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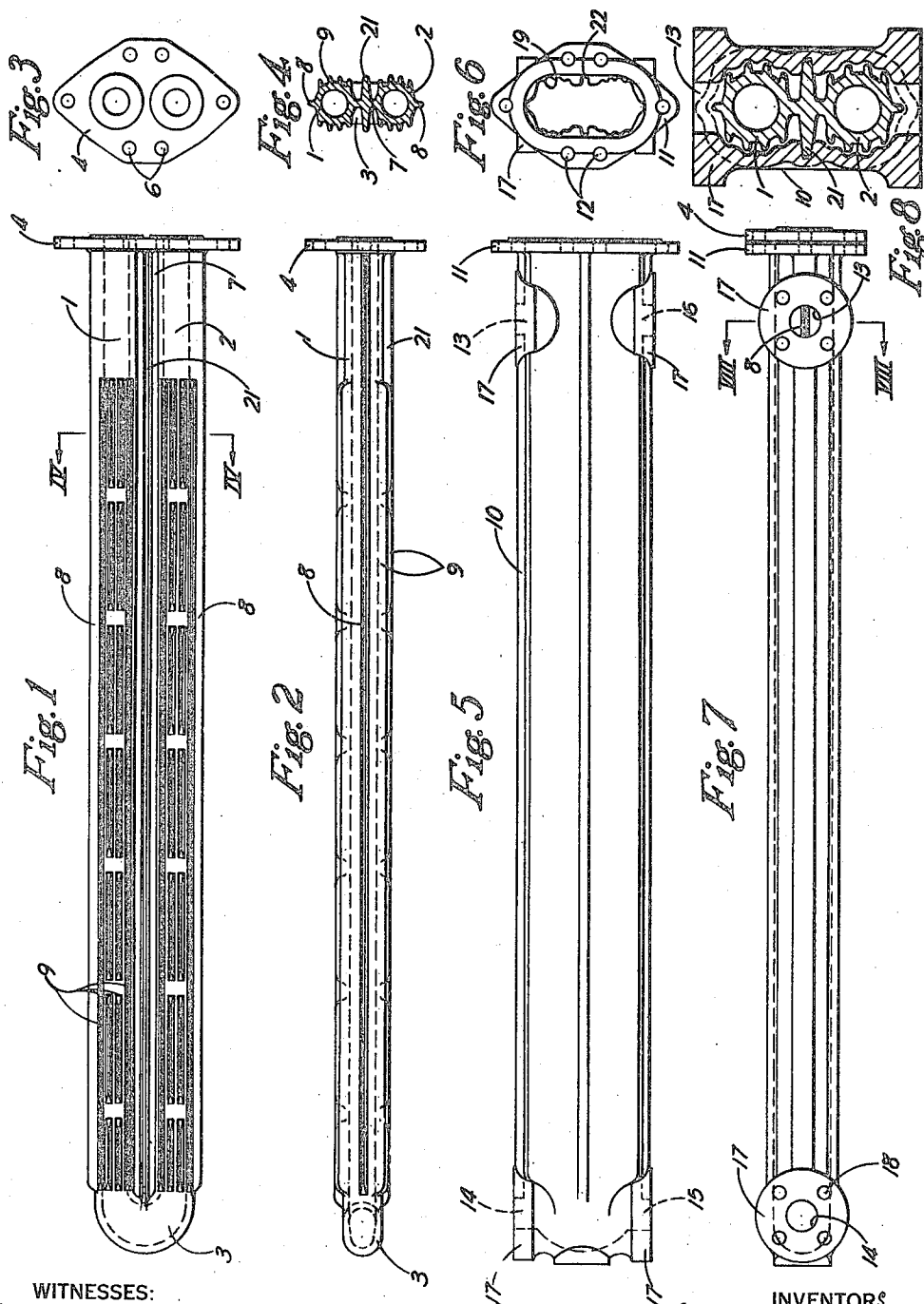
F. J. O'SULLIVAN ET AL

2,452,391

HEAT EXCHANGER

Filed Jan. 18, 1946

2 Sheets-Sheet 1



WITNESSES:

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E. O. Johns

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in the Estate of William B. du Pont,
deceased.
by Brown, Critchlow & Flick
ATTORNEYS

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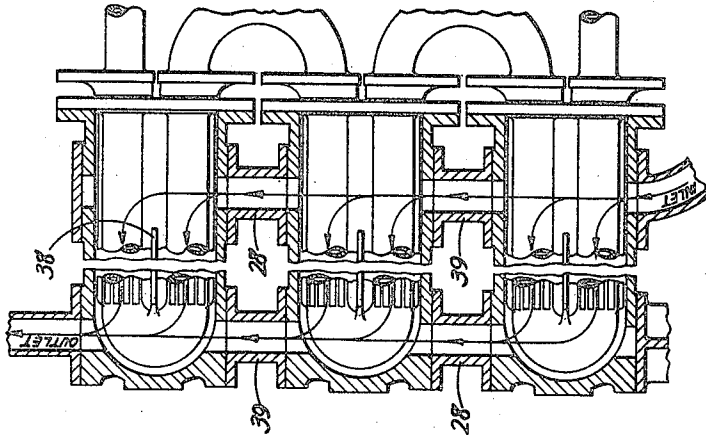


Fig. 11

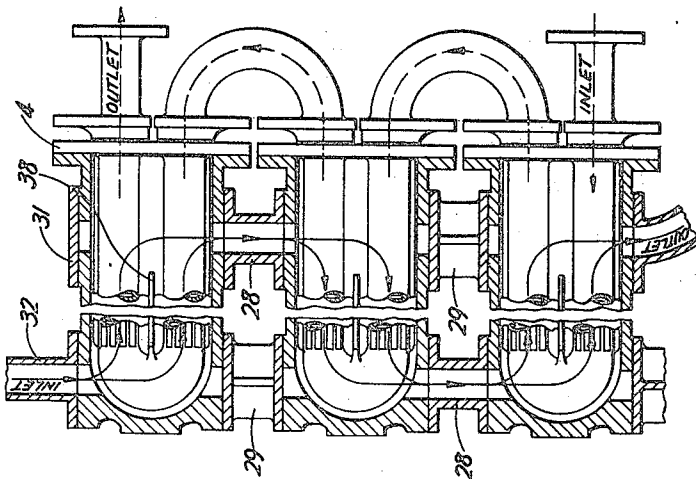


Fig. 10

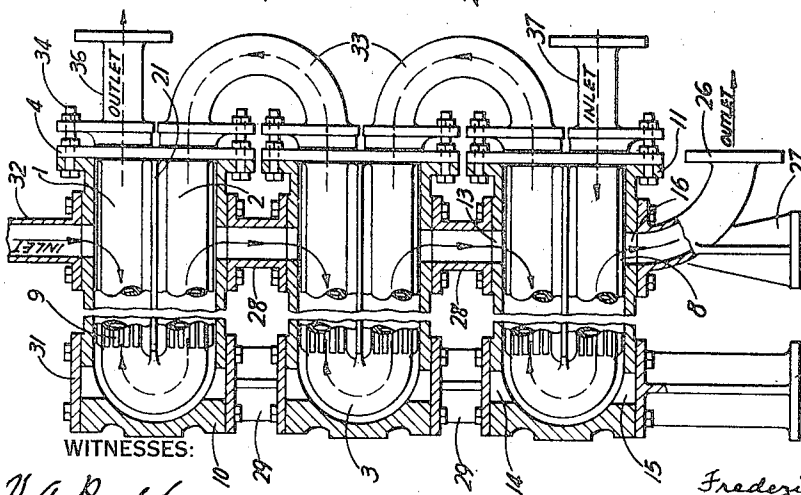


Fig. 9

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UNITED STATES PATENT OFFICE

2,452,391

HEAT EXCHANGER

Frederick J. O'Sullivan, Johnstown, Pa., and William B. du Pont deceased, late of Johnstown, Pa., by Mary A. du Pont, administratrix, Johnstown, Pa., assignors to The National Radiator Company, Johnstown, Pa., a corporation of Maryland

Application January 18, 1946, Serial No. 641,930

1 Claim. (Cl. 257—239)

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This invention relates to heat exchangers, and more particularly to those in which one fluid flows through a U-tube while a fluid of a different temperature flows through a jacket or shell in which the U-tube is mounted.

It is among the objects of this invention to provide a heat exchanger of this character in which a U-tube having a large heat transfer surface is made in one piece from cast iron, in which the U-tube is provided with a flow-directing baffle that supports the tube in a surrounding shell, in which the shell is shaped to guide fluid around the tube at high velocities and low rates of flow, and in which the shell is formed for assembly with like shells in different ways to produce various types of flow patterns.

In accordance with this invention a heat exchanger U-tube, preferably formed in one piece from cast iron, has a pair of parallel legs the sides of which are connected by a web extending lengthwise of them. A plurality of fins also extend lengthwise of the legs. A return bend connects the legs at one end, while a tube sheet surrounds the legs at their opposite end. This sheet is provided with bolt-receiving openings for bolting the U-tube in place, such as in an elongated shell that is open at one end. A baffle plate projects from opposite sides of the tube's web and extends across the surrounding shell into engagement with its opposite side walls which are formed to support the plate with the tube spaced from the walls of the shell. Preferably, the side walls of the shell are provided with slots that receive the opposite edges of the baffle plate. In some cases the baffle plate may extend from the tube sheet to the return bend of the U-tube, while in others it may terminate short of that sheet. The shell is provided with inlet and outlet ports, and its inner surface may be provided with corrugations that register with the fins on the U-tube but are spaced therefrom to leave a narrow passage between them.

This heat exchanger unit generally is disposed horizontally in vertically spaced relation with similar units. The inlet and outlet ports in each shell are disposed near its ends at top and bottom, and spacing members are disposed between the shells to which they are secured around the adjacent ports. At least one of these members between each pair of shells is provided with a passage connecting the ports at its opposite ends. Also, means is provided for closing one of the top ports of the uppermost shell and one of the bottom ports of the lowermost shell. A fluid thus can be made to flow through the connected shells

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in any desired path. A conduit connects the one open end of each U-tube with an open end of the tube below it to provide a fluid circuit through the U-tubes.

The invention is illustrated in the accompanying drawings in which Fig. 1 is a side view of our U-tube; Fig. 2 is a plan view thereof; Fig. 3 is a view of the open end of the tube; Fig. 4 is a vertical section taken on the line IV—IV of Fig. 1; Fig. 5 is a side view of the shell that receives the U-tube; Fig. 6 is a view of the open end of the shell; Fig. 7 is a plan view of the shell with the tube inside; Fig. 8 is a vertical section taken on the line VIII—VIII of Fig. 7; Fig. 9 is a side view of an assembly of shells and U-tubes, with the shells shown in vertical section and with the central portion of the heat exchanger broken away; and Figs. 10 and 11 are views similar to Fig. 9 of different arrangements of the heat exchanger.

Referring to Figs. 1 to 4 of the drawings, a heat exchanger U-tube is shown which has been cast in one piece from iron, although other materials could be used if desired. Cast iron is preferred where exceptional resistance to attack by such fluids as sulphuric acid, alkalies, wet CO₂, sour gas, crude oils, ammonia, bad water, etc. are encountered. The U-tube has a pair of vertically spaced parallel legs 1 and 2 connected at one end by a return bend 3. At the other or open end of the tube the legs are surrounded by a tube sheet 4 provided with bolt-receiving openings 6 (Fig. 3). The two legs of the tube are joined by a vertical web 7 that extends from the tube sheet to the return bend. To increase the heat transfer surface of the tube it is provided with a plurality of circumferentially spaced fins 8 and 9 that extend along each leg. The shape and arrangement of these fins is such that they can be cast integrally with the tube as shown in Fig. 4. Some of the fins may be divided into sections.

This U-tube can be used by itself as a heater or cooler by bolting it into a flanged opening in a tank containing a fluid to be heated or cooled. However, in most cases the tube will be mounted in a shell 10 that forms a jacket for the tube. As shown in Figs. 5 to 8, this shell likewise may be made in one piece from cast iron and is of the same general shape as the U-tube except that the inside is entirely open. One end of the shell is open and surrounded by a flange 11 provided with bolt-receiving openings 12 (Fig. 6) that register with those in the tube sheet when the U-tube is inserted in the shell, as shown in Fig.

7. Near the opposite ends of the shell there are upper and lower vertical ports 13, 14, 15 and 16 each of which is surrounded by a flange 17 the outer horizontal surface of which does not project materially beyond the body of the shell. These flanges are provided with stud-receiving openings 18 that have the same spacing in all flanges. The two ports 14 and 15 at the closed end of the shell facilitate casting of the shell, while the closeness of port flanges 17 to the body of the shell minimizes the danger of breaking them during handling or shipping the shell.

As shown in Figs. 6 and 8, the central portions of the shell's side walls are contracted toward each other, and the inner surface of the shell is provided with longitudinally extending corrugations 19 that register with the fins on the U-tube. That is, the ribs of the corrugations project between the fins a slight amount. This contouring of the shell walls forces the fluid in the shell to flow in a thin stream close to active heat transfer areas, whereby high velocities are obtained at low rates of flow. Also, a shell of this shape is stronger than one having plain, flat walls.

In order to compel fluid passing through the shell to flow in one direction along one leg of the tube and in the opposite direction along the other leg, the shell is divided into two passages by means of a central, horizontal baffle plate 21. This plate, which projects from opposite sides of web 7 and is supported by the shell, also serves as means for supporting the U-tube in the shell in spaced relation thereto. The baffle plate 21 shown in Fig. 1 is integral with tube sheet 4, from which it extends to return bend 3, and it may be tapered outwardly in cross section as shown in Fig. 4. The plate provides additional active heat exchange surface.

The side walls of the shell are provided with longitudinally extending slots 22 (Fig. 6) into which the opposite edges of the baffle plate slide when the U-tube is pushed into the shell. As shown in Fig. 8, the edges of the plate fit in the slots snugly enough to prevent any appreciable leakage of fluid between them. The plate therefore forms a central partition in the shell and divides it into upper and lower passages that are connected only at the return bend end of the tube. If the ports 14 and 15 in the blind end of the shell are closed, fluid entering upper port 13 will flow through the upper passage to the opposite end of the shell and then down into the lower passage and back to the other open port 16. At the same time a fluid of a different temperature can flow through the U-tube so that heat can be exchanged between the two fluids. The upper and lower fins 8 on the U-tube are joined to the tube sheet and therefore are straddled by ports 13 and 16, but the rest of the fins 9 preferably are spaced from the tube sheet to permit better distribution around the U-tube legs of the fluid entering the shell. The longer upper and lower fins provide a means for diverting incoming fluids so as to reduce impingement erosion and to provide additional heat transfer surface.

In Fig. 9 several of our heat exchange units are shown assembled in vertically spaced relation. The blind end of the lowest shell 10 is mounted on a support 25 that is connected by studs to the flange 17 around port 15 which is sealed by the support. At the other end of the shell, port 16 is connected by a pipe elbow 26 to a pipe line (not shown), and the elbow is mounted on a support 27 integral with it. The shells are supported one above another by spools 28 and blind supports

29 which are connected by studs to flanges 17. The blind supports close ports 14 and 15 while the tubular spools connect ports 16 and 13 in adjacent shells. Port 14 in the top shell is closed by a plate 31 while top port 13 is connected to an inlet pipe 32. Thus, fluid introduced through the inlet pipe circulates in a U-shape path through each shell and flows into the one below it through a connecting spool 28 until elbow 26 is reached.

To complete a fluid circuit through the U-tubes, the open ends of legs 2 of the two upper tubes are connected to legs 1 of the tubes below by means of arcuate pipes 33 in the form of return bends which are bolted to the tube sheets 4 by the same bolts 34 that connect the sheets to the shell flanges 11, suitable sealing gaskets being used in making this connection and the others in this heat exchanger. A flanged pipe connection 35 is connected to upper leg 1 of the upper U-tube, while a similar pipe 37 is connected to lower leg 2 of the lowest tube. For counter-current flow, lower flanged pipe 37 will serve as the inlet.

In the heat exchanger shown in Fig. 10 the spool 28 and blind support 29 between the lowest shell 10 and the shell above it are reversed relative to their positions in Fig. 9. The same thing is true of closure plate 31 and inlet pipe 32. Also, the baffle plates 38, corresponding to baffle plates 21 in Fig. 9, and by which the U-tubes are centered in the shells, are terminated short of the tube sheets 4 so that in each shell both ends of the vertically spaced passages formed by plate 38 are connected. Accordingly, fluid does not flow in opposite directions on opposite sides of each baffle plate, but in the same direction. The fluid enters each shell at one end and leaves it at the opposite end.

A shortened baffle plate 38 likewise is used with the U-tubes shown in Fig. 11. The arrangement illustrated differs from that shown in Fig. 10 by the substitution of spools 39 for the blind supports between the shells. The result is that all ports in the intermediate shell are connected by tubular spools to corresponding ports in the shells above and below it. Consequently, fluid flows out of both ends of the lower and intermediate shells, and it enters both ends of the intermediate and upper shells. It is possible to assemble the shells and tubes in still different ways to provide further flow patterns.

According to the provisions of the patent statutes, we have explained the principle and construction of our invention and have illustrated and described what we now consider to represent its best embodiment. However, we desire to have it understood that, within the scope of the appended claim, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

A heat exchanger comprising an elongated shell provided with inlet and outlet ports and having an open end surrounded by a flange, a U-tube disposed in the shell with the open ends of the tube projecting from said open end of the shell and surrounded by a tube sheet engaging said shell flange, means securing said flange and tube sheet together, said shell having opposite side walls provided with a pair of oppositely disposed slots extending lengthwise of said walls from said open end, a baffle plate between the two legs of the tube and extending lengthwise thereof from said tube sheet with its opposite edges disposed in said slots, and webs extending lengthwise of

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the central portion of said plate and connecting it to the legs, said tube legs being provided with circumferentially spaced fins extending lengthwise thereof with the fins at the top and bottom of the U-tube engaging said tube sheet, the rest of said fins being spaced from the tube sheet, and at least one of said ports opening into the space between said last-mentioned fins and sheet and straddling one of said sheet-engaging fins.

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