

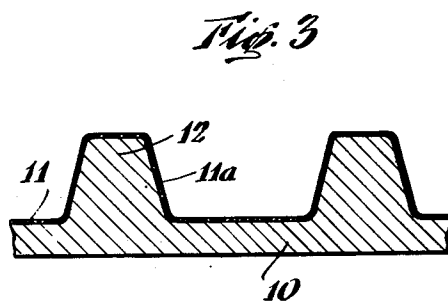
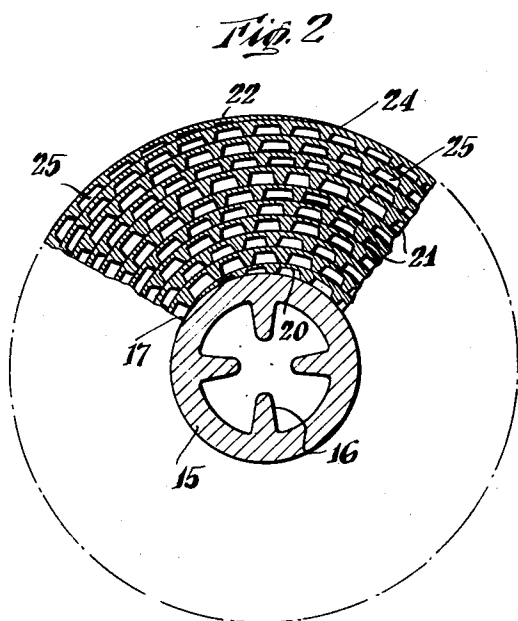
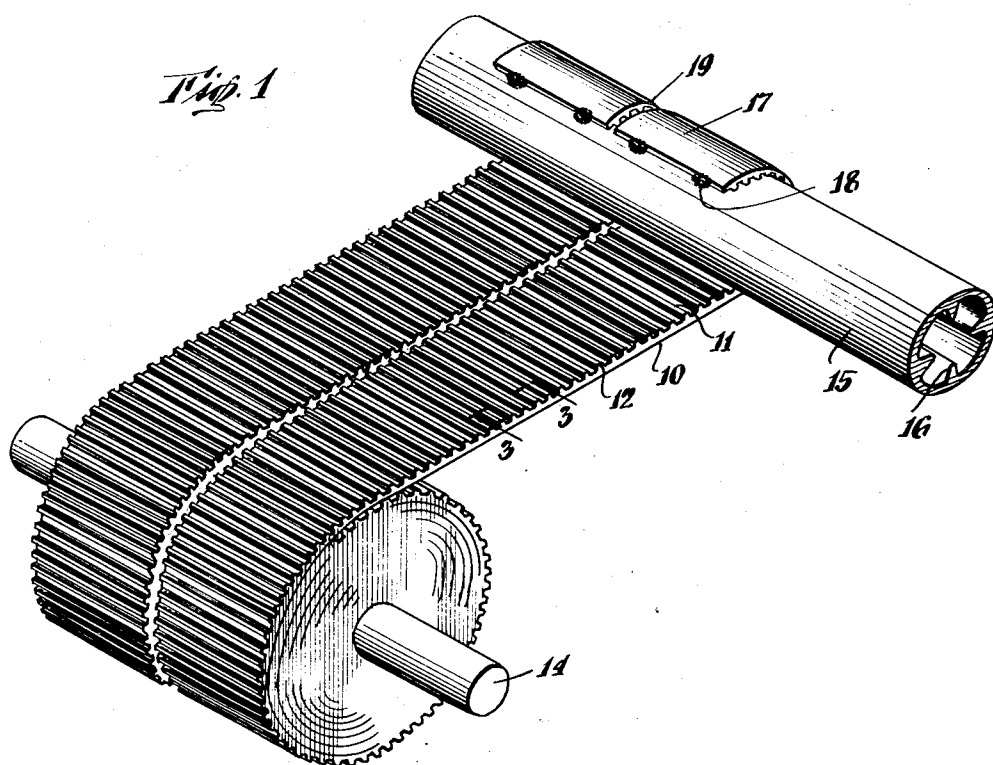
July 8, 1952

R. F. BENENATI ET AL
REGENERATOR AND PACKING THEREFOR

2,602,645

Filed April 9, 1948

3 Sheets-Sheet 1



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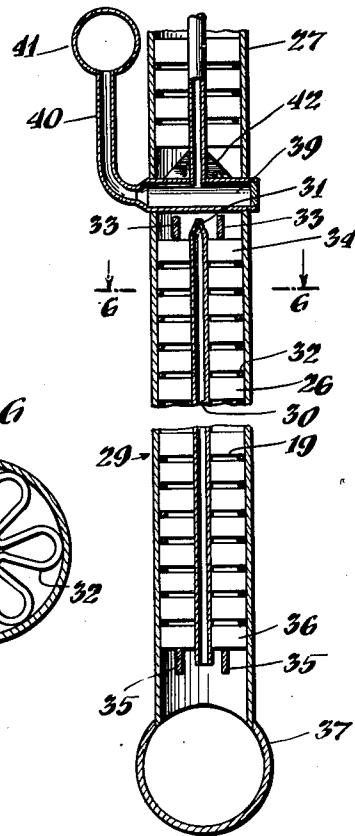
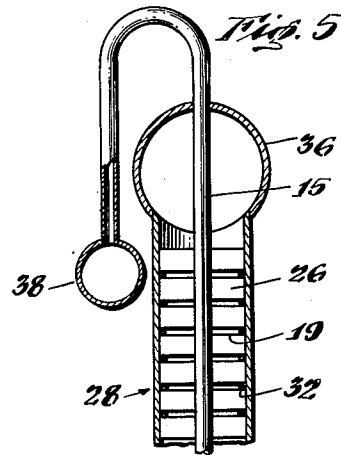
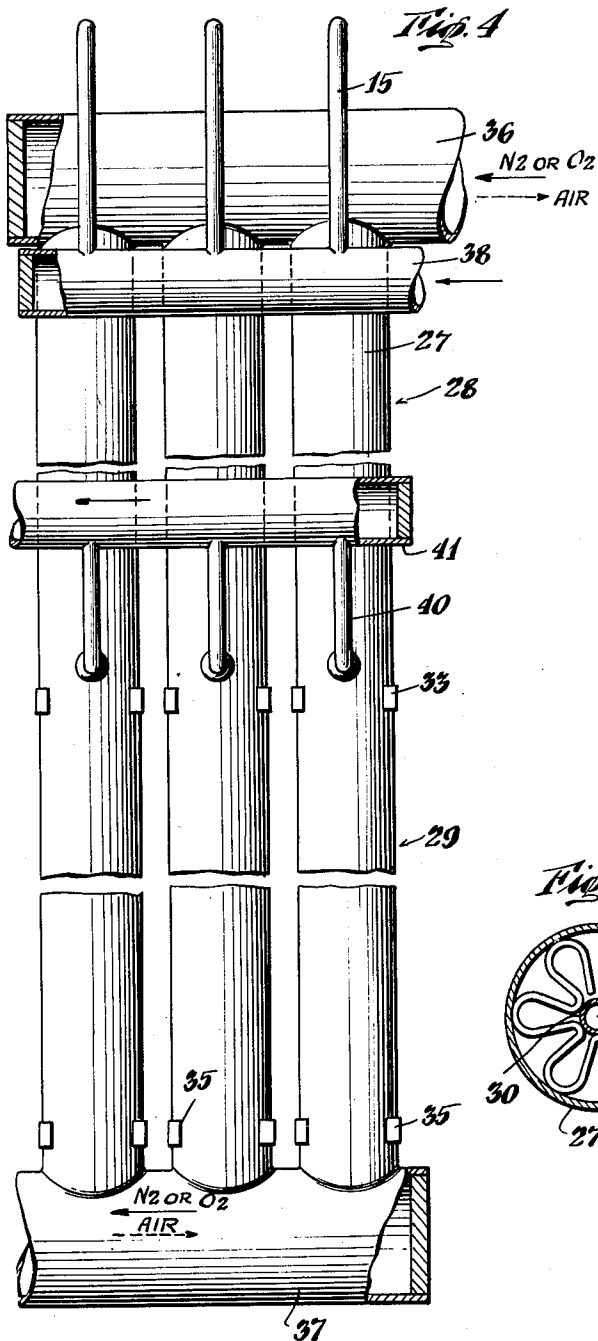
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3 Sheets-Sheet 2



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Fig. 7

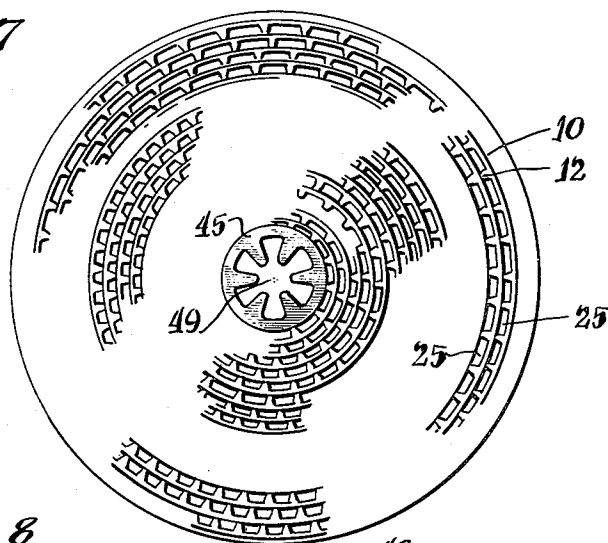


Fig. 8

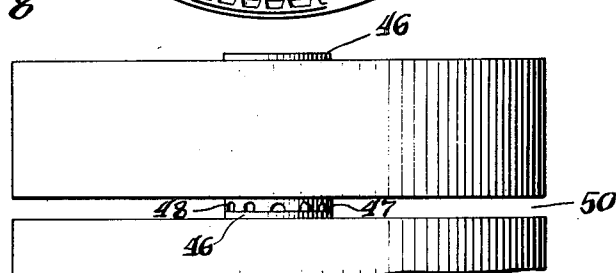


Fig. 9

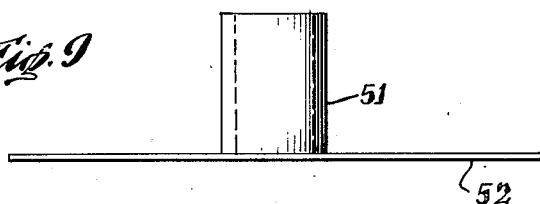
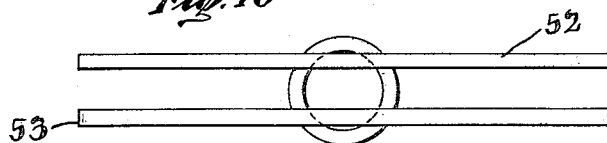


Fig. 10



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REGENERATOR AND PACKING THEREFOR

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Application April 9, 1948, Serial No. 19,952

6 Claims. (Cl. 257—6)

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The present invention relates to improvements in regenerators for recovering the cold content of the outgoing oxygen and nitrogen products of rectification which may be at a temperature of about -280° F. in the production of oxygen by the liquefaction and rectification of air and to a novel method of producing such regenerators. More particularly, it relates to the construction and design of the regenerators including the cold exchange surface areas thereof so as to provide for high cold transfer efficiency between the oxygen and nitrogen products of rectification on the one hand and the air on the other and for efficient purging of the regenerators upon reversal of flow therethrough to effect substantially complete removal from the regenerators of condensibles deposited from the air stream, thereby permitting continuous operation.

Cold regenerators are well known in which the relatively warm incoming air and the relatively cold outgoing oxygen and nitrogen products of rectification are passed with periodically reversed operation, so that streams of warm air are flowed through the same packing-filled spaces as the cold oxygen and nitrogen traversed during the preceding step of the process. In the operation of such regenerators the high-boiling impurities deposited in the packing-filled spaces during the passage of the air therethrough are removed by sublimation during the subsequent flow therethrough of the products of rectification. One type of such regenerator, as heretofore constructed, has involved the use of so-called "pancakes" of heat transfer material formed by winding successive convolutions of corrugated metal on a core to produce disks consisting of successive convolutions of corrugated metal, a multiplicity of which disks are inserted in the regenerator shell one on top of the other to provide the packing for the regenerator. The production of such packing is arduous and time-consuming and greatly increases the cost of the regenerator.

More recently an improved type of regenerator has been suggested involving a large number of packing units disposed in a regenerator, each of the packing units at the cold end of the regenerator being constructed to permit the recycling therethrough of an extraneous gas or a rectification product in indirect heat exchange relation with the air and rectification product passing over the packing during alternate cycles of operation. The recycling of such extraneous gas or rectification product (hereinafter referred to as the recycled gas) in indirect heat exchange re-

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lation with the air and rectification product passing over the packing during alternate cycles of operation results in temperature conditions within the regenerator such that more efficient purging takes place during each reversal of flow to effect removal of condensibles, particularly carbon dioxide, from the regenerator. In the construction of such regenerators it is difficult, if not impossible, to subject the individual units to test under conditions simulating operating conditions to determine whether the units are gas tight from the standpoint that no leakage will occur between the recycled gas and the air or rectification product. Moreover, once the units are assembled to form the desired regenerator and the regenerator is placed in operation, in view of the large number of units involved, should a leak develop in any one unit, as a practical matter it is exceedingly difficult, if not impossible, to determine which unit is faulty or defective.

Among the objects of this invention is to provide a cold regenerator having an exceptionally high area of cold exchanger surface per unit of volume, which can readily be fabricated and assembled, which is so constructed and designed that each individual unit can be tested and evaluated to determine whether in operation satisfactory heat exchange will take place between the recycled gas and the air or rectification product passing through the regenerator, which is so designed that turbulent flow of gaseous media passing over the heat exchange surface takes place and desired temperature gradient conditions are maintained throughout the heat exchange surface area and which is highly efficient in operation in effecting the transfer of cold from the rectification product passing therethrough to the air.

Another object is to provide a simple and efficient process of producing the regenerator packing.

Other objects and advantages of this invention will be apparent from the following detailed description thereof.

In the accompanying drawings forming a part of this specification and showing for purposes of exemplification a preferred form of this invention without limiting the claimed invention to such illustrative instance:

Figure 1 is a perspective view showing the preferred manner of assembling the strips of high heat transfer material on a tubular support to form the packing members disposed in spaced relation along the length of the support with a narrow space between adjacent members;

Figure 2 is a horizontal section through a packing member embodying this invention;

Figure 3 is a fragmentary sectional view on a greatly enlarged scale as compared with the sketch of Figure 1, taken in a plane passing through line 3—3 of Figure 1;

Figure 4 is a fragmentary side elevational view showing a regenerator assembly involving a plurality of regenerator units;

Figure 5 is a vertical section through a regenerator unit embodying this invention;

Figure 6 is a horizontal section taken in a plane passing through line 6—6 of Figure 5;

Figure 7 is a plan view of a modified form of regenerator packing member for use in the portion of a regenerator through which no recycled gas is passed;

Figure 8 is a side elevational view showing the relative positions of the packing members of Figure 7 when disposed within the regenerator;

Figure 9 is a side elevational view of a modified form of support for the strip or ribbon of high heat conducting material, which support may be used in forming the type of packing members shown in Figure 7; and

Figure 10 is a view of the base of the support of Figure 9, looking up at the base.

In accordance with the process of this invention a regenerator packing is produced from a long strip or ribbon of high heat conducting material, such for example as aluminum or copper, preferably aluminum having one side 10 flat and the opposite side 11 provided with integral ribs or projections 12. This strip has a brazing coating 11a of solder or any well known brazing material, e. g., aluminum-silicon composition in the case where the strip is of aluminum on at least one side thereof, desirably on the ribbed side 11, the function of which coating will be explained hereinafter. In order to provide the large mass of high heat conducting material and high area of cold exchanger surface per unit of regenerator volume necessary for effectively recovering the cold content of the outgoing products of rectification, it is important the material of high heat conductivity of each of the strips forming the packing members be relatively thin. Each strip may be from 1 to 6 inches wide, have ribs from .02 to .08 inch high, have a base thickness of from .01 to .04 inch and have the ribs spaced so that the distance from the center of one rib to the center of the next rib is from .1 to .3 inch. Preferably each strip is dimensioned so that it is about 1¼ inches wide, has a total thickness (the distance from the base of the strip to the top of the integral rib or projection 12) of about .07 inch and a base thickness (the thickness of the base from which the ribs project) of approximately .02 inch, and has the ribs spaced so that the distance from the center of one rib to the center of the next rib is approximately .15 inch.

In producing the regenerator packing units of this invention, a plurality of such strips are wound on a support from a reel 14, or a plurality of such reels, containing the desired number and lengths of strips. The number of such strips applied to a support to form a packing unit will depend on the size of the regenerator in which the packing unit is to be disposed.

In the embodiment of the invention shown in Figure 1, the support comprises a tube 15, desirably a hollow tube of high heat conducting material, for example aluminum or copper, having relatively thin walls, e. g., about .12 inch

thick and having integral interior fins 16 extending from the inner wall in a radial direction toward the center of the tube to improve the efficiency of the heat exchange between the gaseous medium passing through tube 15 and that flowing over the packing members disposed on this supporting tube. Tube 15 may have an external diameter of from ½ to 4 inches, preferably 3 inches. These packing members are formed by spot-brazing the leading end 17 of the strips wound on reel 14, as at 18, to the periphery of the tube 15, the several strips being disposed in spaced relationship along the length of tube 15 to form a narrow space 19, preferably about ⅛ inch wide between adjacent packing members. As shown in Figure 2, the leading end 17 of each strip is planed or scarfed to provide a gradual taper conforming in general to the contour of the tubular support 15 resulting in the formation of a firm bond between the end of this strip and the tubular support.

The tubular support 15 containing the leading end of the strips spot-brazed thereto is then rotated to wind the strips thereon forming a multiplicity of convolutions of the strip material with the ribs of the first convolution 20 in contact with the periphery of the tubular support 15 and the ribs 21 of the succeeding convolutions in contact with the flat side of an underlying convolution. Tubular support 15 is desirably coated on its outer surface with solder or brazing material as is the ribbed strip wound thereon. The terminal convolution 22 of the strip is planed or scarfed so that it is generally reduced in thickness and terminates in a knife-like edge 24. In this manner substantially cylindrical packing members result having an external diameter of from 3 to 12 inches, preferably 8 inches.

While in the showing of Figure 1 two strips are shown about to be wound in spaced relation on support 15, actually a larger number of such strips are wound on support 15 with narrow spaces 19 between adjacent strips, the exact number depending on the size of the regenerator. Further, while in Figure 1 it is indicated the two strips are wound simultaneously on support 15, strips applied to the support 15 may be wound successively.

The assembly of the tubular support 15 and packing members thereon, each consisting of a plurality of convolutions and produced as hereinabove described, is then subjected to elevated temperatures and thereafter cooled to cause the ribs to bond with the surfaces with which they contact. This bond is produced by the melting of the solder or brazing coating and subsequent solidification during cooling. In the case of packing members made from an aluminum strip and having an aluminum tubular support provided with a brazing coating of aluminum-silicon composition, the assembly produced as hereinabove described is desirably heated by a stream of hot air to a temperature of 1000° F. and then immersed in a molten salt bath at a temperature of 1150° F. Under these conditions the brazing coating melts and upon removal of the assembly from the salt bath, the molten brazing coating solidifies to produce a firm bond between the ribs and the flat surfaces of underlying convolutions and of the tubular support where the ribs contact same. The resulting assembly is then washed with hot water to remove molten salt adhering thereto and to insure that the longitudinally extending channels 25 interrupted

by the narrow spaces 19 are free of salt deposits. After this water treatment the assembly may be given an acid washing treatment, desirably employing dilute nitric acid containing a small amount of hydrofluoric acid, to remove residual traces of the salt and oxides and thereafter washed with hot water to remove any acid which may adhere to the assembly.

There is thus produced a packing unit consisting of a tubular support 15, a plurality of substantially cylindrical packing members 26 (Figure 5) on the support 15 arranged along the length of the support with a narrow space 19 between adjacent packing members 26. These packing members preferably have the ribs of the first convolution bonded to the periphery of the tubular support 15 so that they are in good heat conducting relation to the tubular support 15. Each packing member consists of a plurality of convolutions of the strip of high heat conducting material, each of the convolutions having a flat side 10 and the other side 11 provided with closely spaced ribs 12 extending across the width of the convolutions, the ribs of the first convolution contacting the support 15 and the ribs of each succeeding convolution contacting and being bonded to the flat surface 10 of a contiguous convolution thus forming in the spaces between the first convolution and the support and between the succeeding convolutions longitudinally extending channels 25, which are interrupted along their lengths by the narrow spaces 19 between adjacent packing members 26. The resultant assembly is disposed in the upper portion of a cylindrical housing 27 which has a diameter such that the assembly can be readily disposed within the housing leaving little clearance between the outer periphery of the assembly and the inner wall of the housing, for example, about $\frac{1}{2}$ inch radial clearance on an assembly about 4 inches in radius. Regenerator section 28 is thus produced through which the recycled gas flows through the hollow tubular support 15 and the air and a rectification product alternately pass through the channels 25.

In the construction of the lower regenerator section 29 of Figure 5, a tubular support 30 is used similar to 15, except that upper end 31 is pinched or sealed off. Alternatively, a solid rod may be used as the support for the packing members. The packing members are produced by winding strips of high heat conducting material on such support with narrow spaces 19 therebetween in the same manner as hereinabove described, except that it is not necessary to bond the first convolution to the support nor contiguous convolutions to one another because no fluid flows through support 30 and hence no heat transferring bond is necessary. To maintain the packing members 26 in desired spaced relation on support 30, spacer members 32, desirably of stainless steel in the form of a wire clip bent into the configuration shown in Figure 6, are disposed in the narrow spaces 19 between adjacent packing members 26. The resultant assembly is positioned within cylindrical housing 27 having a diameter such that the assembly fits within this housing with little or no clearance between the periphery of the assembly and the inner wall of the housing.

A pair of cross pieces 33 extend through housing 27, are suitably welded thereto and contact the top packing member 34 of the lower assembly as shown in Figure 5. Another pair of cross pieces 35 are disposed at the base portion of the

housing extending through the wall thereof, are welded thereto and positioned to engage the lowermost packing member 36. Also, as shown in Figure 5, cross pieces 33 and 35 are disposed to exert a clamping action on the assembly of packing members maintained in spaced relation by the spacers 32 and to prevent relative movement of the individual packing members to each other and to the housing 29.

A plurality of regenerators constructed as hereinabove described, as shown in Figures 4 and 5, are disposed with the upper end connected with a header 36 and the lower end with a header 37. One end of supporting tube 15 passes through header 36 and leads into a smaller header 38. The other end of each tube 15 extends into a conduit 39 which passes through housing 27 at right angles to the axis of this housing and has an end closed and the other end in communication with a pipe 40 leading into a header 41. Triangular plates 42 are welded to the base portion of supporting tube 15 and to conduit 39 to reinforce the joint between this conduit and the lower portion of the tubular support 15. The number of such regenerators connected with headers will depend on the desired capacity of the oxygen plant or other plant in which the regenerators are used.

In the operation of the regenerators of Figures 4 and 5, oxygen, nitrogen, other rectification products such as argon, neon, etc., or air, or an extraneous gas, is supplied to header 38 and recirculated through the supporting tubes 15 existing through conduit 39, pipes 40 and header 41. Periodically nitrogen or oxygen rectification product enters through header 36 and flows downwardly through the longitudinally extending channels 25 in indirect heat exchange relation with the recycled gas passing through supporting tubes 15 and then downwardly through the lower sections 29 of the regenerators into the header 37. Upon reversal, air flows through header 37 up through the lower sections 29 of the regenerators and then through the upper sections 28 in heat exchange relation with the recycled gas passing through the supporting tubes 15, the air leaving through the header 36. The air in flowing over the packing members 26 recovers the cold content of the oxygen or nitrogen product of rectification and is cooled to a temperature close to its dew point at the pressure prevailing in the regenerators. Any carbon dioxide or other condensibles contained in the air are deposited in the regenerators.

Upon reversal, which may take place every three minutes, the nitrogen or oxygen passing through the regenerators removes therefrom carbon dioxide and other condensibles deposited therein during the preceding step of the process.

The narrow spaces 19 between adjacent packing members 26 cause turbulent flow of the air or rectification products passing through the longitudinal channels 25 to take place. Further, these narrow spaces and the stainless steel spacers 32 which are of relatively poor heat conductivity serve to interrupt the transfer of heat from one packing member to another and result in the maintenance of the desired temperature gradient conditions within each regenerator, i. e., in the case of the construction of Figure 5 employed with air flowing from bottom to top of the regenerator, a temperature gradient gradually decreasing from bottom to top.

Instead of having a multiplicity of packing members mounted on a single support 30, as in

Figure 5, section 29 may have disposed therein individual packing members, such as shown in Figure 7, assembled as shown in Figure 8. The packing member of Figure 7 comprises a cylindrical tubular support 45 on which is wound the strip of high heat conducting material having flat side 10 and ribs 12 to form longitudinally extending channels 25. The leading end of the strip is brazed to support 45 and the successive convolutions brazed to each other, as hereinabove described in connection with the construction of Figures 1 and 2. Top extension 46 and base extension 47 project from the opposite sides of the wound strip. Base extension 47 is provided with openings 48 leading into the central opening 49 in support 45.

The packing members of Figure 7 are assembled, as shown in Figure 8, with the base extension 47 of a superimposed member resting on the top extension 46 of an underlying member forming a narrow space 50 in between each pair of packing members. Any desired number of such members are assembled in a housing simply by piling successive members within the housing with the base extension 47 of each resting on the top extension 46 of an underlying member.

In the operation of a regenerator section containing the packing members of Figures 7 and 8, flow of the gaseous media takes place through channels 25 and central opening 49 of each packing member. In the spaces 50 between each pair of packing members flow takes place through openings 48 from the central openings 49 into the longitudinal channels 25 and vice versa. Hence, turbulent flow takes place with optimum transfer of heat from the packing to the gas stream passing thereover during one cycle and from the gas to the packing during the next cycle.

In the modification of Figures 9 and 10, a tubular support 51 has welded or otherwise secured to its base two strap members 52 and 53, each of a length slightly less than the diameter of the packing member. The strip or ribbon of high heat conducting material of the type shown in Figure 1 is wound on support 51 with one edge resting on the strap members 52 and 53. The width of the strip or ribbon is such that the other edge is substantially in the same horizontal plane as the top of support 51. With the support of Figures 9 and 10 it is not necessary to braze the strip or ribbon to support 51, or the successive convolutions to each other since the weight of the strip or ribbon is carried by members 52 and 53 which also serve to space successive packing members when assembled to provide narrow spaces between successive pairs of packing members corresponding to spaces 50 (Figure 8). In other words, the edges of the convolutions rest on members 52 and 53 and are supported thereby eliminating the necessity for brazing successive convolutions to each other to maintain them in the desired fixed relationship.

It will be noted the regenerator of this invention has an exceptionally high surface area of cold exchanger surface per unit of volume of regenerator. With the design of packing units hereinabove described involving packing members made from strips of aluminum dimensioned as hereinabove described, the regenerator may have about 350 square feet of cold exchanger surface per cubic foot of regenerator volume. The turbulent flow caused by the spacing of the individual packing members, as hereinabove described, further improves the cold transfer efficiency of the regenerator. The regenerator is therefore of

exceptionally high transfer efficiency. This makes it possible to have the volumetric space through which the nitrogen or oxygen on the one hand and air on the other flow relatively small, thereby minimizing reversal losses. The feature of the regenerator of this invention involving the positioning of each assembly of supporting tube or rod and packing members in an individual housing permits ready testing of the regenerator under actual operating conditions to determine whether the construction is gastight. Further, should any leak develop in operation, it is a simple matter to determine which regenerator unit is faulty and to make the necessary repair to this unit.

The regenerators shown in Figures 4 and 5 are in a vertical position, the air entering at the lower end and the product of rectification at the upper end. If desired, the regenerators may be inverted so that header 37 is above header 36; also the regenerators may be disposed in other positions than the vertical position shown.

A significant feature of this invention is the high radial thermal conductivity because of the multiple points of contact between the supporting tube and the first convolution of metal strip and between the succeeding contiguous convolutions of metal strip. This radial conductivity is of great importance in operating regenerators in oxygen plants where the temperature difference at the cold end (at a temperature of about -280° F.) between the rectification product stream entering during one period and the air leaving during the subsequent period of operation must be kept within the narrow range of about 5° to 10° F., preferably about 6° to 8° F. Such small temperature differences must be maintained in order that condensible impurities like carbon dioxide deposited in the regenerators by the air passing therethrough are completely removed by evaporation during the passage of the rectification product stream through the regenerators and thereby the regenerators may be operated over long periods without need of a plant shut-down to effect thawing of the regenerators.

It will be understood different embodiments of the invention can be made without departing from the scope of this invention. For example, instead of having regenerator sections 28 and 29 in one housing, each section could be placed in an individual housing providing two regenerators instead of the unitary construction shown.

What is claimed is:

1. A regenerator comprising a hollow cylindrical tube, a plurality of substantially cylindrical packing members on said tube arranged along the length of said tube with a narrow space between adjacent members, each member consisting of a plurality of convolutions of high heat conducting material, each of said convolutions having one side flat and the other side provided with closely spaced integral ribs extending across the width of each convolution, the ribs of one convolution contacting and being bonded to the flat surface of a contiguous convolution thereby forming in the annular spaces between contiguous convolutions longitudinally extending channels defined by said ribs, said channels being interrupted along their lengths by the narrow spaces between adjacent members, a cylindrical housing enclosing the assembly of said packing members and said hollow tube but having the opposite ends of said hollow tube projecting outside of said housing, said housing having a diameter such that with said assembly disposed within said housing little clearance is left be-

tween the outer periphery of said assembly and the inner wall of said housing, and a port in the vicinity of each of the opposite ends of said housing to permit the flow of fluid through said housing separate from the flow of fluid through said hollow tube.

2. A regenerator comprising two sections, one section consisting of a hollow tube for flow of fluid therethrough, a plurality of substantially cylindrical packing members on said tube arranged along the length thereof with a narrow space between adjacent members, said packing members being bonded to said hollow tube, each packing member consisting of a plurality of convolutions of high heat conducting material, each of said convolutions having one side flat and the other side provided with closely spaced integral ribs extending across the width of each convolution, the ribs of one convolution contacting and being bonded to the flat surface of a contiguous convolution thereby forming in the annular spaces between contiguous convolutions longitudinally extending channels defined by said ribs, and the other section consisting of a support, a plurality of substantially cylindrical packing members on said support disposed along the length thereof with a narrow space between adjacent members, a spacer member in said narrow space to maintain the individual packing members in spaced relationship, each of said packing members consisting of a plurality of convolutions of high heat conducting material, each of said convolutions having one side flat and the other side provided with closely spaced ribs extending across the width of each convolution, the ribs of one convolution contacting and being bonded to the flat surface of a contiguous convolution thereby forming in the annular spaces between contiguous convolutions longitudinally extending channels defined by said ribs, a cylindrical housing enclosing both sections but having the opposite ends of said hollow tube projecting outside of said housing, said housing having a diameter such that with said sections disposed within said housing little clearance is left between the outer periphery of said sections and the inner wall of said housing, a port in the vicinity of each of the opposite ends of said housing to permit the flow of fluid through said housing separate from the flow of fluid through said hollow tube, and means at opposite ends of the assembly of packing members on said support for preventing movement of the individual packing members relative to said housing.

3. A regenerator comprising two sections, one section consisting of a hollow tube for flow of a fluid therethrough, a plurality of substantially cylindrical packing members on said tube arranged along the length thereof with a narrow space between each pair of said members, said packing members being bonded to said hollow tube, each packing member consisting of a plurality of convolutions of a strip of aluminum, each of said convolutions having one side flat and the other side provided with closely spaced integral ribs extending across the width of each convolution, the ribs of the first convolution contacting the tube and the ribs of each succeeding convolution contacting and being bonded to the flat surface of a contiguous convolution thereby forming in the annular spaces between the first convolution and the support and between the succeeding convolutions longitudinally extending channels defined by said ribs, said

channels being interrupted along their lengths by the narrow spaces between adjacent members, the second section comprising a rod-like support, a plurality of substantially cylindrical packing members on said support disposed along the length thereof with a narrow space between adjacent members, a spacer member inserted in each of said narrow spaces to maintain the individual packing members in spaced relationship, each of said packing members consisting of a plurality of convolutions of a strip of aluminum, each of said convolutions having one side flat and the other side provided with closely spaced ribs extending across the width of each convolution, the ribs of the first convolution contacting the support and the ribs of each succeeding convolution contacting and being bonded to the flat surface of a contiguous convolution thereby forming in the annular spaces between the first convolution and the support and between the succeeding convolutions longitudinally extending channels defined by said ribs, said channels being interrupted along their lengths by the narrow spaces between adjacent members, a cylindrical housing enclosing both sections but having the opposite ends of said hollow tube projecting outside of said housing, said housing having a diameter such that with said sections disposed within said housing little clearance is left between the outer periphery of said sections and the inner wall of said housing, a port in the vicinity of each of the opposite ends of said housing to permit the flow of fluid through said housing separate from the flow of fluid through said hollow tube, and means at opposite ends of the assembly of packing members on said support for preventing movement of the individual packing members relative to said housing.

4. A regenerator assembly comprising a pair of headers, a multiplicity of cylindrical housings disposed in spaced relationship and communicably connecting said headers, each housing containing two sections, one section consisting of a tubular support, a plurality of substantially cylindrical packing members on said tubular support arranged along the length thereof with a narrow space between adjacent members, said packing members being bonded to said tubular support, each packing member consisting of a plurality of convolutions of high heat conducting material, each of said convolutions having one side flat and the other side provided with closely spaced integral ribs extending across the width of each convolution, the ribs of one convolution contacting and being bonded to the flat surface of a contiguous convolution thereby forming in the annular spaces between contiguous convolutions longitudinally extending channels defined by said ribs, a second pair of headers outside of said cylindrical housings into which lead the upper and lower ends of said tubular support, the other section comprising a rod-like support, a plurality of substantially cylindrical packing members on said rod-like support disposed along the length thereof with a narrow space between adjacent members, a spacer member in said narrow space to maintain the individual packing members in spaced relationship, each of said packing members consisting of a plurality of convolutions of high heat conducting material, each of said convolutions having one side flat and the other side provided with closely spaced ribs extending across the width of each convolution, the ribs

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of one convolution contacting and being bonded to the flat surface of a contiguous convolution thereby forming in the annular spaces between contiguous convolutions longitudinally extending channels defined by said ribs.

5. A regenerator assembly comprising a pair of headers; a plurality of cylindrical housing disposed in spaced relationship and communicably connecting said headers; each housing containing two sections; one section consisting of a tubular support, a plurality of substantially cylindrical packing members on said tubular support arranged along the length thereof with a narrow space between adjacent members, said packing members being bonded to said tubular support, each packing member comprising a plurality of convolutions of a strip of aluminum, each of said convolutions having one side flat and the other side provided with closely spaced integral ribs extending across the width of each convolution, the ribs of the first convolution contacting the tubular support and the ribs of each succeeding convolution contacting and being bonded to the flat side of a contiguous convolution forming in the annular space between the first convolution and the tubular support and the succeeding convolutions longitudinally extending channels defined by said ribs, said channels being interrupted along their lengths by the narrow spaces between adjacent members; a second pair of headers outside of said cylindrical housings into which lead the opposite ends of said tubular support; and the other section comprising a rod-like support, a plurality of substantially cylindrical packing members on said rod-like support disposed along the length thereof with a narrow space between adjacent members, a spacer member inserted in each of said narrow spaces to maintain the individual packing members in spaced relationship, each of said packing members consisting of a plurality of convolutions of a strip of aluminum, each of said convolutions having one

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side flat and the other side provided with closely spaced ribs extending across the width of each convolution, the ribs of the first convolution contacting the rod-like support and the ribs of each succeeding convolution contacting and being bonded to the flat surface of a contiguous convolution forming in the spaces between the first convolution and the rod-like support and between the succeeding convolutions, longitudinally extending channels defined by said ribs, said channels being interrupted along their lengths by the narrow spaces between adjacent members, and holding means at the opposite ends of the assembly of cylindrical packing members on said rod-like support for preventing movement of said packing members relative to said housing in which said other section is disposed.

6. A regenerator according to claim 1, wherein said high heat conducting material is aluminum.

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