March 23, 1971 H. O. CHARNOCK, JR 3,572,430

FLOATING HEAD HEAT EXCHANGER

Filed April 1, 1969

FIG. 2

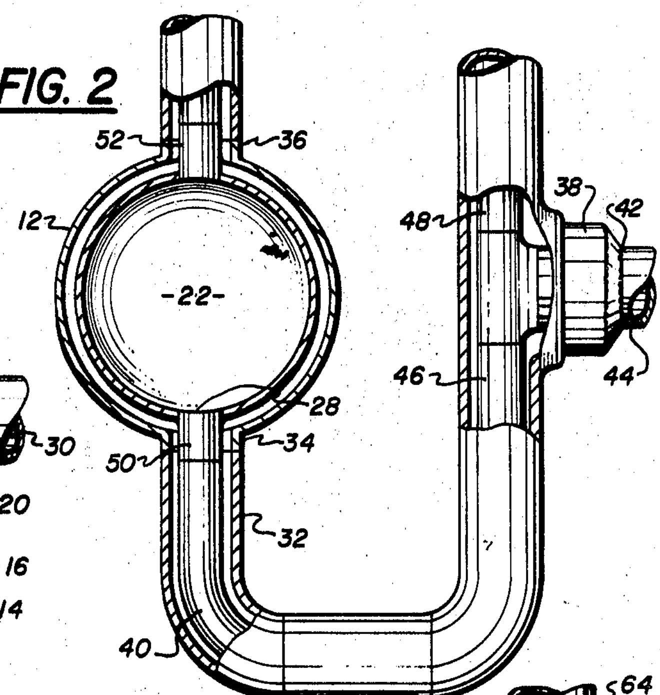
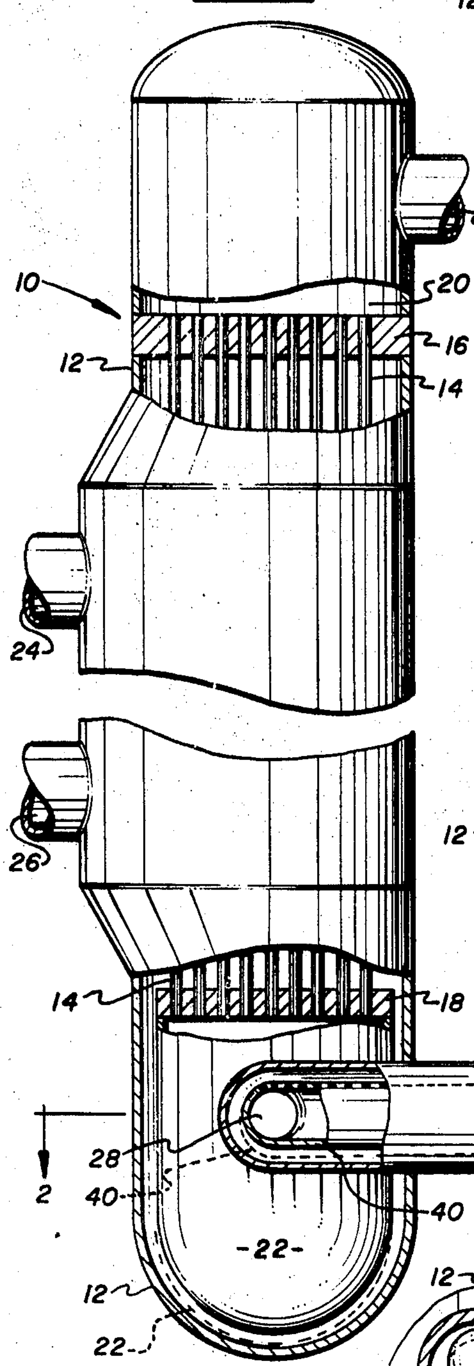


FIG. 1



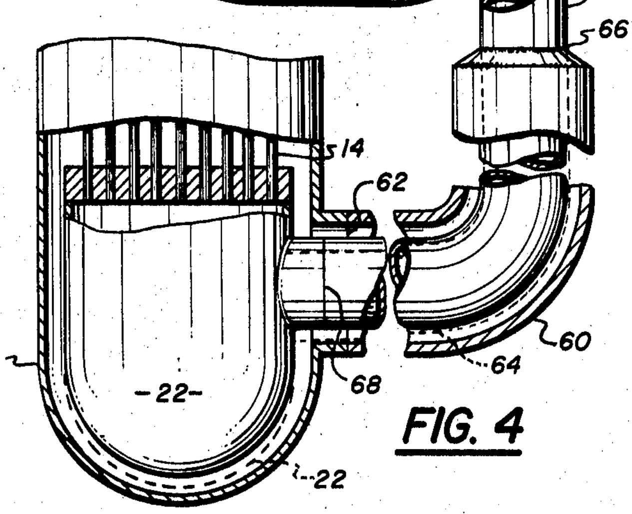


FIG. 4

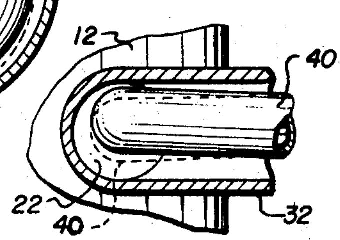


FIG. 3

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FLOATING HEAD HEAT EXCHANGER

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ABSTRACT OF THE DISCLOSURE

A shell-and-tube heat exchanger which experiences differential expansion between the shell and tubes where the exchanger has a floating head that cooperates with a double-pipe mechanical joint which compensates for any differential motion between the floating head and the stationary shell.

BACKGROUND OF THE INVENTION

A heat exchanger is a device that transfers heat from one system or medium to another by thermal coupling, i.e., by conduction, by convection, and by radiation, or any combination thereof.

One type of known heat exchanger, a shell-and-tube heat exchanger, has spaced-apart tube sheets and headers that support the opposite ends of a bundle of tubes, all contained within an outer shell. In transferring heat between two fluids, one fluid usually enters the shell at one end, contacts the outer surfaces of the tubes, and discharges from the other end of the shell, or at the same end, determined by whether a single pass or multi-pass shell-side flow is used. The second fluid, in a single pass counter flow arrangement, flows from one header through the tubes in a flow direction countercurrent to the direction of the first fluid and discharges at the other header end. Since the tubes can be formed from a different metal than the shell and normally experience a temperature different than the shell during operation, the differential thermal expansions or contractions between the shell and tubes can result in excessive thermal stresses. This has led to the development of floating head heat exchangers.

In a floating head heat exchanger, one header is connected to the shell while the other header is permitted to "float" within the shell. The slidable movement, i.e., displacement, of the floating head as the tube bundle expands or contracts relieves excessive stresses and strains between the shell and tubes during operation.

Mechanical pipe connections to the floating head must compensate for the displacement of the floating head without placing excessive stresses and strains on the vessel wall, nozzle connections, and on the external piping system. Known floating head heat exchangers use conventional expansion joints, packing joints or flexible "pancake" joints in single pass heat exchangers, but these expansion joints are relatively unreliable and can develop a leak path between the two fluids. When one of the two fluids is a liquid metal, such as sodium, and the other fluid is water, any leak path that develops through an unreliable mechanical joint can result in a possible interaction between the sodium and water. Such a sodium-water interaction can generate an overpressure condition that can result in the physical destruction of the heat exchanger, and possibly in the destruction of the system in which the heat exchanger finds use.

OBJECTS OF THE INVENTION

Accordingly, it is an object of the invention to provide a new and improved mechanical joint particularly for a floating-head heat exchanger.

It is an object of the invention to provide an improved mechanical joint for a floating-head heat exchanger.

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It is an object of the invention to provide a mechanical joint having a mechanical integrity substantially equal to that of the vessel walls.

It is an object of the invention to provide a mechanical joint permitting flexure and minimizing the possibility of leakage, thereby maximizing reliability.

It is an object of the invention to provide a mechanical joint compatible with conventional piping systems.

SUMMARY OF THE INVENTION

Briefly, in accordance with one form of the invention, a new and improved mechanical joint for a shell-and-tube heat exchanger having a floating head is provided where the mechanical joint is a double-pipe arrangement (outer pipe enclosing an inner pipe) that compensates for any displacement of the floating head in relation to the shell. The outer pipe is connected to the shell of the heat exchanger and to the inner pipe at a point spaced from the shell, while the inner pipe is positioned within the outer pipe and connected between the floating head and an external piping system. Any displacement of the floating head is compensated by torsion or bending, or both, of the inner pipe within the boundaries of the outer pipe without placing excessive stresses on the tube bundle, the double-pipe mechanical joint, and on the external piping system.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which may be regarded as the invention, the organization and method of operation, together with further objects, features, and the attending advantages thereof, may best be understood when the following description is read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an elevation, partly sectional and partly broken away of one improved mechanical joint of the invention for a floating-head heat exchanger;

FIG. 2 is a sectional view, partly broken away, along the line 2—2 of FIG. 1;

FIG. 3 is a partial view, partly broken away, of one modification of the mechanical joint of the invention for a floating-head heat exchanger; and

FIG. 4 is an elevation, partly sectional and partly broken away, of another modification of the mechanical joint of the invention for a floating-head heat exchanger.

DESCRIPTION OF THE INVENTION

A shell-and-tube heat exchanger **10**, as shown by FIG. 1, has a cylindrical shell member **12** with closed ends that contains a bundle of similar tubes **14** positioned between and metallurgically joined to a fixed tube sheet **16** and a movable or floating tube sheet **18**. Tube sheet **16** forms a part of outlet header **20** while tube sheet **18** forms a part of inlet header **22**. Inlet header **22** is a floating header, i.e., slidable within the shell **12** as the tube bundle **14** expands or contracts.

In the heat exchanger **10**, a first fluid, which can be a liquid metal such as sodium (Na), passes through the shell **12** from a shell inlet port **24** to a shell outlet port **26**. A second fluid, which can be water, sodium, or another fluid, passes through the tube bundle **14** from a header inlet port **28** to a header outlet port **30**. The heat exchanger **10** is therefore a countercurrent (first and second fluids pass in opposite directions) and a single pass (each of the fluids pass through the heat exchanger once) shell-and-tube heat exchanger with a floating head.

One form of floating-head heat exchanger has a double-pipe or conduit mechanical joint connected to header inlet port **28** of the heat exchanger **10**, as shown by FIGS. 1 and 2. The improved mechanical joint of my invention absorbs any differential motion between the tube bundle **14** and the shell member **12**.

The mechanical joint of FIGS. 1 and 2 has a generally C-shaped outer housing pipe **32** that is metallurgically joined to the shell member **12** at ends **34** and **36**, and an outer pipe intermediate stub portion **38** that is metallurgically joined to an inner displacement pipe **40** positioned within the outer pipe at joint **42**; all joints preferably leak-tight welds. Inner pipe **40** is connected to an external second fluid source (not shown) through an intermediate tube **44**. Inlet pipe **40** has separate branches **46** and **48** that extend through the C-shaped outer pipe **32** and are metallurgically joined to the floating header **22** at ends **50** and **52**, preferably by leak-tight welds.

The neutral position of the floating head **22** and the inner pipe **40** is shown by the solid lines of FIG. 1 as being generally concentric with the outer pipe **32**. When the tube bundle **14** expands or contracts, the floating head **22** and the inner pipe **40** are displaced. As the floating head **22** is displaced, for example to the position as shown by the dashed lines of FIG. 1, the inner pipe **40** is displaced from the concentric neutral position to the dashed eccentric position within the outer pipe **32**. The displacement of inner pipe **40** compensates for the displacement of the floating head **22** without affecting the leak tight integrity of the joint **42** that connects the outer pipe intermediate stub portion **38** to the intermediate tube portion **44** of the inner pipe **40**. The displacement of inner pipe **38** is generally limited by the internal dimensions of outer pipe **32**. The improved heat exchanger mechanical joint as shown by FIGS. 1 and 2 thereby compensates for displacement of the floating header **22** primarily through torsional loading; however, the compensation can also include bending, or the like. It is contemplated that the displacement can be of the outer pipe only, or can also be of both the inner and outer pipes so that any relative motion between the tube bundle and the shell member is thereby compensated. Because the improved mechanical joint compensates for any displacement of the header, the intermediate tube portion **44** (which is the outer continuation of the inner pipe **40**) can be connected to a conventional piping system wherein the heat exchanger **10** finds use without introducing transferred stresses and strains to the external piping system.

The neutral position of the floating head **22** and the inner pipe **40** can also be as shown by the solid lines of FIG. 3 where the inner pipe **40** is positioned generally eccentric within the outer pipe **32**. When the tube bundle **14** expands or contracts, the floating head **22** and the inner pipe **40** are displaced. The floating head slides within the shell **12** generally parallel with the imaginary longitudinal axis as defined by the shell **12** and the tube bundle **14**. As the floating head **22** is displaced, the inner pipe **40** is displaced from the eccentric neutral position to the dashed eccentric position within the outer pipe **32**.

FIG. 4 shows another form of an improved floating-head heat exchanger having a double-pipe mechanical joint. The same reference numerals are used to indicate corresponding parts previously described in FIGS. 1 and 2.

The double-pipe mechanical joint as shown by FIG. 4 absorbs any differential motion between the tube bundle **14** and the shell member **12** primarily through bending which compensates for any displacement of the floating header **22**. A single, generally L-shaped outer pipe **60** is metallurgically joined to the shell member **12** at end **62**, and to an inner pipe **64** at joint **66**; again all the joints are preferably leak tight welds. Inner pipe **64** is similarly metallurgically joined to the floating header **22** at port end **68**.

The neutral position of the floating header **22** and the inner pipe **64** is shown by the solid lines of FIG. 4. Although shown as being generally concentric within the outer pipe **60**, it is contemplated that the inner pipe **64** can be eccentrically positioned within the outer pipe. As

the floating header **22** is displaced, for example to the position as shown by the dashed lines of FIG. 4, a bending moment is placed on the inner pipe **64** which displaces the inner pipe to the dashed position within the outer pipe **60**. The displacement of the floating header **22** is absorbed by the double-pipe mechanical joint without affecting the leak-tight integrity of the joint **66** that connects the outer pipe **60** to the inner pipe **64**. Again, it is contemplated that the displacement can also be of the outer pipe alone, or of both the inner and outer pipes so that any relative motion between the tube bundle and the shell member is compensated.

As will be evidenced from the foregoing description, certain aspects of the invention are not limited to the particular details of construction as illustrated, and it is contemplated that other modifications and applications will occur to those skilled in the art. It is, therefore, intended that the appended claims shall cover such modifications and applications that do not depart from the true spirit and scope of the invention.

I claim:

1. An improved floating-head heat exchanger comprising:

(a) cylindrical shell means having closed ends,
(b) port means in said shell means,
(c) tube bundle means extending in generally parallel relation to and within said shell means,
(d) at least first and second tube sheet means metallurgically joined to and spaced apart by said tube bundle means,
(e) said first tube sheet means connected to said shell means and said second tube sheet means slidable within said shell means,
(f) said first tube sheet means and said shell means defining a fixed head,
(g) port means in said fixed head,
(h) header means connected to said second tube sheet means and movable therewith,
(i) said second tube sheet means and said movable header means defining a floating head,
(j) port means in said floating head; and
(k) conduit means developing a mechanical joint and passing at least a first fluid, said conduit means connected to said floating-head port means and to an associated one of said shell port means thereby compensating for any differential motion between said floating head and said shell means.

2. The heat exchanger of claim **1** in which said conduit means includes:

(a) outer tube means having at least first and second ends,
(b) said outer tube first end connected to an associated one of said shell port means so that a first fluid passing through said shell means passes through said outer tube means, and
(c) inner tube means positioned within said outer tube means, said inner tube means having at least first and second ends extending through respective ones of said outer tube first and second ends,
(d) said inner tube first end connected to an associated one of said floating-head port means so that a second fluid passing through said floating head and said tube bundle means passes through said inner tube means,
(e) said outer tube second end connected to said inner tube means generally adjacent said inner tube second end so that any differential motion between said floating head and said shell means is compensated by the displacement of said tube means.

3. The heat exchanger of claim **2** in which said displacement is of said inner tube means within said outer tube means.

4. The heat exchanger of claim **2** in which said displacement is of said outer tube means relative to said inner tube means.

5. The heat exchanger of claim 2 in which said displacement is of both said inner and outer tube means relative to each of said tube means.

6. The heat exchanger of claim 2 in which said conduit means includes:

(a) an intermediate stub means extending from said outer tube means between said outer tube first and second ends,

(b) said outer tube first and second ends connected to associated ones of said shell port means,

(c) said inner tube first and second ends extending through respective ones of said outer tube first and second ends and connected to associated ones of said floating-head port means, and

(d) an intermediate tube means extending from said inner tube means and through said intermediate outer tube stub means,

(e) said intermediate stub means connected to said intermediate tube means by a fluid-tight connection.

7. The heat exchanger of claim 2 in which said inner tube means is eccentrically located in a neutral position within said outer tube means with displacement of said inner tube means during any differential motion generally limited by said outer tube means.

8. The heat exchanger of claim 2 in which said inner tube means is concentrically located in a neutral position within said outer tube means with displacement of said inner tube means during any differential motion generally limited by said outer tube means.

9. The heat exchanger of claim 2 in which said first fluid and said second fluid are substantially identical and have similar heat transfer properties.

10. In a floating-head heat exchanger wherein a generally cylindrical shell contains a bundle of tubes positioned between and metallurgically joined to a fixed tube sheet connected to the shell and to a movable tube sheet header that is slidable within the shell, the movable tube sheet header having at least a first port associated with a first shell port, the combination thereof with the heat exchanger of an improved mechanical joint comprising:

(a) outer housing tube having at least first and second ends,

(b) said outer tube first end connected to said first shell port so that a fluid passing through the shell passes through said outer housing tube,

(c) inner displacement tube positioned within said outer housing tube, said inner tube having at least first and second ends extending through respective ones of said outer tube first and second ends,

(d) said inner tube first end connected to the movable tube sheet-header port so that a fluid passing through the bundle of tubes passes through said inner tube,

(e) said outer tube second end connected to said inner tube generally between said inner tube first end and said inner tube second end by a substantially fluid-tight connection so that any differential motion between the movable tube sheet-header and the shell displaces said inner tube within said outer tube and the torsion or bending or both of said inner pipe within said outer pipe compensates for said displacement.

11. In the floating-head heat exchanger of claim 10 wherein the movable tube sheet-header has at least first and second ports associated with at least first and second shell ports, the mechanical joint includes:

(a) an intermediate stub portion extending from said outer tube between said outer tube first and second ends,

(b) said outer tube first and second ends connected to associated ones of the first and second shell ports,

(c) said inner tube first and second ends extending through respective ones of said outer tube first and second ends and connected to associated ones of the movable tube sheet-header first and second ports, and

(d) an intermediate tube extending from said inner tube and through said intermediate outer tube stub portion,

(e) said intermediate stub portion connected to said intermediate tube by a substantially fluid-tight connection.

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U.S. Cl. X.R.

165—159