Jan. 16, 1934. B. M. CARTER 1,943,855

HEAT EXCHANGE APPARATUS

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Fig. 2.

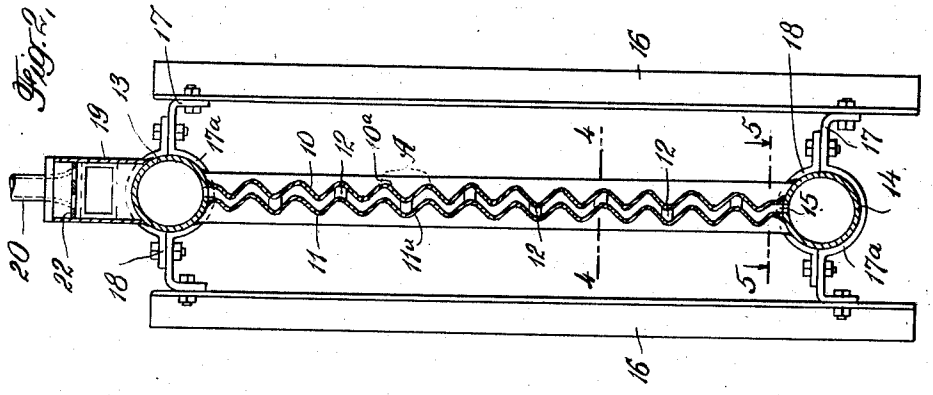
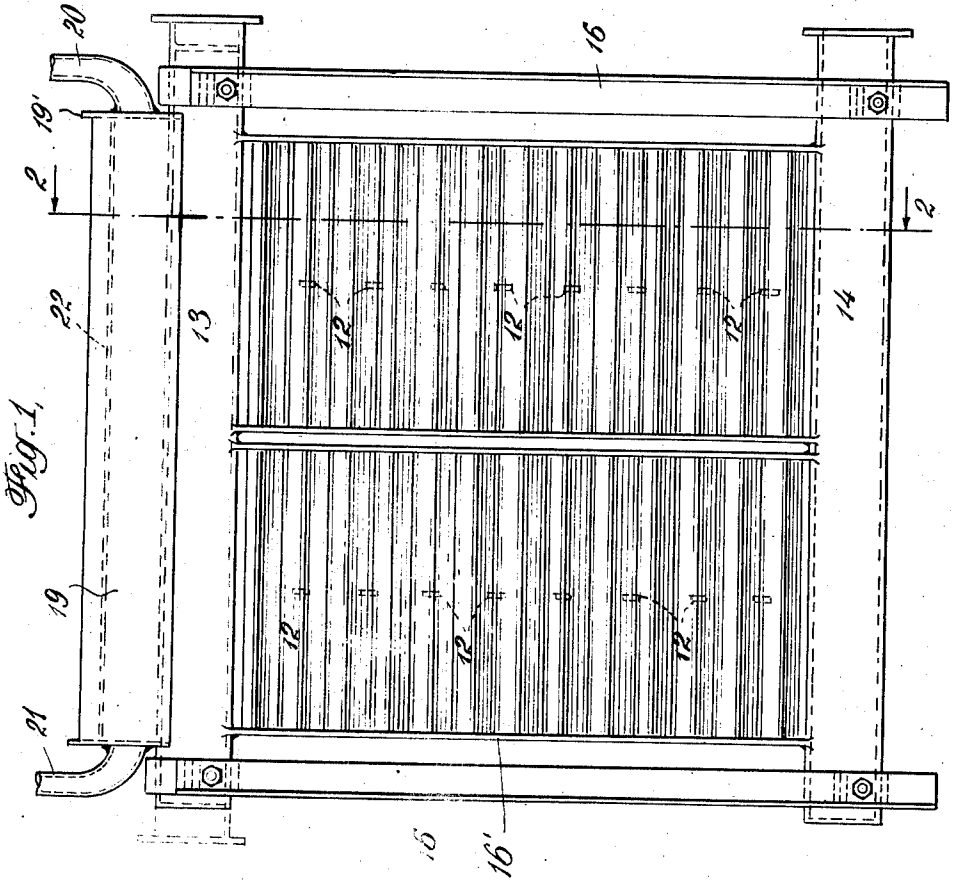


Fig. 1.



INVENTOR
BERNARD M. CARTER
BY Foster Sibley
ATTORNEY

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Fig. 3,

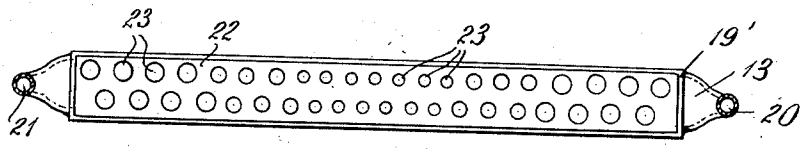


Fig. 4,

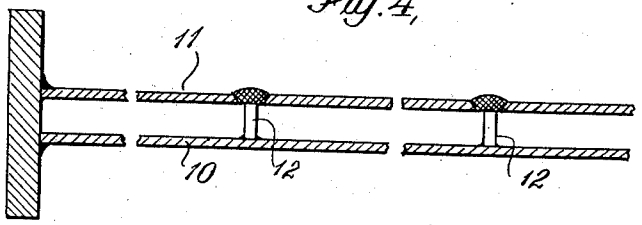


Fig. 5,

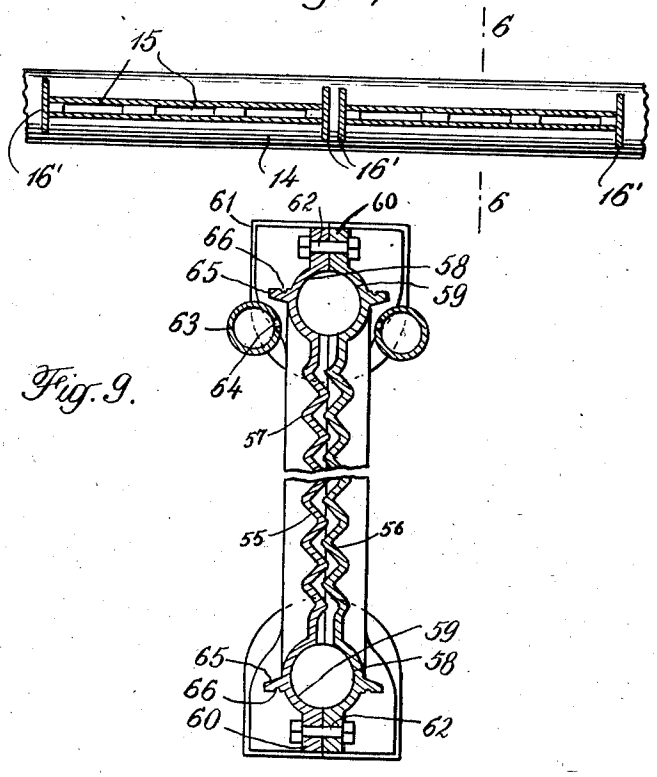
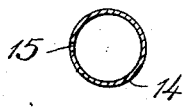


Fig. 9.

Fig. 6,



INVENTOR
BERNARD M. CARTER
BY Fowler Silsby
ATTORNEY

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Fig. 8.

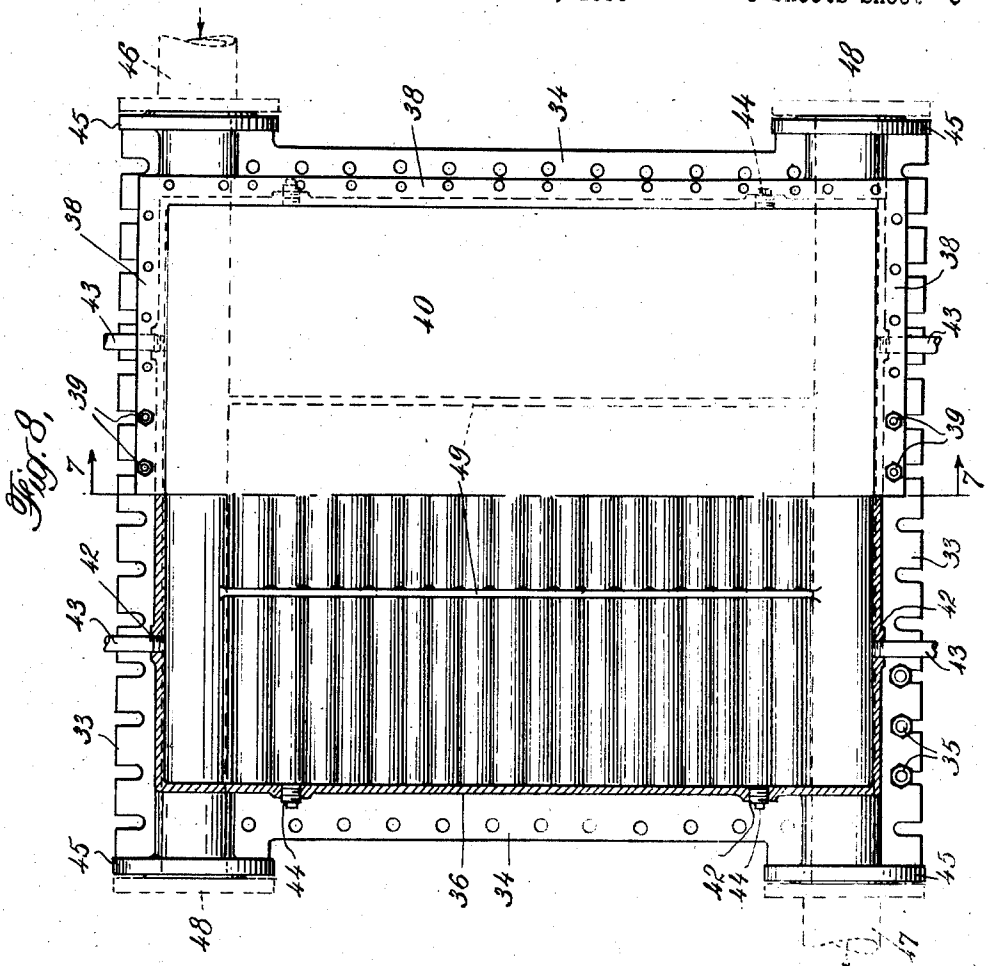
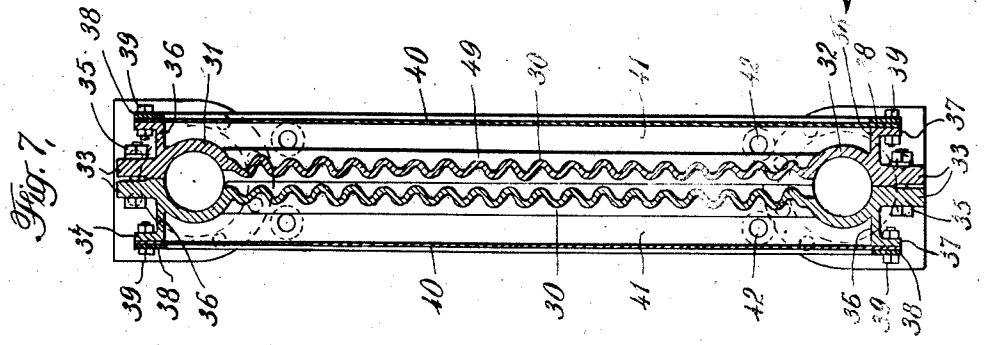


Fig. 7.



INVENTOR
BERNARD M. CARTER
BY Fahs Sibley
ATTORNEY

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UNITED STATES PATENT OFFICE

1,943,855

HEAT EXCHANGE APPARATUS

Bernard M. Carter, Montclair, N. J., assignor to General Chemical Company, New York, N. Y., a corporation of New York

Application June 6, 1930. Serial No. 459,466

15 Claims. (Cl. 257—187)

This application is a continuation in part of my copending application Serial No. 79,070, filed January 4, 1926.

This invention relates to cooling apparatus, and particularly to apparatus adapted for employment in the manufacture of acids, as for example sulfuric acid.

The principal object of this invention is to improve the operating efficiency of coolers of the kind described, and also to simplify the construction, thereby not only reducing the operating, but also the manufacturing and installation costs.

Heretofore, in the cooling of acids, particularly sulfuric acid, it has been the common practice to employ either an open vat through which the acid flowed and in which a coil for the cooling medium was placed, or to use a plurality of pipes connected in series to form a coil through which the acid flowed and over the outer surfaces of which water or other cooling medium was caused to flow. Both of these types of coolers are subject to the objection that a relatively small amount of the acid flows slowly through the cooler in a continuous thin film or sheet in direct contact with the cooling surfaces while the greater amount of the acid flows more rapidly but in a relatively quiescent central core between the films or sheets formed upon opposite walls of the cooling surfaces. Consequently, only that portion of the acid forming the film comes into direct contact with the cooling surfaces. In addition, the slow rate of flow of the film permits the accumulation of iron or lead sulphate or other salts according to the acid being treated and material used for the walls of the cooling pipes, such salts forming a coating upon the cooling surfaces and lowering the efficiency of the device.

A further object of this invention is to construct the cooler so that the formation of the film above referred to will be prevented and the entire amount of acid flowing through the cooler will be brought into direct contact with the cooling surfaces, thus avoiding the formation of a relatively quiescent body or central core. The invention also provides a greater amount of cooling surface without increasing the amount of space required for the cooler.

In the accompanying drawings—

Fig. 1 is a front elevation of one specific construction of a cooler embodying the principles of my invention;

Fig. 2 is a section on line 2—2 of Fig. 1;

Fig. 3 is a plan view of the water trough;

Fig. 4 is a section on the line 4—4 of Fig. 2;

Fig. 5 is a section on the line 5—5 of Fig. 2;

Fig. 6 is a section on the line 6—6 of Fig. 5;

Figs. 7 and 8 are views similar to Figs. 1 and 2 of a modified form of the invention, and

Fig. 9 is a vertical section similar to Figs. 2 and 7 of another modified form of the invention.

Referring particularly to Figs. 1 and 2, the side walls 10 and 11 of the cooler are preferably constructed, say of sheet lead cast or pressed, to form a plurality of substantially Z-shaped ribs or corrugations, and are secured together into closely spaced relationship, by suitable means, such as the filler blocks 12, provided to hold the side walls in properly spaced relation and to prevent buckling thereof. The top and bottom edges of the side walls are burned or otherwise secured to the upper and lower headers 13, 14 respectively, which headers are provided with a plurality of slots 15 arranged in alignment with the space which lies between the side walls and through which the material to be treated, as for instance sulfuric acid, passes from the header 13 and to the header 14.

The headers and side walls, when assembled, form a substantially unitary structure which is supported in a suitable supporting framework consisting of the side bars 16 and cross bars 17. Each of the cross bars 17 is formed at its central portion into a semi-circular clamp 17*a* in which the outer portion of the corresponding cylindrical header is adapted to seat. A clamp 18 is provided to cooperate with the semi-circular clamping portion 17*a*, to hold the assembled side wall and header structure securely in position. When the side walls 10 and 11 of the cooler elements are constructed of comparatively soft or non-rigid material, for example of lead, as in the preferred embodiment of the invention, the cooler may to best advantage be made in sections of short horizontal length as illustrated in Fig. 1. The ends of the cooler sections are formed by the end members 16'. In the embodiment of the invention illustrated in Fig. 1, two cooler sections are shown attached to the headers 13 and 14 and supported by the side bars 16 and the cross bars 17. This division of the cooler as a whole into sections is further shown in Fig. 5. The purpose of this construction is to prevent sagging and bulging of the side walls 10 and 11, and to thus provide sufficient support to maintain the side walls in proper position over a long period of time. The particular number of short sections in one unit is not material to the invention.

Located immediately above the top header 13,

is a water trough 19 provided with the inlets 20 and 21. Extending across the top part of the water trough, between its upper edge and the upper edges of the inlets 20 and 21, is a plate 22 provided with a plurality of perforations 23. These perforations, as clearly shown in Fig. 3 of the drawings, increase gradually in size from the center towards the inlets, the purpose of this being to insure a substantially equal distribution of the water across the entire width of the trough. The short upstanding flanges 19' formed by extensions of the vertical ends of the trough 19, prevent the flow of water over the ends of the trough, and down over the supporting bars 16 where it is of no use.

The operation of the device is as follows:

The acid or other liquid to be treated passes to the header 13, the ends of which, it will be understood, are provided with flanges for connecting thereto the pipes through which the acid is led to the cooler. The acid entering the header flows through the slots 15 to the space between the side walls 10 and 11. The Z-shaped formation of the side walls causes the direction of flow of the acid through the central passageway formed by the side walls to be changed abruptly so that there can be no formation of a relatively quiescent central core of acid. The manner in which the device functions can be best understood by referring to a small section of the cooler such as indicated by the letter A in Fig. 2. Considering the section of the side wall 10 to which the reference character 10*a* has been applied, the viscous liquid flowing along this section of the side wall is directed across the passageway onto the side wall section to which the reference character 11*a* has been applied. The abrupt change in the direction of flow produced by the Z-shaped configuration of the side walls prevents the acid formerly in contact with the side wall section 10*a* from following along the section of the side wall 10 immediately below the section 10*a*. At the same time, the reversal in direction of that portion of the acid which was not in direct contact with the side wall section 10*a* causes this central portion of the acid to break through, as it were, the portion of the acid which had formed the outer envelope of acid as it was flowing through that part of the passageway between the side wall section 10*a* and that section of the side wall 11 immediately opposite the section 10*a*. As the acid flows along the next lower section between the side wall section 11*a* and the opposite section of the side wall 10, a similar breaking through of the central portion and outer envelope of the acid occurs.

It will also be observed that the apex of each inwardly projecting ridge of the side walls 10 and and 11 intersects and projects an appreciable distance through a vertical plane including the longitudinal centers of headers 13 and 14. This construction avoids the possibility of an uninterrupted vertical descent of any liquid directly from the upper header 13 to the lower header 14, and so permitting the passage of liquid particles through the apparatus without causing such particles to be repeatedly projected against the cooled side walls 10 and 11. It is apparent, therefore, that the improved construction is such as to cause a complete breaking up and reversal of all parts of the liquid stream, and a thorough admixture of the particles thereof. It will thus be seen that as the reversals of direction of the acid flow follow each other in rapid succession there is no opportunity for the formation of a central core but instead there will be a continuous mixing effect with the result that all portions of the acid stream are brought rapidly and successively into direct contact with the cooling surfaces.

The cooling effect is secured by passing water or other suitable cooling medium along the outer surfaces of the side walls or, in some cases, simply by the action of the surrounding air. Assuming that water is employed, it enters the trough 19 through the inlets 20 and 21 and passes upwardly through the perforated plate 22, the gradually increasing size of the perforations 23 insuring an equal distribution of the water over the entire width of the trough. The water rises in the trough to the upper edges thereof and flows over the longitudinal edges, then down along the side walls of the trough onto the outer walls of the header 13, flowing around said outer walls to the end members 16' and to the walls 10 and 11 of the cooler along which it flows in a thin continuous sheet, being allowed to drop off the outer walls of the bottom header to be collected in any suitable drain or receptacle, not shown. The configuration of the side walls is such that the cooling liquid flows along the walls in a thin, substantially unbroken sheet. On account of the angularity of the bends in the sheets and the comparatively short inclined connecting portions forming the side walls, the liquid adheres to the surface of the walls, and does not tend to drip off the edges at the convex ridges thus cutting down the flow of the liquid in the concave portions of the wall surface.

In the construction shown in Figs. 7 and 8 I avoid the presence of any joints in the structure at points at which there is acid on one side and water on the other. I secure this result by providing two side members constructed preferably of cast iron, each having a horizontally corrugated or sinuous side wall portion 30, and upper and lower header portions 31 and 32 respectively, integral with the portion 30, and located at the upper and lower edges thereof. The members 30 are provided with longitudinal edge flanges 33, and end flanges 34, the flanges 33 extending from the header portions, and the end flanges 34 projecting from the vertical edges of the side portions. Suitable apertures are provided in said flanges 33 and 34 for the reception of the bolts 35 by means of which the members 30 are secured together. In addition, each of the members 30 is provided with a laterally projecting flange 36 of angular cross section which extends about the perimeter of the side wall portions 30 in the form of a rectangle; the parts of the flanges which form the sides of the rectangle projecting from the side edges of said side wall portions, and the top and bottom parts of the flanges extending outwardly from the top and bottom header portions 31, 32 respectively. Clamped upon the vertical faces 37 of the flanges 36 by means of the clamping members 38 and bolts 39 are the plates 40 which define with the side wall portions 30 and the flanges 36 a pair of closed chambers 41 through which the water or other cooling medium is circulated in contact with the side wall portions 30. At suitable intervals, the side flanges 36 are provided with threaded apertures 42 for the reception of pipes 43 through which the cooling medium is circulated to the closed chambers 41. Certain of said apertures may if desired be closed by the plugs 44.

Each header portion is provided with the pipe flange portion 45 which, when the side members

are bolted together form the pipe securing flanges at each side of the headers. An inlet, or acid supply, pipe 46 is secured to one end of the top header and an outlet pipe 47 is secured to the opposite end flange of the bottom header; closing caps or plates 48 preferably being secured to the other end flanges of each header.

The corrugated side wall portions 30 are provided on their outer faces with the narrow reinforcing strips or ribs 49 to strengthen said portions and prevent warping thereof.

The operation of the structure shown in Figs. 7 and 8 is similar to that of the structure shown in Figs. 1 to 6, the acid entering through the pipe 46 to the top header defined by the header portions 31, then flowing through the restricted passageway formed by the side wall portions 30 to the bottom header formed by the header portions 32 from which the acid is withdrawn through the pipe 47. The cooling medium, preferably water, is at the same time circulated through the closed chambers 41.

In the construction illustrated in Fig. 9, the presence of any joints in the cooler at points at which there is acid on one side and water on the other is avoided. The side members 55 and 56 are constructed preferably of cast iron. Each side members is formed with a plurality of horizontally disposed substantially Z-shaped ribs or corrugations 57, and includes upper and lower header portions 58 and 59, integral with the side members and located at the upper and lower edges thereof. The side wall members are further provided with upper and lower longitudinal edge flanges 60, and end flanges similar to the end flanges 34 in the form of the invention illustrated in Figs. 7 and 8. Side walls 55 and 56 are provided adjacent their vertical edges with outwardly projecting flanges appearing in elevation in Fig. 9 and similar in arrangement to end members 16' of the modification shown in Fig. 1. Each header portion terminates at its ends with a pipe flange 61 which, when the side members are bolted together as by bolts 62, form pipe securing flanges on the ends of the headers. Acid inlet and outlet pipes may be connected to flanges 61 at opposite ends of the inlet and outlet headers similar to the arrangement shown in Fig. 8. The open ends of the headers may be closed off by plates such as the caps 48 shown in Fig. 8.

In the construction disclosed in Fig. 9, the cooling of the acid passing through the sinous passage between the walls 55 and 56 is effected by a thin sheet of water or other cooling liquid flowing down over the outer surface of the apparatus. A supply of cooling liquid is obtained from conduits 63 arranged alongside the upper acid inlet header. The pipes 63 may be supported in the position shown in Fig. 9 either by brackets bolted to the cooler flanges, or by any other suitable means associated with the cooler unit. The water in the conduits 63 is under some degree of pressure, and is sprayed over the upper outer edge of each side wall through a series of perforations 64 in the sides of the conduits immediately adjacent the surface of the cooler. The perforations 64 are spaced closely, and act to spray water onto the sides of the cooler in such a manner that the cooling liquid forms a substantially even sheet which flows down over the outer surfaces of the cooler in the form of a thin film.

The header portions 58 and 59 are each provided with an outwardly projecting horizontal flange 65. Grooves 66 are formed on one surface of the flanges 65 immediately adjacent the header portion. Water flowing down over the sides of the cooler drips off the outer edges of the lower flanges 65. Grooves 66 on the under sides of the lower flanges 65 serve to catch and deflect any small quantities of liquid which may tend to flow back along the lower surfaces of the flange 65, and thus prevent water from reaching the joint along the lower edge of the cooler. The under sides of the flanges 65 on the upper header act to turn the spray from conduits 63 downwardly over the outer surface of the cooler. By including a groove 66 in the flat face of each flange 65, the sides 55 and 56 are duplicates, and thus the opposite sides of the cooler are interchangeable.

It will also be seen that the apex of each inwardly projecting ridge of the side walls 55 and 56 intersects and projects an appreciable distance through a vertical plane including the longitudinal centers of the inlet and outlet headers. As previously mentioned, this construction avoids the possibility of an uninterrupted vertical descent of any of the liquid directly from the upper header to the lower header. It will appear that this construction is such as to cause a complete breaking up and reversal of all parts of the liquid stream, and a thorough admixture of the particles thereof.

The operation of the apparatus shown in Fig. 9 is substantially the same as that already described in connection with Fig. 2, with the exception of the manner of distributing the cooling liquid over the upper edges of the cooling surfaces. The operation of the latter feature will be sufficiently understood from the foregoing description in connection with the drawings.

In all forms of the invention the same principle of causing a series of abrupt, rapid and successive reversals of the flow of the acid is employed whereby the continuous mixing of all portions of the acid stream occurs, no relatively quiescent central core can form, and all portions of the acid are brought into direct contact with the cooling surfaces. In addition, the structures of Figs. 7, 8, and 9 have the further advantage of preventing the presence of acid and water on opposite sides of connecting joints.

The configuration of the side walls, as herein disclosed, not only possesses the advantage of insuring a more intimate contact of all portions of the acid with the cooling surfaces and the formation of a central core, but also enables a much larger area of cooling surface to be obtained without increasing the external dimensions of the cooler.

The provision of he flanges at both ends of the headers enables the coolers to be connected in any desirable manner to form batteries of coolers through which the acid may be circulated, either in series or in parallel.

I claim:

1. In apparatus for the manufacture of sulphuric acid or the like, a cooler having a restricted passageway through which the acid to be cooled is passed, the side walls of the said passage comprising similarly formed plates having angular, sharply formed convex and concave portions connected by short inclined portions, said inclined and concave and convex portions being so associated and arranged as to cause the acid within the passage to be projected successively across the passage from one side wall to the other and to limit linear travel of acid to a distance not substantially more than the thick-

ness of the passageway, the angularity of the concave and convex portions being such that liquid flowing down over the outside of the wall surface adheres thereto and forms a substantially evenly distributed film over the entire outer surface of the side walls.

2. In an apparatus of the character described comprising a pair of spaced side walls forming a passage through which a liquid medium is adapted to be passed, and means to furnish the outer surface of the passage with an evenly distributed supply of liquid medium including an overflow trough located above the side walls, the improvement which comprises an inlet for said trough, and means for maintaining a substantially uniform supply of liquid to the trough throughout the entire length thereof.

3. In an apparatus of the character described comprising a pair of spaced side walls forming a passage through which a liquid medium is adapted to be passed, and means to furnish the outer surfaces of said side walls with a substantially evenly distributed supply of a cooling medium, said means including an overflow trough located above said side walls, the improvement which comprises an inlet at each end of said trough and a plate located between said inlets and the top of said trough, said plate being provided with a plurality of apertures of gradually increasing diameter from the mid-point of said plate outwardly to secure a substantially uniform supply of cooling medium to said trough throughout the entire length thereof.

4. In apparatus for the manufacture of sulphuric acid or the like, a cooler having a restricted passageway through which the acid to be cooled is passed, the side walls of said passageway being provided with a plurality of sharply inclined, reversely extending surfaces to cause the acid to be projected across said passageway from an inclined surface of one side wall towards an inclined surface of the other wall and means to furnish the outer surfaces of said side walls with a substantially evenly distributed supply of a cooling medium, said means comprising an overflow trough located above said side walls, an inlet at each end of said trough and a plate located between said inlets and the top of said trough, said plate being provided with a plurality of apertures of gradually increasing diameter from the mid-point of said plate outwardly to secure a substantially uniform supply of cooling medium to said trough throughout the entire length thereof.

5. In apparatus for the manufacture of sulphuric acid, a cooler constructed of a pair of side members each having a side wall section provided with a plurality of sharply inclined, reversely extending surfaces, and a header portion adjacent opposite edges of said wall section; means for connecting said side members to form an unitary structure having a central connecting joint between said members, the inner surfaces of said side wall sections forming a restricted tortuous passageway through which the acid to be cooled is flowed, and said header portions forming a header at each end of and communicating with said passageway; and means for causing a cooling medium to flow along the outer surfaces of said side wall sections out of contact with said connecting joint.

6. Heat exchange apparatus comprising a pair of side members each having a side wall section, and a header portion adjacent opposite edges, means for connecting said side members to form a unitary structure having a centrally disposed connecting joint between said members, the inner surfaces of said wall sections forming a passageway through which a fluid is adapted to be flowed and said header portions forming a header at each end of and communicating with said passageway, means for flowing a fluid medium along the outer surfaces of the wall sections, and means arranged adjacent the borders of the wall sections to prevent fluid medium from coming into contact with said connecting joint.

7. Heat exchange apparatus comprising a pair of side members each having a side wall section and a header portion adjacent opposite edges, means for connecting said side members to form a unitary structure having a centrally disposed connecting joint between said members, the inner surfaces of said wall sections forming a passageway through which a fluid is adapted to be flowed and said header portions forming a header at each end of and communicating with said passageway, means for flowing a fluid medium along the outer surfaces of the wall sections, and flanges arranged adjacent the borders of the wall sections and projecting outwardly from the faces thereof to prevent said fluid medium from coming into contact with the connecting joint.

8. Heat exchange apparatus comprising a pair of side members each having a side wall section and a header portion adjacent opposite edges, means for connecting said side members to form a unitary structure having a centrally disposed connecting joint between said members, the inner surfaces of said wall sections forming a passageway through which a fluid is adapted to be flowed and said header portions forming headers with the upper and lower edges of and communicating with said passageway, means for flowing a fluid medium along the outer surfaces of the wall sections, and deflecting members arranged adjacent the lower edges of the wall sections to prevent fluid medium flowing down over the outer face of the wall sections from coming into contact with the connecting joint.

9. Heat exchange apparatus comprising a pair of members each having a side wall section, a header portion adjacent outer edges of said wall section and outwardly extending flanges lying substantially in the plane of the wall section, means for connecting the flanges to form a unitary structure having a centrally disposed connecting joint between said members, the inner surfaces of said wall sections forming a passageway through which a fluid is adapted to be flowed and said header portions forming a header at each end of and communicating with said passageway, means for flowing a fluid medium along the outer surfaces of the wall sections, and means arranged adjacent the borders of the wall sections to prevent fluid medium from coming into contact with said connecting joint.

10. Heat exchange apparatus comprising a pair of side members each having a side wall section provided with a plurality of sharply inclined, reversely extending surfaces, a header portion adjacent opposite edges of said wall section and outwardly extending flanges lying substantially in the plane of the wall section, means for connecting the flanges to form a unitary structure having a centrally disposed connecting joint between said members, the inner surfaces of said wall sections forming a restricted tortuous passageway through which a fluid is adapted to be flowed and said header portions forming a header at each end of and communicating with said

passageway, means for flowing fluid medium along the outer surface of the wall sections and flanges arranged adjacent the borders of the wall sections and projecting outwardly from the faces thereof to prevent said fluid medium from coming into contact with the connecting joint.

11. Heat exchange apparatus having a pair of spaced side walls forming a restricted passageway through which a liquid medium is adapted to be passed, the side walls of said passage comprising similarly formed plates having angular, sharply formed convex and concave portions connected by short inclined portions, said inclined and convex and concave portions being so associated and arranged as to cause liquid within the passage to be projected successively across the passage from one side wall to the other and to limit linear travel of liquid to a distance not substantially more than the thickness of the passageway, the angularity of the concave and convex portions being such that liquid flowing down over the outside of the wall surface adheres thereto and forms a substantially evenly distributed film over the entire outer surface of the side walls.

12. In apparatus for the manufacture of sulfuric acid, a cooler having a restricted passageway through which the acid to be cooled is passed, the side walls of said passage comprising similarly formed plates having angular, sharply formed convex and concave portions connected by short inclined portions, said inclined and concave and convex portions being so associated and arranged as to cause the acid within the passage to be projected successively across the passage from one side wall to the other and to limit linear travel of acid to a distance not substantially more than the thickness of the passageway, and means including an overflow trough to furnish the outer surfaces of said side walls with a substantially evenly distributed supply of a cooling medium, the angularity of the concave and convex portions of the side walls being such that liquid flowing down over the outside of the wall surface adheres thereto and is maintained in the form of substantially an evenly distributed film over the entire outer surface of the side walls.

13. Heat exchange apparatus having a pair of spaced side walls forming a restricted passageway through which a fluid medium is adapted to be passed, the side walls of said passage comprising similarly formed plates having angular, sharply formed convex and concave portions connected by short inclined portions, said inclined and convex and concave portions being so associated and arranged as to cause fluid within the passage to be projected successively across the passage from one side wall to the other and to limit linear travel of fluid to a distance not substantially more than the thickness of the passageway, said side walls being arranged so that the apex of each inner convex surface of the side walls extends at least to a longitudinal plane disposed centrally of the side walls, the angularity of the concave and convex portions being such that liquid flowed over the outside of the wall surfaces adheres thereto and forms a substantially evenly distributed film over the entire outer surface of the side walls.

14. Heat exchange apparatus comprising a pair of side members each having a side wall section provided with a plurality of convex and concave surfaces and a header portion adjacent opposite edges, means for connecting said members to form a unitary structure having a centrally disposed connecting joint between said members, the inner surfaces of said side wall sections forming a passageway through which a fluid is adapted to be flowed, and said header portions forming a header at each end of and communicating with said passageway, said side walls being arranged so that the apex of each inner convex surface of the side walls extends at least to a longitudinal plane including the centrally disposed joint, means for flowing a fluid medium along the outer surfaces of the wall sections, and means arranged adjacent the borders of the wall sections to prevent fluid medium from coming into contact with said connecting joint.

15. Heat exchange apparatus having a pair of spaced side walls forming a restricted passageway through which a fluid medium is adapted to be passed, the side walls of said passage comprising similarly formed plates having angular, sharply formed convex and concave portions connected by short inclined portions, said inclined and convex and concave portions being so associated and arranged as to cause fluid within the passage to be projected successively across the passage from one side wall to the other, said side walls being arranged so that the apex of each inner convex surface of the side walls extends at least to but not substantially beyond a longitudinal plane disposed centrally of the side walls, and means for contacting fluid medium with the outer surfaces of the walls.

BERNARD M. CARTER.