United States Patent

[11] **3,540,702**

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[54] **MULTI-WAVE PACKING MATERIAL AND A DEVICE FOR UTILIZING THE SAME**
13 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **261/112**
[51] **Int. Cl.** **B01f 3/04**
[50] **Field of Search** ..... 261/112, 98–111(C.T.)

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ABSTRACT: A packing material for cooling towers or the like comprising a thin plate of plastic material or sheet metal which is formed with zigzag-shaped corrugations and bent transverse to its plane along a plurality of lines extending transverse to the corrugations. A plurality of such plates are joined back to back so that the bent portions of adjacent plates extend in opposite directions to form between themselves large flow passages for gas, while the corrugations of the plates form flow passages for a liquid.

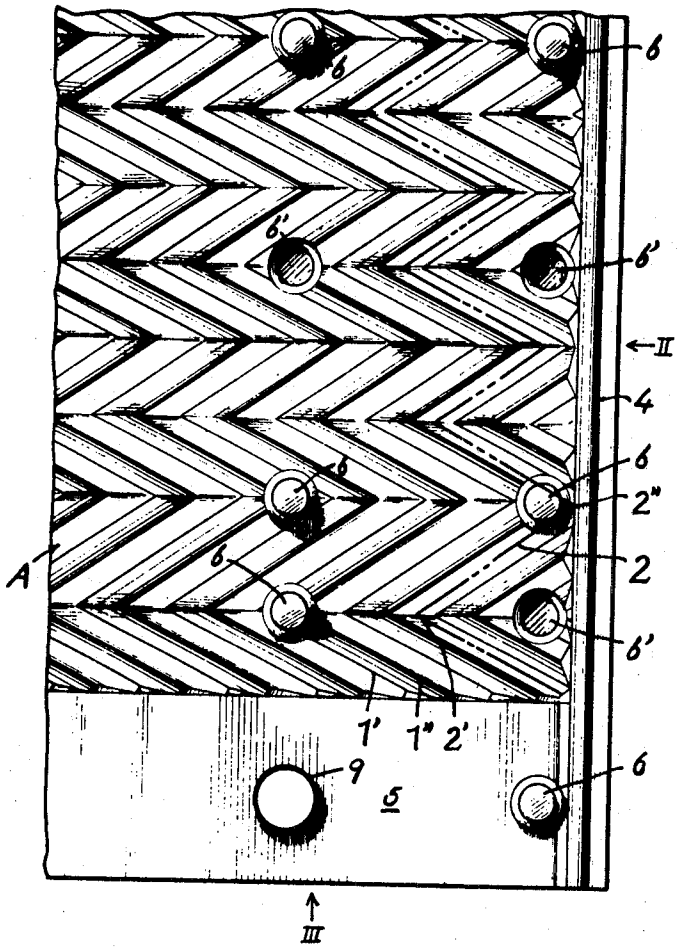

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FIG. 1

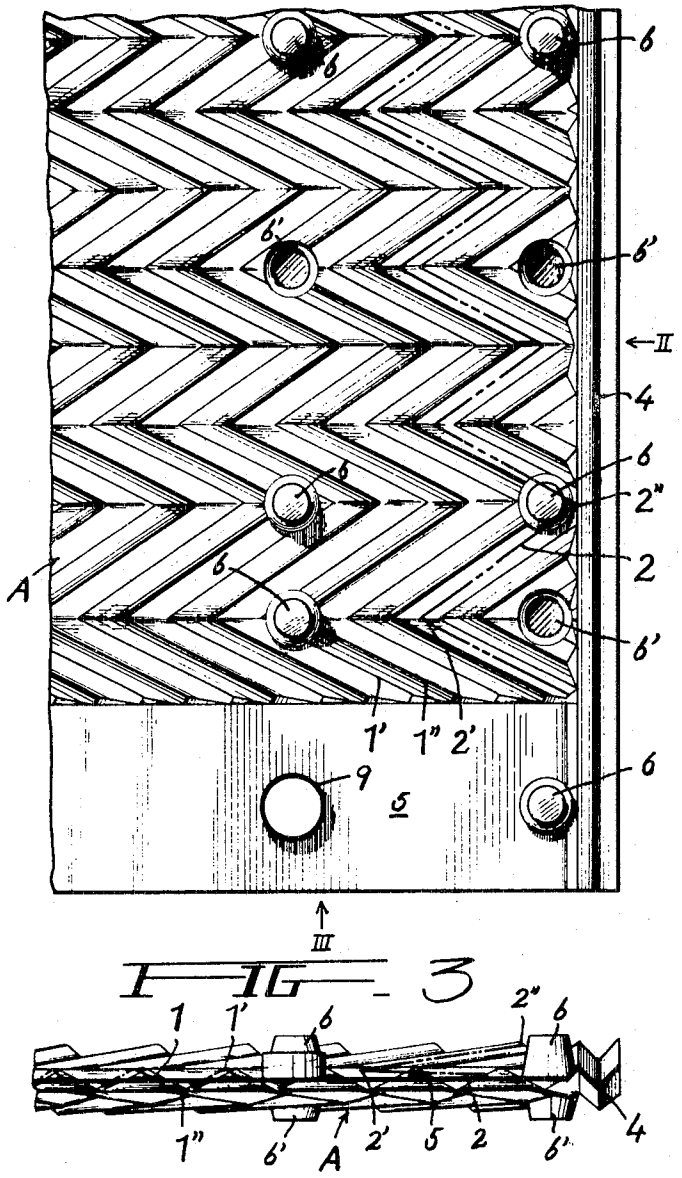

FIG. 2

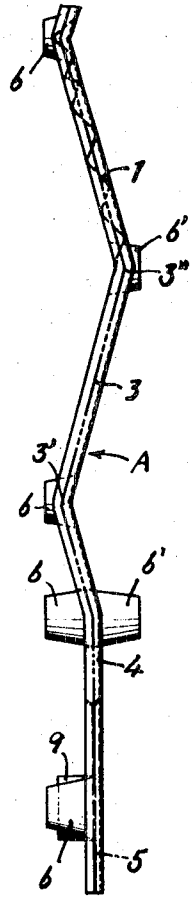

FIG. 3

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FIG. 4

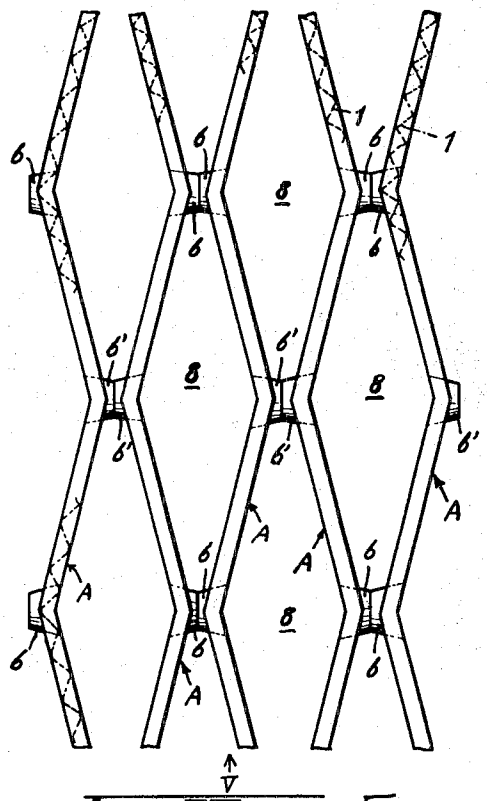

FIG. 5

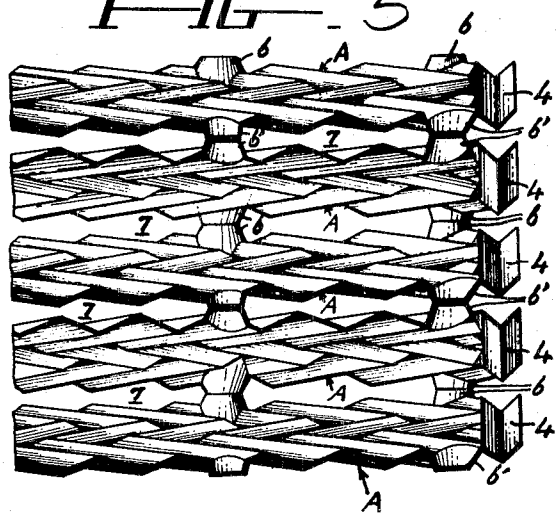

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FIG. 6

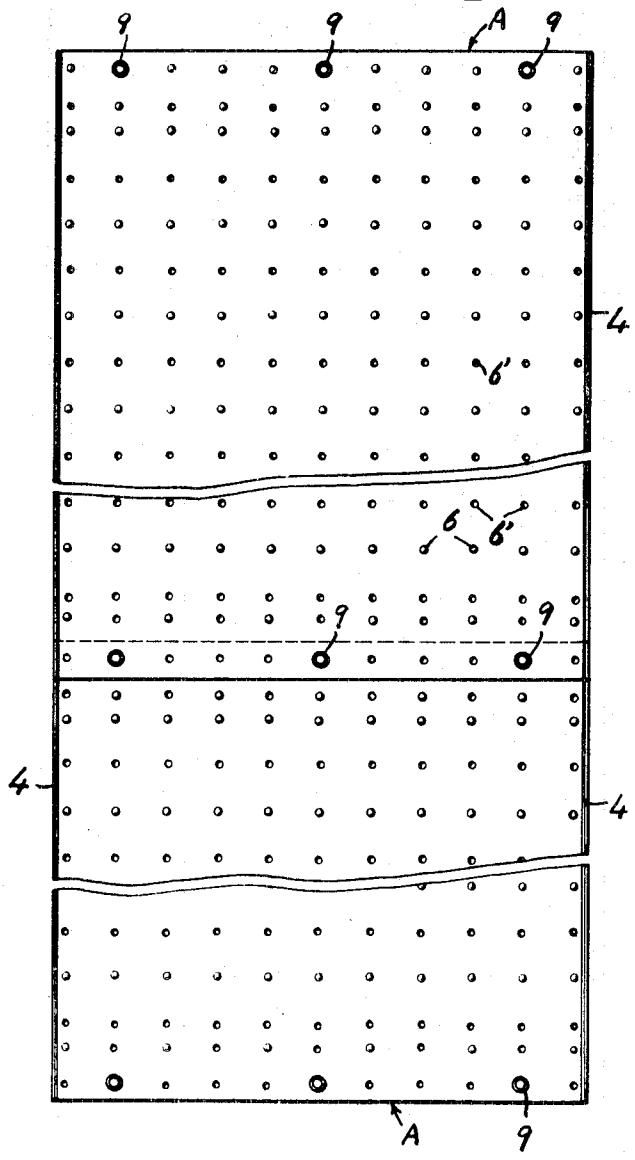

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FIG. 7

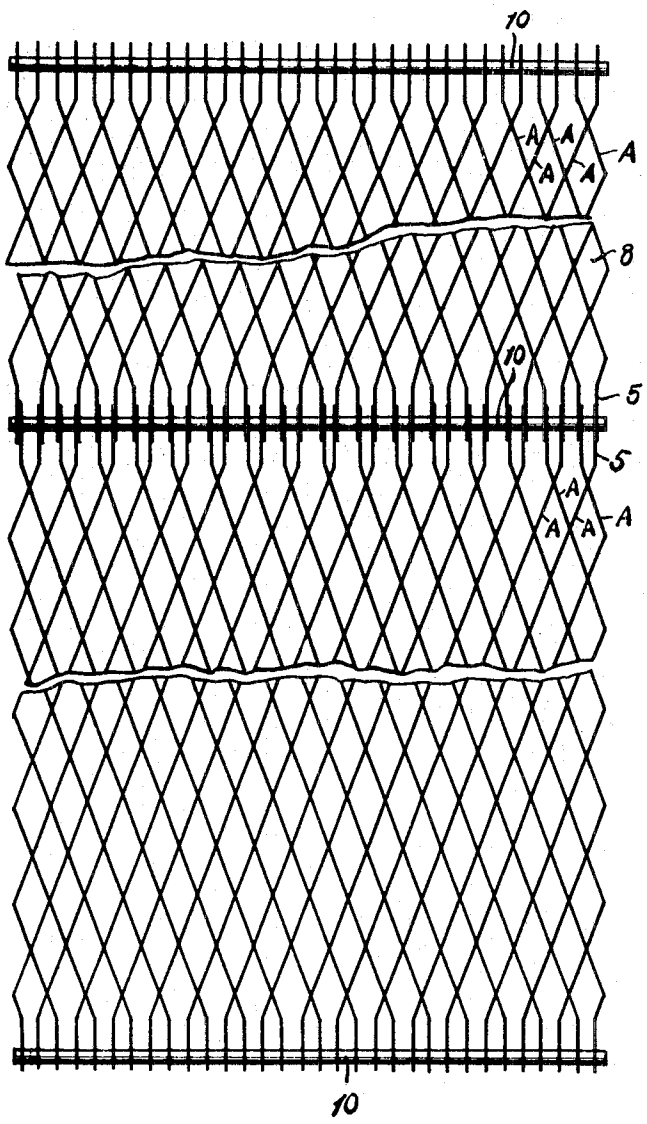

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FIG. 8

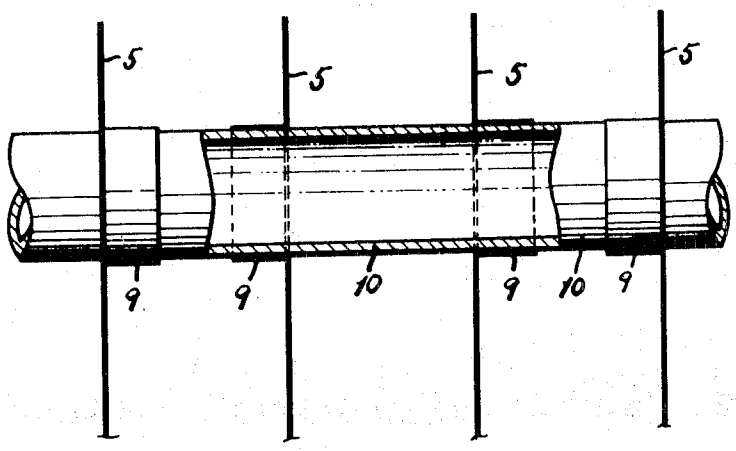

FIG. 9

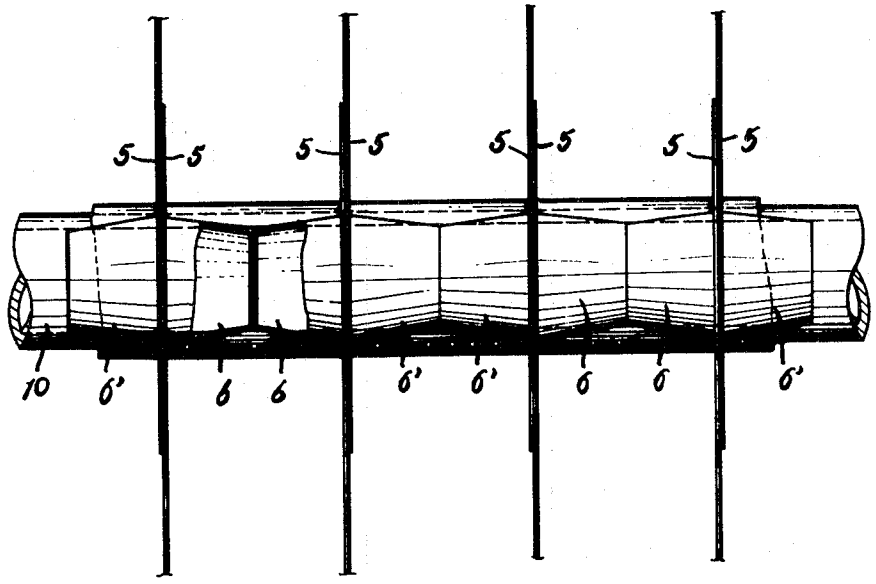

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FIG. 10

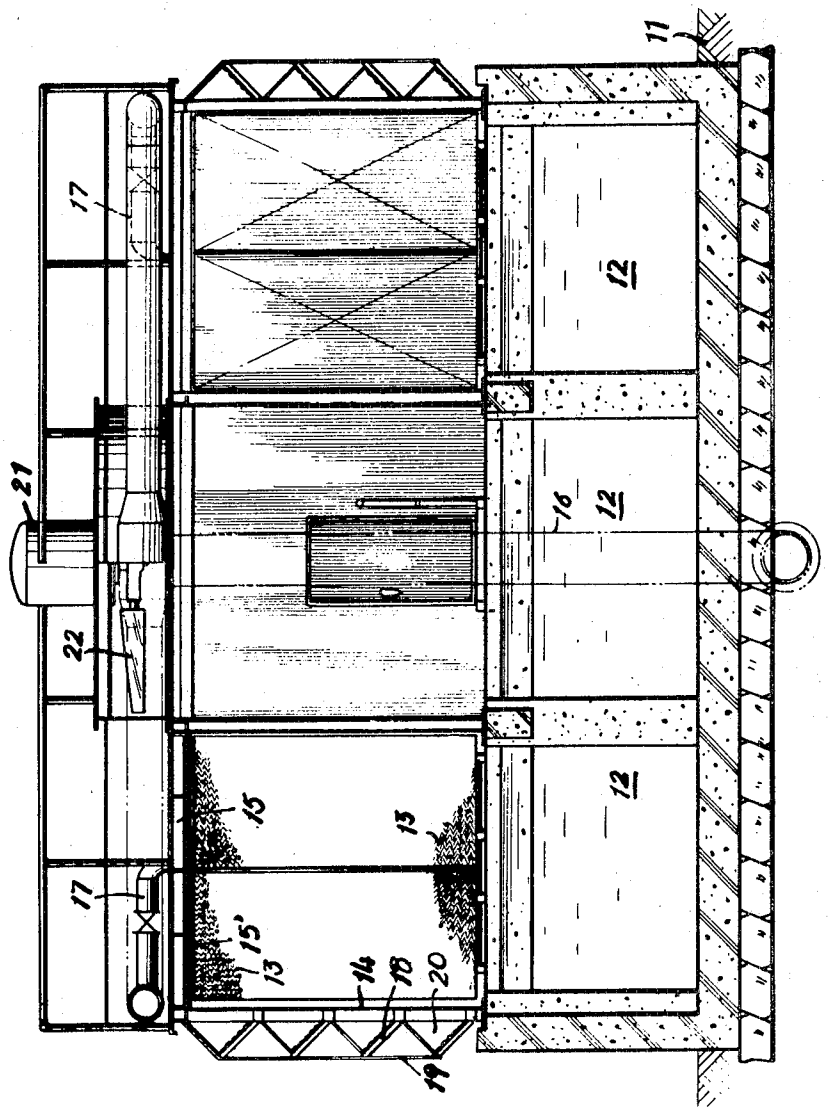
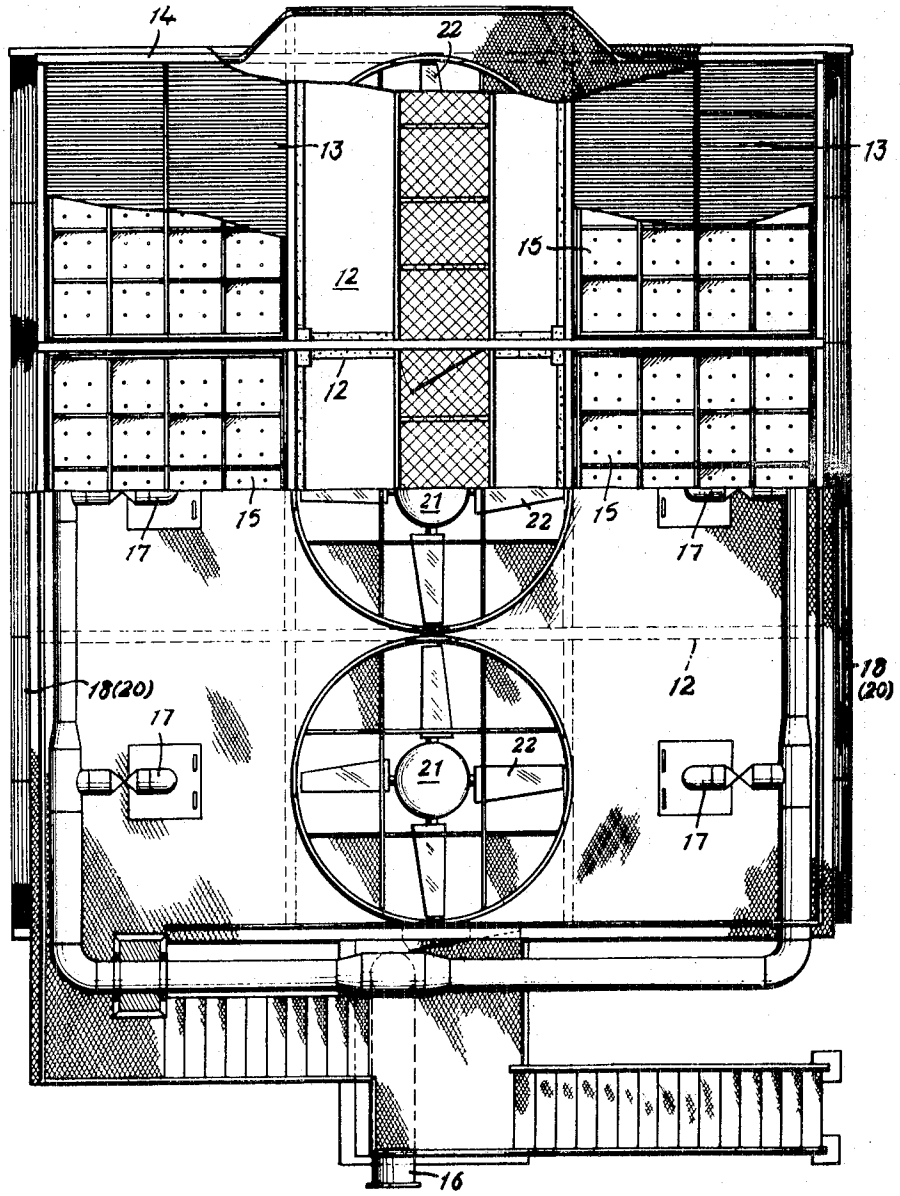


FIG. 11



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MULTI-WAVE PACKING MATERIAL AND A DEVICE FOR UTILIZING THE SAME

This invention relates to multiwave packing material and a device for utilizing the same. The object of the present invention is to provide a packing material which is advantageously applicable to a heat exchange system for a cooling tower, air-cooler, airconditioner and others, a gas-liquid contact system of chemical reactor, etc. as well as a desirable device for utilizing said material.

Packing material has been used in systems for contact of gas and liquid and heat exchange. For these purposes various kinds of this material have been devised and used. The requirements for this material are many and the main requirements are listed below:

I. Industrially easy realizability;
II. Low production cost;
III. Less resistance to the passage of gas;
IV. High resistance to passage of liquid and a long staying time of liquid;
V. A large total heat transfer coefficient (K.G.a);
VI. High strength;
VII. Easiness of mounting;
VIII. Light weight; and
IX. High corrosion resistance.

Many of these requirements are technically contradictory one to another. Although some kinds of packing material can fulfill a part of these requirements, no material satisfying all of these requirements has been obtained.

The basic object of the present invention is to provide packing material for a gas-liquid contact system and gas-liquid exchange system which is characterized, first of all, by ease of production at a low cost, by small resistance to the passage of gas, high resistance to the passage of liquid, a long staying time of liquid and high total heat transfer coefficient. To this end the present invention provides a synthetic resinous or metal thin laminated plate provided with corrugation of appropriate height, parallel to the laminated sheet in the direction of thickness similarly to conventional corrugated plates.

These corrugations are however not linear, but constitute a V- or wave-shaped pattern in the direction of width or length of the blank plate. The blank plate provided with the zigzag-shaped corrugations is further provided with a relatively large bend in the direction transverse to its plane. The packing material of the present invention provided with the zigzag-shaped corrugations can be easily made from a synthetic resinous plate or metallic thin laminated plate merely by press-forming or the like, simply in a single step in most cases, and at a low cost. The resistance against the passage of liquid flowing down along the surface of packing material is considerably increased by the above triple bent construction so as to elongate the stay time of fluid. Moreover by assembling said packing materials back to back, a relatively large gas passage area is formed between said large bends so as to reduce the resistance against gas passage. This makes it possible to utilize gas with a reduced loss of gas pressure, profitably economizing a power expense and the like, with addition of an increased total heat transfer coefficient.

Another object of the present invention is to obtain packing material excellent in strength. Packing material according to the present invention is provided with first, second and third bends joined altogether in triple, respectively functioning as reinforcement of blank plate. Generally a single bent, though it reinforces a blank plate, has directionality so that its reinforcing effect is limited to one direction. On the contrary, packing material of the present invention, provided with three bends displays a reinforcing effect fully in all directions. Even a synthetic resinous thin laminated material of 0.5 mm or less in thickness can well stand pressure of gas or the like not only in loading or mounting operation, but during operation so that packing material of high durability can be obtained from this material.

Another object of the present invention is to obtain packing material which can be mounted exactly and easily. Generally in applying this kind of packing material, it is essentially

required to keep respective packing plates spaced at a required distance from each other for the flow of liquid or gas therebetween. In the present invention, by joining apexes of third bends back to back a fixed space can be automatically kept. The joint can be made easily and exactly. Especially in an embodiment of the present invention, an appropriately outward projecting joint seat is formed at the apex portion of the third bend. By joining packing materials with these joint seats, each packing material can be mounted appropriately and exactly with an exact space at all times, eventually under assistance of a small spacer.

Another object of the present invention is to obtain packing material of light weight as well as a device for utilizing said material. Since packing material of the present invention has a reinforcing effect without directionality, as above stated, a relatively thin laminated material can be used so that packing material itself as well as a device for utilizing the same are lightened. This packing material of triple curved construction becomes naturally bulky. In this respect attention is paid by the present invention to lighten the device. As typical raw material this packing material synthetic resin is used. Even in case of using metal material, the use of aluminum or other light metal plate or light metal alloy plate assures the light weight property of the present material in all cases.

Another object of the present invention is to obtain a packing material having an excellent corrosion resistance. As above stated, packing material according to the present invention utilizes synthetic resin as typical raw material. This gives the product excellent corrosion resistance. In case that metal material is adopted, the application of plating, chromate treatment or coating gives the product sufficient corrosion resistance. As above stated, since the blank plate itself consists of a sufficiently thin laminated plate, the coating permits it to obtain a packing material practically with no difficulties.

The above described construction of the present invention effectively checks liquid from flowing out from the packing surface by the complicated bending property, even if the construction confronts a gas stream. Moreover the embodiment of the present invention forms a bent groove vertically provided along peripheral side of the packing material. This bent groove effectively checks liquid from flowing out from the surface of the packing material either on top surface or on the back surface. In joining a plurality of packing materials together, two bent groove portions superposed one on the other also function as a connection construction, thereby playing a role in effective disposition of packing materials in row.

Another object of the embodiment of the present invention is to provide a means for mounting packing material in a device. To this end the present invention provides holes at the end of packing material. The packing material with pipe or the like inserted into these holes is suspended in the device. This packing material thus suspended may be placed with the lower end on an appropriate rack. Thus the mounting is much simplified.

Other many excellent characteristics and effect and merits of the present invention will be better understood from the following description of embodiment in connection with the accompanying drawings in which;

FIG. 1 is a plan view showing a portion of the packing material of the present invention.

FIG. 2 is a side view, partly in section, viewed in the direction of arrow II in FIG. 1.

FIG. 3 is a side view, partly in section, viewed in the direction of arrow III of FIG. 1.

FIG. 4 is a side view, partly in section, showing the application of joined packing materials of the present invention.

FIG. 5 is a side view viewed from the direction of arrow V in FIG. 4.

FIG. 6 is a partial front view showing the application of packing materials of the present invention arranged in a row, with the the curve construction omitted.

FIG. 7 is a partial plan view for the same object as FIG. 6, only showing the third bend in a diagrammatic manner.

FIG. 8 is a partially enlarged sectional view showing the insertion of a suspending rod for each packing material.

FIG. 9 is an enlarged sectional view of connecting portion of packing materials of said rod.

FIG. 10 is a side view, partly in section of an apparatus with packing material of the present invention applied to a cooling tower.

FIG. 11 is a plan view, partly in section, of said device.

The present invention will now be described with reference to the embodiment shown in the drawings. FIGS. 1—5 show a typical example of a packing material of the present invention. The raw material, a relatively thin laminated sheet A, 0.5 mm or less in thickness made of hard vinyl chloride or other synthetic resin, or metal as above stated is used. The thin laminated sheet A is formed with corrugations 1 which are of appropriately low wave or V-shaped form and having each a peak portion 1' and valley portion 1'' continuously in parallel to each other. The direction of the corrugations 1 is not linear as in standard corrugated sheets, but changes at spaced points 2' 2'' in a V-shaped manner to form a zigzag pattern as shown by the dash-dot line in FIG. 1. The thin laminated sheet A thus provided with zigzag-shaped laminations in the direction of its width or length is further provided with a bend 3 as shown in three in dash-dotted line in FIG. 2 and continuously bent at equal distances to form apex 3' lines and bottom lines 3''. The illustrated embodiment is formed such that a straight line connecting points 2' are located on apex 3' and similarly bottom line 3'' is positioned on a straight line connecting points 2''.

Further as apparent in FIGS. 2 and 3, the packing blank plate A is provided with a V-shaped groove portion 4 on both edge portions (Right side of FIG. 1). This groove portion 4 is substantially equal in height to the corrugations. These portions are adapted to prevent liquid flowing down along the surface of blank sheet A from being blown out of the sheet A by wind or wind pressure. At the upper or lower end of plate A (lower side in FIG. 1) a flat surface 5 of appropriate width is provided as shown in FIGS. 1 and 3. This flat surface 5 serves to join blank sheets A to each other as mentioned hereinafter.

In the packing material of the present invention apex portion 3'' and bottom portions 3'' are alternately joined back back. For such joining projecting seats are formed at appropriate distances in apex portion 3' and in bottom portion 3'' and depressed joint seats 6' are also formed at appropriate distances. The seats 6 and 6'' are joined by welding or adhesion.

In case packing material thus obtained is applied to contact or heat exchanging system to which the present invention is applied, passage 7 defined by joining the corrugations 1 together end-to-end is utilized as passage for liquid. Relative large passages 8 as shown in FIG. 4 and FIG. 5, obtained by joining the seats is utilized as passage of gas. In case of utilizing the packing material of the present invention in a system of gas-liquid exchange type, passage 7 is utilized for passage of liquid which flows down along the surface of the material and wetting the same. To this end passage 8 is utilized as a passage for gas. This restricts the flow down speed of liquid so as to elongate the staying time of liquid, and besides increases the wet surface of the packing material resulting in increasing its total heat transfer coefficient. In case of applying the present invention to a system of gas-liquid counter flow type, liquid flows down in the direction of passage 8 and along the surface on which the corrugations 1 are formed and gas rises in counter flow between such surfaces. Since liquid flows down with a velocity restricted by rising gas and moreover lowered by the corrugations 1, with addition of large wet area of packing material, the total heat transfer coefficient can be increased.

In order to mount the present packing material in a gas-liquid contact system or heat exchange system, techniques as shown in FIGS. 6—9 are adopted. At least at the upper end of each packing material, a tubular cylindrical insertion stud 9 is formed. The detail of said stud is shown in FIG. 8. Into this cylindrical stud 9 a pipe or rod-shaped member 10 of vinyl chloride or other synthetic resin is inserted and joined thereto with adhesive. Each blank plate A is joined to rod-shaped members 10 at a fixed pitch set by considering the joint relation between seats 6 and 6 or between 6' and 6'. As shown in FIG. 6 joint portions to be vertically connected are attached with flat surfaces 5 and 5 superposed one on the other. The upper and lower ends of the packing material plates are preferably provided with flat surfaces 5 as shown in FIG. 7. Especially flat surface 5 of the upper end serves to distribute water or other liquid flowing down from above as stated hereinafter on each blank plate. Further by fixing suspension pipes or other similar rod-shaped members 10 respectively inserted into joint portion and flat surface 5 of the lower end as shown in FIG. 9 through the medium of interposed spacers (made of pipe cut), the entire packing material is mounted stably in a system.

FIGS. 10 and 11 show the state of packing material assembly mounted in a cooling tower. A desired number of sump tanks 12 are provided on both sides of base 11. Above these sump tanks 12, packing material 13 assembled as shown in FIG. 9 is positioned enclosed in an appropriate enclosure 14. In the upper portion of packing material 13 a water sprinkle tank 15 is mounted provided at the bottom with water sprinkle opening 15' and partitioned in appropriate size. To this water sprinkle tank 15 conduit pipes 16 are connected by means of an appropriate pumping mechanism (not shown) and branch feed pipes 17 feed water to each water sprinkle tank, thereby feeding water on packing material 13 from water sprinkle opening 15'. The above enclosure 14 is provided on each side with admission port 20 provided with a louver 18 and wire net 19, thereby having air sucked into layer of packing material through the wire net 19 and louver 18. Fan 22 rotated by motor 21 in the middle of the device above water sprinkling tank serves to have air or other gas suctioned into packing material 13. Namely packing material 13 is provided laterally with passages 8 to provide communication between louver 6 and the middle of the device, vertical passages 7 provide communication from water sprinkle tank 15 to sump tank 12. Air sucked from louver by the rotating fan passes through passages 8 of packing material 13, comes to the middle of device and then is exhausted by fan 22. Relative to such a flow of air, water or other liquid is fed from water sprinkle tank in the upper portion of the device into packing material and then flows down along the surface of said material to be received by sump tank in the lower portion of the device, thereby making heat exchange or gas-liquid contact in the portion of packing material 13.

To explain an example of concrete operation with the device of the present invention, a variety of field experiments were made with devices mounted with packing materials shown in FIGS. 1—5 respectively at a distance of 25 mm or 33 mm as shown in FIGS. 6—7 and with devices mounted with this kind of commercial heat exchange packing materials. The results obtained were determined. In the experiment arranging commercial packing materials respectively at a distance of 33 mm, and feeding air at a velocity of 2.5 m/sec and water at a rate of 20—30 $m^3/m2/hr$, a performance value Ka was 12,000—13,700 $Kcal/m^3/hr/\Delta^t$ and pressure loss was 4.1—4.6 mm Ag/m. In the case of arranging packing materials of the present invention, similarly at a distance of 33 mm, and feeding air at a velocity of 3 m/sec and water similarly to the above, a performance value Ka was 13,500—15,300 $Kcal/m^3/r/\Delta$ i and pressure loss was 2.46—2.76 mm Ag/m desirably confirming the improvement of performance value and the reduction of pressure loss. In the case of arranging commercial packing materials at a space of 27 mm, and feeding air at a velocity of 3 m/sec and water at a rate of 25—30 $m^3/m2/hr$, a performance value Ka was 14,000—15,000 $Kcal/m^3/r/\Delta^t$ and pressure loss was 6.39—6.7 mm Ag/m. In the case of arranging packing materials of the present invention at a distance of 25 mm, the design point of air feeding was 4 m/sec. In feeding water at a rate of 25—30 $m^3/m2/hr$, a performance value obtained was 12,400—21,300 $Kcal/m^3/hr/\Delta^t$ with pressure loss of 4.5—4,85 mm Ag/m, thus confirming

characteristics far better than before. Namely according to the present invention, packing material can be manufactured relatively simply and easily and at a relatively low cost, no matter whether synthetic resin or metal material is used. By virtue of a low resistance to passage of gas, with addition of an increased resistance to passage of liquid and an elongated staying time of liquid, this packing material can demonstrate aforementioned particularly excellent performance and at the same time accomplish aforementioned many technical objects.

I claim:

1. A multiwave packing material for cooling towers or the like comprising plates of thin sheet material, each formed with zigzag-shaped corrugations and being bent transverse to its plane along a plurality of spaced substantially parallel bend lines extending transverse to said corrugations so that plate portions between said bend lines include angles with each other while said bend lines alternately define peak portions and valley portions of each plate.

2. A packing material as defined in claim 1 wherein each of said plates is provided with a plurality of projecting seat portions arranged spaced from each other along said bend lines, said seat portions on one line projecting in a direction opposite to the direction of the seat portions on the adjacent line.

3. A packing material as defined in claim 2, wherein said projecting seat portions have a substantially frustoconical configuration.

4. A packing material as defined in claim 2, wherein said bend lines extend transverse to side edges of said plates and wherein each of said plates is provided on opposite side edges thereof with longitudinally extending grooves which respectively connect the ends of corrugations at said side edges to each other.

5. A packing material as defined in claim 4, wherein each of said plates has an upper and lower marginal flat portion which are free of corrugations and serve to join plates to each other.

6. A packing material as defined in claim 5, wherein said flat marginal portions are provided with openings therethrough spaced from each other in transverse direction and projecting seat portions between said openings.

7. A packing material as defined in claim 4, wherein a plurality of said plates are arranged back-to-back with said projecting seat portions of one plate abutting against the corresponding seat portion of the adjacent plates so that portions of adjacent plates form between said bend lines large passages for flow of gas therethrough, whereas the corrugations form passages for a liquid.

8. A packing material as defined in claim 7, wherein said seat portions are fixedly connected at abutting ends thereof to each other.

9. A packing material as defined in claim 8, wherein said plates are made from plastic material and said abutting ends of said seat portions are bonded to each other.

10. A packing material as defined in claim 8, wherein said plates are made from sheet metal and said abutting ends of said seat portions are welded to each other.

11. A packing material as defined in claim 6, wherein the flat marginal lower portion of one plate is overlapped by the flat marginal upper portion of another plate with said openings and seat portions on said marginal portions aligned with each other, and connecting means extending through said aligned opening for connecting said marginal portions to each other to form a unit of at least two longitudinally connected plates.

12. A packing material as defined in claim 11, wherein a plurality of such units are arranged back-to-back with said projecting seat portions of one unit joined to the projecting seat portions of adjacent units, said connecting means comprising elongated rod-shaped members extending through aligned openings of said units.

13. A packing material as defined in claim 7, wherein said plates are arranged in substantially vertical position, and including means for feeding a gas through said large passages and liquid into the upper ends of said corrugations.