Nov. 1, 1938. E. R. BRODTON 2,135,432

VAPOR CONDENSER

Original Filed March 31, 1934 3 Sheets-Sheet 1

Fig. 1.

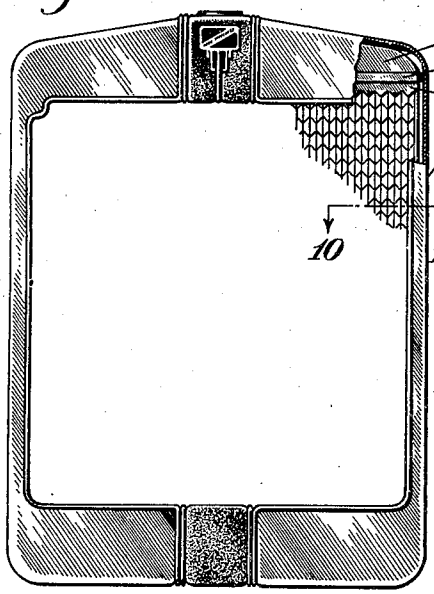
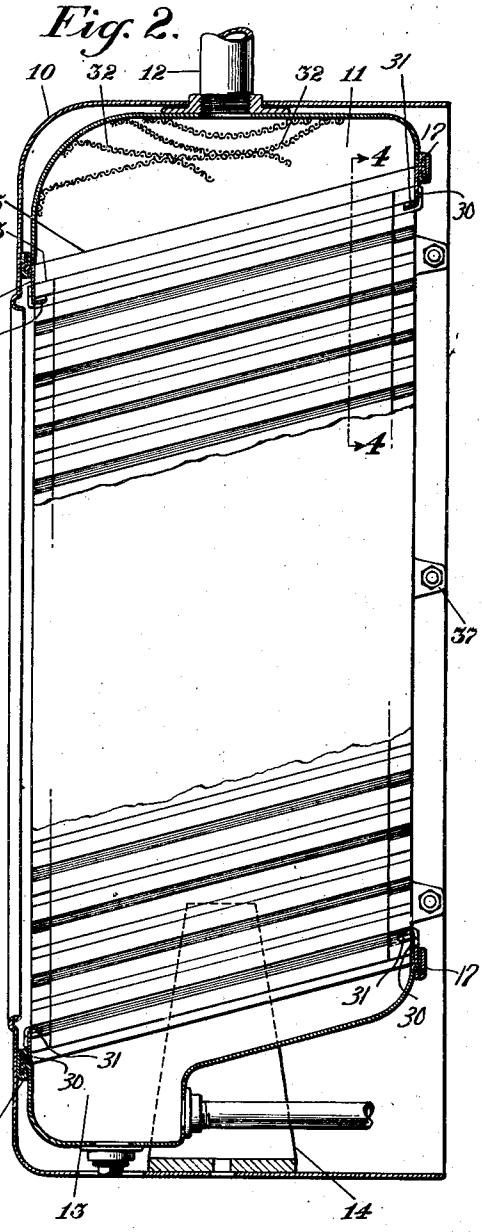


Fig. 2.



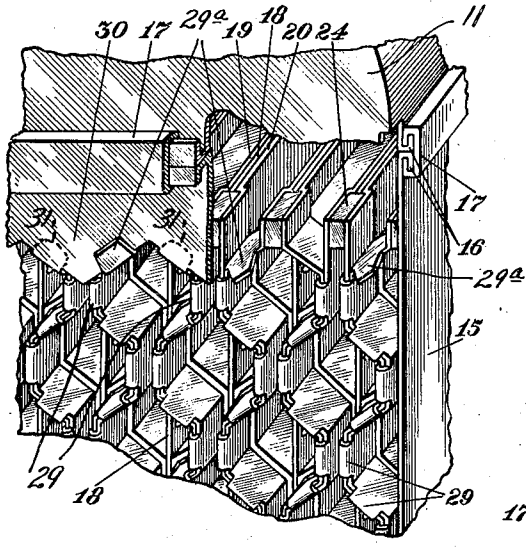


Fig. 3.

INVENTOR.

Edward R. Brodton

BY Chas. J. Williamson

ATTORNEY.

Nov. 1, 1938. E. R. BRODTON 2,135,432

VAPOR CONDENSER

Original Filed March 31, 1934 3 Sheets-Sheet 2

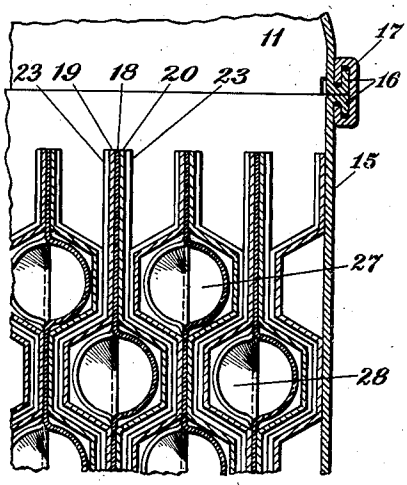


Fig. 4.

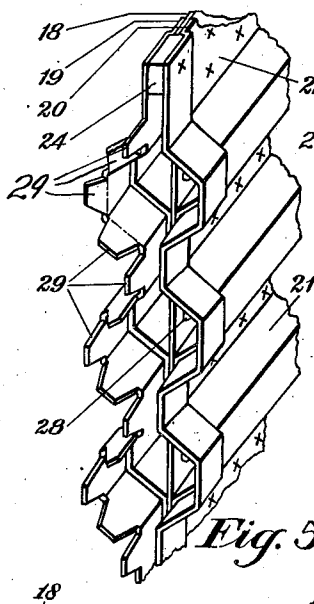


Fig. 5

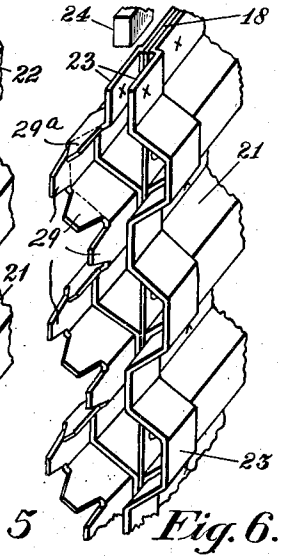


Fig. 6.

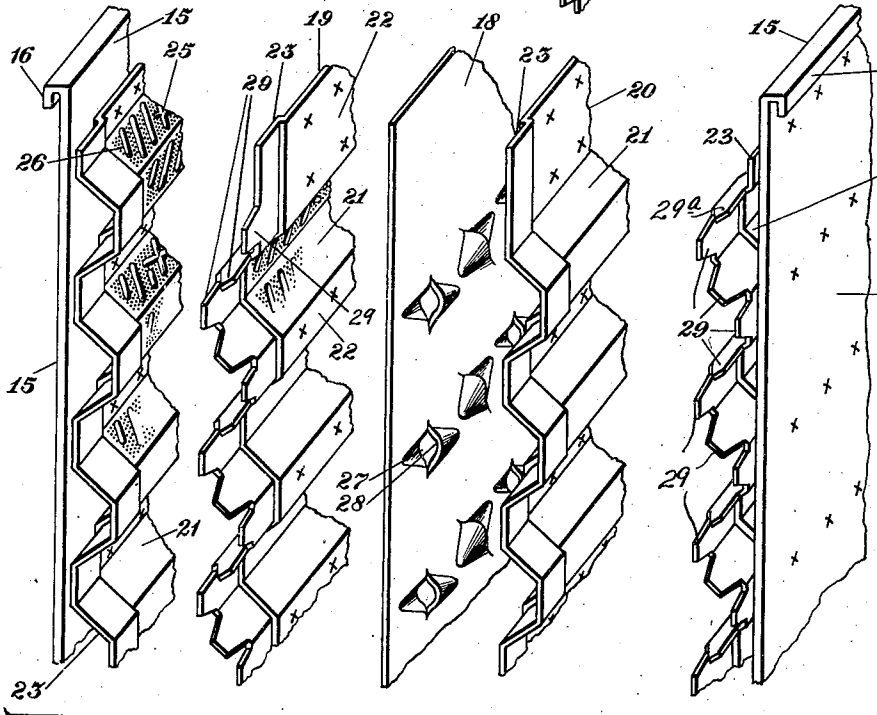


Fig. 7.

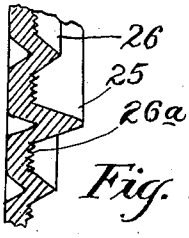


Fig. 7a

INVENTOR.
Edward R. Brodton
BY Thos. J. Williamson
ATTORNEY.

Nov. 1, 1938. E. R. BRODTON 2,135,432

VAPOR CONDENSER

Original Filed March 31, 1934 3 Sheets-Sheet 3

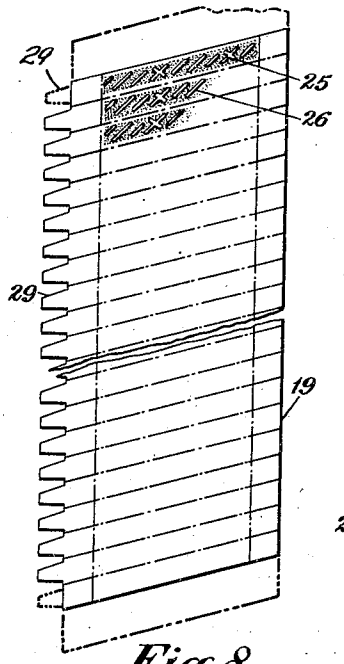


Fig. 8

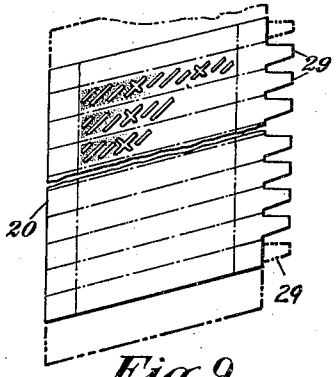
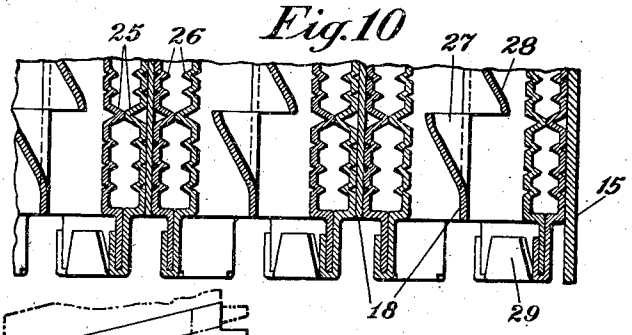


Fig. 9

Fig. 10



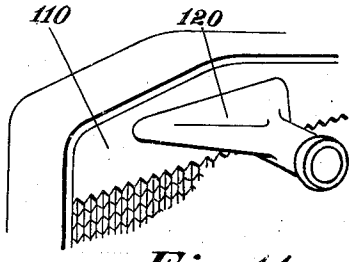


Fig. 11

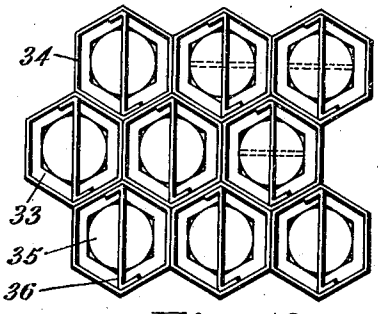


Fig. 12

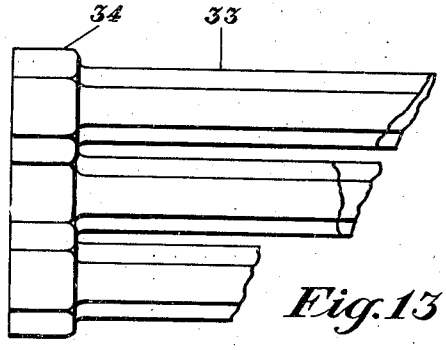


Fig. 13

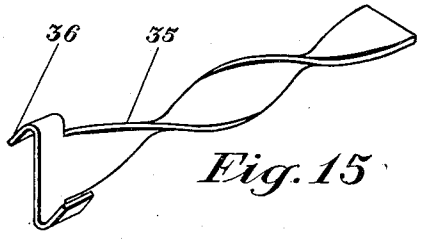


Fig. 15

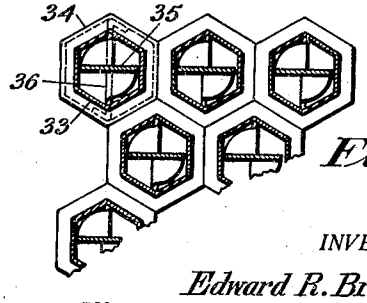


Fig. 14

INVENTOR.

Edward R. Brodton

BY

Chas. F. Williamson

ATTORNEY.

Patented Nov. 1, 1938 2,135,432

UNITED STATES PATENT OFFICE

2,135,432

VAPOR CONDENSER

Edward R. Brodton, Collingswood, N. J.

Application March 31, 1934, Serial No. 718,504
Renewed September 15, 1937

3 Claims. (Cl. 257—245)

The object primarily to be achieved by my invention is the provision of a novel and highly efficient condenser of the honeycomb type to condense vapor produced by boiling or ebullition, or the application of heat to the liquid, which will be of high efficiency, and which will be strikingly much more efficient from the standpoint of heat transfer than the most efficient honeycomb condenser heretofore in use. The structural and functional characteristics of a condenser embodying my invention by which this important object is achieved are, of course, set forth hereinafter in the detailed description of the embodiments of my invention shown in the drawings and therefrom other advantages of my invention will be seen.

My invention consists in whatever is described by or is included within the terms or scope of the appended claims.

In the drawings:

Fig. 1 is a front elevation of a honeycomb type condenser embodying my invention, with parts broken away to simplify and otherwise better illustrate my invention;

Fig. 2 is a vertical section thereof;

Fig. 3 is a detail view in perspective of a portion of such condenser with wall-parts shown broken away;

Fig. 4 is a detail view on the line 4—4 of Fig. 2, with the parts shown on a larger scale;

Figs. 5 and 6 are, respectively, detail views in perspective of portions of the core;

Fig. 7 is a detail view in perspective showing portions of the core-forming elements separated from each other;

Fig. 7*a* is a detail section to show the rough core-plate surfaces;

Figs. 8 and 9 are, respectively, detail views in elevation of portions of opposite vertical side plates used in the make-up of the core;

Fig. 10 is a horizontal section on the line 10—10 of Fig. 1, on a larger scale;

Fig. 11 is a detail view in perspective of the upper or head portion of a condenser that is a different embodiment of my invention; and

Figs. 12 to 15 are, respectively, end, side, cross-section and perspective views of different means than is shown in other of the figures for effecting a whirling motion of the cooling fluid used in such a condenser.

The embodiments of my invention shown in the drawings are suited especially for condensing vapors of a chemical liquid having characteristics of that of my Patent No. 1,575,967. In dealing with chemical compounds and their vapors especially when associated with heat it is imperative that the design, structure and materials of the apparatus shall be such as will not subject the fluid or the apparatus to injurious catalytic action.

Describing in detail the embodiment of my invention shown in Figs. 1 to 9, within a shell 10, open from front to back for the free horizontalwise flow of air as a cooling medium, I place the condenser structure proper which includes a hollow head 11, to the top of which the vapor inlet pipe 12, is secured, the core, and the base, chambered to provide the condensate collector well or hot well 13. The core reaches vertically from the underside of the head 11 to the top of the well 13, the core having numerous external surfaces to and over which progressively downward the vapor to be condensed and the condensate pass and having numerous internal passages that extend at an incline downward from their open ends at the back of the shell 10, to their open ends at the front of the shell so that there may be free flow of the cooling medium into their lower ends from the front of the shell through such passages in an upwardly inclined direction and outward therefrom at their back open ends and through the back opening in the shell 10. The well 13 may be supported from the bottom of the shell 10 by a bracket 14, with upwardly extending arms that straddle the well. An outlet from the well for the distillate is provided which as shown may be a pipe leading from the bottom or low point of the well.

The cooling medium used in the condenser shown in the drawings, is air, but, of course, I do not restrict myself to use of or adaptation of the construction for any particular cooling medium. And the condenser shown in the drawings and about to be described in detail is one designed for condensing the vapors of chemical compounds which vaporize at low temperatures, but, of course, I do not restrict the scope of my invention to a condenser for dealing with the vapors of any particular vaporizable material; and it is to be understood that I regard my invention as extending in whole or in part to application to any heat transfer appliance to or in connection with which it is available.

The core which has a honeycomb formation, the cells of which in cross-section are hexagonal and whose external walls provide the outside surfaces over which the vapor and resulting condensate flow downwards and which enclose the internal passages for the flow of the cooling medium, is situated between and supported by

two spaced apart parallel vertical side walls each in the form of a plate **15**. The side walls at top and bottom are secured by lapped joints to the bottom edges of the head **11**, and the top edges of the well **13**. Such lapped joints are formed by similar but opposite return flange-forming bends **16**, on the adjacent edges of the parts and a bar **17**, of substantially C-form in cross-section, with flanges to interlock with those of said parts.

The core may be considered as formed of numerous similar units each including a vertical series of spaced apart hexagonal cells whose centers are in vertical alinement and in alinement with a central vertical web, adjacent units being arranged so that the cells of one unit project into the spaces between adjacent cells of the other unit, but without contact of the side walls so as to leave a thin or narrow space between the outsides of the cells of adjacent units and thereby provide a zig-zag or circuitous passage from top to bottom of the core so that the vapor starting from the top will pass downward in the form of a thin film or sheet and in contact with the cooling or heat-receiving surfaces formed by the zig-zag walls and these walls being of thin sheet metal, it will be seen that a highly efficient heat transfer arrangement is provided or created, both as to structure and as to flow of fluid to be deprived of heat. And it will be seen that the paths of flow thus provided are multiple or very numerous and these multiple paths are relatively short and wide so that a considerable volume of fluid is handled and yet the structure is most compact.

As best shown in Figs. 4 to 7, each unit is composed of three plate-form members, a metal flat or substantially flat vertical plate **18**, and two opposite or reversed but otherwise similar members **19** and **20**, of sheet metal or a thin metal plate each from top to bottom being of zig-zag form due to the fact that each includes half hexagons **21**, that are spaced apart and joined by vertical substantially central flat members **22**, that lie in contact with opposite sides of the metal plate **18**.

Fig. 5 shows assembled the opposite plates **19** and **20** and the middle plate **18** and united rigidly by spot welding at the points marked X.

The zig-zag or circuitous vapor channels provided between adjacent units are closed at front and back by an outwardly offset rib **23**, on each of the members **19** and **20** and extending from top to bottom thereof, which contacts with the corresponding and adjacent rib; and the contacting surfaces are joined securely as by spot welding. The spaces between the offsets **23**, at top and bottom, are closed liquid-tight by interposed filling blocks **24**, which also are spot welded.

To assure and maintain uniform spacing of adjacent vapor passage forming walls of adjacent units, spacing devices are provided. These may be cruciform or X-shape bosses **25**, struck up from the plates at suitable intervals apart and situated so that the boss **25**, on one member will touch or bear against the similar boss on the adjacent member. Besides said spacer bosses, other bosses not so high and in the form of spaced apart ribs **26**, are provided which are laterally inclined to give direction to the fluid flow over them. They also increase the cooling surface area with which the fluid has contact to promote heat transfer. And as indicated in Fig. 7 and Fig. 7*a*, the surfaces may be roughened by sharp-pointed or fairly sharp-pointed or tapered small or minute protuberances **26***a*. This while increasing the cooling surface, accomplishes greater and faster transfer of heat for it has been experimentally shown that such protuberances have that action and especially with liquids of low viscosity such as I prefer to use. The lateral inclination of the ribs **26** is towards the forward lower ends of the cells for it will be remembered that the cell walls themselves incline from back to front so that there is a downwardly inclined direction to the narrow channels between adjacent units. The fluid and the condensate in particular is thus subjected to a lateral flow from rear to front, as well as a downward flow simultaneously. Thus heat transfer is augmented by the agitation and rubbing effect of the flowing fluid as it passes over the zig-zag ribbed and inclined surfaces. And to secure a similar action on the cooling medium flow through the cells, there are surfaces within the cells which agitate the cooling medium by changing its direction and causing a whirling flow thereof. This may be accomplished by providing at intervals in the portion of the central plate **18**, within the cells, slots or holes **27** and oppositely horizontally offset grooves **28**, which result in the circuitous flow of fluid from one side of the plate **18**, to the opposite side as the fluid cooling medium passes through the cells from end to end. The fluid-engaging surfaces of the grooves or deflectors **28** of an opposite pair are inclined and the pairs of adjacent grooves are inclined with reference to one another in such a way as to cause a portion of the cooling fluid to whirl in a helical course as it passes through the upward sloping hexagonal cell with roughened surfaces. By this motion all portions of the cooling fluid are brought into rubbing contact with the roughened outer surfaces of the narrow space passages through which flows the fluid from which the heat is to be absorbed.

The plate **18** not only serves the purpose just explained, but it is a strengthening web for the unit where it crosses the cells diametrically, and it serves as a heat radiating fin or element where it lies in contact with the adjacent parts **19** that go to make up with it a unit which, of course, receive heat from the flowing vapor and condensate and transfer it to the intervening web.

As well shown in Figs. 5 to 10, each unit member **19** and **20** at one edge has at one end of each of the half hexagon-forming walls tab-form lugs **29**, which as clearly shown in Figs. 3 and 10, are bent over and lapped against the adjacent wall of the hexagon of the unit adjoining, and thus a simple and yet strong and rigid connection is made between the units that go to make up the complete core.

Besides the lap joint connection between the side walls **15** and the bottom edge of the head **11**, whereby the core is attached to the head at those points, there is an attachment between the front and back walls of the head and the core at the top. This attachment includes front and back plates **30**, which at the upper edge have a joint connection with the head **11** similarly to that between the side walls and the head, and at the bottom edge are secured at intervals by some of the tabs as lugs **29** as shown in Fig. 3. The lower edge of the plate **30** is saw-tooth or zig-zag in form so as to clear the ends of the internal passages to avoid obstruction of cooling medium flow therethrough. Also, certain of the tab-lugs **29**, such as lug **29***a*, shown in Figs. 3, 6 and 7 on alternate units engage over the edge of and

against the plates **30** in a direction opposite to that of the lugs **31**, thus locking the plates **30** in position. The C-strips which provide the lap joint connection at all four sides of the head are, of course, slipped endwise into place and the last-inserted strip overlaps at the ends the other lap joint so as to cover the joint thereat and the structure at all external joints is made leak-proof by final soldering.

Before assembling the core and head and hot well for the connection hereinbefore described, the edges of the core at front and back and top and bottom are dipped in silver solder for sweating both to effectually seal all joints against leakage and to contribute to the connection of said parts.

It is desirable quickly and thoroughly to distribute the vapor entering the head so that the wide extent of the core surfaces from front to back and side to side may be utilized by the delivery of the vapor thereto at the outset. To achieve this result, I place in the space within the head above the core, a series of perforated barriers **32**, preferably of wire mesh, the strips or sheets of wire mesh being placed successively further and further from the inlet to the head **11**, some arching in a concavo-convex form from the underside of the head across the inlet and others being attached to and extending from the front side of the head across to or near the center thereof, these others being in the widened space in the head at the front due to the downward inclination of the core top. Besides the obviously satisfactory wide distribution of the vapor for delivery to the top of the core, said barriers being preferably made of metal of high thermal conductivity, take heat from the incoming vapor and conduct it to the head walls.

If desired as shown in Fig. 11, the inlet may be in the form of a pipe or tube with a laterally extended flattened portion **120**, that opens into the side of the head **110**.

As shown in Figs. 12 to 15, there may be used tubes **33**, of hexagonal cross-section placed side by side and spaced apart to provide the zig-zag channel or passage between them by abutting or contacting enlargements **34**, at their ends, and to secure the circuitous flow therethrough of the cooling medium, there may be placed within the tubes twisted strips **35**, such as of the form shown best in Fig. 15, these strips having at their ends bent lugs **36**, diametrically opposite and secured to the diametrically opposite inner walls of the tubes.

As shown in Fig. 2, a support connection may be used between the side walls **15** of the core and the wall of shell **10**, consisting of several bolt and lug connections **37**.

Metals used in the construction of my condenser are such that their surfaces will not be subject to corrosion or disintegration by the action of air or moisture or any catalytic action when the liquid from which the vapor is generated is of such chemical nature or composition as to result in any such action. It has been found that metals suitable for the purpose are an alloy known to the trade as "Ampco" metal, certain aluminum bronzes, Monel metal, and "Stainless steel".

The efficiency and other advantages of a condenser embodying my invention may be readily shown by comparison thereof with what may be considered the most efficient honeycomb type of condenser now on the market. Assume such a condenser with a core twenty and three-quarter inches wide by six inches deep by seventeen inches high that represents about one and a quarter cubic feet and giving a frontal area of 2.44 sq. ft. Such a condenser has 130 sq. ft. of air contact surface and 119 sq. ft. of vapor contact surface and a heat transfer constant, for example of (5) B. t. u./min. per sq. ft. of surface per degree difference in temperature.

The honey-comb type of condenser shown in the drawings and described hereinbefore and having the like core dimensions and frontal area, includes 78 sections, 156 plates and 78 cooling medium whirl producing sheets and 1950 air tubes and giving 162.5 sq. ft. of air contact surface when the latter is not embossed or 211 sq. ft. when embossed; and 134 sq. ft. of vapor contact surface without embossing and 200 sq. ft. with surfaces embossed.

With the same heat transfer constant, my condenser within the same space will transfer about 67% more heat under the same conditions. And upon the basis of experimentally available data on the heat transfer due to the surfaces my condenser affords; the effective drainage of the condensate; the advantage from the thin vapor film flow over the cooling surfaces; the increase of speed in action; and the great agitation of the cooling medium in its passage through the core tubes, it is believed that there is a transfer constant several times as great as given in the foregoing comparison.

As will be apparent, the core construction besides performing with high efficiency its function of bringing the vapor into contact with the cooling or heat extracting surfaces and causing the flow of the air or cooling medium to utilize it to very great advantage, gives the maximum of strength and rigidity with minimum amount of metal and is a structure of easy assembly and union or connection of parts.

To prevent loss of heat from the condensate received by the hot well, the latter may be thermally insulated. The condensate from the hot well is, of course, available for re-use in the boiler or vapor generator for conversion again into vapor.

What I claim is:

1. Heat transfer apparatus comprising a core that includes a plurality of parallel tubes open from end to end and extending in an inclining downward direction from rear to front of the core, the lower or front ends of the tube being the inlet ends of a cooling medium for passage therethrough in an upwardly inclined direction, the exteriors of adjacent tubes being spaced apart from the top of the core downward to provide channels for the passage in contact with the tube exteriors of a fluid from which heat is to be removed, means to introduce such fluid to such channels at the top of the core, said channels being closed at opposite sides, and ribs in said channels inclined downwardly toward the lower end of the tubes whereby the fluid therein is subjected to a lateral flow from the rear of the core to the front thereof while flowing downwardly in said channels.

2. In a heat transfer apparatus, a core of the honey-comb type comprising a plurality of units each including two oppositely zig-zagged wall plates having alternate zig-zag portions contacting, thus providing a plurality of cells, the units being arranged so that the cells of one unit project into the spaces between adjacent cells of adjacent units, the zig-zag edges of the plates of each unit being outwardly offset from the body of

their respective plates to form relatively narrow passages between the plates of adjacent units from top to bottom of the core, and tab-lugs on angular portions of the zig-zag edges of one of said plates of each unit bent over the edge and lapped against the adjacent wall of the adjoining unit, whereby the adjacent offset portions of the plates are secured together to close the sides of said passages and whereby the units are secured together.

3. A heat transfer apparatus as set forth in claim 2, further characterized by having plates closing the sides of the core, a chambered head and a chambered base at the upper and lower ends of the core, respectively, communicating with the passages therein; front and back closing plates at the end portions of the core having tab-lugs thereon bent over the edges of and lapping against the walls of certain of said cells, certain of said tab-lugs on the plates of said units similarly engaging adjacent edges of said front and back plates; the adjacent edges of the side plates, front and back plates, the head and base being secured together.

EDWARD R. BRODTON.