Aug. 16, 1955 E. J. REINOLD ET AL 2,715,516

HEAT EXCHANGER DESIGN

Filed Oct. 25, 1951 3 Sheets-Sheet 1

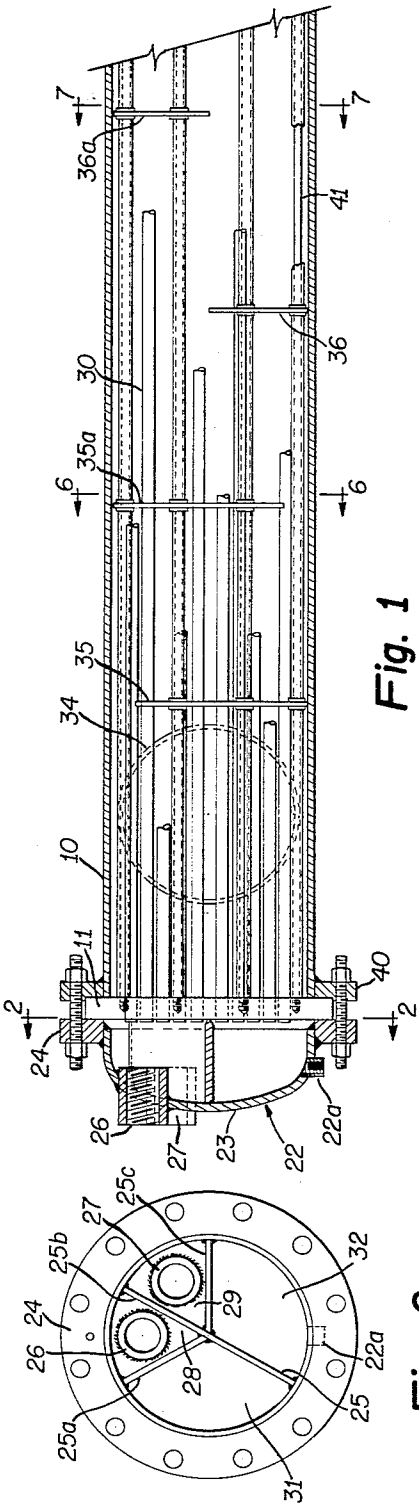


Fig. 1

Fig. 2

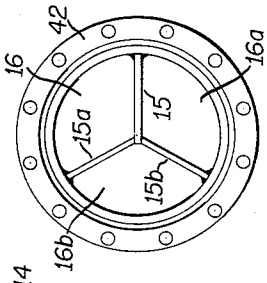


Fig. 3

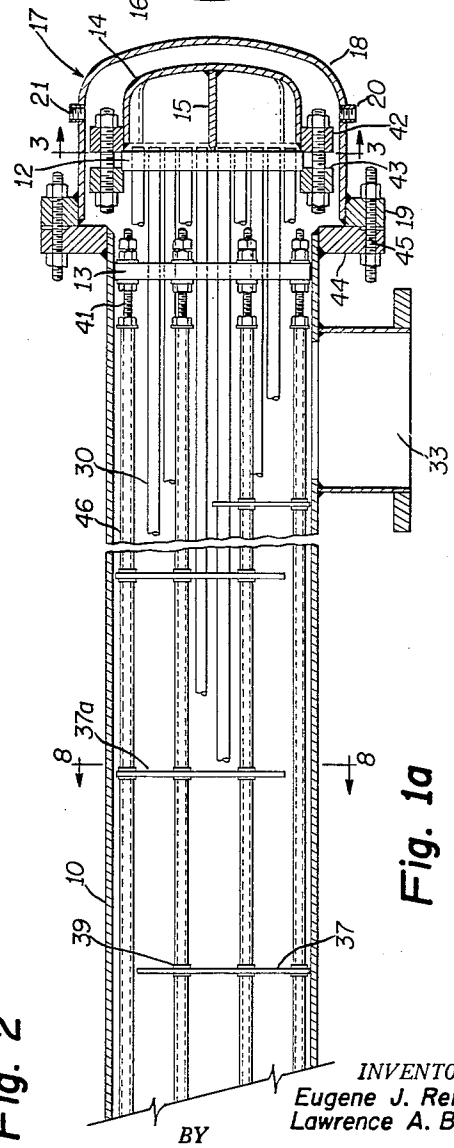


Fig. 1a

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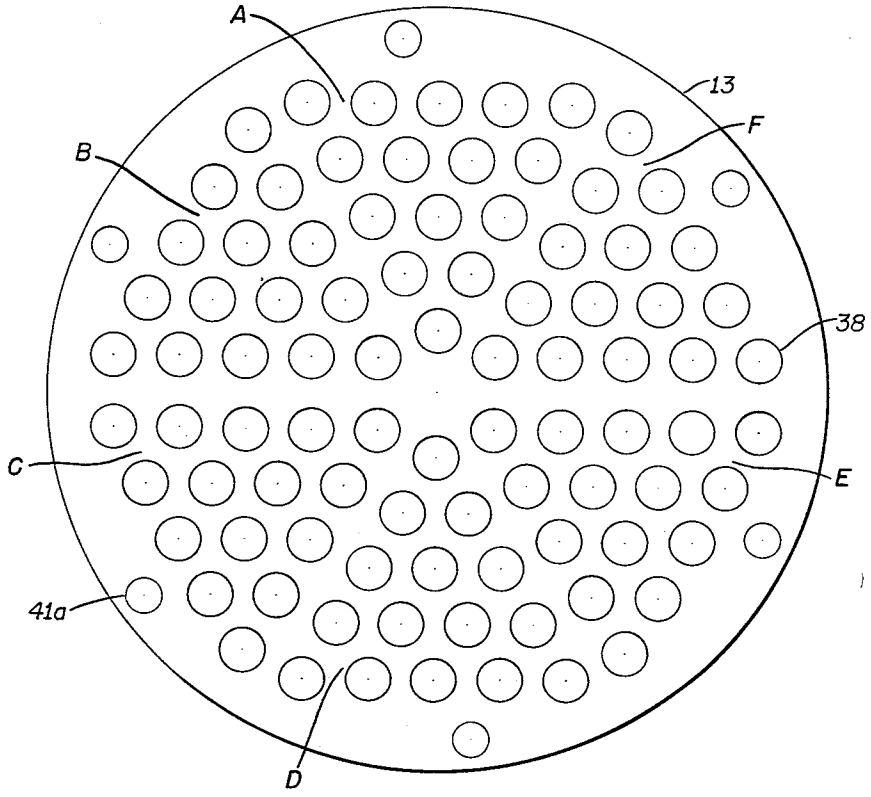


Fig. 5

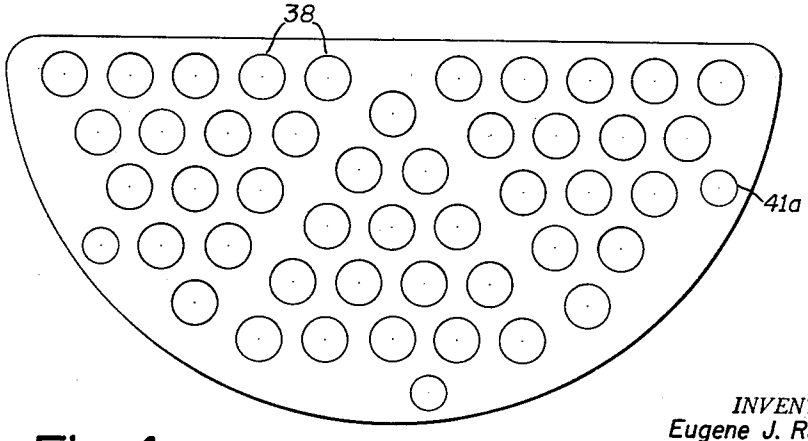


Fig. 4

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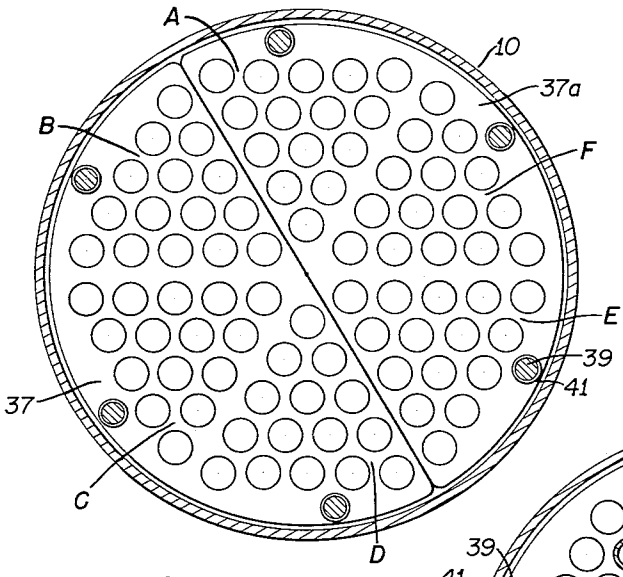


Fig. 8

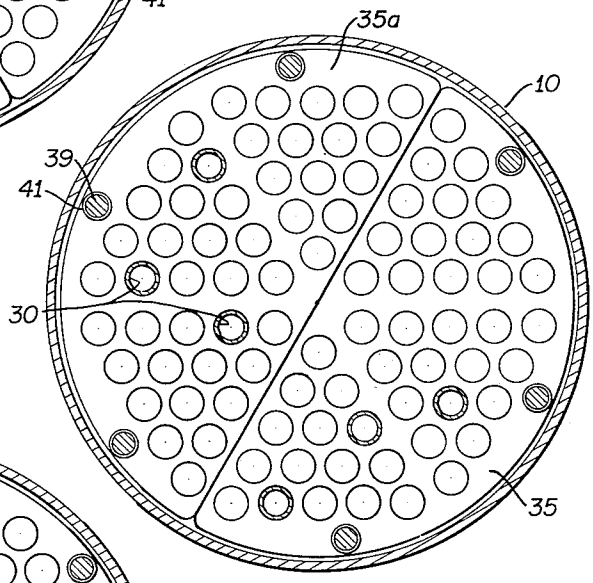


Fig. 6

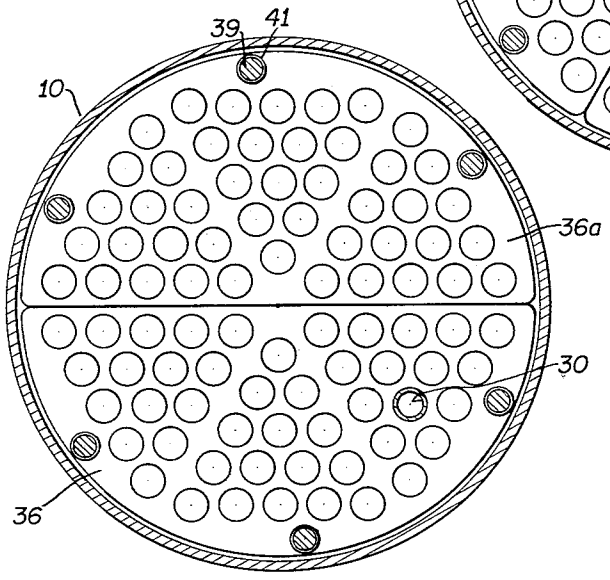


Fig. 7

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HEAT EXCHANGER DESIGN

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Application October 25, 1951, Serial No. 253,176

2 Claims. (Cl. 257—236)

This invention relates to heat transfer apparatus and more particularly to heat exchangers of the type wherein heat is transferred between two fluids, one flowing through a bundle of tubes and another fluid flowing through a shell surrounding the tube bundle.

Baffled heat exchangers are well known in the art, in one form the baffles being arranged substantially parallel to the tubes in the tube bundles, but in such an arrangement it becomes virtually impossible to provide an equal number of tubes in each pass through the exchanger. In another form baffles are arranged transversely to the tube bundle but heretofore it has been necessary to cut the baffles in such a manner that the inner or chordal edge of the baffle embraces only a segment of at least some of the tubes which are enclosed by the baffle. This condition results in a wear point susceptible to fatigue and corrosion, especially in an exchanger handling pulsating air or vapors such as is the case when the exchanger is used on an air compressor. Many tube failures result at this point of wear.

The object of our invention is to provide an improved construction of a heat exchanger of the tube-in-shell type and more specifically an improved construction and arrangement of the baffle and tubes systems for so supporting the tube bundle as to avoid mechanical failure. Another object of our invention is to provide a baffle system wherein no tube is only partially embraced by a given baffle. A further object of the baffle system is to direct and regulate the flow of the fluid externally of the tube bundle. An additional object of our invention is to increase the flow path through the heat exchanger without increasing the length of the shell or of the tubes. These and other objects of our invention will become apparent as the description thereof proceeds.

Briefly our exchanger design attains the objects of our invention and eliminates the difficulties with conventional baffled exchangers by providing 180° baffles, each succeeding pair of which is turned 60° about the longitudinal axis of the heat exchanger. It will be seen that by having a multiplicity of alternate pairs of baffles arranged according to our invention each tube is supported at spaced points along its length from several radial directions. Thus in addition to increasing the agitation of the fluid being passed through the shell, this arrangement of baffles ties the bundle together in one rigid mass which is mechanically more stable than any conventional apparatus because it resists the vibration of the tubes due to fluid pulsations and avoids any baffles which do not completely embrace each tube passing through the baffle. Other features and details of construction will become apparent from the following description taken with the accompanying drawings wherein:

Figures 1 and 1*a* are sectional elevations of a preferred form of our invention;

Figure 2 is a section taken along 2—2 in Figure 1 showing a stationary head construction;

Figure 3 is a section taken along 3—3 in Figure 1*a*

showing the floating head construction with the shell cover removed;

Figure 4 is a plan view of one of the baffle elements used in the heat exchanger construction;

Figure 5 is a plan view of a tube sheet showing the pattern of the tube banks; and

Figures 6, 7 and 8 are sections taken along the lines 6—6, 7—7 and 8—8, respectively, of Figures 1 and 1*a*, showing the rotation of the alternate pairs of baffles.

Referring to the drawings, we have illustrated one preferred embodiment of our invention in which a tubular heat exchanger has a cylindrical shell **10**, a circular stationary tube sheet **11** secured at one end of the shell **10** and a circular floating tube sheet **12** mounted at the opposite end thereof. Six banks of tubes A to F are mounted between tube sheets **11** and **12** and pass through a floating end support plate **13** arranged near the floating end of the shell **10**. A convex floating head **14**, secured to the floating tube sheet **12**, is provided with three partitions **15**, **15***a*, **15***b* which divide the header into 120° segments or chambers **16**, **16***a*, **16***b*.

A shell cover **17** comprises a convex cap **18** welded to the shell cover flange **19** and is provided with threaded drain and vent plug couplings **20** and **21**. The opposite end of the heat exchanger is provided with a stationary head **22** including a convex cap **23**, a flange **24**, and partition plates **25**, **25***a*, **25***b*, and **25***c*, as shown in Figure 2. Threaded inlet **26** and threaded outlet **27** communicate with the chambers **28** and **29** defined by the stationary tube sheet **11**, a portion of the convex cap **23**, and the baffles **25***a*, **25***b*, and **25***c*.

With the construction illustrated, a fluid entering through inlet connection **26** in the stationary head **22** flows through the top-most bank A of tubes **30** through a reversing chamber **16** formed by the floating tube sheet **12** and partitioned floating head **14**, then through the next bank of tubes B arranged counter-clockwise from the inlet bank A and thence into the reversing chamber **31** defined by baffles **25** and **25***a* and a portion of the stationary head **22**. The fluid returns through tube bank C to the reversing chamber **16***a*, and then in series alternately in opposite directions through tube banks D and E, and finally into tube bank F which discharges into header chamber **29** and finally from the exchanger via outlet **27**.

The shell **10** is provided with an inlet **33** and an outlet **34** at opposite ends thereof. The interior of the shell **10** between the floating end support plate **13** and the stationary head **22** is provided with a baffle system for directing the flow of the fluid along and about the banks of the tubes. A series of semi-circular baffles **35**—**35***a*, **36**—**36***a*, **37**—**37***a* etc. are mounted in the shell **10** transversely to the tube banks A to F. Each of the baffles is provided with a set of circular openings **38** for the tubes **30**. Each baffle is semicircular and embraces about 180° of the circular cross-sectional area of the shell. Each baffle embraces three adjacent banks of tubes and each successive pair of baffles is turned 60° with respect to the preceding and succeeding pair of baffles. Each baffle is provided with the tube-receiving ports **38** and in each instance an entire tube **30** is surrounded by a portion of the baffle.

In assembling the heat exchanger according to our invention, the tubes **30** and a pair of baffles **35**—**35***a*, **36**—**36***a*, **37**—**37***a* etc., the stationary tube sheet **11**, floating tube sheet **12**, floating end support plate **13**, and tie rods **41** are prefabricated as a unit and inserted into the shell **10**. The stationary tube sheet **11** is bolted between the shell flange **40** and the stationary head flange **24**. In so doing the partitions **25**, **25***a*, **25***b*, **25***c* contact the tube sheet **11** to form the four compartments **31**, etc. for directing flow through the tube banks A to F.

The floating end support plate **13** and the stationary tube sheet **11** are tied by means of the tie rods **39** which pass through the baffles at their periphery. Brass washers **41** are provided at each point where the rods **39** pass through a baffle. The 180° baffles are in turn mounted at spaced points along the tie rods **39** as shown in the drawings with spacer spools or sleeves **46** on the tie rods **39** between the adjacent baffles.

The floating head **14** having partitions **15**, **15***a*, **15***b* is fixed to the floating tube sheet **12** by means of the floating head flange **42** and the split ring flange **43**. This floating head assembly is enclosed by means of the shell cover **17** which is held to the shell flange **44** by means of stud bolts **45**.

With the baffle array illustrated, the heat-exchange fluid enters the shell **10** via flanged inlet **33** and flows in a substantially helical path about and along the tube banks A to F directed by the baffles **35**—**35***a*, **36**—**36***a*, **37**—**37***a*, etc. With this arrangement of baffles and with the arrangement of passes of tube banks A to F, the path of flow of the fluids is substantially increased in length without a corresponding increase in the over-all length of the heat exchanger. Likewise, by the mounting of the pairs of baffles **35**—**35***a*, **36**—**36***a*, **37**—**37***a* on a 60° rotation pattern, each bank of tubes is supported from all directions and at a multiplicity of points along the length of the tubes. The tie rods **39** with spacer spools **46** also support and align the baffles independently of the tubes which pass through the baffles. This structural arrangement of tubes and baffles results in preventing the tube damage which previously occurred in similar heat exchangers when split baffles were arranged in opposed upper and lower pairs. The described apparatus is mechanically stable to surges of fluids through the shell and makes for an efficient heat transfer.

In Figures 6, 7 and 8, comprising sections **6**—**6**, **7**—**7** and **8**—**8** in Figures 1 and 1*a*, we have illustrated the relative positions of three pairs of baffles **35**—**35***a*, **36**—**36***a*, and **37**—**37***a*, each pair being rotated clockwise 60° with respect to the adjacent pairs of baffles. Thus, referring to Figures 6 and 7, the baffle **35***a* assumes the position of **36***a* when rotated as in Figure 7 and finally is in the position of **37***a* when rotated an additional 60°, as shown in Figure 8. Additional pairs, arranged in similar sequence complete the exchange.

Although we have described our invention in terms of tube banks in triangular array and with 180° baffles, it is contemplated that smaller and larger numbers of triangular banks can be used. For example, we may use from between about 3 and 12 banks arranged in circular sectors of the exchanger. When this is done, however, the shape of the baffle may be altered so that the weir or chordal edge of each baffle can always lie along a tubeless space between banks of tubes. The banks of tubes occupy aliquot circular sectors of the shell and each pair of baffles is angularly displaced about the axis of the exchanger from each adjacent pair of baffles a distance corresponding to said circular sector.

Thus it will be seen that the objects of our invention have been attained by providing the described apparatus. Although we have illustrated and described a preferred form or embodiment of our invention, it will be apparent to those skilled in the art that in view of our description certain changes may be made in the form of the apparatus without departing from the spirit of our invention as described above or as defined by the appended claims.

We claim:

1. In a tube and shell heat exchanger the combination of a cylindrical shell, a removable heat exchange core unit comprising a bundle of six banks of tubes, each bank of tubes occupying about 60° of the cross-sectional area of the shell, a stationary tube sheet closing a first end of said shell and supporting said banks of tubes, a floating end support plate across the second end of said shell and supporting a terminal portion of said tube banks, a floating tube sheet for said terminal portion beyond the end of said shell, a convex floating head fixed to said floating tube sheet and having co-operating radial partitions forming return cells for connecting adjacent pairs of tube banks, a partitioned convex stationary head supported in fluid-tight relation to said stationary tube sheet, said convex floating head and said convex stationary head co-operating to provide series flow through each of said tube banks in sequence, an inlet and an outlet to said convex stationary head whereby fluids flow through said head, through each of said banks of tubes in series countercurrent to fluids flowing in adjacent banks of tubes, and through said floating convex head, and a plurality of pairs of plate-like semicircular apertured baffles arranged transverse to said tube banks and spaced longitudinally of the said shell, the individual baffles in each successive pair being 180° out of register with each other and each pair of baffles being rotated as a unit clockwise about 60° out of phase with respect to the next pair of baffles, such successive rotation of each pair of baffles placing an edge of any baffle in a tubeless zone between adjacent banks of tubes in said bundle.

2. In a heat exchanger of the tube and shell type the improvement which comprises the combination of a cylindrical shell, a bundle of tube banks in triangular array, each bank occupying an aliquot circular sector of said shell, a stationary tube sheet closing a first end of said shell and supporting one end of said tube banks, a floating end support plate within the second end of said shell and supporting a terminal portion of said tube banks, a floating tube sheet about the end of said tube banks beyond the second end of said shell, a partitioned convex stationary head supported in fluid-tight relation to said stationary tube sheet, an inlet to a first of said tube banks through said stationary head, a convex floating head fixed to said floating tube sheet and having co-operating radial partitions arranged in alignment with the tubeless zones between adjacent pairs of tube banks, an outlet to the last of said tube banks through said stationary head, said convex stationary head co-operating to provide series flow through said tube banks, whereby fluids flow through each of said tube banks in series countercurrent to fluid in adjacent tube banks, longitudinally spaced pairs of plate-like semicirular baffles raranged transverse to the said tube banks, the individual baffles of each successive pair having their weir edges in register with each other and adjacent pairs of baffles being longitudinally spaced in said shell, each successive pair of baffles being rotated as a unit with respect to the next pair an angle corresponding substantially to the angle of each said aliquot circular sector occupied by each bank, such displacement of each successive pair of baffles placing the weir edges of any baffle in a tubeless zone between adjacent tube banks in said bundle.

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