Nov. 29, 1938. J. M. BARCLAY ET AL 2,138,469

HEAT EXCHANGER

Filed Aug. 21, 1935 3 Sheets-Sheet 1

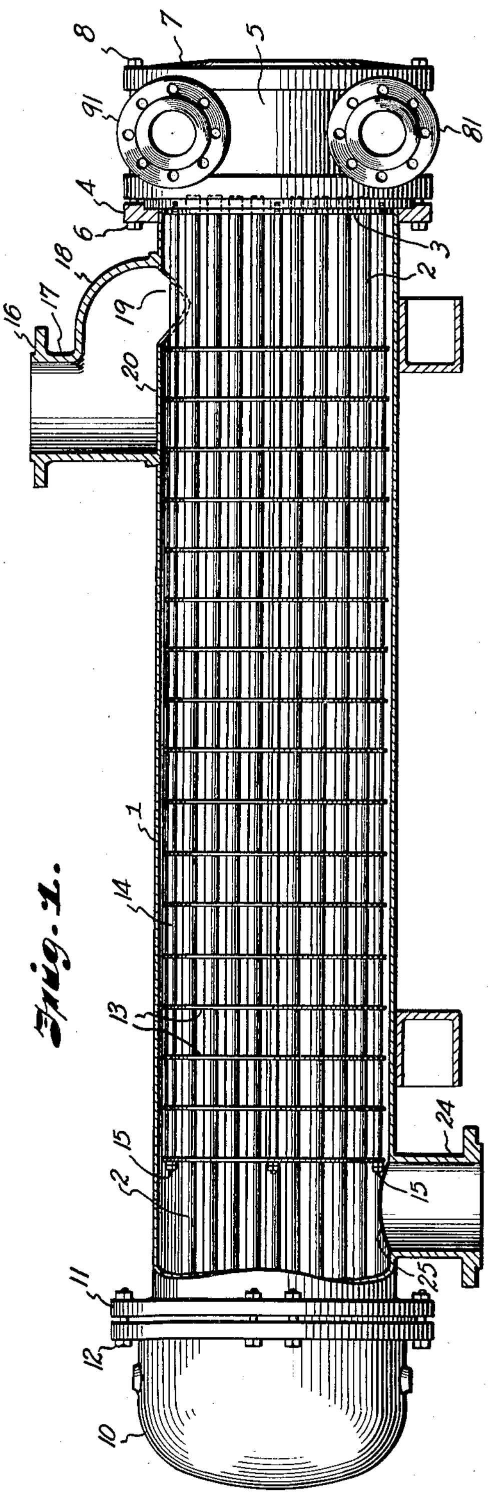

Fig. 1.

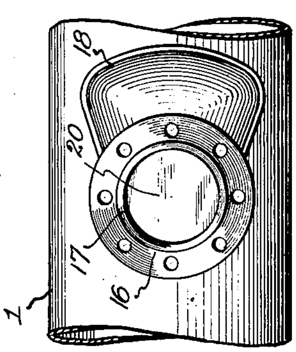

Fig. 3.

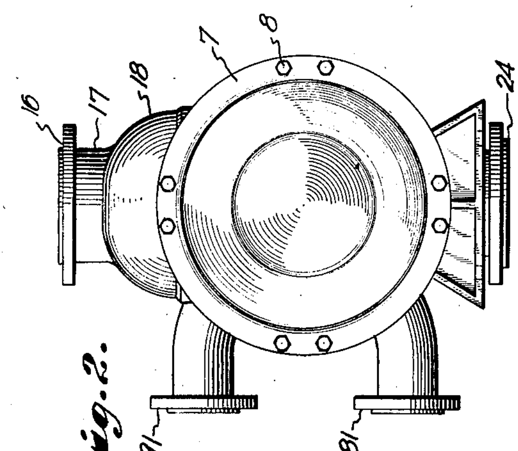

Fig. 2.

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Filed Aug. 21, 1935 3 Sheets-Sheet 2

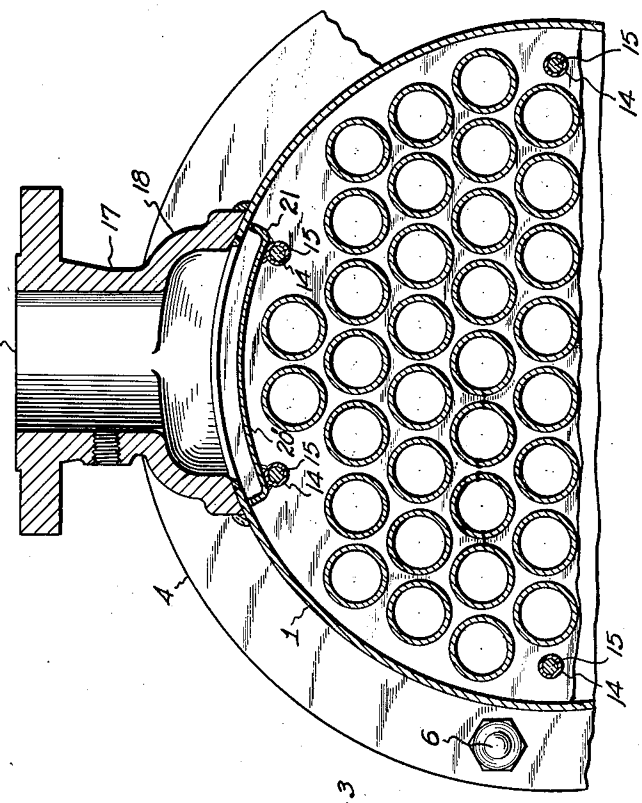

Fig. 5.

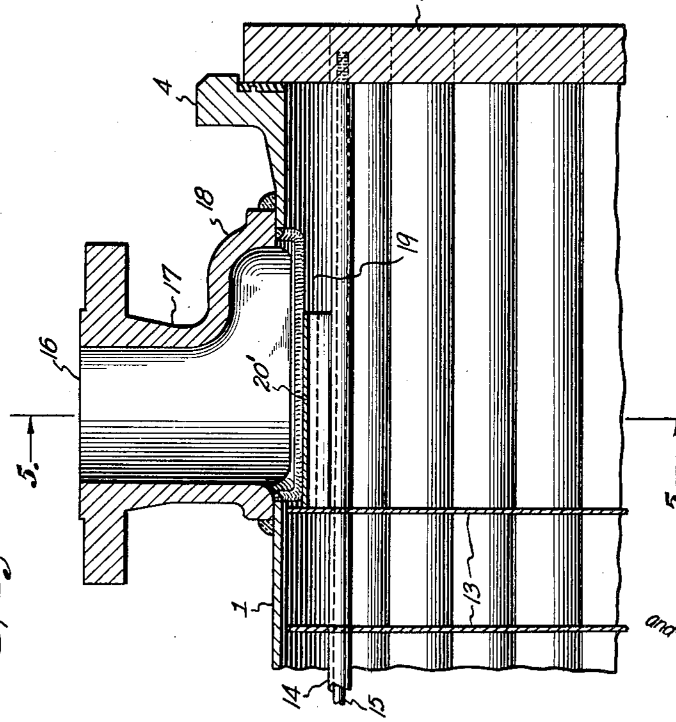

Fig. 4.

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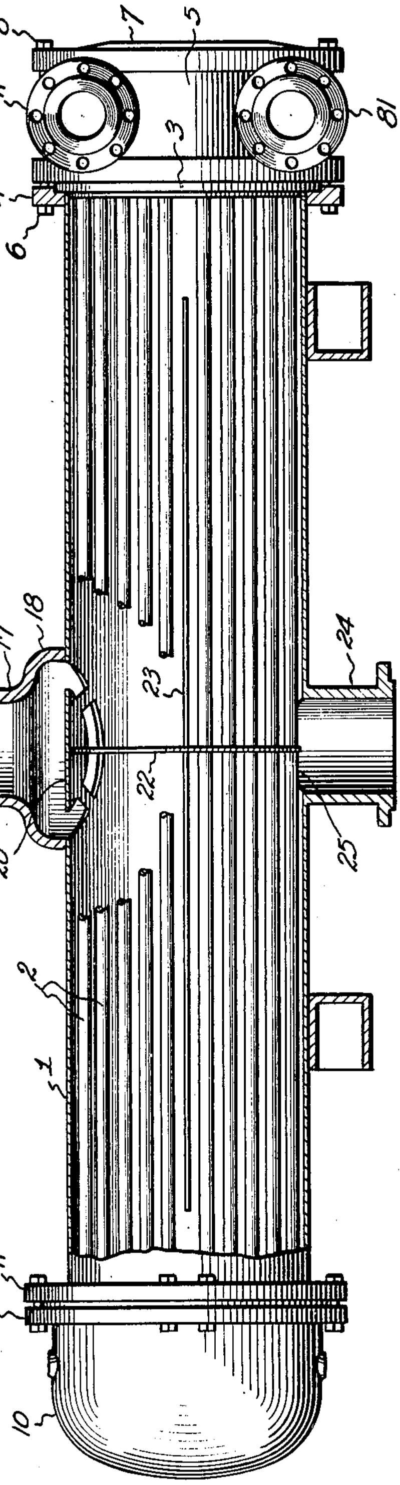

Fig. 6.

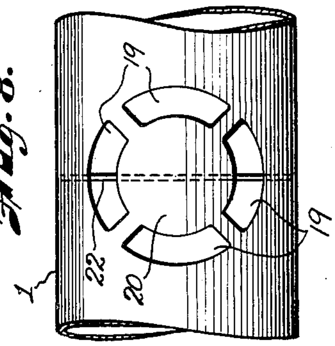

Fig. 8.

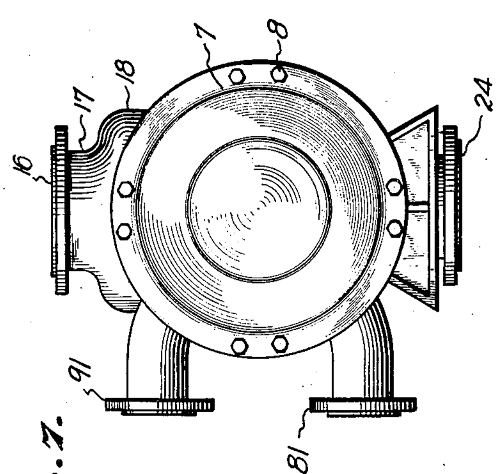

Fig. 7.

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UNITED STATES PATENT OFFICE

2,138,469

HEAT EXCHANGER

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Application August 21, 1935, Serial No. 37,142

4 Claims. (Cl. 257—239)

Our invention relates to shell and tube heat exchangers and more particularly to improvements in the construction and arrangement of inlet nozzles for directing vapor or liquid into the shell space in which the exchanger tubes are located.

A type of heat exchanger commonly used in many industries, particularly in the refining of petroleum is that comprising a number of parallel, serially connected tube bundles enclosed by a shell. A hot liquid or vapor to be cooled is caused to flow at high velocity into the shell and around the tubes through which flows a cooler liquid. The tubes are secured to a fixed tube sheet at one end of the shell and to a floating tube sheet at the other end. The nozzle for feeding the hot fluid into the shell is frequently located at one end of the shell adjacent the fixed tube sheet in which the tubes are mounted. Within the shell and transverse to the tubes are generally positioned a number of baffle plates. The tubes carrying the cooling liquid pass through enlarged holes in these baffles, so that hot vapor in passing through these openings closely contacts the tubes and is more efficiently cooled. Obviously, it is desirable to provide such baffling throughout the length of the tubes for greatest efficiency. However, when the usual type of straight tubular inlet nozzle is positioned at the end of the shell adjacent the fixed tube sheet, the number of baffles permissible at that end is limited since the nozzle shape particularly because of the bolting flanges necessitates positioning the nozzle and therefore the shell opening at some distance from the fixed tube sheet and, of course, from the adjoining ends of the tubes. Because of this, the desired contact of vapors with the full length of the tubes is not attained and some stagnation and pocketing of the vapors in the shell occurs adjacent the fixed tube sheet.

A further objection to the use of the conventional type of straight tubular inlet nozzle construction is that erosion of the tubes is caused by direct high velocity impingement of the hot fluid on the tubes. The fluids ordinarily met with in petroleum refining carry sufficient calcareous and other solid matter to render the erosion effect of importance. Obviously, the gradual wearing down of the tubes only hastens the time when the exchanger must be shut down for tube replacement.

It is an object of our invention to overcome these disadvantages in a simple and expeditious manner.

It is an object of our invention to permit the effective use of transverse baffles in portions of a heat exchanger shell where such baffles were heretofore ineffective or incapable of being used.

It is another object of our invention to provide a heat exchanger construction promoting efficient contact of the hot vapors throughout the length of the cooling tubes and reducing the undesirable formation of slow moving quantities of hot vapors adjacent the region of vapor introduction.

It is a further object of our invention to effectively reduce the inlet velocity of the hot vapors entering a heat exchanger shell and prevent the direct impingement of these high velocity vapors on the cooling tubes.

It is still another object of our invention to appreciably reduce the erosion caused by impingement of hot vapors on the tubes of a heat exchanger.

Other and further objects of our invention will appear from the following description and appended claims.

In the accompanying drawings, which form part of the instant specification and are to be read in conjunction therewith, and in which like numerals refer to like parts throughout the several views;

Figure 1 is a longitudinal part sectional view in elevation with parts omitted of a heat exchanger embodying a preferred form of inlet.

Figure 2 is an end view of the heat exchanger of Figure 1.

Figure 3 is a plan view of the nozzle shown in Figure 1.

Figure 4 is a view in elevation of a cross section of part of a heat exchanger embodying a modified form of our invention.

Figure 5 is a view taken along the line 5—5 of Figure 4.

Figure 6 is a longitudinal part sectional view in elevation with parts omitted of a heat exchanger embodying another form of our invention.

Figure 7 is an end view of the heat exchanger shown in Figure 6.

Figure 8 is a view showing the arrangement of the vapor inlet openings in the heat exchanger shell of Figure 6.

In general, our invention comprises a combined distribution and impingement baffle in conjunction with an inlet nozzle having a tubular entrance or neck portion formed integrally with an expansion or body portion of appreciably larger cross sectional area. The velocity of the vapor fed through the entrance portion of the nozzle is rapidly reduced in the body portion due to expansion occurring in the greater volume of the body portion of the nozzle. The body portion of the nozzle is fastened to the shell of a heat exchanger and communicates through an opening in the shell with the interior. The vapor passing through the nozzle impinges on a baffle which may be a portion of the shell or a member separate therefrom and thereafter flows laterally around the tubes in the shell. Direct impingement of high velocity vapors on the tubes is thus avoided.

Where the inlet nozzle is employed adjacent one end of the exchanger, the nozzle is formed with its tubular entrance or neck portion located at one side of its body or expansion portion. This formation permits locating the orifice through which vapor enters the exchanger shell at a region closer to the fixed tube sheet than would be practical with a conventional straight tubular type of inlet nozzle construction. This follows by reason of the fact that the orifice over which a conventional type nozzle is positioned must be located sufficiently far from the header or channel of the exchanger that the bolting flange of the nozzle will not prevent access to adjacent portions of the exchanger header for the performance of bolting operations. Obviously, as the orifice is moved farther from the fixed tube sheet of the header, the space available for baffles is reduced, whereas the present invention enables the employment of additional baffles and the elimination of previous bolting problem. In addition, the impingement baffle, against which the vapors flowing through the nozzle are directed, assists the flow of vapor around the tube portion adjacent the fixed tube sheet, thus promoting more efficient heat exchange in these portions through vapor contact.

Referring now more particularly to the drawings, a fixed tube sheet 3, in which the tubes 2 are thereby fixedly held at one end, is clamped between a flange 4 of the shell 1 and a channel ring 5 removably fastened to the flange 4 by a plurality of bolts or other suitable clamping devices 6. The opposite ends of the tubes 2 are fastened in a conventional manner to a floating header (not shown). A channel cover plate 7 is removably attached to the channel 5 by means of a plurality of peripherally disposed bolts or other suitable clamping devices 8. The channel ring 5, fixed tube sheet 3 and cover plate 7 together form a fixed header for passing cooling fluid through the tubes 2, this header being internally divided into a pair of compartments (not shown) by an imperforate partition member (not shown).

It will be obvious from the foregoing that a flow of cooling fluid through the tubes 2 may be effected in accordance with conventional practice. Thus, cooling fluid fed into one of the pair of compartments in the fixed header will flow through the tubes 2 communicating therewith, through the floating header, and through the remainder of the tubes 2 into the other compartment of the pair with which they communicate.

A nozzle 81, for feeding cooling oil, or other suitable cooling fluid into one of the pair of fixed header compartments, is fastened to the channel 5 and communicates through an opening therein with one of the pair of compartments of the fixed header. A nozzle 91, for withdrawing the cooling oil from the other of the pair of fixed header compartments after passage of the oil through the tubes 2, is fastened to the channel 5 and communicates through an opening therein with the other of the pair of fixed header compartments.

The floating head end of the shell is covered by means of a cap 10 removably fastened to a flange 11 of the shell by bolts or suitable clamping means 12.

Referring now more particularly to Fig. 1, a plurality of baffles 13 formed with openings through which the tubes 2 pass are positioned transversely of and within the shell 1 and spaced from each other by a number of spacer tubes 14 through which run the tie rods 15 fastened at one end to the fixed tube sheet 3 as is best shown in Fig. 4. The openings in each baffle through which the tubes 2 pass are larger than the tubes, with the openings in succeeding baffles arranged in staggered formation to secure a vapor flow across the tubes. The arrangement of these openings may take many forms and forms no part of our invention.

A vapor inlet nozzle 16 having a generally tubular entrance or neck portion 17 formed integrally with an enlarged expansion or body portion 18, as shown, is fastened to the shell 1 as by welding or in any other suitable manner and communicates with the shell space through an opening 19 formed in the shell between the fixed tube sheet 3 and the first of the series of transverse baffles 13.

In Figure 1, which shows a preferred embodiment of our invention, we have shown the nozzle 16 having its tubular entrance portion 17 positioned directly over a section 20 of the shell 1. In this form of nozzle, the neck or entrance portion 17 is positioned at one side of the enlarged expansion or body portion 18 which latter communicates with the opening 19. The portion 20 of the shell 1 also enclosed by the body portion serves as an impingement and distribution baffle. A vapor outlet nozzle 24 communicates with the shell space through an opening 25 in the shell 1 at the floating head end of the shell.

In Figures 4 and 5, we have shown a modified form of impingement and distribution baffle 20′ having flanged side edges 21 fixedly attached as by welding to a pair of the spacing tubes 14 thus spacing the baffle from and positioning it within the shell 1 directly below the tubular entrance or neck portion 17 of the nozzle 16. The flanged edges 21 of the baffle press tightly against the inner surface of the shell, while the rear unflanged edge abuts the first of the series of transverse baffles 13. In this form of construction, that portion of the shell in the area embraced by the enlarged expansion or body portion 18 of the nozzle is removed to form a vapor opening in the shell. The arrangement of the impingement baffle 20′ as a separate member within permits its removal for cleaning with the cooling tubes 2 and transverse baffles 13.

In Figures 6, 7, and 8, we have shown still another modification of our invention in which the nozzle 16 is fastened to the shell 1 substantially centrally thereof. The shell within the area embraced by the enlarged expansion or body portion 18 of the nozzle is formed with a plurality of vapor inlet openings 22 circumferentially disposed about a portion of the shell forming a central imperforate impingement baffle 20″ positioned directly below the inlet portion 17 of the nozzle. The shell space is internally divided, by a central imperforate transverse partition 22 and a central longitudinal partition 23 spaced from the shell ends into a number of compartments as shown. A vapor outlet nozzle 24 communicates with the compartments through an opening 25 in the shell.

In the operation of the heat exchanger shown in Figures 1–5 hot petroleum vapor enters the nozzle 16 at considerable velocity through the entrance or neck portion 17 and expands in the enlarged expansion or body portion 18 and through the opening 19 in the shell with attendant reduction in velocity. The vapors striking the impingement and distribution baffle 20 in Figs. 1

and 3 and impingement baffle **20'** in Figs. 4 and 5 are caused to flow laterally around the cooling tubes **2** between the first baffle **12** and the fixed tube sheet **3** and toward said tube sheet. The vapors are redirected by the tube sheet along the tubes through the transverse baffles **13** and are eventually removed through the discharge opening **25** and nozzle **24**. It will be observed that by this construction direct impingement of high velocity vapors on the cooling tubes is prevented, erosion is reduced and tube life is prolonged. In addition, the longitudinal movement of the lower velocity vapors along the tubes adjacent the fixed tube sheet results in more effective use of this portion of the cooling tubes than has heretofore existed. Also, by virtue of the laterally offset arrangement of the base portion inlet nozzle, it is possible to locate the opening into the shell closer to the tube sheet than was practical with conventional nozzle constructions heretofore. This permits the insertion of additional transverse baffle means with resultant greater efficiency of heat transfer through better control of vapor flow.

In the modification shown in Figure 6, the impingement baffle **20''** functions in the same manner as in Figures 1–4, the vapors at reduced velocity flowing through the openings **19** in all directions into the shell space through which they travel and are discharged through opening **25** and nozzle **24** in the manner shown. However, in this modification, the impingement baffle does not function mainly to distribute the vapors along the cooling tubes, but mainly to reduce the vapor velocity and thus prevent erosion of the tubes.

Although we have described our invention with relation to the flow of vapor through the heat exchanger, it is to be understood that the use of such term is not intended to be restrictive as our invention is applicable to handling of fluids in general whether liquid, vapor or gas.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in details within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, what is claimed is:

1. A heat exchanger comprising in combination, a shell; a header sealing one end of said shell; a tube bundle in said shell connected to said header; a series of baffles within said shell transverse to the tubes of said bundle; an orifice in the periphery of said shell between said header and said series of baffles; means other than said shell forming a nozzle fastened to said shell at a locus wholly spaced from either end of said shell for feeding fluid through said orifice, said nozzle means having a neck portion and an enlarged body portion integral with said neck portion; said body portion being positioned over said orifice and said neck portion being joined to said body portion at a region farthest removed from said header; and, an impingement baffle longitudinally positioned between said tube bundle and said shell to receive fluid discharged through said orifice and to direct the fluid along the tubes toward said header, said impingement baffle being carried by said tube bundle.

2. A heat exchanger comprising in combination, a shell; a header sealing one end of said shell; a tube bundle in said shell connected to said header, said tube bundle being removable from said shell; a series of baffles within said shell transverse to the tubes of said bundle; an orifice in the periphery of said shell between said header and said series of baffles; means other than said shell forming a nozzle fastened to said shell at a locus wholly spaced from either end of said shell for feeding fluid through said orifice, said nozzle means having a neck portion and an enlarged body portion integral with said neck portion, said body portion being positioned over said orifice and said neck portion being joined to said body portion at a region farthest removed from said header; and, an impingement baffle longitudinally positioned between said tube bundle and said shell to receive fluid discharged through said orifice and to direct the fluid along the tubes toward said header, said impingement baffle being supported by said tube bundle and being removable therewith.

3. A heat exchanger comprising in combination, a shell; a header sealing one end of said shell; a tube bundle in said shell connected to said header; a series of baffles within said shell transverse to the tubes of said bundle; an orifice in the periphery of said shell between said header and said series of baffles; means other than said shell forming a nozzle fastened to said shell at a locus wholly spaced from either end of said shell for feeding fluid through said orifice, said nozzle means having a neck portion and an enlarged body portion integral with said neck portion, said body portion being positioned over said orifice and said neck portion being joined to said body portion at a region farthest removed from said header; and, an impingement baffle longitudinally positioned between said tube bundle and said shell to receive fluid discharged through said orifice and to direct the fluid along the tubes toward said header, said impingement baffle having one end abutting the first baffle of said series of transverse baffles and having flanged edge portions abutting said shell at opposite sides of said orifice.

4. A heat exchanger comprising in combination, a shell; a header sealing one end of said shell; a tube bundle in said shell connected to said header; a series of baffles within said shell transverse to the tubes of said bundle, the first baffle of said series being spaced from said header by tubular spacing collars; an orifice in the periphery of said shell between said header and said series of baffles; means other than said shell forming a nozzle fastened to said shell at a locus wholly spaced from either end of said shell for feeding fluid through said orifice, said nozzle means having a neck portion and an enlarged body portion integral with said neck portion, said body portion being positioned over said orifice and said neck portion being joined to said body portion at a region farthest removed from said header; and, an impingement baffle longitudinally positioned between said tube bundle and said shell to receive fluid discharged through said orifice and to direct the fluid along the tubes toward said header, said impingement baffle being fastened to said collars.

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