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D. S. JACOBUS

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METHOD OF MAKING FLUID HEAT EXCHANGE APPARATUS

Original Filed Nov. 20, 1934

Fig. 1

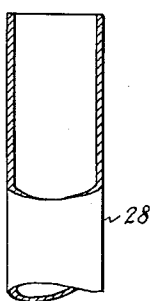


Fig. 2

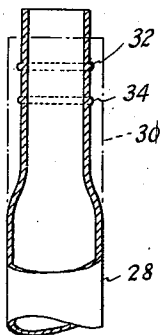


Fig. 3

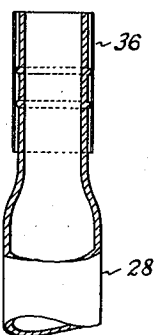


Fig. 4

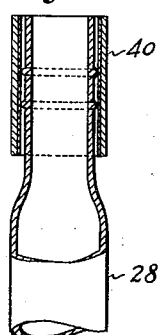


Fig. 5

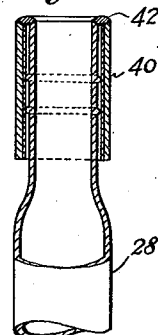


Fig. 6

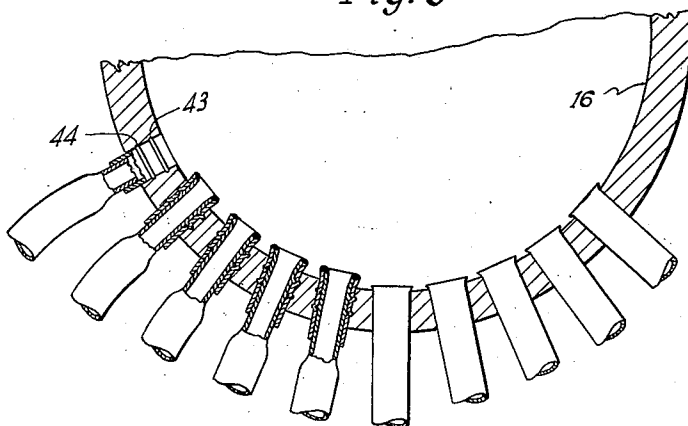


Fig. 9

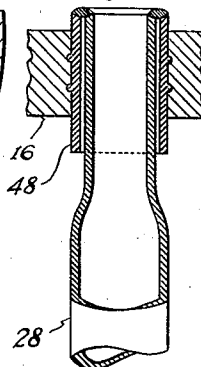


Fig. 8

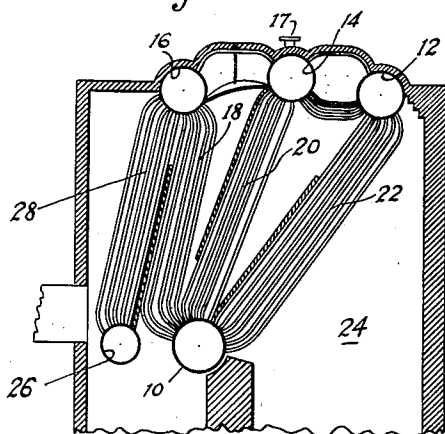
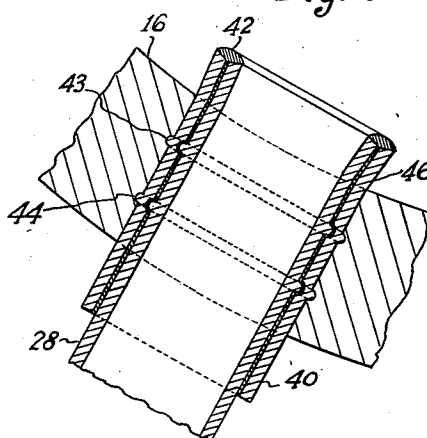


Fig. 7



INVENTOR
David S. Jacobus
BY *Barry R. Newcomb*
ATTORNEY

UNITED STATES PATENT OFFICE

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METHOD OF MAKING FLUID HEAT
EXCHANGE APPARATUS

David S. Jacobus, Montclair, N. J., assignor to
The Babcock & Wilcox Company, Newark,
N. J., a corporation of New Jersey

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12 Claims. (Cl. 29—157.4)

This invention is predicated upon improvements in metallic tubular structures, and it is exemplified herein by tubular connections employed in fluid heat exchange apparatus.

When, in such apparatus, a fluid at one temperature passes through tubes to a metallic vessel at a higher temperature, experience has shown that the consequent differential metal expansions soon cause defects in the connections between the tubes and the metal of the vessel. This is especially true of economizer tubes connected to the drums of steam boilers operating at high fluid pressures.

It is an object of the invention to overcome this disadvantage.

A further object is to provide a Stirling boiler with an integral economizer the tubes of which are joined to a feed-water drum in accordance with the teachings of this invention.

Other objects will appear from consideration of the following description of the Stirling water tube steam boiler shown in the accompanying drawing, in which:

Figs. 1-5 inclusive are detail sections indicating different steps of a method which may be employed in practicing the invention.

Fig. 6 is a vertical section through a boiler drum having tubes connected thereto.

Fig. 7 is a section showing a tubular drum connection.

Fig. 8 is a view in the nature of a vertical section, showing a Stirling boiler having an integral economizer.

Figure 9 is a sectional view.

The drawing discloses a Stirling boiler including the mud drum 10 and the upper steam and water drums 12, 14 and 16, the first of which is provided with a steam off-take 17. The latter drums are connected to the mud drum by separate banks of steam generating tubes 18, 20 and 22, exposed in separate gas passes to furnace gases from the combustion chamber 24.

Feed water is supplied from any suitable source to the economizer drum 26 which is connected to the rear drum 16 by the economizer tubes 28 located in the last gas pass of the boiler. Although the temperature of the feed water is raised during its movement through these tubes it may be at a temperature much less than the temperature of the drum 16 when it enters the latter. The tubes 28 therefore tend to contract relative to the metal of that drum, causing a loosening of the tubes when they are directly expanded into the drum. Furthermore, this undesirable condition is aggravated by the continued supply of low tem-

perature fresh feed water to the drum 26 and the continued circulation through the drum 16 of water which has been heated to a higher temperature by the tubes 22 in the hottest gas pass. Such circulation takes place through the drum 10 which directly connects the banks of tubes 18 and 22.

When it is considered that many boilers of the type shown operate at fluid pressures in excess of 1000 lb. per sq. inch it will be readily appreciated that any loosening of the tubes 28 in their seats in the drum 16 is apt to be a matter of no small moment. As a matter of fact, experience has shown that such results are grave disadvantages in boilers operating at much lower pressures. This is particularly true when the boilers are operated at 300 to 500% ratings. The water level in the drum 16 is apt to be below the upper ends of some of the tubes 28. The connections of these tubes with the drum are then apt to become loosened so that steam leaks develop. It finally becomes necessary to take the boiler off the line for repairs, and if the tubes are merely re-expanded into the drum, the same cycle is repeated. To avoid this excessive "outage" the economizer tubes are connected to the drum 16 in the manner described below.

The end of a tube 28 is first swaged to produce a portion of smaller diameter. This is indicated by the full lines in Fig. 2, comparison with the dotted lines 30 of this figure indicating the effect of the swaging operation. There is, of course, a lengthening of the tube, and circumferential external ribs 32 and 34 may also be formed during the swaging. The swaging of the tubes makes it possible to use wider ligaments between the tubes and allows a higher pressure to be carried for a given thickness of drum shell. In constructions other than the Stirling boiler shown it is sometimes preferable to refrain from swaging down the ends of the economizer tubes where they are connected to the steam and water drum.

As the next step in the illustrative procedure a sleeve 36 is telescoped upon the swaged end of the tube. When this sleeve is of the internal diameter shown it fits tightly upon the ribs 32 and 34 and is held in position thereby, spaced from the exterior surface of the tube. It is preferably formed of some self-supporting material, and, under different embodiments of the invention the material may be paper, or a metal having a low fusing temperature. Low fusing point alloys may be used in some instances, and in others, a cellular heat insulating material.

Tin and lead are examples of metals which may be used.

In the illustrative method, a tubular metallic ferrule 40, preferably of the same material as the tube, is tightly telescoped over the sleeve 36. This may be done in some cases before the sleeve is placed in the position shown in Fig. 3, but the particular sequence of these acts depends upon the sequence of the remaining method steps, as well as upon the materials used.

The sleeve 36 and the ferrule 40 both terminate coincidentally with the tube to facilitate the completion of the circumferential weld 42 which forms a fluid tight connection between the tube and the ferrule but the invention also contemplates the extension of the tube beyond the ferrule in some cases. The tube is now ready to be held within a tube seat in the drum 16 while an expander is operated within the tube to form a rigid and fluid tight drum connection. When the circumferential grooves 43 and 44 are formed as parts of the tube seat, the expanding operation will cause some of the metal of the ferrule to occupy the grooves to lock the ferrule more securely to the drum. Fig. 7 shows the grooves to be entirely filled with such metal. The expanding operation may also result in such a bell-ing of the end of the tubes as indicated at 46 in Fig. 7. This further locks the ferrule to the drum and tends to prevent any endwise movement of the ferrule.

In some embodiments of the invention the ferrule 40 may be separately expanded against the tube seats, and the tubes thereafter co-axially placed within and spaced from the ferrules so that the circumferential welds may then be completed. In these cases the ferrules may be additionally welded directly to the drum metal, and this welding as well as the expanding of the ferrules may be done in the shop where the drum is manufactured. This promotes economy of manufacture by reducing erection costs.

When the boiler is put into operation after a heat convertible material such as paper is used between the ferrule and the tube, the paper or the compound formed on heating the paper acts to insulate the main body of the ferrule from the tube. When tin, lead, or some low fusing point alloy is used as the sleeve, the latter melts when the boiler is placed in operation, leaving an annular space between the ferrule and the sleeve.

In some embodiments of the invention the ribs 32 and 34 may not be employed. The sleeve may fit the tube tightly throughout its length. Such an arrangement of elements is indicated in Fig. 9 of the drawing, wherein the ferrule 48 may be expanded into the drum in the shop and the tube thereafter inserted and welded to the inner end of the ferrule in the field. With this construction there is an annular space between the tube and the ferrule.

The construction may be used to advantage for connecting alloy steel superheater tubes to the outlet header of a superheater when the header is made of plain carbon steel. In such a case expanding the alloy steel tubes directly into the outlet header may result in leakage in a hydrostatic test of the superheater such as is usually made during a shutdown period after the superheater has been in service. The coefficient of expansion and contraction of the alloy steel on changing the temperature is greater than in plain carbon steel and, on cooling down the superheater after it has been in operation, the alloy steel tubes may leak where

they are expanded into the carbon steel headers. By employing ferrules of plain carbon steel around the ends of the alloy steel superheater tubes arranged in the way shown and described and extending the ferrules and tubes a sufficient distance into the header the difference in the expansion of the tubes and the ferrules will not cause the ends of the plain steel ferrules to become loose where they are expanded into the header as these ferrules will have the same coefficient of expansion as the header. This will overcome the tendency to leak on account of a difference in the coefficients of expansion. If desired, the ferrules may be welded to the header in which case it is advantageous to have the same coefficient of expansion in the ferrules as in the header. By welding the ferrules to the header on the outside of the header the stresses due to the expansion of the tubes and the ferrules would be distributed along the lengths of the ferrules thereby avoiding a concentration of stress due to the reinforcing action of the welding. The ferrules may be made of comparatively thin wall section because the tube ends would prevent them from collapsing.

What is claimed is:

1. In a method of forming a tubular connection, the steps of forming a tube seat in a drum, swaging the end portion of a steel tube to an outside diameter less than the diameter of the tube seat and simultaneously forming a plurality of external circumferential ribs on the swaged portion, tightly telescoping over the ribs a sleeve formed of a metal having a fusing temperature which is but a fraction of the fusing temperature of the metal of the tube, tightly telescoping a metallic ferrule over the sleeve, expanding the ferrule against the tube seat by action within the swaged down tube end, and exposing the entire structure to heat until the sleeve is fused so that there is a heat insulation space between the ferrule and the tube.

2. In a method of forming a tubular connection, the steps of forming a tube seat in a metallic structure, swaging the end portion of a steel tube to an outside diameter less than the diameter of the tube seat, tightly telescoping over the swaged portion a sleeve formed of a metal having a fusing temperature which is lower than the fusing temperature of the metal of the tube, tightly telescoping a metallic ferrule over the sleeve, expanding the ferrule against the tube seat by action within the swaged down tube end, and exposing the entire structure to heat until the sleeve is fused so that there is a heat insulation space between the ferrule and the tube.

3. In a method of forming a tubular connection, the steps of forming a tube seat in a metallic pressure part, swaging the end portion of a metallic tube to an outside diameter less than the diameter of the tube seat, telescoping over the swaged portion a sleeve formed of a metal having a low fusing temperature, tightly telescoping a metallic ferrule over the sleeve, joining the end of the tube and the ferrule by a circumferential weld, expanding the ferrule against the tube seat by action within the swaged down tube end, and exposing the entire structure to heat until the sleeve is fused and removed so that there is a heat insulation space between the ferrule and the tube.

4. In a method of forming a tubular connection, the steps of forming a tube seat in a drum, swaging the end portion of a steel tube to an outside diameter less than the diameter of the tube

seat, telescoping over the swaged portion a sleeve formed of a metal having a low fusing temperature, welding the inner end of the ferrule to the end of the tube to form a fluid tight joint, positioning the combined tube and ferrule in the tube seat with the inner end of the ferrule projecting inwardly of the drum beyond the tube seat, expanding the ferrule against the tube seat by action within the swaged down tube end, and exposing the entire structure to heat until the sleeve fuses and flows away to leave a heat insulation space between the ferrule and the tube.

5. In a method of forming a tubular connection, the steps of forming a tube seat in a thick walled steel pressure vessel for a high pressure and high temperature water tube steam boiler, the tube seat diameter being approximately of the order of the thickness of the vessel wall, positioning a tubular metallic ferrule of uniform internal diameter in the tube seat with its inner end beyond the tube seat and within the vessel, expanding the ferrule to secure it to the vessel, telescoping a tube within the ferrule with its inner end within the vessel and its outer surface being of uniform diameter and being spaced radially from the inner surface of the ferrule and welding the inner end of the ferrule to the tube while maintaining the annular spacing of the tube and the ferrule.

6. In a method of forming a tubular connection including a metallic ferrule, the steps of forming a tube seat in a drum, swaging the end portion of a steel tube to an outside diameter less than the inside diameter of the ferrule, tightly telescoping over the swaged portion a sleeve formed of paper, telescoping a metallic ferrule over the sleeve, expanding the ferrule against the tube seat by action within the swaged down tube end, and exposing the entire structure to heat until the sleeve is carbonized or burned away so that the heat insulation between the ferrule and the tube is increased.

7. In the formation of a tubular connection, the steps of telescoping a metallic ferrule externally over a tube with a spacer interposed relative to the ferrule and the tube, uniting the ferrule and the tube by a circumferential weld, expanding the combined structure of ferrule and tube against the walls of a tube seat in a pressure vessel, and subjecting the elements of the expanded connection to heat which so affects the spacer that the capacity of the combined structure for heat transfer from the ferrules directly to the tube is at least reduced.

8. In a method of forming a tubular connection,

the steps of telescoping a metallic ferrule over a tube with another metal of lower fusion point interposed relative to the ferrule and the tube, expanding the tube and ferrule against the walls of a tube seat, and heating the expanded structure to fuse said other metal and leave a heat insulation space between the ferrule and the tube.

9. In a method of forming a tubular connection, the steps of swaging the end portion of a metallic tube to an outside diameter less than the remainder of the tube, telescoping a metallic ferrule over the swaged portion with a low fusing point metal interposed, joining the tube and the ferrule by a circumferential weld near the end of the tube, expanding the ferrule and the tube against the walls of tube seat, and exposing the entire structure to heat until the sleeve becomes fused and flows out of position leaving an insulation space between the ferrule and the tube.

10. In a method of forming a tubular connection for a drum having tube seats therein, the steps of swaging the end portion of a steel tube to an outside diameter less than the diameter of the tube seat, telescoping over the swaged portion a ferrule with a low fusion point metal interposed, welding the ferrule to the tube to form a fluid tight joint, positioning the combined tube and ferrule in one of the tube seats with the inner end of the ferrule projecting inwardly of the drum beyond the tube seat, expanding the combined structure against the tube seat, and exposing the entire structure to heat until the sleeve fuses and flows away to leave a heat insulation space between the ferrule and the tube.

11. In a method of forming a tubular connection to a pressure vessel having tube seats formed therein, the steps of telescoping a metallic ferrule over a tube with compression resisting material of low heat conductivity interposed, and expanding the combined tube and ferrule structure against the walls of one of said tube seats with the structure extending inwardly of the vessel.

12. In the formation of a tubular connection and associating a vessel therewith, telescoping an external metallic ferrule and an internal tube with a circumferential spacer interposed relative thereto, establishing a fluid tight connection between the ferrule and the tube near the end of the latter, and heating the ferrule and the tube together with the associated vessel and thereby so affecting the spacer that the capacity of the combined structure for heat transfer from the ferrules directly to the tube is reduced.

DAVID S. JACOBUS.