Oct. 18, 1955 A. L. JONES 2,720,976

THERMAL DIFFUSION APPARATUS

Filed Feb. 27, 1952

FIG.1.

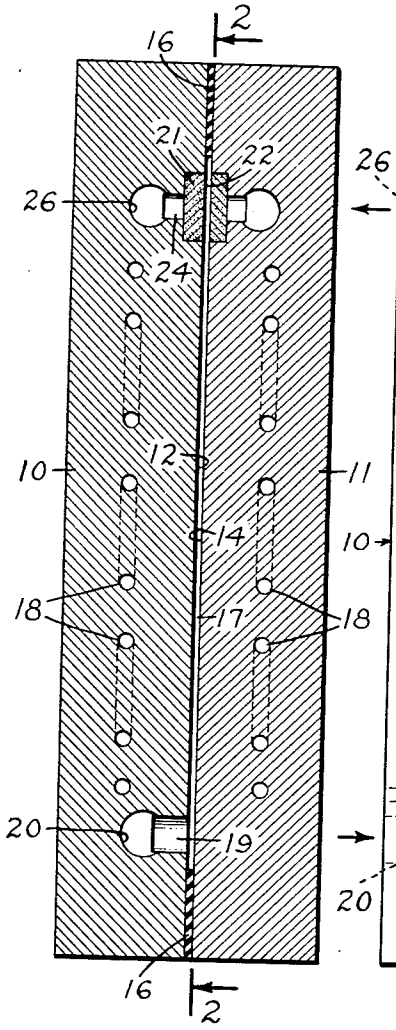
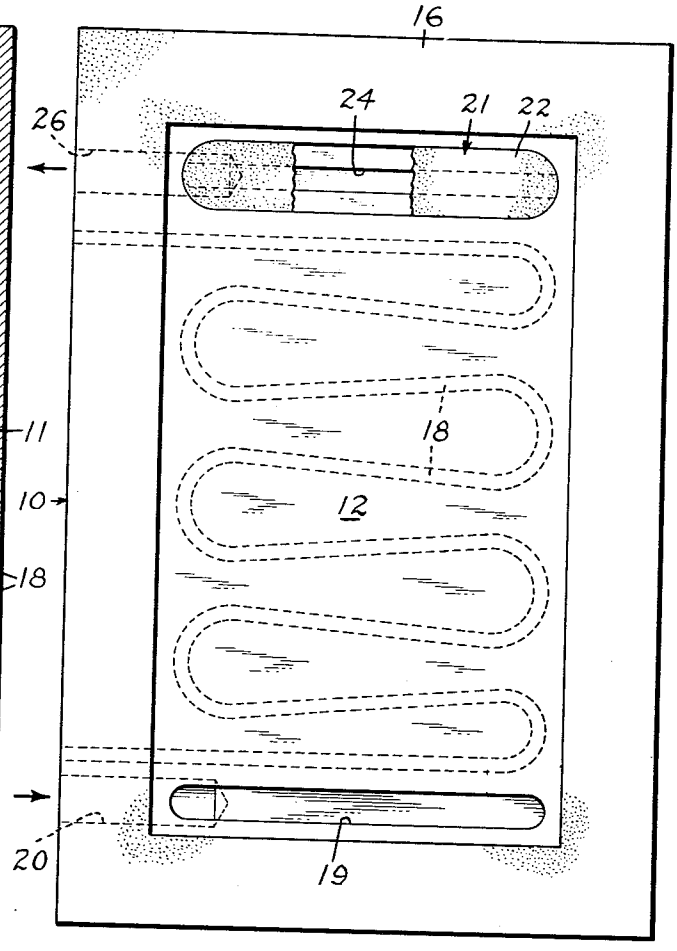


FIG.2.



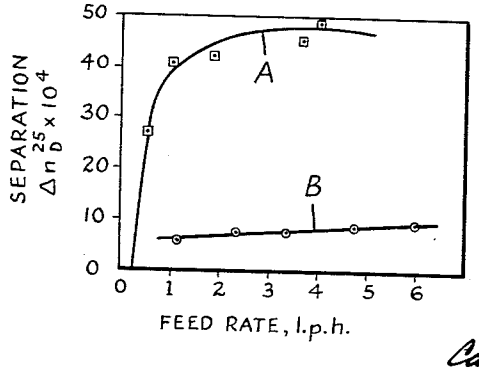


FIG.3.

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United States Patent Office 2,720,976
Patented Oct. 18, 1955

2,720,976

THERMAL DIFFUSION APPARATUS

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Application February 27, 1952, Serial No. 273,738

4 Claims. (Cl. 210—52.5)

The present invention relates to a new and useful improvement in apparatus for separating liquid mixtures by continuous thermal diffusion.

It has been known for some time that it is possible to separate liquid mixtures into two or more dissimilar fractions by subjecting a thin film of liquid mixture to a temperature gradient. For many years this was accomplished in apparatus consisting essentially of two closely spaced, parallel walls forming a narrow slit and provided at each end of the slit with a reservoir having a volume considerably in excess of the volume of the slit. By filling such an apparatus with a liquid mixture and maintaining the opposed walls at different temperatures, the liquid in one reservoir becomes enriched in one component of the liquid mixture, and the liquid in the other reservoir becomes impoverished in said component or enriched in another component.

After many hours or several days, the liquids in the two reservoirs are separately withdrawn.

The amount of liquid that can be subjected to thermal diffusion in apparatus of this type is extremely small, being measured in tens of ccs., and the time and heat energy required is so great that the technique of separating liquid mixtures by thermal diffusion remained nothing more than a laboratory curiosity for some eighty years.

More recently it has been proposed, e. g., in Patents 2,541,069–071, to subject liquid mixtures to thermal diffusion by maintaining a temperature gradient across a narrow slit formed by closely spaced concentric or flat walls, and continuously passing a stream of the liquid mixture through the slit. It was found that by such means the rate of separation obtainable is much improved.

The slit widths of liquid thermal diffusion columns are extremely narrow, i. e., less than about 0.15" and desirably not more than about 0.06". When continuous liquid thermal diffusion is carried out in apparatus designed for concurrent flow, i. e., where the liquid mixture to be subjected to thermal diffusion is introduced at one portion of a vertical, horizontal or inclined slit, and the dissimilar fractions are withdrawn from adjacent the hot and cold walls, respectively, at points remote from the point of introduction, there is, theoretically, no limit to the minimum slit width due to the absence of endwise thermal circulation within the slit. For practical considerations, however, the minimum slit width for concurrent flow is of the order of about 0.01".

There is reason to believe that the withdrawal of dissimilar fractions of a liquid mixture from a thermal diffusion column, particularly when they move through the slit concurrently, causes sufficient turbulence to bring about a rather considerable remixing, immediately prior to withdrawal, of the fractions separated within the slit. The end result of this is that the degree of separation obtainable is less than the degree of separation actually obtained within the slit, i. e., the efficiency of withdrawal is not commensurate with the efficiency of separation by thermal diffusion.

The present invention is addressed particularly to improving the efficiency with which fractions separated by thermal diffusion within a column can be withdrawn. In essence, the improvement with which the present invention is concerned is an improved form of withdrawal port, which comprises an elongated section in the face of one of the walls that is porous and has a longitudinal axis transversely of the direction of flow of liquid within the slit, and a passage for liquid extending to the exterior of the apparatus, one portion of which is substantially coextensive with and contiguous to the porous section.

The porous section may be an integral portion of one of the walls or built up by providing an elongated groove in the face of one of the walls forming the thermal diffusion slit and fitting an elongated strip member of porous, inert material in the groove, one face of the strip member being in substantially the same plane as the wall face.

The strip member may be of any suitable material or structure capable of distributing substantially uniformly the flow of liquid through it over the entire area of the member. Thus, for example, it may be, and preferably is in the form of a strip of sintered metal or porous ceramic material, e. g., porcelain, or it may have a composite structure, e. g., it may comprise fine screening material at the surfaces enclosing fibrous packing material, clay or the like.

To further promote substantially uniform distribution of flow of liquid through the porous section or strip member, the portion of the passage that is substantially coextensive with and contiguous thereto and the portion of the passage extending to the exterior of the apparatus are sufficiently large in volumetric proportions in relation to volumetric flow capacity of the porous strip member to assure substantially uniform flow through all of the pores but not so large as to delay unduly the displacement from the passage of unseparated liquid mixture with which it is initially filled upon commencement of the liquid thermal diffusion process, or hold up more than necessary of the separated fraction during the continued operation. The passage, particularly the portion contiguous to the porous section, may be tapered to assist in uniform withdrawal, especially if the volumetric proportions are relatively small.

One of the primary advantages of the withdrawal port of this invention is that it increases enormously the efficiency, probably due to a minimization of turbulence, with which fractions separated within a thermal diffusion slit can actually be removed from the slit.

This and other advantages, as well as the utility of the invention, will become further apparent from the following detailed description made with reference to the accompanying drawing, wherein:

Figure 1 is a cross-sectional view of a liquid thermal diffusion apparatus, provided with two withdrawal ports illustrative of the invention;

Figure 2 is a cross-sectional view taken along section line 2—2 of Figure 1; and

Figure 3 is a graph demonstrating the superior efficiency of withdrawal ports constructed in accordance with this invention as compared with that of a groove type take-off port.

Referring now to Figures 1 and 2 illustrating schematically a liquid thermal diffusion apparatus utilizing two withdrawal ports constructed in accordance with the present invention, the opposed walls **10** and **11** having wall faces **12** and **14**, respectively, are substantially parallel, liquid impervious and stationary. The wall faces **12** and **14** are separated from one another a distance of less than about 0.15", desirably not more than 0.06" and preferably from about 0.01 to about 0.035" apart by one or more gaskets **16** to form a narrow slit **17**. The walls

10 and 11 may be maintained in their position relative to one another by any suitable means, such as bolts extending through the walls and the gasket or gaskets adjacent the edges thereof and may be maintained at different temperatures by any suitable means such as circulation of fluids through coils indicated at 18. The apparatus illustrated in Figures 1 and 2 is provided with an inlet port comprising an elongated groove 19 in the face 12 of the wall 10 and a passage 20 through which the liquid mixture can be introduced from outside the apparatus by any suitable means and to the slit 17 by way of groove 19.

The apparatus illustrated by way of example in Figures 1 and 2 is provided, at the end of the slit 17 remote from the inlet port 19, 20, with two withdrawal ports, one in wall 10 and the other in wall 11. The withdrawal port in wall 10, for example, comprises an elongated groove in the face 12 and an elongated strip member 21 of porous material fitted in the groove. The face 22 of the strip member 21 is in substantially the same plane as the wall face 12. Under, adjacent and substantially coextensive with the strip member 21 there is an elongated flow-equalizing portion 24 of a passage for liquid that communicates with a passage portion 26 extending to the exterior of the wall 10.

A series of tests were run on apparatus essentially similar to that illustrated in Figures 1 and 2 wherein the width of the slit 17 was 0.035", the slit was in the vertical position shown, and the effective length and breadth of the slit were both 10". One wall was maintained at a temperature of 270° F. and the other was maintained at a temperature of 70° F. In one series of tests the two withdrawal ports were constructed as shown in the drawing, the strip member 21 being a porous, sintered metal strip.

In a comparative series of test runs all conditions were identical, except that instead of the withdrawal ports illustrated in Figures 1 and 2, grooves having a depth of one-eighth of an inch and a width of between two and three-sixteenths of an inch, connected by means of equally spaced holes in the bottom of the groove to a passage similar to passage 26 of the apparatus illustrated, but extending the entire length of the groove, were used.

In each test a 50/50 mixture of cetane and methylnaphthalene was fed into the column by way of inlet port 19, 20 at various rates of flow, and fractions from adjacent the hot and cold walls, respectively, were withdrawn through the oppositely disposed withdrawal ports at equal rates. To measure the degree of separation obtained in each instance, the index of refraction at 25° C. of the two fractions were obtained, the difference in indices of refraction between the hot wall product and the cold wall product being an accurate indicator of the extent to which separation took place. The results of these tests are illustrated in the graph of Figure 3, wherein the curve A represents the degree of separation, in terms of difference between the indices of refraction of the hot wall and cold wall products obtained with the thermal diffusion column having the withdrawal ports of this invention, and curve B represents the degree of separation, expressed similarly, obtained under identical conditions but with a simple groove type of withdrawal port. These curves reveal that with the withdrawal ports of the present invention, the degree of separation rises rapidly as the feed rate is increased to about one liter per hour and remains practically level at higher feed rates, whereas with the simple groove type withdrawal ports the degree of separation is less than one-fifth as great at feed rates ranging from about 1 to 6 liters per hour.

The degree of separation that takes place within a thermal diffusion slit is determined, for any given liquid mixture, by such conditions as temperature gradient, slit width, wall surface area and residence time of the liquid, all of which were the same in the comparative tests. It is self-evident, therefore, that the results obtained in these tests are indicative of the great superiority of the withdrawal ports of this invention over the groove type of withdrawal port. The withdrawal ports of this invention make it possible to separate physically the fractions concentrated adjacent the hot and cold walls within the thermal diffusion slit with far greater efficiency than has heretofore been possible.

It is to be understood that various changes and modifications will readily occur to those skilled in the art upon reading this description. All such changes and modifications are intended to be included within the scope of the invention as defined in the appended claims.

I claim:

1. Liquid thermal diffusion apparatus comprising two substantially parallel, liquid-impervious stationary walls, the opposed faces of which are smooth and spaced apart a distance less than about 0.15 inch to form a substantially uniform narrow slit, means for relatively heating and cooling said walls to impose a temperature gradient across said slit an inlet communicating with the slit and at least two outlets communicating with the slit, wherein at least one of the outlets comprises an elongated porous section in the face of one of the walls, one face of the porous section being in substantially the same plane as the wall face, and a passage for liquid extending to the exterior of the apparatus, one portion of said passage being substantially coextensive with and contiguous to the porous section.

2. The apparatus defined in claim 1 wherein the slit forming walls are vertical and two outlets are disposed, one in each wall, at one end of the slit.

3. Liquid thermal diffusion apparatus comprising two substantially parallel, liquid-impervious stationary walls, the opposed faces of which are smooth and spaced apart a distance less than about 0.15 inch to form a substantially uniform narrow slit, means for relatively heating and cooling said walls to impose a temperature gradient across said slit an inlet communicating with the slit and at least two outlets communicating with the slit, wherein at least one of the outlets comprises an elongated groove in the face of one of the walls; an elongated strip member of porous material fitted in the groove, one face of the strip member being in substantially the same plane as the wall face; and a passage for liquid extending to the exterior of the apparatus, one portion of said passage being substantialy coextensive with and contiguous to the strip member.

4. Liquid thermal diffusion apparatus comprising two substantially parallel, liquid-impervious stationary walls, the opposed faces of which are smooth and spaced apart a distance less than about 0.15" to form a substantially uniform narrow slit, means for relatively heating and cooling said walls to impose a temperature gradient across said slit wherein at least one of the walls is provided with an elongated porous section in the face thereof, said elongated porous section having its greatest dimension extending in a direction transverse to the direction of flow of liquid within the slit and one face of the porous section being in substantially the same plane as the wall face, and with a passage for liquid extending to the exterior of the apparatus, one portion of said passage being substantially coextensive with and contiguous to the porous section, and at least one of said walls having an inlet for supplying liquid to said slit, said inlet being spaced from said porous section.

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