bed formed of packing members each comprising an open ended tubular member the maximum transverse dimension of which in a plane perpendicular to its longitudinal axis (hereinafter referred to as its "diameter") is greater than the length of a coaxial right tube having the same cross-section as the tubular member at one end thereof and having the same surface area as the tubular member (hereinafter referred to as its "width"), and which tubular member has one or more ribs or protrusions extending inwardly from the inside wall of the member, the packing member having an overall length less than its diameter (as herein defined). In accordance with a modification thereof the invention also provides fluid-fluid contact apparatus of the type described above wherein the packing elements comprise grids formed of fused elements having a diameter greater than their length and, suitably, having one or

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more ribs or protrusions extending inwardly from the inside walls elements. In the following description it will be understood that reference to possible modification of the single elements also refers to possible modification of grids formed thereof.

In the following description, reference will be made to the accompanying drawings illustrating packing elements for use in the apparatus of the invention, and in which:—

Figure 1 is a plan view of a packing element having inwardly extending radial ribs;

Figure 2 is a plan view of a packing element having diametric ribs;

Figure 3 is a diametric section through a packing element having inclined inwardly extending inwardly directed ribs;

Figure 4 is a diametric section through a packing element (omitting the internal ribs) having a concave wall;

Figure 5 is a diametric section (omitting the internal ribs) through a packing element having a convex side wall;

Figure 6 is a diametric section (omitting the internal ribs) through a packing element having channel-shaped walls;

Figure 7 is a diametric section through a packing element having cruciform side walls;

Figure 8 is a side elevation of a packing element having circular apertures in the walls thereof in the same plane;

Figure 9 is a side elevation of a packing element having rectangular apertures in the side walls thereof in different planes;

Figure 10 is a diametric section through a thick-walled packing element having venturi-like apertures in the walls thereof;

Figure 11 is a side view of a packing element having tabbed apertures;

Figure 12 is a plan view of the packing element shown in Figure 10;

Figure 13 is a plan view of a packing element having curved tabbed apertures;

Figure 14 is a side view of the packing element shown in Figure 12;

Figure 15 is a plan view of a packing element also having outwardly directed radial ribs;

Figure 16 is a diametric section (omitting the internal ribs) through a packing element having sinuous edges;

Figure 17 is a diametric section (omitting the internal ribs) through a packing element having serrated edges;

Figure 18 is a perspective view of a packing element having an extended hub and radial ribs connecting therewith.

Figure 19 is a plan view of a packing element having a central collar connected to the cylindrical element by radial ribs;

Figure 20 is a side elevation of the packing element shown in Figure 19;

Figure 21 is a diametric section through

another packing element having a central collar connected to the cylindrical element by radial ribs; and

Figure 22 is a plan view of the packing element shown in Figure 21.

In the drawings reference numbered 1 refers to the cylindrical member, reference numbered 2 to any apertures therein, reference numbered 3 to any ribs or projections, reference numbered 4 to any hubs and reference numbered 5 to any subsidiary rings or collars.

The tubular members forming the packing elements used in the apparatus of the invention may be of any desired cross-section, curvilinear and/or polygonal and when made of metal, for example, need not necessarily be sealed closed tubes, the edges closing the tube merely abutting each other. Thus, for example, the tubular element may be triangular, rectangular (preferably square), hexagonal, elliptical or circular in cross-section. In practice, it is generally preferred that the tubular element be of circular cross-section (and, for the sake of simplicity the elements shown in the drawings are all of circular cross-section).

It is generally preferred that the ribs or protrusions extending from the inner wall of the tubular member are flat in at least one dimension.

The inwardly directed ribs may extend the whole of the length of the packing element or only a part thereof and may extend radially from the walls or at an angle thereto. Further, the ribs may be continuous diametrical or radial ribs (Figure 2) or may only extend a part of the way into the inner part of the packing element (Figure 1). The ribs may be parallel to the longitudinal axis of the packing element, normal thereto or at an angle thereto (Figure 3).

The inwardly directed ribs or protrusions extending partially or wholly across the tubular member tend to improve the alignment of the packing members in a bed thereof; i.e. to increase the percentage of elements having a more generally favourable alignment by preventing individual elements from "nesting" in each other.

In addition to the inwardly directed ribs, the tubular members may be provided with other modifications so that their configuration departs from that of a right tube having the same cross-section.

Thus, the physical configuration of the tubular member may be further modified by:—

(a) modifying the shape of the side walls of the cylindrical member;

(b) introducing holes or apertures into the walls of the cylindrical member;

(c) providing additional ribs or like protrusions extending outwardly from the

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walls or edges of the cylindrical member;
(d) providing the edges of the cylindrical member with a non-linear configuration; or
(e) roughening the surface(s) of the walls of the cylindrical member.

Where the shape of the walls of the tubular member is modified, the walls may, for example, be concave (Figure 4), convex (Figure 5), channel-shaped (Figure 6), cruciform (Figure 7), hyperbolic or parabolic in section.

The holes or apertures in the walls of the packing element may, for example, be circular, elliptical, square or rectangular in shape (see Figures 8 and 9). Where the packing element is a thick-walled element, the cross section of the hole may vary through the thickness of the wall so as to provide a venturi-like arrangement (Figure 10; the internal ribs are omitted for the sake of clarity). The tower packing element may suitably be provided with two or more holes in the walls thereof and these may be suitably arranged equidistantly around the circumference of the wall and may or may not be in the same radial plane (Figures 8 and 9). The holes or apertures in the walls may be large enough to permit the through-flow of liquid and vapour or small so as to permit only the transfer of liquid therethrough. The holes or apertures may be associated with internal ribs, i.e. in the case of a metallic element the ribs may take the form of tabs punched out to form apertures in the walls (Figures 11, 12, 13 and 14).

Ribs or protuberances extending outwardly from the walls may extend the whole of the height or length of the walls and may be parallel to (Figure 15), or, preferably, at an angle to the longitudinal axis of the tower packing element. The ribs may also extend around the walls of the cylindrical member and, for example, the packing element shown in Figure 7 can be regarded as having inwardly and outwardly directed circumferential ribs.

Where the edges of the packing element are non-linear, they may be, for example, serrated or sinuous in form (see Figures 16 and 17).

The tower packing elements of the invention may be provided with a combination of modifications, for example a combination of apertures and ribs or protuberances referred to above and the ribs themselves may be ribbed (Figure 18). The packing element provided with ribs and/or apertures may also have a non-linear, for example, a serrated edge, as described above.

It is often helpful that the inwardly directed ribs meet to form a "hub" which extends beyond the plane of the end of the tubular member (see Figure 18) since this

modification will tend to prevent the elements from aligning themselves directly on each other and thereby occluding each other. The hub can also be shorter than the distance between the planes of the ends of the tubular member or only one end thereof may extend beyond the plane of the end of the tubular member.

The walls of the tubular member may be apertured and, if desired, these apertures may be provided with tabs extending therefrom as in the conventional Pall ring and, further, these tabs may be angled to the longitudinal axis of the cylindrical member.

In accordance with another preferred embodiment of the invention the cylindrical element is provided with a single central collar or cylindrical connected thereto by means of radial ribs (Figures 19—22).

As stated above the packing elements used in the apparatus of the invention have a maximum diameter greater than their maximum width. Preferably the ratio of their diameter to their width will be more than 1.5:1 but will preferably be less than 10:1, advantageously the ratio will be in the range 2:1—5:1 and, particularly, in the range 2:1—4:1.

It should be noted that the width of an element is not necessarily the same as its total or overall length and, for example, the width of the elements shown in Figures 16, 17, and 18 is less than the overall length thereof whereas the elements shown, for example, in Figures 3, 4, and 5 have a width equal to their overall length.

The actual physical size of the packing elements will of course depend upon their intended use and purpose but, in general, the packing element may be found useful when the ratio of their diameter to that of the bed is in the range 1:3 to 1:30.

The basic conformation of the packing elements used in the invention tends to lead to packing of the element in a vessel or column so that the packing orientates itself to the vessel walls in such a manner as to encourage the transfer of liquid running down the column wall back into the mass of the packing. In addition, the tower packing elements will tend to improve the efficiency of a packed column in that liquid migration to the vessel walls tends to be reduced. Further, pressure drop may be reduced.

In general it may be said that the tower packing elements used in the apparatus of the invention tend to align themselves so that a larger percentage of them is aligned in a generally horizontal manner (i.e. with the axis of the tubular member vertical) than is the case of corresponding conventional packings having an overall length to diameter ratio of greater than unity. The resultant packed bed generally shows a decreased pressure drop as compared with

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similar beds of conventional packing elements and more particularly show a markedly enhanced capacity. Thus, packed beds of elements as shown in Figure 13 and Figure 14 of the drawings showed an increase in capacity of up to 30% as compared with comparable packed beds of equal thickness of conventional Pall rings of about the same diameter.

The tower packing elements used in the invention may be formed of any suitable material for example, of ceramic material, plastics material, or metal or multilayers of gauzes or meshes formed therefrom. In the case of elements formed of ceramics these will generally have a relatively thick wall section and, similarly, any ribs or protuberances there will similarly be generally thick. The tower packing elements of the invention formed of plastics material may be prepared, for example, by an injection moulding technique and the material of which they are formed should, of course, be chemically resistant to the materials with which it is intended that the packing element be brought in contact. Suitable materials include, for example, reinforced or unreinforced thermoplastic materials.

Tower packing elements formed of metals such as stainless steel or mild steel will generally have apertures and/or ribs formed therein by stamping and cutting operations and will generally be of fairly thin section.

The apparatus of the invention may take any of the forms in which packed beds of elements are utilized to effect fluid-fluid contact; for example it may take the form of distillation, absorption, desorption, water-cooling, biological treatment (e.g. effluent "filtration"), gas-scrubbing, gas-humidification, liquid-liquid extraction apparatus, general microbiological wash or any combination thereof.

The bed(s) of packing elements within the apparatus are simply prepared by dumping the elements into the bed. Where the apparatus is of the cross-flow type it may be advisable to turn the elements in the bed through 90° and this may be achieved by physically turning the bed on a suitable support or by flooding the apparatus.

The invention also provides a method of contacting a fluid with another fluid which comprises bringing the fluids into contact in an apparatus according to the invention.

WHAT WE CLAIM IS:—

1. Fluid-fluid contact apparatus comprising a packed bed and means for introducing fluids to said bed for contact therein in which at least a part of the bed is a dumped bed formed of packing members each comprising an open-ended tubular member having a diameter (as hereinbefore defined) greater than its width (as hereinbefore defined) and having one or more ribs

or protrusions extending inwardly from the inside wall of the member, the overall length of the packing member being less than its diameter (as hereinbefore defined).

2. Fluid-fluid contact apparatus as claimed in claim 1 in which the tubular member is of circular cross-section.

3. Fluid-fluid contact apparatus as claimed in claim 1 or claim 2 in which the tubular member forming the packing element has one or more holes or apertures in the walls thereof.

4. Fluid-fluid contact apparatus as claimed in claim 3 in which the inwardly directed ribs or protrusions are associated with said apertures as tabs extending from one side wall of the holes or apertures.

5. Fluid-fluid apparatus as claimed in any one of claims 1—3 in which the inwardly directed ribs meet at a central hub.

6. Fluid-fluid contact apparatus as claimed in claim 5 in which the ends of the hub extend beyond the planes of the ends of the cylindrical member.

7. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which edges of the walls of the tubular member forming the packing element have a non-linear configuration, as viewed from a direction perpendicular to the longitudinal axis of the tubular member.

8. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the cylindrical member forming the packing element have roughened surfaces.

9. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the walls of the tubular member forming the cylindrical element are curved.

10. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the tubular member is also provided with outwardly directed ribs.

11. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the ratio of the diameter to the width of the cylindrical member is at least 1.5:1.

12. Fluid-fluid contact apparatus as claimed in claim 11 in which the said ratio is not more than 10:1.

13. Fluid-fluid contact apparatus as claimed in claim 12 in which the said ratio is from 2:1 to 5:1.

14. Fluid-fluid contact apparatus as claimed in claim 13 in which the said ratio is from 2:1 to 4:1.

15. Fluid-fluid contact apparatus as claimed in claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

16. A modification of the fluid-fluid contact apparatus as claimed in any one of claims 1—15 wherein the packing is a dumped bed of grids formed of a plurality of

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similar beds of conventional packing elements and more particularly show a markedly enhanced capacity. Thus, packed beds of elements as shown in Figure 13 and Figure 14 of the drawings showed an increase in capacity of up to 30% as compared with comparable packed beds of equal thickness of conventional Pall rings of about the same diameter.

The tower packing elements used in the invention may be formed of any suitable material for example, of ceramic material, plastics material, or metal or multilayers of gauzes or meshes formed therefrom. In the case of elements formed of ceramics these will generally have a relatively thick wall section and, similarly, any ribs or protuberances there will similarly be generally thick. The tower packing elements of the invention formed of plastics material may be prepared, for example, by an injection moulding technique and the material of which they are formed should, of course, be chemically resistant to the materials with which it is intended that the packing element be brought in contact. Suitable materials include, for example, reinforced or unreinforced thermoplastic materials.

Tower packing elements formed of metals such as stainless steel or mild steel will generally have apertures and/or ribs formed therein by stamping and cutting operations and will generally be of fairly thin section.

The apparatus of the invention may take any of the forms in which packed beds of elements are utilized to effect fluid-fluid contact; for example it may take the form of distillation, absorption, desorption, water-cooling, biological treatment (e.g. effluent "filtration"), gas-scrubbing, gas-humidification, liquid-liquid extraction apparatus, general microbiological wash or any combination thereof.

The bed(s) of packing elements within the apparatus are simply prepared by dumping the elements into the bed. Where the apparatus is of the cross-flow type it may be advisable to turn the elements in the bed through 90° and this may be achieved by physically turning the bed on a suitable support or by flooding the apparatus.

The invention also provides a method of contacting a fluid with another fluid which comprises bringing the fluids into contact in an apparatus according to the invention.

WHAT WE CLAIM IS:—

1. Fluid-fluid contact apparatus comprising a packed bed and means for introducing fluids to said bed for contact therein in which at least a part of the bed is a dumped bed formed of packing members each comprising an open-ended tubular member having a diameter (as hereinbefore defined) greater than its width (as hereinbefore defined) and having one or more ribs

or protrusions extending inwardly from the inside wall of the member, the overall length of the packing member being less than its diameter (as hereinbefore defined).

2. Fluid-fluid contact apparatus as claimed in claim 1 in which the tubular member is of circular cross-section.

3. Fluid-fluid contact apparatus as claimed in claim 1 or claim 2 in which the tubular member forming the packing element has one or more holes or apertures in the walls thereof.

4. Fluid-fluid contact apparatus as claimed in claim 3 in which the inwardly directed ribs or protrusions are associated with said apertures as tabs extending from one side wall of the holes or apertures.

5. Fluid-fluid apparatus as claimed in any one of claims 1—3 in which the inwardly directed ribs meet at a central hub.

6. Fluid-fluid contact apparatus as claimed in claim 5 in which the ends of the hub extend beyond the planes of the ends of the cylindrical member.

7. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which edges of the walls of the tubular member forming the packing element have a non-linear configuration, as viewed from a direction perpendicular to the longitudinal axis of the tubular member.

8. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the cylindrical member forming the packing element have roughened surfaces.

9. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the walls of the tubular member forming the cylindrical element are curved.

10. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the tubular member is also provided with outwardly directed ribs.

11. Fluid-fluid contact apparatus as claimed in any one of the preceding claims in which the ratio of the diameter to the width of the cylindrical member is at least 1.5:1.

12. Fluid-fluid contact apparatus as claimed in claim 11 in which the said ratio is not more than 10:1.

13. Fluid-fluid contact apparatus as claimed in claim 12 in which the said ratio is from 2:1 to 5:1.

14. Fluid-fluid contact apparatus as claimed in claim 13 in which the said ratio is from 2:1 to 4:1.

15. Fluid-fluid contact apparatus as claimed in claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

16. A modification of the fluid-fluid contact apparatus as claimed in any one of claims 1—15 wherein the packing is a dumped bed of grids formed of a plurality of





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the elements having a diameter greater than their width and having inwardly directed ribs extending from the inside walls thereof.

shown in Figure 18 of the accompanying drawings.

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5 17. A method of contacting a fluid with another fluid which comprises bringing the fluids together in an apparatus as claimed in any one of claims 1—15.

18. A packing element substantially as

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By a direction given under Section 17 (1) of the Patents Act 1949 this application proceeded in the name of FRACTIONATION RESEARCH LIMITED, a British Company of District Bank Chambers, High Street, Newcastle.

THE PATENT OFFICE

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