

Aug. 11, 1931.

G. T. MOTT

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APPARATUS FOR HEAT EXCHANGING

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2 Sheets-Sheet 1

Fig. 1

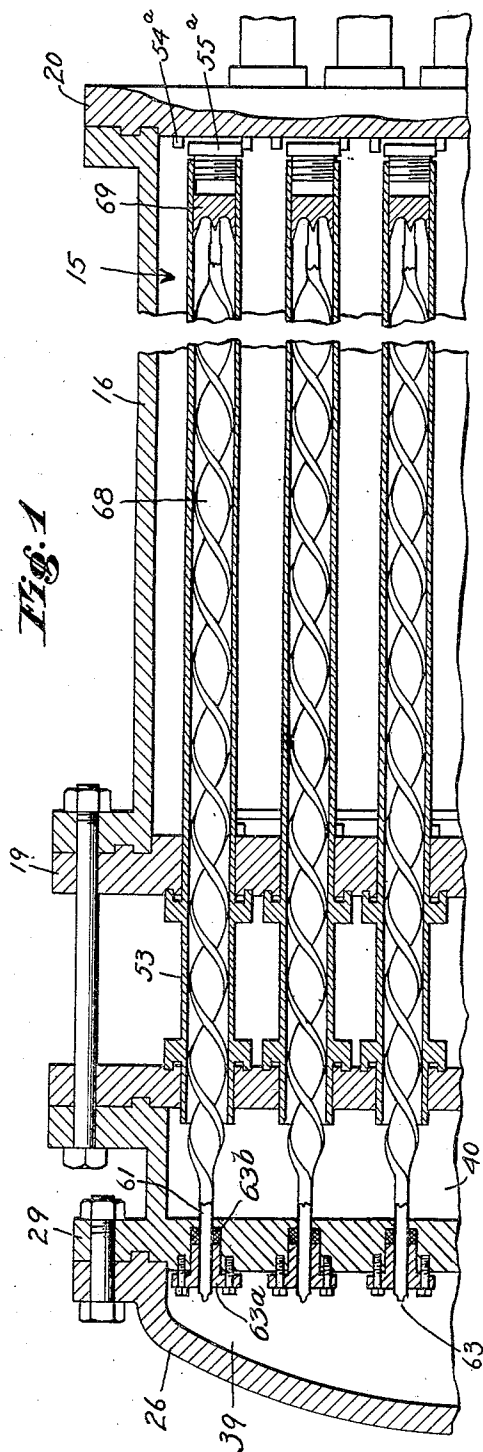
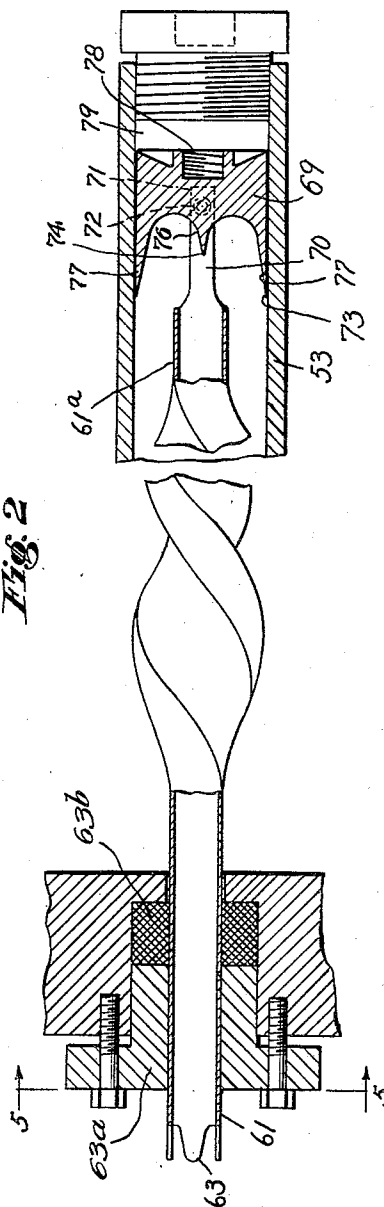


Fig. 2



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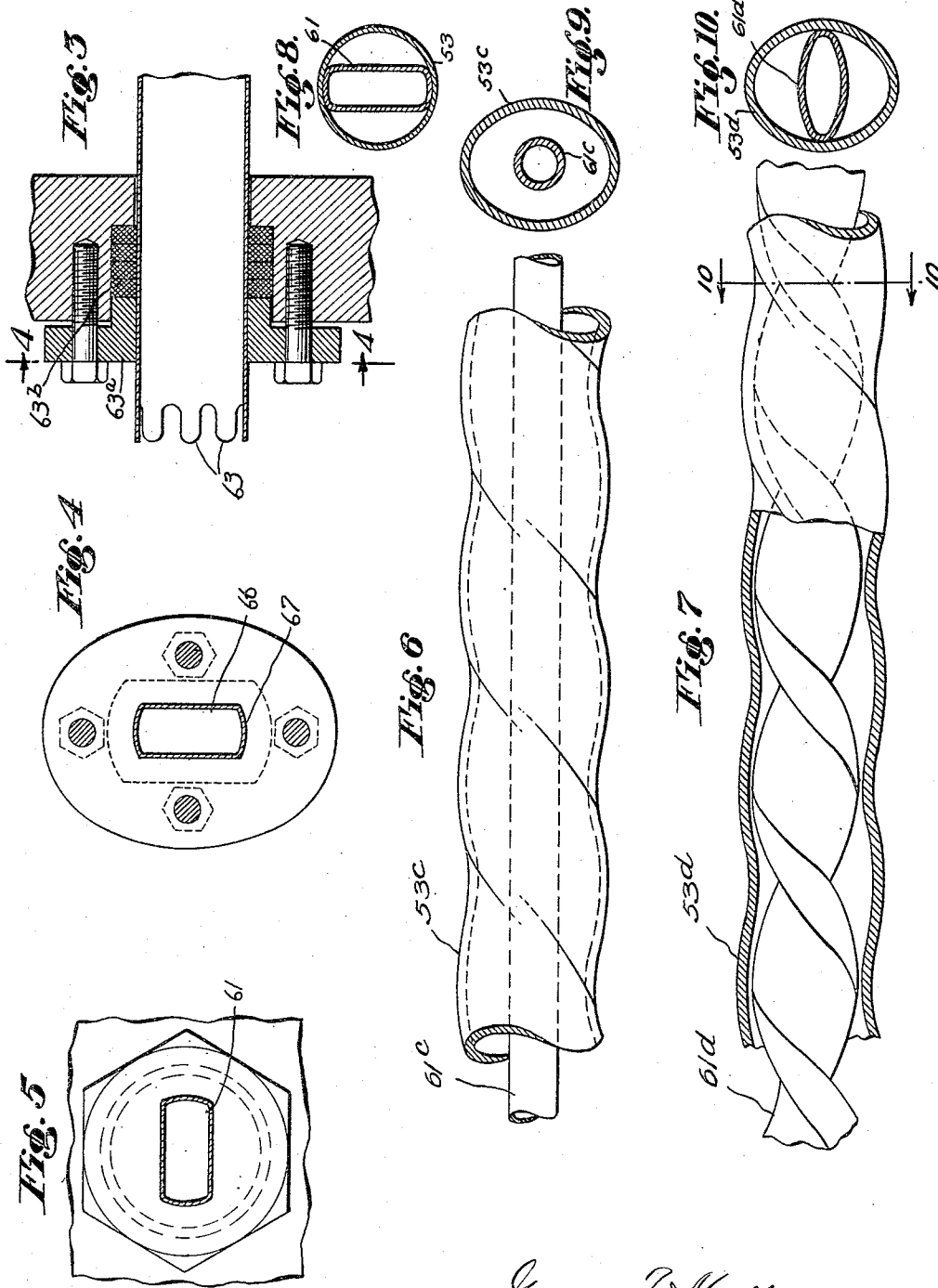
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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APPARATUS FOR HEAT EXCHANGING

Application filed August 10, 1928. Serial No. 298,789.

The invention relates generally to heat exchangers and, while the invention may be embodied in constructions adapted for various purposes, it is more particularly directed to the tubes used in heat exchangers as heat transfer surfaces between the heat containing and heat absorbing agents and thru which tubes one of said agents flows.

A prime object of the invention is to provide in a heat exchanger a double tube heat transfer surface so shaped and arranged as to provide diagonal cross flow transfer within a single flow element of a heat exchange unit, thus bringing about an augmented scouring effect; an extension of the contact areas; an induced thermal activation in the heat absorbing medium; and a consequent augmented thermal transfer. This and other objects of the invention will be set forth in the following description.

Of the accompanying drawings, which are referred to herein and form part hereof,—

Figure 1 is a longitudinal cross-section of part of a heat exchanger in which is employed and shown tubes constructed in accordance with the invention and which form the heat transfer surfaces of the heat exchanger;

Fig. 2 is an enlarged view, parts being broken away, in longitudinal cross-section of an inner and an outer tube shown in Fig. 1;

Fig. 3 is a longitudinal cross-section of an end of a modified form of inner tube used in the device, showing details, and is taken on a plane at right angles to the plane of the section shown in Fig. 1;

Fig. 4 is a view, partly in elevation and partly in cross section, taken on the line 4—4 of Fig. 3;

Fig. 5 is a similar view, taken on the line 5—5 of Fig. 2;

Fig. 6 is a fragmentary perspective view of a modification;

Figure 7 is a fragmentary view, partly in perspective and partly in section, of another modification;

Fig. 8 is a transverse section of the tubes shown in Fig. 1, taken at the point 68;

Fig. 9 is a transverse section of the tubes shown in Fig. 6; and

Fig. 10 is a similar view of the tubes shown in Fig. 7, taken on the line 10—10 of Fig. 7.

Referring to the drawings in detail, and first to Figs. 1 to 5, inclusive, there is illustrated therein a preferred embodiment of the invention as used in a heat exchanger of the type shown in my co-pending application, Serial No. 127,039, filed August 4, 1926, and which need not be described in detail herein. Said heat exchanger consists generally of a main vapor receptacle 15 formed with a cylindrical shell 16, having heads 19 and 20 and provided with the usual vapor flow ports, not shown. At one end of said vapor receptacle 15 and spaced apart therefrom is arranged a container 26 divided by a partition wall 29 into receptacles 39 and 40 which are provided with inlet and outlet ports not shown. One of the heat agents, as for example, oil, enters the receptacle 39 and then tubes 61. These tubes lead from said receptacles 39 and, passing through the receptacle 40, project into outer tubes 53. These latter tubes 53 lead from the receptacle 40 and, traversing the space between the container 26 and the vapor chamber 15, project into the vapor chamber 15 through the head 19. The closed ends of the tubes 53 are freely supported on curved supporting members 54^a, see Fig. 1, preferably cast integrally with the head plate 20. These supporting members 54^a are arc-shaped and are employed, four to each tube end, with space between each two arc members. The supported ends of the tubes 53 are sealed with plugs 55^a, preferably screwed into the ends of the tubes. It will be seen that the oil entering the tubes 61 will pass therefrom at their extreme inner ends into the outer tubes 53 and, abruptly changing the direction of flow, pass thru said outer tubes 53 into the receptacle 40, absorbing in its passage the heat from the heat-containing vapor in the vapor chamber 15.

It is with these tubes and their associated parts that this invention is more particularly concerned. A description of the foregoing circulation tubes and parts will be sufficient for an understanding of the present invention. And here it may be noted that the direction of flow of the heat-absorbing agent, as

oil, through the tubes may be reversed and flow, first, through the outer tube and thence into and through the inner tube. Also, the heat exchanger may be used so that the heat-containing agent flows through the tubes while the heat-absorbing agent is in the chamber 15. And it may be further noted that both said heat-containing and heat-absorbing agents may be gases or liquids, of any character, or one of said agents may be a gas and the other of said agents may be a liquid. The tube thru which the heat agent or liquid enters the tube element is preferably provided with an entry port of the type shown in my co-pending application, Serial No. 167,684, filed February 12, 1927, to which reference is hereby made and which port need not be described in detail herein. The peripheral wall of the tube 61 is formed with a serrated edge, forming extending tongues 63, see Fig. 3, with intervals of space between them, and the entering liquid stream is admitted to the tube at different intervals and entry planes about and between the tongues. With an entry port of this type the liquid is admitted to the tube proper in volume equal to the full capacity of the tube. As shown, the tube is secured in place with a gland 63^a which fits tightly over the stuffing 63^b. And it is pointed out that when the direction of the flow is reversed and the heat agent enters the outer tube 53 first and then flows from the tube 53 into the inner tube 61, the entry port of the tube 53 may be fashioned as above described in connection with the entry port of the tube 61, or as shown.

The inner and outer tubes are relatively so formed, as in cross-sectional contour, that ample space will be afforded between the inner and outer tubes for the passage there-through in continuous flow, and with substantially undiminished velocity, of the liquid issuing from the inner tube 61 into the outer tube 53. For example, one of said tubes, preferably and as shown, see Fig. 4, the inner tube 61, is contracted on one diameter, forming long sides 66, and expanded on another diameter, forming short sides 67, so as to approach in cross-sectional contour an oval formation, while the other or outer tube 53 may assume such cross-sectional contour as will provide enlarged spaces. Preferably, the inner tube is centrally disposed in the outer tube. It will be seen that the large spaces 68, thus provided, see Fig. 1, for example, between the tubes on the opposite ends of the minor axis of the inner tube, provide severally, by reason of the twisting effect in the liquid flow, for swift flow of the entire liquid stream issuing from the inner tube, a twisting scouring contact, and a consequent reduced frictional effect. Also, because of said large spaces 68 the abrupt change of direction of the flow of the liquid is rendered easier. Furthermore, the frictional

resistance of the liquid being reduced, the raising of temperature caused by said frictional resistance is also eliminated and with it the many and serious evils attendant thereon.

In order to reduce the frictional resistance in a short sharp turn of the liquid, when passing from one tube to the other, and the accompanying customary disadvantages, a diverging block or deflector 69 is provided in the outer tube 53 adjacent the inner end of the inner tube 61, see Fig. 1, and is fastened by suitable means, as by lugs 70 extending, one on each side, from the end of the inner tube 61 and fitting into suitable recesses, one in each of the opposite sides of said block. An end 71 of each lug 70 is turned and fits into another suitable recess in said block and additionally the lug is fastened to the block with a screw 72 or other device. The diverging block or deflector 69 fits snugly into the outer tube 53 and is formed with relatively sharp peripheral edges 73 made necessary by the requirements for a smooth surface and a low resistance effect. Said block or deflector 69 is formed with an end dishied out or recessed on each side of a median line, forming a sharp edge 74, extending across the end of the block. On each side of this sharp median edge 74, the oppositely curved faces 76 and 77 of each recess diverge from said median edge in such manner as to provide at every point throughout each entire face the exact angle of divergence for a liquid of any given viscosity, and for the diameter of any particular turn or diversion. It will be seen that the liquid stream, following these curves, first in one direction towards the end of the outer tube and then swerving swiftly but with a gradual change of direction will make the desired change in flow without undue frictional resistance and consequent erosive effects on the tubes.

It is to be noted that the diverging blocks may be formed with their curved faces 76, 77 in variable form on opposite sides of the recessed portion of the block or deflector so that the liquid may flow from the outer tube to the inner tube in the same continuous flow and without the customary measures of frictional resistance included in a reverse flow. It is pointed out that the block or deflector 69 is so positioned with relation to the end of the inner tube 61 that the full volume of liquid will be permitted to flow from one tube to the other with a comparative reduction in the normal frictional resistance to such a change of direction, this being effected by the position and variable curvature of the deflecting faces. It is to be understood that the deflecting blocks will vary in structure and curvature to meet the requirements for all gases and fluids or liquids in accordance with their temperatures, vapor contents or viscosities. The block is further formed

with a threaded orifice 78 so that a pipe or rod may be applied for direct cleaning. It will be noted also, see Fig. 2, that a space 79 is afforded in the outer tube between said diverging block or deflector 69 and the sealing plug 55^a at the end, if desired.

In a heat exchanger, as commonly constructed, the liquid, as oil, will flow thru the tubes in a swift, even, continuous flow. The greatest efficiency of the exchanger cannot be attained, however, because of the lack of the device in several important particulars. For example, the flow, in assuming (in a straight tube of the art) a parallel unbroken symmetry, retains a stratified or film flow relationship to the heat exchange surface, and this, by reason of its tranquility in relation to cross flow (a highly important measure), induces comparatively an insulating effect; that is to say, prevents the fullest measure of heat transfer thru the surface separating the heat containing from the heat absorbing agent and because of this unbroken film flow.

According to the present invention, therefore, the tubes are so formed and arranged with relation to each other as to form a double tube heat transfer surface so shaped and arranged that a complete return flow will be accomplished within the tube unit and so further arranged that the flow stream in at least one direction shall assume a tortuous or rotating effect against the direction of the return flow. In a single element, therefore, one tube is twisted (not coiled) around a straight, open, included flow line, which flow line is in length equal only to the shortest length of the tube in its fitted position and may be represented by a straight line drawn thru the tube without touching any part of said tube, the straight open flow space corresponding, for example, to the central solid core of a screw bit or drill.

The length of flow at the outer edges of said tube will correspondingly be of much greater length than that of the said straight open flow space, as the flow follows the convolutions of the tube. The straight, open, flow space, while necessarily including the center or axis of the tube, need not necessarily be only centrally disposed but may obviously be eccentric on the included center and yet retain the open flow. In the diagonal or bias flow thus accomplished, there is effected a twist flow against a return straight line flow, or a reverse twist flow against a twist flow contained within the one flow element of the exchange unit.

By the cross transfer effect in the liquid strata, due to the mechanical twist of the tube, there is provided a rotating thermal transfer scouring effect; a lengthening of flow, as compared with the straight line flow, in at least one direction; and a consequent augmented thermal transfer, as compared to that of a parallel reverse flow. Preferably,

therefore, one of the tubes, as shown in Figs. 1 and 2, the inner tube 61, may be generally described as being of elliptical or oval formation in cross-section, and is twisted on itself on a common included or contained open center in a manner, as stated, similar to the solid center of a screw bit or twist drill.

Inasmuch as, however, the liquor passing thru a spiral passage must reverse its rotative or spiral action on the return flow, it is desirable that the liquid flow at the point of return shall be stabilized in reference to rotative action. The end of the tube, therefore, thru which the liquor is flowing, for instance the end 61^a, of the inner tube 61, see Fig. 2, for a suitable distance is left in its original shape with one diameter expanded, as heretofore described. The increased scouring effect is evidenced also during the process of steaming out, or steam cleansing, the tubes of carbon or other deposit. During this latter period the steam whirling thru the tubes with a high rotating velocity has a scouring effect immensely superior to the action of a straight steam flow. Also this spiral flow with the tumbling effect will reduce to a minimum the tendency to a precipitation of carbon or other matter in suspension, permitting this to occur only at the terminations of the tubes due to the change of direction of the flow of the medium.

A further advantage inherent in the twisted or spiral tube is that of stability against collapse. The inner tube of the preferred embodiment of the invention has in cross-section relatively large flat areas. Due to the distortion of the flat plate in the spiral tube formation, however, the surface of the flat area is not continuous as flat surface and hence there is provided a structure greatly superior in strength to the original tube.

In Fig. 6 is illustrated another embodiment of the invention in which the inner tube 61^c is circular in cross-section and the outer tube 53^c is formed with major and minor diameters and with a spiral or twist as in the case of the inner tube described in connection with the preferred embodiment.

Yet another embodiment of the invention is illustrated in Fig. 7, where the inner tube 61^d is shown as flattened and twisted in the manner of the inner tube shown in the preferred embodiment illustrated in Figs. 1 and 2, while the outer tube 53^d is also flattened and spiralled like the outer tube of Fig. 6. In this embodiment also the beneficial results of the invention are obtained as in the other embodiments described.

It will be seen that a heat exchanger constructed in accordance with the principles of the invention as hereinbefore shown and described will carry out the objects of the invention as set forth besides possessing other advantages which will be apparent to those skilled in the art.

The invention in its broader aspect is not confined to the particular constructions shown and described, as many changes may be made in the details thereof without departing from the main principles of the invention or sacrificing its chief advantages.

I claim:

1. A return flow element including in combination, an outer tube having a closed end, and an inner tube encased within and communicating with the outer tube, one of said tubes being twisted to afford a tortuous passage therethru including a straight flow passage.
2. A return flow element including in combination, an outer tube having a closed end, and an inner tube encased within and communicating with the outer tube, one of said tubes being twisted and formed with a major and a minor diameter and affording a tortuous passage thru said tube including a straight flow passage.
3. A return flow element including in combination, an outer tube having a closed end, and an inner tube encased within and communicating with the outer tube, said inner tube being twisted and formed with a major and a minor diameter and affording a tortuous passage through said tube including a straight flow passage.
4. A return flow element including in combination, an outer tube having a closed end, and an inner tube encased within and communicating with the outer tube, said outer tube being twisted and formed with a major and a minor diameter and affording a tortuous passage thru said tube including a straight flow passage.
5. A return flow element including in combination, an outer tube having a closed end, and an inner tube encased within and communicating with the outer tube, one of said tubes being twisted to afford a tortuous passage therethru including a central straight flow passage.

In testimony whereof, I have affixed my signature hereto.

GEORGE T. MOTT.

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