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Bare

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[54] **MODULAR HEAT EXCHANGER CONSTRUCTION**

[72] Inventor: **Howard J. Bare,** 1721 South Bluff Road, Los Angeles, Calif. 90640

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[52] **U.S. Cl.** **165/158,** 165/175

[51] **Int. Cl.** **F28f 9/14**

[58] **Field of Search** 165/81, 82, 158, 175, 176; 220/55, 3

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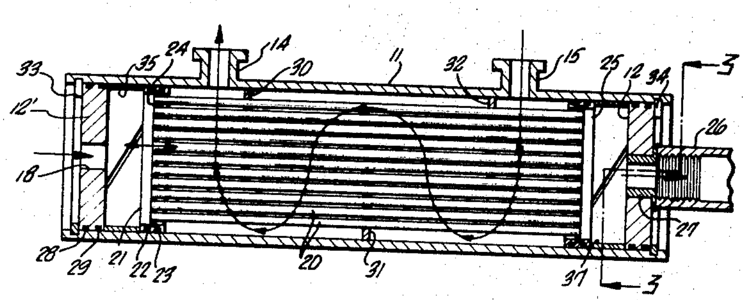
Primary Examiner—Frederick L. Matteson
Assistant Examiner—W. C. Anderson
Attorney—Roger A. Marrs

[57] **ABSTRACT**

A heat exchanger construction is disclosed herein that is assembled from selected prefabricated components which include an outer shell for housing a tube assembly having a plurality of tubes carried as a unit by tube sheets and having snap-lock retainers releasably secured to the shell for holding the tube unit circulating fixed position within the shell. Means are provided for circuhating one fluid through the tube and for circulating another fluid around the tube within the shell for effecting an exchange of heat therebetween.

4 Claims, 5 Drawing Figures



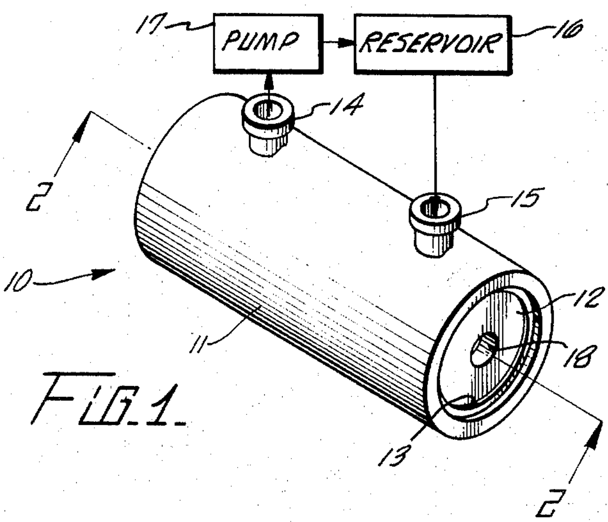


FIG. 1

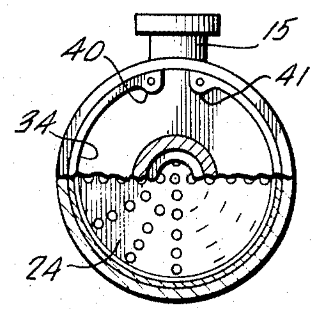
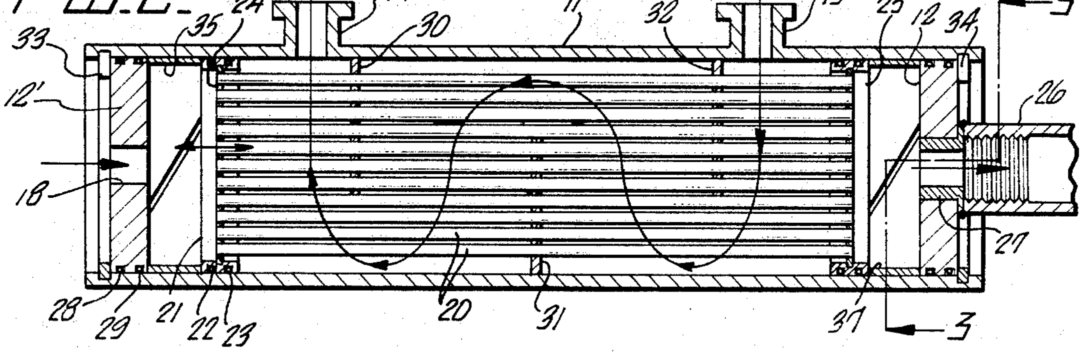


FIG. 3

FIG. 2



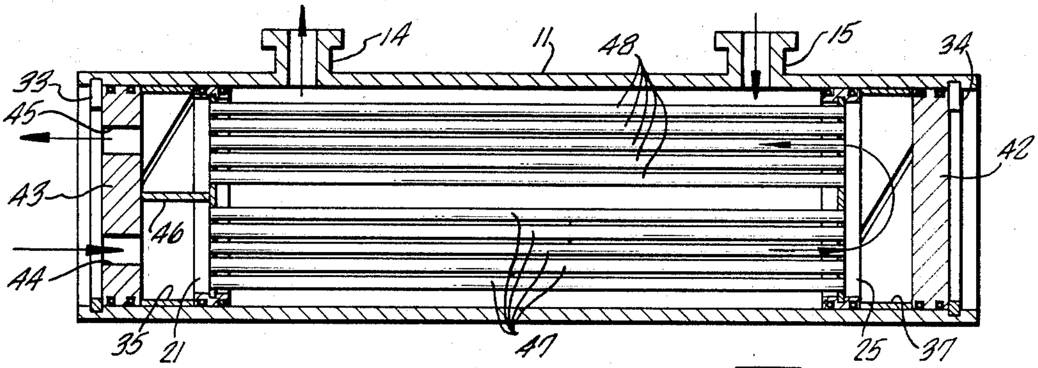


FIG. 4

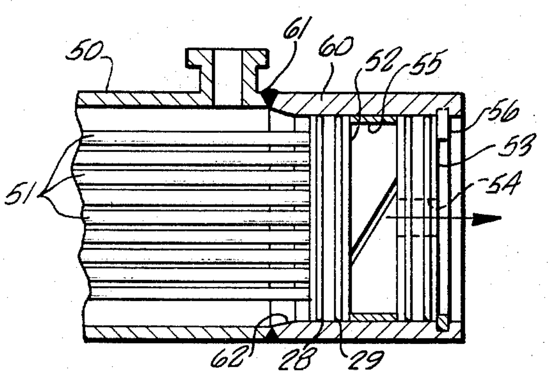


FIG. 5

INVENTOR
HOWARD J. BARE
BY Roger A. Marrs

MODULAR HEAT EXCHANGER CONSTRUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of process equipment and, more particularly, to a novel modular heat exchanger assembled from selected prefabricated components designed to meet the specifications of most heating, cooling or process applications.

2. Description of the Prior Art

The rapid growth of the process industries over the past 25 years has been accompanied by many improvements and innovations in heat exchanger design. During this period, many inventors have pioneered in the development of heat exchangers to satisfy the increasing demand of industry. Heat exchangers which are currently designed and manufactured are basically of the shell and tube type. Heat is exchanged between one fluid flowing through a plurality of tubes comprising a bundle and another fluid flowing in the space around the tubes bundle within the shell. There are four basic considerations in choosing a mechanical arrangement which provides for efficient heat transfer between the two fluids while taking care of such practical matters as preventing leakage from one into the other. These basic considerations may be briefly stated as: consideration for differential thermal expansion of tube and shell; means for directing fluid through the tubes; methods of controlling fluid flow through the shell; and consideration for ease of maintenance and servicing.

Various types of heat exchangers have been developed with different approaches to these fundamental design factors with the result that most heat exchangers must be designed from the ground up depending on their application, size and desired efficiency. Each component in the exchanger has many more possible variations than can be covered in a standard design. Therefore, a need has long existed to provide a process or heat exchanger assembled from a variety of different components that may be readily selected from an inventory of modular units. In the selection of materials, for example, great dependence is placed upon how corrosive the liquid to be handled will be under given process conditions. Therefore, in the modular concept, certain components of the exchanger may be made from different materials so that the modular units not only include structural differences between prefabricated modular components in the inventory but offer a wide latitude in the choice of material.

For this reason, conventional process and heat exchangers are presently being built by conventional methods and to standards which have been in use for many years. A tremendous amount of expense and labor goes into the creation of the exchanger, whether it be used for a heat exchanger, a condenser or cooling applications. Improvement in process equipment techniques which are permitted by modern technological approach and conceptual improvement can readily reduce the cost of such structures and make them more durable. By prefabricating the assemblies and components of exchangers, they may be assembled into a variety of constructions so as to lower cost, save time and labor and be more adaptable for modern mass production techniques.

SUMMARY OF THE INVENTION

The difficulties and problems encountered with the prior art or conventional process equipment are obviated by the present invention which provides a plurality of modular components adapted to be selected from inventory in accordance with a predetermined set of specifications so as to produce a desired process construction. The construction includes an elongated, cylindrical shell or housing having open ends so as to insertably receive a tube core or bundle. The tube bundle includes a plurality of tubes arranged in parallel spaced-apart relationship having their opposite terminating ends held together by the tube sheets disposed in sliding relationship with respect to the inner wall surface of the housing shell. Closure caps or pieces are situated in the ends of the shell housing

to effect sealing and, in cooperation with resilient means, to prevent axial movement of the tube bundle after insertion. By selecting suitable components from the prefabricated inventory, heat exchangers or the like may be constructed for a wide variety of uses and applications having a choice of design configuration. For example, a U-tube design, fixed tube sheet design, floating head or other special designs may be constructed from the modular components.

Therefore, it is among the primary objects of the present invention to provide a novel process equipment construction wherein the various component parts are preformed and subsequently selected from inventory so as to make up a desired unitary construction.

Another object of the present invention is to provide a novel process or heat exchanger construction having its various component parts fabricated and selected from a plurality of preformed modular components.

Another object of the present invention is to provide a novel heat exchanger having an insertable tube bundle adapted to be slidably received into the central bore of an elongated shell and which includes end caps for securing the tube bundle in position to complete construction.

Yet another object of the present invention is to provide a novel heat exchanger having a tube bundle situated within its enclosing shell and held in position by end pieces which are releasably secured to the shell by means of snap-lock retainers.

Still another object of the present invention is to provide a novel heat exchanger adapted to be readily assembled from a plurality of preformed modular components and adapted to be readily disassembled for maintenance and repair purposes whereby the structural design follows a modular construction and assembly concept.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, in which:

FIG. **1** is a perspective view of the novel process construction of the present invention illustrated in the form of a heat exchanger;

FIG. **2** is a longitudinal cross-section view of the heat exchanger shown in FIG. **1** as taken in the direction of arrows **2—2** thereof;

FIG. **3** is a transverse cross-sectional view of the heat exchanger as taken in the direction of arrows **3—3** of FIG. **2**;

FIG. **4** is a longitudinal cross-sectional view of another embodiment of the present invention illustrating a U-tube exchanger equivalent; and

FIG. **5** is a fragmentary cross-sectional view of another embodiment of the invention showing the shell structure fabricated from dissimilar metals.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1**, the process equipment of the present invention is illustrated in the form of a heat exchanger shown in the direction of arrows **10** which includes an elongated cylindrical housing or shell **11** having a central bore which encloses a tube bundle (not shown) and which is closed at its opposite ends by means of closure caps or pieces, such as cap **12**. The respective end caps or pieces are retained in position by means of a snap-lock retainer **13** against which the end piece bears in sealing relationship. A pair of flanged connections **14** and **15** are provided to permit a first fluid communication and flow to be introduced into the heat exchanger shell **11** from a reservoir **16** by means of a pump **17** and circulated back to the reservoir. Although flow may be indicated in either direction and the flange connectors **14** or **15** may be arranged on opposite sides of the shell if desired, it is to be understood that the illustrated location of the flange connectors as well as the first fluid flow direction through the exchanger is for illustrative purposes and is not to be considered as a limiting feature. Also, it is to be noted that end cap **12** is provided with a central opening **18** to which a suitable exhaust or outlet tube may be carried for handling recirculation of a second fluid flow. It is to be understood that the end cap carried on the opposite end of the housing or shell **11** from the end shown is similarly provided with means for carrying an inlet pipe for introduction of the second fluid to the enclosed tube bundle.

Referring now in detail to FIG. **2**, it can be seen that the general design of the heat exchanger is equivalent to a conventional "fixed tubesheet" heat exchanger in which the first fluid is introduced via inlet flange connector **15** and circulated past a tube bundle or unit and which is then exhausted or returned to the reservoir via outlet flange connector **14**. The second fluid is introduced via end cap **12'** through its central opening **18'** to the forward end of a plurality of tubes, as indicated collectively by numeral **20** comprising the tube bundle. The forward ends of the plurality of tubes are fixedly connected to a forward tubesheet **21** which comprises an annular ring having a pair of parallel grooves formed in the external surface thereof for seating a pair of elastomeric seals **22** and **23** known in the trade as "**0**" rings. The inside diameter or surface of the annular ring holds a circular disc **24** retained within an annular groove and the forward ends of the tubes are fixedly carried thereon.

The rearmost ends of the tube **20** comprising the tube bundle are similarly mounted and fixed to a rear tubesheet **25** identical to the construction immediately described with respect to tubesheet **21**. In this manner, it can be seen that the tube bundle forms a unit comprising a plurality of tubes **20** having their opposite ends joined to a forward tubesheet **21** and a rear tubesheet **25** whereby the tube bundle forms a unit readily slidable within the inside wall diameter or bore of the housing **11**. The rear end of the heat exchanger is closed by cap **12** and is illustrated in FIG. **2** as having a suitable pipe or conduit **26** welded to a flange intermediate connector **27** so as to be carried on the cap **12** and projecting upwardly therefrom. In a manner similar to the tubesheets, both caps **12** and **12'** include a pair of elastomeric seals **28** and **29** which may be referred to as conventional O-rings.

In order to achieve an optimum coefficient of heat transfer within the shell **11**, a plurality of baffles, such as indicated by numerals **30**, **31** and **32**, are used to modify shell side flow conditions. Inasmuch as the configuration shown in FIG. **2** is an equivalent of a single pass shell heat exchanger, fluid enters via connector **15** of the shell, distributes itself across the tube bundle, and flows slowly, generally parallel to the tubes (without baffles) to the outlet end via tube or connector **14**. There would be a minimum of "wiping" action against the heat transfer surface without baffles. There would also be a tendency to by-pass the tube bundle along the path of least resistance. However, by incorporating the baffles **30–32**, velocity is greater, flow is more turbulent and "wiping" action is increased as the fluid sweeps from side to side or from top to bottom along the tubes **20**. By-pass areas are minimized.

The pair of end caps **12** and **12'** are retained in position at the opposite ends of the shell **11** by means of snap-lock retainers **33** and **32** located near the terminating ends of the shell respectively. The snap-lock retainers are releasably secured to the respective ends of the shell by means of an annular groove formed on the inside wall surface of the shell bore. Therefore, it can be seen that when the U-shaped retainers are compressed inwardly, the retainers may be inserted into the inner diameter of the shell bore and that when released, the retainers will forcibly expand outwardly into the respective grooves. Inasmuch as the retainers project into the bore of the shell **11**, the end caps will bear against the inside surface of the retainers and therefore will be prevented from leaving the bore of the shell. In order to prevent axial movement of the tube bundle as well as to forcibly urge the end caps against their respective retainers, a forward and a rearward resilient means is provided which is expandably disposed between the opposing surfaces of the end caps and their respective tubesheets. As is presently illustrated, a forward radially expanding sleeve **35** is shown with a slot **36** formed therein so as to be normally fabricated with an outwardly directed bias. Upon inward compression of the sleeve **35**, the sleeve may be inserted into the bore of shell **11** and permitted to outwardly expand when released so as to forcibly urge with the wall surface defining the shell bore. The width of the sleeve **35** is dimensioned so as to fully occupy the area between the end cap and the tubesheet. It is to be understood that a rear sleeve **37** is provided which is identical to the forward sleeve **35**. It is also to be understood that although outwardly expanding split sleeves **35** and **37** are illustrated, other resilient means may be provided such as springs of either the coil or leaf type.

Referring now to FIG. **3**, it can be seen that the tubesheet **24** carries one end of the plurality of tubes **20** and it is unnecessary for the purpose of the present invention to define a particular geometry at which the terminating end of the tubes are disposed. It is also to be noted in this FIGURE, that the expandable retainer **34** is of the split-ring type having opposing ends **40** and **41** which form apertured lobes into which a suitable tool, such as pliers, may be inserted for use in opening and closing the retainer during assembly or disassembly.

Therefore, it can be seen that the embodiment shown in FIGS. **1–3** inclusive forms a novel heat exchanger construction in which the tube bundle may be readily inserted into the bore of the shell **11** and may be slid into position via the sealing rings carried on the forward and rear tubesheets. Once the tube bundle has been approximately disposed within the shell, the spacers or sleeves **35** and **37** may be inserted through the openings on the respective ends of the shell followed by the slidable insertion of the tube caps **12** and **12'**. Insertion of the tube caps is assisted by the sealing rings **28** and **29** and the caps are forced into abutting relationship with the opposing sides of the sleeves **35** and **37**, respectively. Next, the expandable retainers **33** and **34** are expanded into their respective grooves formed in the inside wall surface of the shell so that assembly is completed. Again, it is to be understood that any suitable inlet or outlet conduit may be attached to the respective end caps **12** and **12'** and it is to be again understood that the inlet and outlet flanged connectors **14** and **15** carried on the shell **11** may be placed on the same side of the shell as illustrated or may be placed 180° apart depending on the requirement of the heat exchanger application.

Referring now to FIG. **4**, another embodiment of the present invention is shown which is an equivalent of the conventional U-tube heat exchanger which is known as a multi-pass design since the fluid must traverse the bundle at least twice. Since the present invention incorporates a modular component concept for constructing heat exchangers or other process equipment having a variety of applications, similar and identical components noted in connection with the fixed tubesheet design of FIG. **1** will employ the same identification characters or numbers. The same numbers will be employed where the parts are identical and therefore, it will be more readily understood that the concept of employing modular components is novel. In connection with FIG. **4**, tube shell **11** is identical as well as the tube bundle except for the removal of the centermost tube in the bundle or unit. The tubesheets **21** and **25** are identical as well as the sealing means therefor and the releasable retainers **33** and **34** are identical. The resilient means or sleeves **35** and **37** are the same and the manner of construction or assembly is identical to that previously described. However, the end caps or pieces are substantially different. It is to be noted that a rear end cap **42** is a solid disc while the forward end cap **43** incorporates an inlet opening **44** and an outlet opening **45**. Also, a separating member **46** is disposed or carried between the opposing surfaces of the forward tubesheet and the forward end cap so as to divide the forward chamber into an inlet chamber and an outlet chamber in fluid communication with inlet **44** and outlet **45**, respectively. By this means, it can be seen that a U-shaped circular flow of the second fluid is effected whereby the fluid is initially introduced into the inlet chamber via the inlet **44** and then into a first plurality of tubes indicated collectively by numeral **47** and expelled into an intermediate chamber defined between the opposing surfaces of rear end cap **42** and the rear tubesheet **25**. The pressurized fluid is then forced into a second portion of tubes collectively indicated by numeral **48** which carry the fluid into an exit chamber defined on the other side of separator **46** between the opposing surfaces of end cap **43** and tubesheet **21** for exit through the outlet **45**. Therefore, it can be seen by simply selecting the majority of components from stock, either a multi-pass or single pass heat exchanger can be provided and by changing the end caps with inclusion or exclusion of the separator **46**, either of the aforementioned types of exchangers is produced.

By the same token, it is possible to incorporate floating tubesheets by eliminating either resilient means **35** or **37** respectively. For example, if the sleeve **37** were to be left out, then the rear tubesheet **25** would be free to axially expand and contract in accordance with various thermal differentials encountered during exchanger operation. By means of the seals carried about the periphery of the rear tubesheet, the rear end of the tube bundle is permitted such axial movement.

In many instances, the material for use in a heat exchanger is important. Selecting materials of construction for a particular heat exchanger application depends primarily upon how corrosive the liquid to be handled will be under given process conditions. In most instances, this information will be readily available and known. In instances where a polar, or electrolytic liquid is involved, the choice of materials is difficult to ascertain in that some materials are less expensive than others and consequently, from a competitive position, it is desired to use materials of less cost, while in other instances depending upon the fluid, more expensive materials must be employed. By means of the modular concept of assembly, the present invention provides and promotes the use of different materials in as many of the same constructions as possible so that the cost of the exchangers may be reduced. An example of this assembly construction is shown in FIG. **5** in which an elongated cylindrical shell **50** is provided for housing a plurality of tubes, such as collectively indicated by numeral **51**, terminating in a rear tubesheet **52** as previously described. End cap **53** is employed which in the present instance includes an outlet opening **54** such as is used in connection with an application for a single pass exchanger. However, it is to be understood that an end cap, such as indicated by numeral **54** in FIG. **4**, may be employed in the event a multi-pass exchanger is contemplated. Similarly, resilient sleeve **55** and rear retaining snap ring **56** are identical to those previously described. However, it is to be noted that the rear elements of the exchanger, namely, tubesheet **52**, sleeve **55**, end cap **53** and snap retainer **56** are located in the reduced bore of an endpiece **60** which is fixedly attached to the extreme end of the shell **50** by means of a weld **61**. In this manner, the material of the shell **50** may be substantially different from the material of the endpiece **60**. This is possible since the first fluid to be circulated about the tube bundle need be compatible with the materials of both shell **50** and endpiece **60** while the second fluid carried by the tubes **51** and introduced into the rear chamber for exit through the outlet **54** need only be compatible with the material composing endpiece **60**. Consequently, in the event the material compatibility of endpiece **60** requires an expensive composition, the composition of the shell **50** may be composed of less expensive material and therefore a tremendous cost saving is produced.

Furthermore, the tube bundle terminating in end tubesheet **52** as well as rear sleeve **55** and rear cap **53**, may be wedged or force fitted into the reduced bore of the endpiece **60** so as to effect a sealing relationship therewith. The bore of shell **50** may be much larger so that the tube bundle may be readily slid or insertably passed through the body of the shell **50** before encountering the interference relationship with the reduced diameter bore of the endpiece **60**. The reduced diameter bore of the endpiece is provided with an inwardly tapered entrance **62** so that the rear tube sheet **52** may be readily forced into its interference fit therewith. Even in the event that the shell **50** and the endpiece **60** are composed of the same material, a feature resides in providing shells which are of a standard diameter and yet which may be provided with endpieces having a different size diameter for assembly purposes or for any special applications. For example, the endpiece may be provided with a suitable flange adapted to be bolted to a fixture or the endpiece may be of a cylindrical design as illustrated. In any event, the main shell **50** may be used in either application.

In view of the foregoing, it can be seen that a variety of heat exchanger configurations and constructions may be provided by incorporating similar preformed components which may be judiciously selected and combined to provide a specific construction. For example, single pass and multi-pass heat exchangers are constructed from substantially identical components.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. In a process apparatus assembled from prefabricated components selectively chosen from a plurality of modular components, the combination comprising:

an elongated cylindrical shell having a central bore extending therethrough;

a tube bundle disposed with said bore of said shell so as to leave an exposed region of said bore at each of its opposite ends;

closure means carried in each of said exposed regions and releasably secured to said shell;

means for introducing a first fluid to said tube bundle for providing a flow path through said tube bundle;

means in fluid communication with said bore for recirculating a second fluid about said tube bundle between the opposite ends of said tube bundle;

each of said closure means including an end cap insertably disposed in said bore;

a spacer disposed between said end cap and said tube bundle so as to define a chamber between the opposing surfaces of said end cap and said tube bundle for accommodating recirculation of said first fluid through said tube bundle; and

a snap-lock retainer cooperatively disposed between said end cap and said shell for releasably retaining said closure means and said tube bundle in a fixed location within said shell bore.

2. The invention as defined in claim **1** including

a tubesheet fixed to the extreme terminating ends of the tubes in said tube bundle so as to hold the tubes in fixed spaced apart parallel relationship.

3. In a process apparatus assembled from prefabricated components selectively chosen from a plurality of modular components, the combination comprising:

an elongated cylindrical shell having a central bore extending therethrough;

a tube bundle disposed with said bore of said shell so as to leave an exposed region of said bore at each of its opposite ends;

closure means carried in each of said exposed regions and releasably secured to said shell;

means for introducing a first fluid to said tube bundle for providing a flow path through said tube bundle;

means in fluid communication with said bore for recirculating a second fluid about said tube bundle between the opposite ends of said tube bundle;

a tubesheet fixed to the extreme terminating ends of the tube in said tube bundle so as to hold the tubes in fixed spaced apart parallel relationship;

each of said closure means including an end cap;

a resilient means separating said end caps from said respective tube sheets so as to define chambers permitting recirculating flow of said first fluid through said tube bundle; and

snap-lock retainer means releasably carried on said shell for immobilizing said tube bundle, end caps and resilient means from axial movement within said bore.

4. The invention as defined in claim 3 including

sealing means carried on each of said tubesheets to prevent communication of said central chamber with said other chambers; and

additional sealing means carried on said end caps to prevent communication of said other chambers exteriorly of said shell bore.

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