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2,728,146

ROTARY HEAT EXCHANGER

Filed May 21, 1952

2 Sheets-Sheet 1

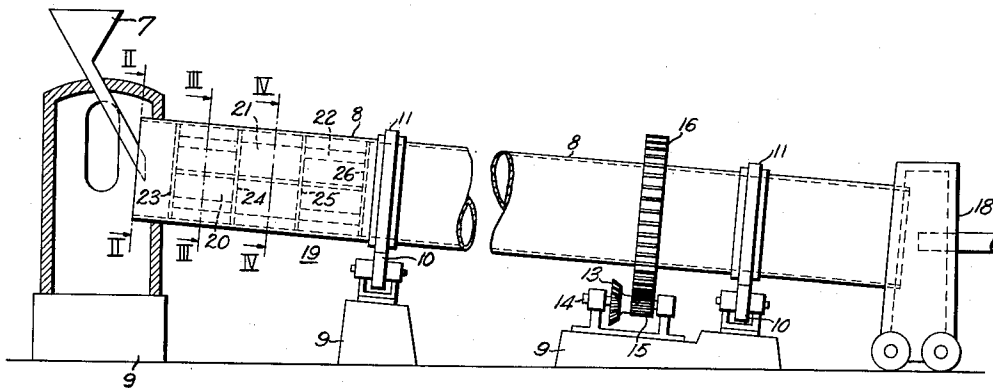


Fig. 1

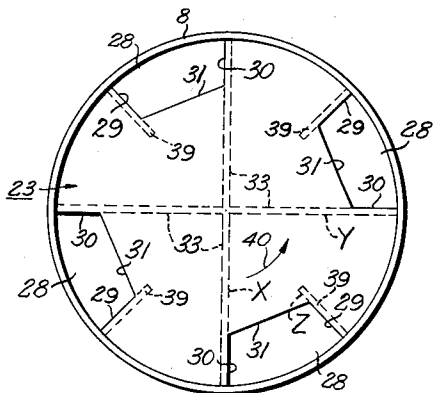


Fig. 2

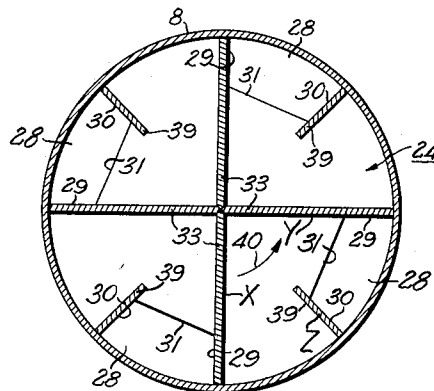


Fig. 3

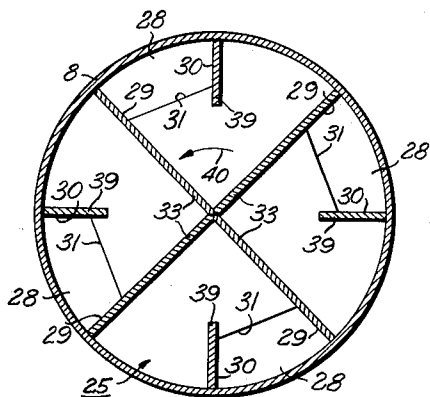


Fig. 4

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2 Sheets-Sheet 2

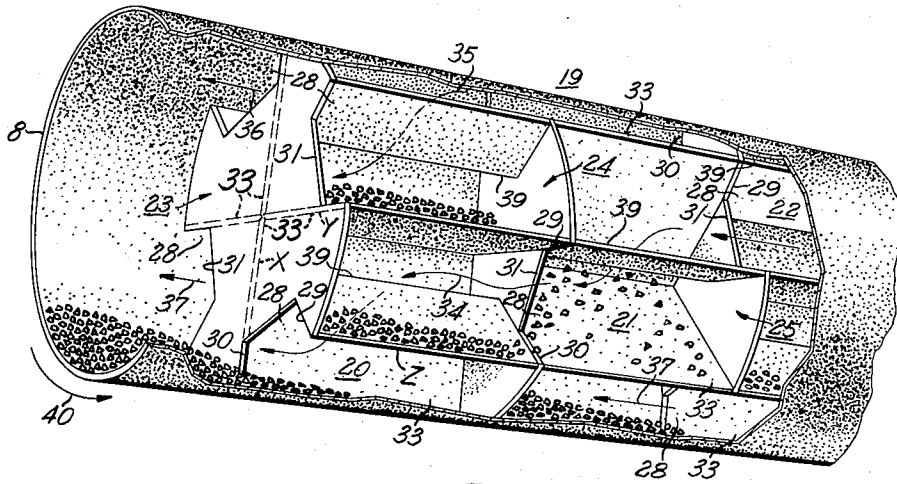


Fig. 5

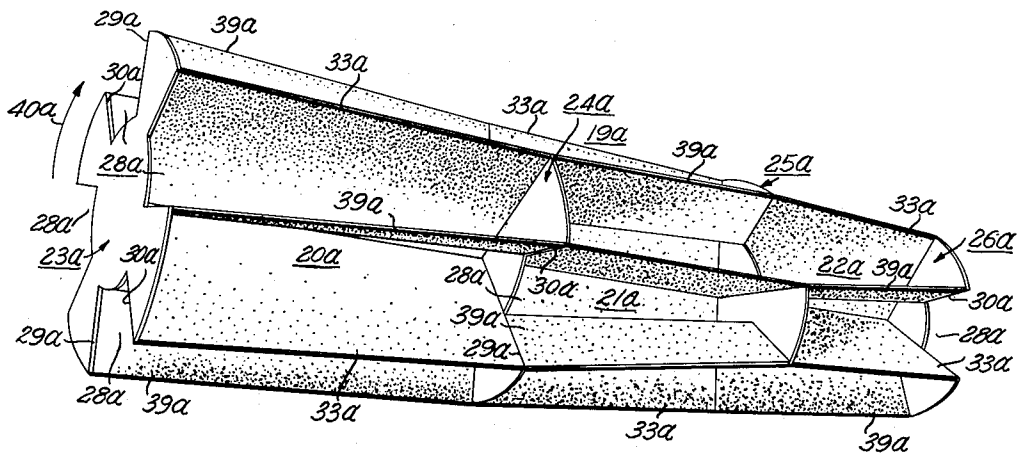


Fig. 6

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2,728,146

ROTARY HEAT EXCHANGER

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10 Claims. (Cl. 34—109)

This invention relates generally to heat exchangers and more particularly to rotary heat exchangers. The invention may be embodied in kilns or in preheater units for use in the feed end of rotary kilns; or in rotary cooler units. Some prior art heat exchangers involve the conduction of heat from supporting or analogous surfaces to the material, and/or the direct transfer of heat to the material from hot gases. The invention relates to heat exchangers of these types. More specifically the invention relates to heat exchangers constructed to shower material through a stream of hot gases. The principal object of the invention is the provision of new and improved heat exchangers of these types.

Rotary preheaters or coolers have not heretofore been capable of effectively causing the flow of hot or cold gases about a mass of material to be preheated or cooled. Usually the material has been agitated in a relatively resting position by suitable means secured to the inner surface of the kiln. This type of apparatus exposes only a small heat exchanging area of the material at one time, with the result that direct heat transfer between the gases and the material as a whole is not efficient. Other heat exchangers have been designed to shower the material through the gases in order to raise the efficiency of operation. In heat exchangers of this type the material is showered in the form of a vertical blanket or curtain through gases passing axially through the heat exchanger parallel to both sides of the curtain of material. Only a portion of the total surface of the material is ever directly in contact with the gases applied in this manner, the heat exchanging surfaces of the particles adjacent other particles comprising the curtain being left totally unaffected by direct heat exchanger.

A principal object of this invention is the provision of means which will avoid the defects in the prior art; particularly such means as will increase conduction of heat from supporting or analogous surfaces adapted to contact the material, and/or increase the direct transfer of heat between the material and the gases.

Another object of the invention is to provide means which will expose the maximum heat transfer surface of each particle of material to the gases flowing through the exchanger.

Another object is to increase the surface of material in heat exchanging contact with supporting surfaces.

Another object is to increase the time of direct exchange of heat between the material and supporting surfaces.

Another object of the invention is to provide means to effect positive control of the direction of flow of the gases, and, more particularly, so that the gases will be caused to flow from one side of a curtain of material, through the curtain, to the other side of the curtain and, still more particularly, so that the gas flow will be turbulent.

Other objects will appear hereinafter as the description of the invention proceeds.

The novel features of the invention and how the objects are attained will appear from this specification and the

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accompanying drawings forming a part of this application, and all these novel features are intended to be pointed out in the claims.

In the drawings:

Fig. 1 is a side elevation of a rotary kiln embodying the invention;

Fig. 2 is a view taken along line II—II of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a section taken along line III—III of Fig. 1, looking in the direction of the arrows;

Fig. 4 is a section taken along line IV—IV of Fig. 1, looking in the direction of the arrows;

Fig. 5 is a perspective view of the preheater unit embodied in the kiln shown in Fig. 1, showing the passage of material and path of hot gases therethrough; and

Fig. 6 is a perspective view of another embodiment of the preheater.

As shown in Fig. 1, a rotary kiln, comprising a cylindrical kiln shell 8, is rotatably carried on a foundation 9, constructed to impart a slight downward inclination to the kiln from the feed end to the discharge end. The inclination may be of the order of one-quarter inch to five-eighths inch per foot, for example, but may be any desired suitable amount. Rollers 10 mounted on the foundation 9 cooperatively engage riding rings 11 mounted on the kiln shell 8 in any well known manner, for rotation of the shell about the kiln axis. Appropriate driving means, not shown, may actuate a bevel gear 13 fixed to a shaft 14 which carries a pinion 15 in intermeshing co-action with a gear 16 carried by the kiln shell 8 for revolving the kiln. The lower end of the kiln is associated with a firing system 18, for furnishing hot gases, which may be either of coal, oil or gas burning type. The upper end (the feed end) of the kiln proper, is formed to receive a preheater unit 19.

Directing means is provided within the shell 8 for causing the material to progress within the shell 8 of the preheater part 19 in a generally helical path in the illustrated embodiment, and, more specifically, in a plurality of such paths. The preheater unit 19 as shown in Figs. 1 through 5 comprises three longitudinal divisions 20, 21 and 22. The means for directing the progress of the material includes partition means, in this instance including a plurality of axially spaced partitions such as 23, 24, 25 and 26 transversely arranged to the axis of rotation. The partitions 23, 24, 25 and 26 are similar to one another and are constructed to snugly fit the inner surface of the kiln shell 8 except for gaps as will now appear. Means are provided for admitting material to the respective divisions 20, 21 and 22 and for discharging material from said divisions, these means including peripheral gaps 28 provided in the partitions 23, 24, 25 and 26. The radial marginal limits of each gap are defined by a leading edge 29, a trailing edge 30 and an intermediate edge 31. The terms "leading" and "trailing" are used with reference to the direction of rotation (arrow 40) of the kiln, because with respect to that direction the edge 29 leads the edge 30. One or more peripheral gaps 28 are provided in each of the partitions 23, 24, 25 and 26, four peripheral gaps in each partition being herein illustrated. The leading edge 29 and trailing edge 30 are here shown as extending radially from the kiln shell inner periphery toward the axis of rotation a distance sufficient to provide a gap of desired size. The intermediate edge 31 may be straight, arcuate or of other suitable shape. The gaps 28, in a given partition, are preferably equally spaced circumferentially, and, as shown in Figs. 2, 3, 4 and 5, have their respective leading and trailing edges 29, 30 spaced a circumferential distance from each other equal in degrees to one half the ratio of 360 degrees to the number of gaps in each partition. In other words the circumferential distance

between the leading edge 29 and trailing edge 30, defining each gap 28 is 45 degrees in the present embodiment.

As herein shown, the partitions 23, 24, 25 and 26 are so disposed that the set of gaps 28 of partition 24 are displaced 45 degrees circumferentially from the set of gaps 28 of partition 23; and each succeeding partition is likewise so displaced from the preceding one.

In the embodiment herein shown, each longitudinal division 20, 21 and 22 is divided into circumferentially spaced chambers or cells, in this instance four cells for each of said divisions. The walls defining a set of four cells may include the kiln shell 8 itself and four walls 33 extending axially between the partitions 23, 24, of the division 20, for example, and extending radially from the inner periphery of the shell 8, inward toward the axis of rotation. The radially inner ends of the cells may be closed and separated from each other by any suitable axially disposed wall means, whether this axially disposed means be a part of the walls 33 or a separate member. The closing means in the shown embodiment is provided by the extension radially inward of circumferentially adjacent walls 33 so that they meet each other and thus close the inner end of the respective cell. Any other suitable and desirable construction may be adopted for closing the radially inner ends of the cells.

The walls 33 in one longitudinal division such as 20, are shown engaged and aligned with the trailing edges 30 of the gaps 28 of the partition 23, while the opposite longitudinal ends of said walls 33 are engaged and aligned with the leading edges 29 of the gaps 28 of the next partition 24. (See in particular Figs. 2, 3 and 5.) The longitudinally opposite ends of the set of walls 33 in longitudinal divisions 21 are respectively similarly engaged and aligned with the trailing edges 30 of the gaps 28 in the partition 24 and the leading edges 29 of the gaps 28 in the partition 25; and the longitudinally opposite ends of the set of walls 33 in longitudinal division 22 are respectively similarly engaged and aligned with the trailing edges 30 of the gaps 28 in the partition 25 and the leading edges 29 of the gaps 28 in the partition 26.

The sets of walls 33 together with the gaps 28 in the partitions 23, 24, 25 and 26, and the shell 8, define a plurality of passages as indicated by the arrows 34, 35, 36 and 37 in Fig. 5. The number of said passages defined is determined by the number of walls 33 or cells in each longitudinal division 20, 21 and 22; hence, in this instance, the number of said passages is four. From the feed end of the kiln, each passage progresses in a generally helical path in the direction of rotation (arrow 40) of the kiln shell. Each generally helical path is of composite form being made up of alternate generally circumferential and axial portions. The passages 34, 35, 36 and 37 are somewhat analogous to a multiple threaded screw; and each passage is entirely separate from each of the other passages.

It will be obvious that each wall 33 serves as means to rotate or move material on that side of the wall leading with respect to the direction of rotation about the axis of rotation. This movement of the material comprises one circumferential portion of the generally helical progression of the material. Means is also provided for causing axial movement of material from one longitudinal division into and in the next succeeding one, such means including a respective shelf 39 cooperating with an opening 28 as will more fully appear.

There being a plurality of paths or passages 34, 35, 36, 37 there are a plurality of shelves 39. A shelf 39 is disposed in each of the passages 34, 35, 36, 37 between the defining partitions of each of the longitudinal divisions 20, 21 and 22. The radially inner edges of the shelves 39 are spaced from the axis of rotation and extend radially outward to the inner surface of the shell 8. One end of each shelf 39 in division 20 abuts the leading edge 29 of a gap 28 of the partition 23, and the other end of each

shelf 39 abuts the trailing edge 30 of a gap 28 of the next adjacent partition 24. The shelves 39 in the divisions 21 and 22 are similarly related to the pairs of partitions 24-25 and 25-26. It is therefore apparent that the shelves 39 in one longitudinal division in the present embodiment are axially aligned with respective walls 33 in the next longitudinal division. Inasmuch as the walls 33 are longitudinally parallel to the axis of rotation, the shelves 39 are similarly parallel.

The shelves 39 serve also to provide means for causing showering of the material in each division 20, 21, 22 and in each of the helical paths 34, 35, 36 and 37 as will appear more fully.

Assuming the direction of rotation to be as indicated by the arrow 40, the operation is as follows.

The material enters the preheater part of the kiln shell 8 through feeding means 7 and progresses axially through those gaps 28 of the partition 23 which are at the moment the lowermost, and, due to the gravitational effect and inertia disturbances created by the inclination and rotation of the kiln, the material further progresses generally helically through the preheater. For clarifying the principle of operation, the material will be traced through one passage of the preheater, namely the passage which is indicated by arrow 34. Those two walls 33 which in the illustrated embodiment define a quadrant in division 20, forming the first part of path 34, have been designated with the letters x and y (see Fig. 3) for convenience of identification.

Assuming that material has entered the gap 28 in partition 23 leading to the quadrant between walls x and y, the material will be moved counterclockwise (as viewed in Fig. 3) by the wall x. Sufficient counterclockwise movement (less than 180°) will bring the wall x to a position greater than the angle of repose of the material, thereby causing the material to slide radially inward on the wall x and accumulate near the center of the preheater between the walls x and y.

When the wall y has rotated somewhat more than 180° from its originally assumed position, it will have reached a position in which material will slide radially outwardly on said wall against the inner periphery of the shell 8. From that position some of the material will slide axially on the wall y, and by reason of the provision of the gap 28 in the partition 24, at least some of the material will slide through said gap onto that shelf 39 in the division 21 which is aligned with the wall y. However, since the preheater continues its rotation, the material slides on aforesaid shelf 39 radially outward against the inner periphery of the shell 8, and, concurrently, at least some more material slides axially through aforesaid gap 28 onto the inner periphery of the shell 8 in the division 21. Thus after the material has been rotated a predetermined amount in the division 20, at least some of it will be moved axially into division 21, and, more specifically, into that part of division 21 which is part of the passage 34.

Before following the material which has moved axially into division 21 as hereinbefore just described, we shall follow the material which for the time being remains in division 20.

As the wall y continues to rotate, beyond the position in which at least some of the material thereon moves axially into division 21 as hereinbefore described, said wall eventually assumes the vertical position, originally occupied by the wall x as shown in Fig. 3. Further, counterclockwise rotation of the preheater causes the material which remained on wall y to slide circumferentially on the inner periphery of the shell 8 against the leading face of that shelf 39 which is disposed between the walls x and y; aforesaid shelf being identified specially by the character z. Still further rotation of the preheater causes aforesaid shelf z to assume a position in which the material slides therefrom generally radially inward

onto the wall *x*. Thus the material is discharged or showered from the aforesaid shelf *z* and falls in the form of a blanket or curtain through the hot gases flowing in the cell defined within the shell 8 by the walls *x* and *y*, and the transverse partitions 23 and 24. It will be obvious that the flow of hot gases (coming from firing means 18) is through the gap 28 in the partition 24 into the aforesaid cell, thence through and across the curtain of showered material, to and out of the gap 28 in the partition 23. Stated in other words, it will be apparent that in the illustrated embodiment, because of the longitudinal displacement of the partitions 23 and 24, and the circumferential displacement of the respective gaps 28 in said partitions the path of gas flow is generally helical and therefore has a circumferential component across the curtain of material showered from the generally longitudinally and radially extending shelf *z*. The described path of gas flow, which is enforced to be sinuous, not only insures flow of gas across the showered curtain but causes turbulence and further improvement of contact between the gas and material. In the illustrated embodiment it will be apparent that in each of the paths 34, 35, 36 and 37 the material and gases flow in opposite directions.

As the preheater is further rotated counterclockwise, the material which was showered onto the wall *x*, as hereinbefore described, will be further rotated and directed and moved in the same manner as described with respect to the material initially taken onto the wall *x* through the respective gap 28 in the wall 23. Thus, for each revolution of the preheater, some of the material in path 34 in division 20 is discharged into that part of path 34 which is in division 21, and material which remains in division 20 in path 34 is showered from shelf *z* at every revolution. It will be obvious that material in path 34 which enters division 21 from division 20, and that material which enters division 22 from division 21 will be treated in the respective divisions in the same way as hereinbefore described with respect to the treatment of the material in division 20.

In the foregoing the treatment of material which at a given revolution has entered a gap 28 in the partition 23 and been fed onto the leading side of wall *x* has been described, but it is of course obvious that at every revolution, when said gap again reaches a lowermost position, new material is fed through said gap and added to any material remaining on the leading side of wall *x*.

The mode of operation in the paths 35, 36 and 37 is identical with that in the path 34 hereinbefore described. Hence, it is obvious that at every revolution of the preheater material is successively fed into the multiple paths (four in this instance) thereby greatly increasing the capacity of the preheater, while permitting efficient showering and heating of the material.

It is of course apparent that when the material in the respective paths 34, 35, 36 and 37 reaches the division 22, it will be discharged therefrom into the kiln proper through respective gaps 28 in the partition 26. The hot gases from the kiln proper (originating from the firing means 18) of course enter the preheater through the same gaps 28 in the partition 26 from which the material is discharged into the kiln proper.

Besides providing a large number of curtains of showered material for efficient treatment by hot gases, the described construction, a further advantage of providing a plurality of paths for the flow and treatment of the material is that a given feed of material can be spread over a relatively larger area of heating surface, thereby increasing the area of the material which is in contact with the heating surface. The aforesaid heating surfaces in the illustrated embodiment are of course the walls 33, the shelves 39 and the inner periphery of the shell 8 in the respective divisions 20, 21, and 22.

Another embodiment of the invention is shown in Fig. 6 wherein parts similar to those described in the previous

embodiment are given the same reference numerals with the suffix "a" added thereto.

The embodiment of the preheater in Fig. 6 differs principally from the previous embodiment in that shelves 39a are skewed with respect to the axis of rotation of the preheater. The preheater illustrated in Fig. 6 is preferably rotated in the direction indicated by arrow 40a.

The gaps 28a in respective partitions 23a, 24a, 25a and 26a are preferably equally circumferentially spaced in their respective partitions. The circumferential distance in degrees between leading edges 29a and trailing edges 30a defining the marginal limits of the gaps 28a is greater than in the case of the embodiment of Fig. 5; specifically the number of degrees is 45° in the latter case and 48° in the case of Fig. 6. The ends of the walls 33a in division 20a are engageably aligned with the trailing edges 30a and leading edges 29a of respective partitions 23a and 24a. The gaps 28a in the partitions 23a and 24a are so displaced circumferentially that the walls 33a are longitudinally parallel to the axis of rotation as in the case of the embodiment of Fig. 5. It is therefore obvious that the shelf 39a (seen between those two walls 33a which are visible in the division 20a of Fig. 6) is skewed 6 degrees with reference to the axis of rotation instead of being longitudinally parallel to the axis of rotation as in the case of the shelves 39 of the embodiment of Fig. 5. The values of 48 degrees and 6 degrees are given merely by way of illustration and not limitation, it being obvious that any desired and suitable amount of skewing may be adopted.

In general, the ends of the shelves 39a are engageably aligned with the leading edges 29a and trailing edges 30a of respective partitions 23a and 24a; the shelves 39a in longitudinal divisions 21a and 22a are similarly arranged with the marginal limits of the gaps 28a in the partitions defining the respective divisions. Due to the greater circumferential distance between the leading and trailing edges 29a, 30a, respectively, defining the gaps 28a, as compared with the leading and trailing edges defining the portions of the partitions between the respective gaps, the shelves 39a in each division assume a longitudinally skewed position in this instance opposite to the direction of rotation of the kiln viewed from the feed end of the kiln. The walls 33a and the shelves 39a are preferably radially disposed between the axis of rotation and the outer periphery of the preheater unit as defined by the maximum radius of the partitions 23a, 24a, 25a and 26a, said radius being the same for all of said partitions. (The partitions look progressively smaller toward the right of Fig. 6 because of true perspective.)

It will be noted that the left hand ends of walls 33a of division 21a extend from the right hand ends of the shelves 39a of division 20a, said walls 33a being disposed longitudinally parallel to the axis of rotation; and that the left hand ends of the walls 33a of the division 22a extend from the right hand ends of the shelves 39a of division 21a. This is analogous to the arrangement in the construction of Fig. 5, except that because of the skewing of the shelves 39a in the respective divisions, the sets of walls 33a of succeeding divisions are progressively displaced opposite to the direction indicated by the arrow 40a.

The operation of the embodiment of Fig. 6 of the invention differs principally from the operation of the previous embodiment in that the material is more uniformly and continuously showered through the hot gases due to the skewed shelves 39a and the material progresses more rapidly from the feed to the discharge end of the heat exchanger.

From the foregoing it will be apparent to those skilled in the art that the illustrated embodiments of the invention provide new and improved rotary heat exchangers and accordingly accomplish the objects of the invention. On the other hand, it will also be obvious to those skilled in the art that the illustrated embodiments of the invention

may be variously changed and modified, or features thereof, singly or collectively, embodied in other combinations than those illustrated, without departing from the spirit of the invention, or sacrificing all of the advantages thereof, and that accordingly the disclosure herein is illustrative only, and the invention is not limited thereto.

It is claimed and desired to secure by Letters Patent:

1. A rotary heat exchanger comprising: a cylindrical shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end, said axis being inclined downwardly from the feed end to the discharge end; partitions disposed transversely of said shell to define a division, each of said partitions having an opening spaced from said axis; a shelf in said division extending generally radially inward from said shell with the radially inner edge of said shelf disposed a distance from said axis not greater than the distance of any point of said openings to said axis and with said openings at the ends of said division staggered to be disposed on opposite sides of said shelf; means for rotating said shell to cause material therein to be rotated in said shell, to be showered from said shelf in a curtain defining a plane extending generally longitudinally of said axis, and to be discharged from said division through one of said openings; means for moving gas from one end of the shell to the other end thereof, one of said partitions causing said gas to pass through said opening therein and to flow radially along one side of said shelf past said edge thereof in a direction toward said axis, and means within said shell for baffling said gas around said edge of said shelf and causing said gas to flow radially along the other side of said shelf in a direction away from said axis toward said staggered opening of the other of said partitions to define a helical gas flow in said division and to direct said gas flow transversely of said plane of said curtain of material.

2. A rotary heat exchanger comprising: a cylindrical shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end, said axis being inclined downwardly from the feed end to the discharge end; partitions disposed transversely of said shell dividing said shell into a plurality of longitudinal divisions, each of said partitions having an opening spaced from said axis whereby there is communication from each of said divisions to adjacent said divisions; a shelf in each of said divisions extending generally radially inward from said shell with the radially inner edge of said shelf disposed a distance from said axis not greater than the distance of any point of said openings to said axis and with said openings at the ends of each of said divisions staggered to be disposed on opposite sides of said shelf; means for rotating said shell to cause material therein to be rotated in said shell, to be showered from said shelves in curtains defining planes extending generally longitudinally of said axis, and to be discharged from one of said divisions to an adjacent said division through one of said openings; means for moving gas from one end of the shell to the other end thereof, said partitions causing said gas to pass through said openings therein and to flow radially along one side of said shelves past said edges thereof in a direction toward said axis, and means within said shell for baffling said gas around said edges of said shelves and causing said gas to flow radially along the other sides of said shelves in a direction away from said axis toward said staggered openings of the adjacent said partitions to define a helical gas flow in each division and to direct said gas flow transversely of said planes of said curtains of material.

3. A rotary heat exchanger comprising: a cylindrical shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end, said axis being inclined downwardly from the feed end to the discharge end; partitions disposed transversely of said shell to define a division, each of said partitions having openings spaced from said axis; a plurality of walls disposed in said division extending substantially radially inward

from said shell for dividing said division into a plurality of chambers; each of said chambers having a shelf interposed intermediate said walls extending generally radially inward from said shell with the radially inner edge of said shelf disposed a distance from said axis not greater than the distance of any point of said openings to said axis and with said openings at the ends of said division staggered to be disposed on opposite sides of said shelves; means for rotating said shell to cause material therein to be rotated in said chambers, to be showered from said shelves in a curtain defining a plane extending generally longitudinally of said axis, and to be discharged from said division through said openings; means for moving gas from one end of the shell to the other end thereof, one of said partitions causing said gas to pass through each of said openings therein and to flow radially along one side of said shelf past said edge thereof in a direction toward said axis, said walls baffling said gas around said edge of said shelf and causing said gas to flow radially along the other side of said shelf in a direction away from said axis toward said staggered opening of the other of said partitions to define a helical gas flow in each chamber and to direct said gas flow transversely of said plane of said curtain of material.

4. A rotary heat exchanger comprising: a cylindrical shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end, said axis being inclined downwardly from the feed end to the discharge end; partitions disposed transversely of said shell dividing said shell into a plurality of longitudinal divisions, each of said partitions having openings spaced from said axis whereby there is communication from each of said divisions to adjacent said divisions, the openings of successive said partitions being staggered; a plurality of walls disposed in each of said divisions extending substantially radially inward from said shell for dividing each of said divisions into a plurality of chambers; each of said chambers having a shelf interposed intermediate said walls extending generally radially inward from said shell with the radially inner edge of said shelf disposed a distance from said axis not greater than the distance of any point of said openings to said axis and with said openings at the ends of each of said divisions staggered to be disposed on opposite sides of said shelves; means for rotating said shell to cause material therein to be rotated in said chambers, to be showered from said shelves in a curtain defining a plane extending generally longitudinally of said axis, and to be discharged from one of said divisions to an adjacent said division through said openings; means for moving gas from one end of the shell to the other end thereof, said partitions causing said gas to pass through each of said openings therein and to flow radially along one side of said shelf past said edge thereof in a direction toward said axis, said walls baffling said gas around said edge of said shelf and causing said gas to flow radially along the other side of said shelf in a direction away from said axis toward said staggered opening of the adjacent said partition to define a helical gas flow in each chamber and to direct said gas flow transversely of said plane of said curtain of material.

5. A rotary heat exchanger comprising: a cylindrical shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end, said axis being inclined downwardly from the feed end to the discharge end; partitions disposed transversely of said shell dividing said shell into a plurality of longitudinal divisions, each of said partitions having openings spaced from said axis whereby there is communication from each of said divisions to adjacent said divisions; the openings of successive said partitions being staggered; a plurality of walls disposed in each of said divisions extending substantially radially inward from said shell for dividing each of said divisions into a plurality of chambers; each of said chambers having a shelf interposed intermediate said walls extending generally radially inward from said

shell and skewed with respect to the axis of said shell with the radially inner edge of said shelf disposed a distance from said axis not greater than the distance of any point of said openings to said axis and with said openings at the ends of each of said divisions staggered to be disposed on opposite sides of said shelves; means for rotating said shell to cause material therein to be rotated in said chambers, to be showered from said shelves in a curtain defining a plane extending generally longitudinally of said axis, and to be discharged from one of said divisions to an adjacent said division through said openings; means for moving gas from one end of the shell to the other end thereof, said partitions causing said gas to pass through each of said openings therein and to flow radially along one side of said shelf past said edge thereof in a direction toward said axis, said walls baffling said gas around said edge of said shelf and causing said gas to flow radially along the other side of said shelf in a direction away from said axis toward said staggered opening of the adjacent said partition to define a helical gas flow in each chamber and to direct said gas flow transversely of said plane of said curtain of material.

6. A rotary heat exchanger comprising: a shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end and said axis being inclined downwardly from said feed end to said discharge end; partitions dividing said shell into a plurality of longitudinal divisions, said partitions having solid portions and openings therein placing adjacent said divisions into communication, said solid portions and said openings at opposite longitudinal ends of respective said divisions being displaced circumferentially with respect to each other; means for admitting material from said feed end to the adjacent one of said divisions; means to cause rotation of said material within said divisions; shelf means to cause said material to be showered in said divisions in the form of curtains defining planes extending generally longitudinally in said divisions; and means cooperating with said shelf means, said shell and said partitions to provide a path of gas flow through said divisions by way of said circumferentially displaced openings to give said path a circumferential component to cause gas flowing in said path to flow transversely through said planes of said curtains.

7. A rotary heat exchanger comprising: a shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end and said axis being inclined downwardly from said feed end to said discharge end; partitions disposed transversely of said shell dividing said shell into a plurality of longitudinal divisions, each of said partitions having a solid portion and an opening whereby said partitions permit material to enter and leave said divisions and adjacent said divisions are placed into communication; and a shelf disposed generally longitudinally in each of said divisions, said partitions at opposite longitudinal ends of each said division having their said openings and their said solid portions staggered with respect to each other to dispose said openings on opposite faces of said shelf.

8. A rotary heat exchanger comprising: a shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end; partitions disposed transversely of said shell to define a longitudinal division; said partitions having solid portions and openings therein permitting passage of material through said division, said solid portions and said openings at opposite longitudinal

ends of said division being staggered with respect to each other; means for admitting material from said feed end to said division; means to cause rotation of said material within said division; shelf means to cause said material to be showered in said division in the form of a curtain defining a plane; and means cooperating with said shelf means, said shell and said partitions to provide a path of gas flow through said division by way of said staggered openings to give to said path a component transverse to said curtain to cause gas flowing in said path to flow transversely through said plane of said curtain.

9. A rotary heat exchanger comprising: a shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end; partitions dividing said shell into a plurality of longitudinal divisions, said partitions having solid portions and openings therein placing adjacent said divisions into communication, said solid portions and said openings at opposite longitudinal ends of respective said divisions being staggered with respect to each other; means for admitting material from said feed end to the adjacent one of said divisions; means to cause rotation of said material within said divisions; skewed shelf means to cause said material to be showered in said divisions in the form of curtains defining planes; and means cooperating with said shelf means, said shell and said partitions to provide a path of gas flow through said divisions by way of said staggered openings to give to said path a component transverse to said curtains to cause gas flowing in said path to flow transversely through said planes of said curtains.

10. A rotary heat exchanger comprising: a shell rotatably mounted about its longitudinal axis, said shell having a feed end and a discharge end and said axis being inclined downwardly from said feed end to said discharge end; partitions dividing said shell into a plurality of longitudinal divisions, said partition means having solid portions and openings therein placing adjacent said divisions into communication, said solid portions and openings at opposite longitudinal ends of respective said divisions being staggered with respect to each other; means for admitting material from said feed end to the adjacent one of said divisions; means to cause rotation of said material within said divisions; shelf means to cause said material to be showered in said divisions in the form of curtains defining planes extending generally longitudinally in said divisions; and means cooperating with said shelf means, said shell and said partitions to provide a path of gas flow through said divisions by way of said staggered openings to give to said path a component transverse to said curtains to cause gas flowing in said path to flow transversely through said planes of said curtains.

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