May 8, 1928. 1,669,062

E. MENZEL

HEAT EXCHANGE APPARATUS

Filed July 11, 1927 3 Sheets-Sheet 1

Fig. 1

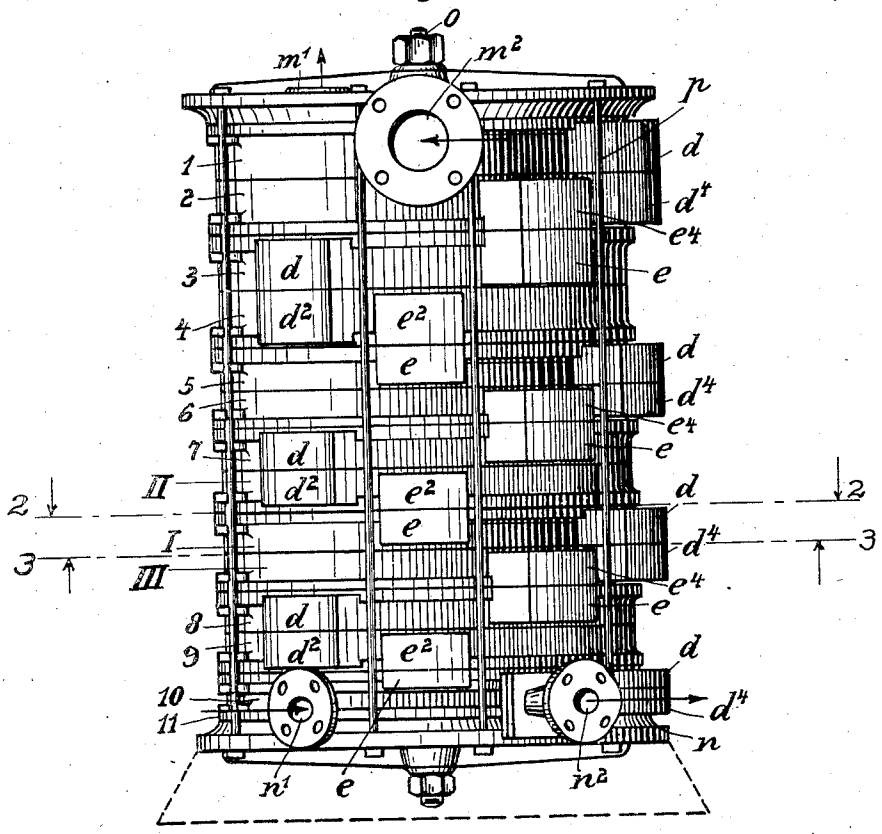
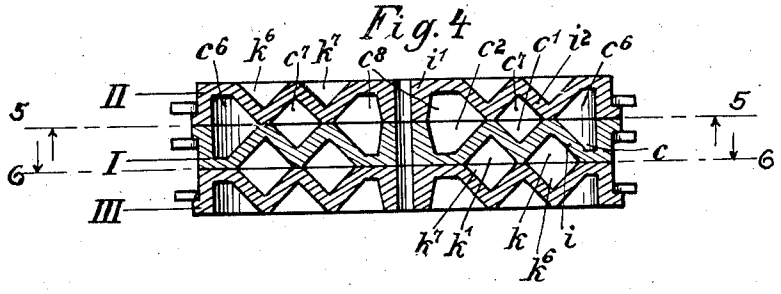


Fig. 4



Inventor:
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Fig. 2

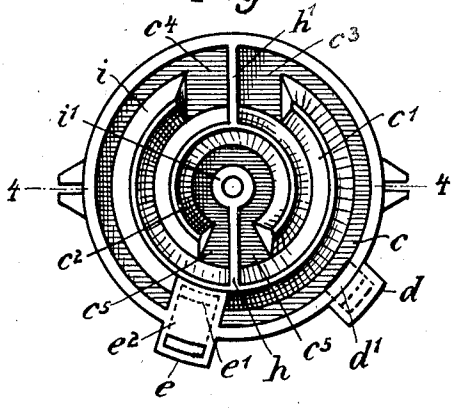


Fig. 5

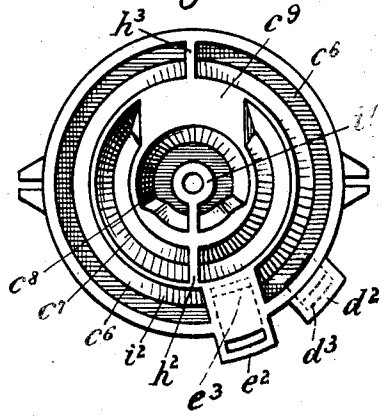


Fig. 3

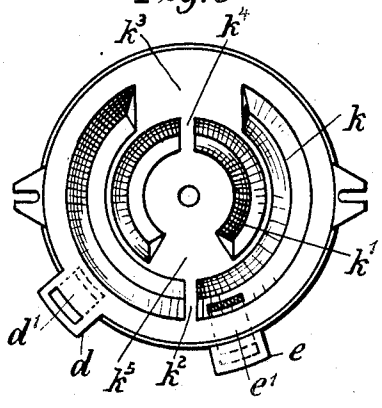
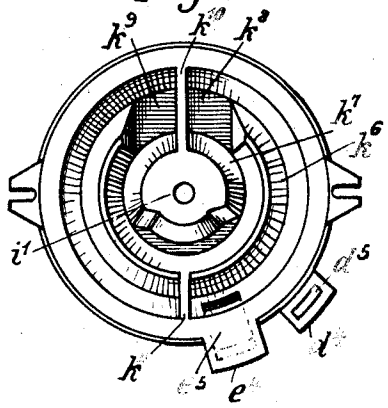


Fig. 6



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HEAT EXCHANGE APPARATUS

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Fig. 7

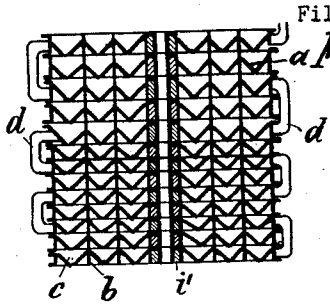


Fig. 8

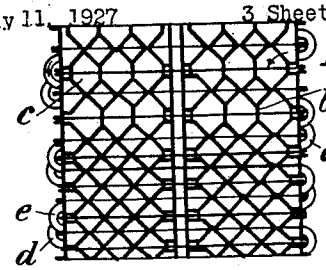


Fig. 9

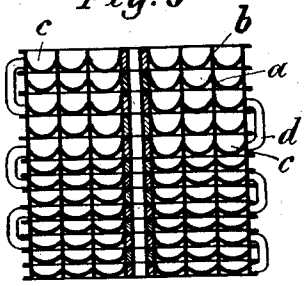


Fig. 10

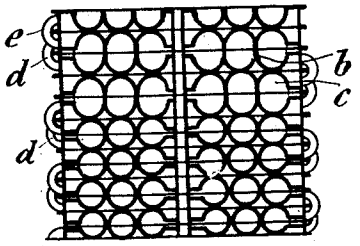


Fig. 11

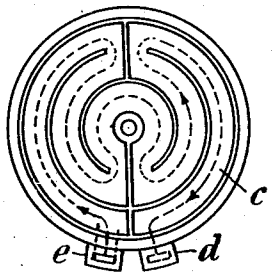


Fig. 12

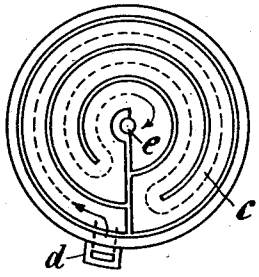


Fig. 13

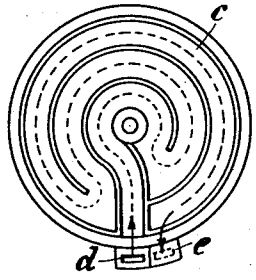


Fig. 14

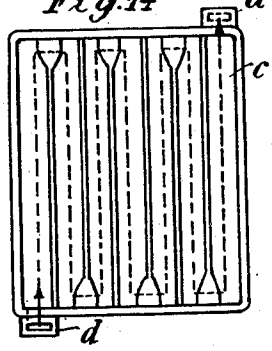


Fig. 15

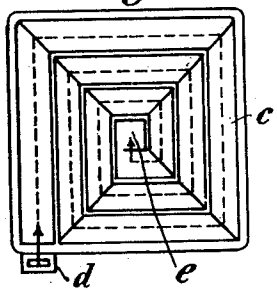
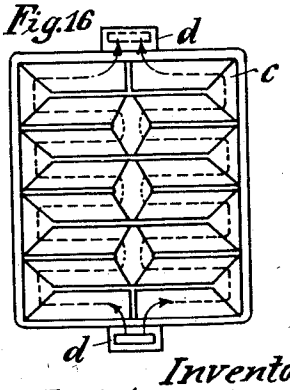


Fig. 16



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Patented May 8, 1928. 1,669,062

UNITED STATES PATENT OFFICE.

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HEAT-EXCHANGE APPARATUS.

Application filed July 11, 1927, Serial No. 204,723, and in Germany October 28, 1924.

This invention relates to heat exchange columns or reaction towers for gases, vapours or liquids.

Among the main objects of the present invention it is aimed to provide a column or tower of the type referred to, in which the efficiency and output are generally increased by complete utilization of the surfaces provided in the apparatus for the exchange of heat between the two separate currents or streams which are passed through the same.

The invention relates more particularly to that type of apparatus which is made up of a series of superimposed plates, and one of the main features resides in the peculiar construction which is given to the plates to compel the substances passed through the apparatus to touch every point of the heat exchange surfaces, so that ineffective areas are fully eliminated and the effective faces actually conform with the area provided.

The details of construction hereinafter referred to constitute other features of the invention.

These and other features, capabilities, objects and advantages of the invention will appear from the subjoined detail description of one specific embodiment, which is described with reference to the accompanying drawings, in which

Fig. 1 shows by way of example a form of embodiment of the heat exchange column in side view.

Fig. 2 taken on the line 2—2 of Fig. 1 shows the plate (hereinafter termed 'I") of this column seen from above.

Fig. 3 taken on the line 3—3 of Fig. 1 shows the same plate viewed from the bottom, and

Fig. 4 is a section according to the line 4—4 in Fig. 2 through three superimposed plates ("II", "I" and "III" respectively).

Fig. 5 taken on the line 5—5 of Fig. 4 shows an underneath view of the plate "II", and

Fig. 6 taken on the line 6—6 of Fig. 4 a view from above of the plate "III".

Figs. 7–10 show in diagrammatical form several forms of embodiment of the column in vertical section. These views disclose various possibilities of arranging the plates, and various forms of embodiment of the channels provided in the plates.

Figs. 11–13 show in plan view several different methods of arranging the channels in the case of round plates, and

Figs. 14–16 show, also in diagrammatical form, different embodiments of rectangular plates with various arrangements of the channels.

The plate I is arranged with a central perforated hub i^1 and a flange extending about the margin with the portion intermediate the hub and flange of sinuous or V shape in cross section, as shown at i, forming in one side or face of the plate a channel c^1 of angular cross section and with the plate flange and hub substantially similar channels c, c^2 concentric to each other and the channel c^1, and forming the opposite side of the plate with similar concentric channels k, k^1, the V shaped wall portion i constituting a sloping separating wall between the channels, c, c^1, and c^2 at the one side of the plate and the channels k, k^1 at the opposite side of the plate. The channels c, c^2 are divided by means of a radially disposed rib h extending from the hub i^1 transversely of the channels c^2, c^1 to the outer wall of channel c^1, said rib being situated diametrically opposite to a rib h^1 which extends from the outer wall of channel c transversely of the channels c, c^1 to the inner wall of channel c^1. The channel c is divided into two parts by a part e^2, the wall between the two channels c, c^1 is not extended as far as the rib h^1 providing spaces c^3, c^4 at opposite sides of the rib through which the channels are in communication with each other. The innermost channel c^2 surrounds the hub portion i^1. The wall i between the innermost channel c^2 and the adjacent channel c^1 merges into the rib h^1 and extends oppositely therefrom terminating at opposite sides of the rib h a short distance therefrom providing spaces c^5 through which free communication is possible at opposite sides of the rib h between the innermost channels c^2 and the adjacent channel c^1.

The plate I is arranged with hollow, box-like abutments d and e, of which the abutment d is closed on the upper side, and is situated with its lower edge in a plane with the lower edge of the plate I. The hollow interior of this abutment member d communicates by means of a passage or port d^1 with the outermost channel c.

The abutment member e is closed on the lower side, and lies with its upper edge in

a plane with the upper edge of the plate I. The interior of this abutment member e communicates by means of a passage or port e^1 with the outermost channel k (Fig. 3) on the under side of the plate I, which channel will be described later.

The walls i of the channels c, c^1, c^2 are flattened off at the top, and form packing faces which are situated in a plane with the upper edge of the plate I.

On the upper side of the plate I rests the under side of the plate II, which is illustrated in Fig. 5. In the plate II the channels c^6, c^7, c^8 are arranged with the same radius and in concentric manner to the channels c, c^1, c^2 in the plate I. The walls or ribs i^2 are flattened off as before, and fit exactly against the flattened walls i of the channels c, c^1, c^2 in the plate I. The plate II also possesses a rib h^2 and a rib h^3 conforming with the ribs h and h^1 respectively in the plate I. The channel c^7 is broken by imperforate material at c^9, the position of c^9 conforming with the two parts c^3 and c^4 of the plate I. In similar manner the plate II is also furnished with box-like abutments d^2, e^2, of which the abutment e^2 coincides with the abutment e of the plate I when the plate II (Fig. 5) is placed over the plate I (Fig. 2). The hollow interior of the abutment member e^2 communicates by means of a passage e^3 with the channel c^6. The abutment member d^2 is so arranged that the same when the plates I and II are laid together is situated on the left hand side of the abutments e, e^2, as viewed in Figure 1.

When the plate II rests on the plate I, the channels c, c^1 and c^2 coincide with the channels c^6, c^7 and c^8 (Fig. 4), so that accordingly the following continuous passage way is provided: From abutment d through passage d^1 to right hand channel c, c^6 in Fig. 2, continuing through c^3 to channel c^1, c^7, further through c^5 to channel c^2, c^8, from the latter through left hand passage c^5 into left hand channel c^1, c^7, through passage c^4 into left hand channel c, c^6, and thence through passage d^3 to abutment member d^2.

As will readily be apparent from Fig. 4, all elevated portions on the upper side of the plate I (Fig. 2) form corresponding recesses or cavities on the under side of the same plate. Accordingly, on the lower side of the plate I there are two channels k, k^1, of which the channel k is broken by a rib k^2 and the projectory material k^3 conforming with the recesses c^3, c^4 on the upper side of the plate (Fig. 2). The channel k^1 is broken by a rib k^4 and the projectory material k^5 conforming with the recess c^5 on the upper side of the plate. The meeting edges of the sloped walls of the channels k, k^1 are flattened off, and are situated in a horizontal plane with the lower edge of the plate I.

Against the under side of the plate I rests the upper side of the plate III, as illustrated in Fig. 6. This plate III possesses two channels k^6, k^7, which are concentric to the channels k, k^1, and which are connected with each other by the passages k^8, k^9. k^8 and k^9 are separated from each other by means of the rib k^{10}, the channel k^6 being divided by a rib k^{11}.

It is to be observed that the under side of the plate III conforms exactly with the underside of plate II, as shown in Fig. 5, and the upper side of the plate II conforms with the upper side of plate III, as shown in Fig. 6, so that accordingly the plates II and III are similar.

The plate III also possesses box-like abutment members d^4, e^4. The passage d^5 of the member d^4 is open towards the top, and opens out on to the under side of the plate III, whilst the passage e^5 of the member e^4 is open towards the bottom and runs into the channel k^6.

When the plates I and III are placed together, a continuous passage way is formed running as follows: From passage e^1 through channel k, k^6, passage k^9, channel k^1, k^7, passage k^8 to the right hand part of the channel k, k^6, and passage e^5 of the member e^4.

In the column (Fig. 1) the plates according to Figs. 2 and 3 alternate with plates which are constructed on the upper side according to Fig. 6 and on the under side according to Fig. 5. The plate II may accordingly be regarded as being identical with the plate III, with the exception that the passage d^3 in the member d^2 opens out in the case of the plate II into the left hand part of the channel c^6, whereas in the case of plate III the passage d^5 of the member d^4 which is to be regarded as identical with member d^2 of plate II terminates in the right hand part of the channel c^6, and with the further exception that the passage e^3 in the member e^2 in the case of the plate II opens out into the left hand part of the channel k^6, whereas in the case of plate III the passage e^5 of the member e^4 which is to be regarded as identical with member e^2 of plate II terminates in the right hand part of channel k^6.

The plate I, which in the assembling of the column plates follows both the plate II as well as the plate III, also possesses alternately set-off abutment members d, e, so that in the first instance these abutment members are arranged as shown in Figs. 2 and 3, and in the second instance in such manner that the passage d^1 communicates with the left hand part of the channel c and the passage e^1 with the right hand portion of the channel k.

According to Fig. 1, the column is composed of plates of different thickness, the

plates increasing in thickness from the bottom towards the top, so that between the upper plates the channels are also larger in cross-section than at the bottom. This arrangement has the particular advantage that with the advancing cooling and compression of the vapours, with resulting diminishment in the volume thereof, the cross-section of the channels is also decreased.

The column according to Fig. 1 is closed at the top by a cover member m and at the bottom by a floor portion n. The cover member m is provided with an opening through a boss or the like m^1 for discharge of the cooling agent. The uppermost plate 1 conforms with the plate I as described, with the exception that in place of the abutment member e it is provided with a flanged boss having an inlet therethrough, as shown at m^2. The outlet in boss m^1 leads from the left hand part of the channel c of the plate 1.

The undermost plate 11 conforms with the plate III as described, with the exception that in addition to the abutment member d^4 which is provided with a flanged boss having an inlet therethrough, as at m^1, and a flanged boss with an outlet therethrough, as shown at n^2, the latter leading from the upper side of the plate 11 and the former to the underside of the plate 11, as indicated by the arrows.

All plates comprising the column are mounted on a central rod o, which passes through the hub portion i^1 of each plate, and is furnished at the top and bottom with a thread, the whole column being held together by means of nuts which are screwed on to the rod o. In addition, anchoring means p are provided, which are passed through holes in the cover m and the bottom n, and comprise rods which are tightened by means of nuts, so that the column is united to form a whole and the individual plates are pressed tightly one on to the other. Certain of the tie rods p engage bifurcations in lugs p^1 extended laterally from the plate and thus hold the plates against rotative displacement one relative to the other. A suitable packing material is provided between the plates and the flattened parts of the walls i, which is very readily brought into position in view of the extremely simple nature of the column.

The operation of the apparatus is substantially as follows: The cooling agent, such as a fluid, introduced through the inlet n^1, and the material, such as ammonia, benzole or other liquid, or gases and vapors, to be treated to effect a lowering of the temperature thereof, is introduced through the inlet n^2. The direction of flow is as follows: The material to be cooled entered at m^2 flows through the passageway formed by the channels k—k^1, k^6—k^7 arranged in the underside of the plate 1 and in the upper side of the plate 2. The passageway k—k^1, k^6—k^7 is in a circuitous direction from the inlet m^2 at the margin of the plates to the center of the plates, and then in a circuitous direction from the center to the margin of the plates to the outlet in abutment e^4. The material as it passes out through the outlet end abutment member e^4 of plate 2 passes through the passage in the abutment member e of plate 3 and proceeds to the under side of plate 3. The material then flows through the passageway formed by the channels k—k^1, k^6—k^7 in the underside of plate 3 and the upper side of plate 4, through the outlet in abutment member e^2 of plate 4 into the inlet passage in the abutment member e of plate 5, and proceeds through the abutment member e to the passageway formed by the channels k—k^1, k^6—k^7 in the under side of plate 4 and the upper side of plate 5, and so on until the same finally passes out through the abutment member e of plate 10 below said plate and over the plate 11 to be discharged through the outlet end 2.

It will be noted that the walls, i, i^2 of plates I, II, for instance serve as the separating wall between the channels at opposite sides of such plates, and also serve as the separating walls between the passages formed by said channels, as clearly shown in Figure 4, and consequently the cooling medium passing through the passages formed by the channels in adjacent sides of juxtaposed plates will be in contact with substantially the entire surface area of one of such walls while the medium to be cooled passing through the passages formed by the channels at the opposite sides of said wall will be in contact with substantially all of the opposite surface area of the separating walls for the passages through which the cooling medium passes, and thus greatly increasing the efficiency of the heating or cooling of the passage of one medium through one passageway at one side of the plates by the passage of another medium through the passageway at the opposite sides of the plates.

The cooling agent introduced through the inlet n^1, passes between the under side of the plate 11 and the bottom portion n, proceeds through the abutments d^4, d into the passageways formed by the channels c, c^6, c^1, c^7, c^2, c^8 on the upper side of plate 10 and the under side of the plate 9, is passed through the abutment member d^2 of the plate 9 into the abutment d of the plate 8, and thence through the passageway formed by the corresponding channels in the opposite sides of the plates 8 and III through the abutments d^4, d, and so on, until it passes out through the outlet m^1.

As will readily be apparent, each current touches each plate on the one side and is compelled to pass over the entire surface, at

the same time its direction being repeatedly changed. Since no point of the plates remains untouched, all ineffective parts are accordingly eliminated, so that the interchange of heat is therefore as efficient as possible.

The plates comprising a column may be arranged with channels of equal cross-section, in which case the height or thickness of the plates is the same throughout the whole apparatus. Or the channels at the top and the bottom may be arranged of unequal cross-sectional form. It is to be distinctly understood that the invention is not restricted to the angular form of the channels. As shown in Figs. 9 and 10, the channels may be arcuate form, so that each plate in its vertical cross-section then presents a corrugated form in place of the zig-zag form shown in Figs. 7 and 8. The invention is neither restricted to circular plates. The plates may also be rectangular in form, in which case the arrangement of the channels requires to be adapted to the particular form of plate, and in this connection attention is called to the fact that the channels repeatedly vary their direction in each plate and are arranged to communicate with each other forming a continuous passageway or channel. As a further example, the channels may be arranged in spiral formation in either circular or rectangular plates (Fig. 15), in which case the passageways between the channels of two plates to the channels of the next pair of plates but one may be taken alternately through the abutment members *d* as described and points *e* at the centre of the plates. The plates are preferably so formed that the channels on the upper side of a plate *p* coincide in their arrangement with the channels on the under side of an adjacent plate. This, however, is not essential, and the arrangement may be such that all plates are equal on the upper sides and under sides respectively, as indicated diagrammatically in Figs. 7 and 9. In this case the summit points of the channel walls will be situated vertically one above the other, the channels between each two plates being separated from each other. To provide for this separation stays or ribs *b* are fitted between each "upper" summit point and the under side of the adjacent plate. The passages *d*, *e* from the channels between two plates to the channels between the next pair of plates but one then require to be arranged accordingly. Attention is called to the fact that the two streams always flow in counterflow direction through the column and along entirely separate paths.

The cross-sectional form of the plates allows the chambers formed by the channels to offer very considerable resistance to the pressure of the medium being passed through the same, and this applies particularly if only the one medium is conducted under pressure, whilst in the adjacent channel system there is no pressure and possibly a vacuum prevailing.

It will be obvious that various changes and modifications may be made in details of construction and arrangement of parts without departing from the scope of the invention, and that portions of the invention may be used without others and come within the scope of the invention.

What I claim as new and desire to secure by Letters Patent is:

1. In a heat exchanging column, a series of plates disposed in superimposed relation, each plate having circuitously arranged channels in the opposite sides the walls of which channels constitute the walls of the channels at one side of the plates and also the walls of the channels at the opposite side of the plates and adapted to have mating connection with the walls of the channels in the contiguous side of adjacent plates to form continuous circuitous passageways between the mating sides of adjacent plates, and the plates having portions arranged for connecting the passageways at one side of the plates and portions for connecting the passageways at the opposite sides of the plates to arrange and connect the passageways between the plates in two separate continuous passageways extending through the entire column, and each of said passageways having an inlet and an outlet at opposite ends of the column, and means to secure the plates in superimposed relation.

2. A heat exchanging column as claimed in claim 1, wherein the one passage has an inlet at the upper end of the column and an outlet at the lower end, and the other passageway has an inlet at the lower end of the column and an outlet at the upper end thereof for the passage of the mediums through said passageways in opposite directions.

3. A heat exchanging column as claimed in claim 1, wherein the passageways between successive plates are of progressively increasing cross sectional area from one end of the column to the opposite end.

4. A heat exchanging column as claimed in claim 1, wherein the portions for connecting the passageways between alternate mating sides of the plates to arrange the passageway between the plates in two separate passageways are arranged in abutments extending laterally from the respective plates.

5. A heat exchanging column as claimed in claim 1, wherein the channels in the plates have portions arranged one within the other about the center of the plates and extending continuously from the marginal portion of the plates toward the center thereof and from the center toward a marginal portion of the plates.

6. A heat exchanging column as claimed

in claim 1, wherein the plates are arranged with a flange about the margin and a central hub with the intermediate portion of sinuous shape in cross section forming the separating walls between the channels at opposite sides of the plates.

7. A heat exchanging column as claimed in claim 1, wherein the channels in the plates are of V shape in cross section, and said plates forming with the channels in a mating plate passageways of diamond shape in cross section, and said walls constituting the separating walls between said passageways.

8. A heat exchanging column as claimed in claim 1, wherein the means for securing the plates in superimposed relation comprises a tie rod extending centrally through the plates and anchor rods extended through marginal portions of the end plates, and the plates arranged with means to co-operate with said anchoring rods to hold the plates against rotative displacement.

9. A heat compensating column as claimed in claim 1, wherein the walls of the channels in one side of the plates also constitute the walls of the channels at the opposite side of the plates and serve as the separating wall between the passageways formed by said channels with the plates in mating relation, whereby the medium flowing through the passageway at one side of the plates will be at one surface of the walls and the medium flowing through the other passageway will be at the opposite surface of the walls.

In testimony whereof I affix my signature.

ERNST MENZEL.