

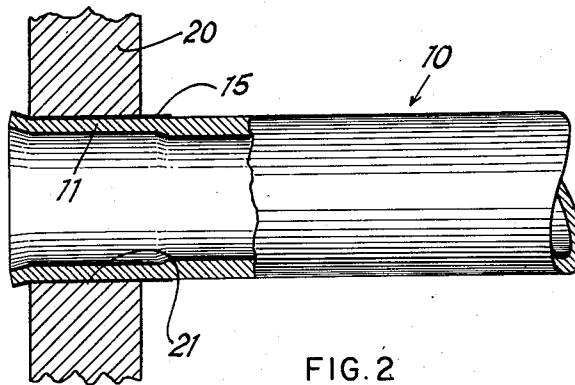
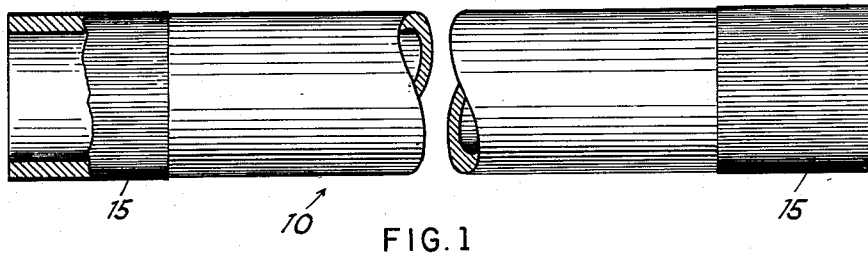
May 11, 1954

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2,678,224

SILVER PLATED TUBE ENDS FOR EXPANDED TUBE SEATS

Filed April 19, 1951



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2,678,224

SILVER PLATED TUBE ENDS FOR
EXPANDED TUBE SEATS

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Application April 19, 1951, Serial No. 221,820

5 Claims. (Cl. 285—56)

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This invention relates to pressure vessel constructions of the type comprising a pressure vessel, such as a drum or header, having one or more tubes or pipes connected thereto. More particularly, the invention is directed to such a construction in which the ends of the tubes are inserted through openings in the header or drum wall and the tube ends are then expanded to form pressure tight seats with the seating surfaces formed by the peripheries of such openings.

With the increasingly higher pressures and temperatures being used in modern highly efficient vapor generators, the problem of providing pressure tight joints between drums or headers and tubes becomes increasingly acute. The difficulties are encountered by virtue of the cyclically varying temperature and pressure conditions resulting from variations in load and output. As a result, stresses are developed in the interconnected members which tend either to loosen the joint or sometimes to result in failure of one or both interconnected elements.

The practical effects of such stress conditions resulting from the cyclical temperature and pressure variations can be substantially alleviated by making the interconnected members of the same material, whereby both members have substantially the same co-efficient of expansion and stress patterns under the temperature and pressure conditions encountered. At the higher temperatures, of 1000° F. or better, and higher pressures, of 1000 p. s. i. or better, used in the more modern vapor generators, particular attention must be given to the material of which the components are formed. The usual metals or alloys used with lower temperatures and pressures do not have the requisite strength and other characteristics to adequately withstand the stresses encountered at such higher temperatures and pressures, particularly under cyclically varying conditions.

Consequently, designers of such components have resorted to alloys of the so-called "stainless steel" type, such as 18-8, 25-20, and similar alloys. Generally, such alloys are used with a Cb addition and/or with a stabilizing element such as niobium or titanium to render them resistant to intergranular corrosion. However, when it is desired to form a pressure tight expanded joint between a tube of such high alloy material and a header of similar material, difficulty is experienced due to the relative hardness of such alloys, which mitigates against the requisite plastic deformation or flow of metal required to make a pressure tight joint.

Another problem encountered in such pressure vessel constructions is that of resistance to oxidation and corrosion, particularly at the tube seats. The oxidation and corrosion are particularly pronounced in the case of boilers in which the tube and tube sheet joints are subjected to the action of flue gases and boiling water. Oxi-

dizing and acidic conditions are created due to the action of the boiling water and the corrosive or acidic constituents of the flue gas.

It has been proposed to use copper liners on the tubes at the seating portions, to obtain a pressure tight joint and one which is more oxidation and corrosion resistant. However, with the higher temperatures and pressures involved in modern pressure vessel installations, the task of providing a pressure tight joint which is oxidation and corrosion resistant becomes increasingly more acute.

In accordance with the present invention, it has been found that a pressure tight joint, which is satisfactory at high temperatures and pressures and under cyclically varying pressure and temperature conditions, can be formed by covering the seating ends of the tubes with silver before the tube ends are inserted into the tube seats of the drum or header. When the tube ends are expanded against the tube seats, a pressure tight joint is formed between the tube seat and the tube end, the silver covering forming an intimate bond between the tube and tube seat. The silver is not only more resistant than copper to oxidation and corrosion at high temperatures, but also, under the tube expanding pressure, flows more easily and completely into the minutest irregularities in the contacting surfaces, having a flow characteristic, under pressure, considerably superior to that of copper. Expanded joints formed in this manner have been found completely satisfactory at temperatures as high as 1300° F. and pressures of 1030 p. s. i. or greater. Furthermore, when such joints have been subjected to cyclically varying pressure and temperature conditions, they have remained completely tight after a large number of such cycles and have shown no leakage when subjected to a hydrostatic test of 1.5 times the working pressure following the cyclical temperature and pressure variations.

The silver covering on the tube ends may be provided in any desired manner, but a preferred procedure is to silver-plate the tube ends to provide an electro-deposited silver covering of the order of 0.003 inch to 0.010 inch, although thinner and thicker coatings have been found satisfactory.

For an understanding of the invention principles, reference is made to the following description of a typical embodiment thereof as illustrated in the accompanying drawings.

In the drawings:

Fig. 1 is an elevation view, partly in section, of a pressure tube having its seating ends covered with silver in accordance with the present invention; and

Fig. 2 is a sectional view illustrating an expanded joint involving a header and the end of a tube such as shown in Fig. 1.

Referring to the drawings, a pressure tube 10

of suitable temperature and pressure stress resistant material is illustrated as having layers of silver 15 covering its seating ends. The silver layers 15 extend inwardly from the tube ends for a distance sufficient to assure a layer of silver being in contact with the header or drum seating surface.

Referring to Fig. 2, a silver covered end of tube 10 is shown as expanded onto a tube seat 21 formed in a header or drum 20. Such expansion may be effected by the usual tube expanding apparatus customarily utilized in seating tube ends in pressure vessels. As is known to those skilled in the art, such expansion procedures result in a deformation of the wall of tube 10 into tight engagement with the tube seat 21, as indicated at 11.

It has been found, upon examination, that the silver cover or layer 15, as a result of such expansion of the tube end and subjection to temperature and pressure cycles such as encountered in service, forms a bond between the metal of tube 10 and the metal of header or drum 20 of such intimate contact that all surface irregularities are filled in the minutest detail thus making an absolutely tight joint. It is very difficult to find a line of separation between the metals of the tube seat, even when examined microscopically under high magnification. For example, upon removal of such an expanded tube from the header, it has been found that particles of the silver coating are embedded in and firmly bonded to the tube seat 21.

For high temperature, high pressure service conditions, such as 1000° F. or better, and 1000 p. s. i. or better, the tube 10 and header 20 are preferably both formed of a suitable temperature and pressure stress resistant alloy such as 18-8 Cb or 25-20 Cb. Such alloys have been found to be best suited to withstand the stresses encountered under cyclically varying conditions at the mentioned temperatures and pressures.

The silver coating 15 is preferably plated onto the tube ends. Such plating may be effected in any suitable manner. One such procedure is to clean the tube ends with a known pickling solution containing hydro-fluoric acid and nitric acid. A nickel strike is then made on the cleaned tube surface followed by a silver strike thereon, and then a heavy silver deposit is formed from a concentrated cyanide solution. Silver coatings from 0.003 inch to 0.010 inch have been used and found satisfactory, although thinner or thicker silver coatings may be used depending upon the particular conditions involved.

The tube seat 21 does not need any special preparation and may be either a plane seat or a grooved tube seat, counterbored or not. Imperfections in the tube seats in the nature of lengthwise scars and cuts thereon have no effect on the tightness of the silver plated joint. This is a desirable feature from the viewpoint of field assembly, service and maintenance of the pressure vessel assemblies, as the lack of sensitivity of the joint to seat conditions greatly reduces the cost of assembly, service and maintenance. The tightness of the joint is apparently due to the formation of such absolute and intimate contact between the silver and the adjacent steel that even incipient penetration of fluid into the joint is prevented.

When silver plated tubes according to the invention, expanded into a header of the same material, were tested at temperatures from 850° F. to 1350° F. and at a pressure of 1030 p. s. i., the

seats were found tight even after as many as 195 pressure cycles and 10 temperature cycles. The testing of the tightness of the joints was made by subsequently subjecting the assembly to a pressure of 1.5 times the working pressure.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of invention principles, it will be understood that the invention may be otherwise embodied without departing from such principles.

I claim:

1. In a high pressure heat exchanger, the combination of a pressure element having apertures for receiving the ends of tubes, the peripheries of the apertures forming tube seats for the tubes; and tubes each having a seating surface on at least one end inserted in an aperture of the pressure element and expanded into tight seating engagement with the tube seat formed by the associated aperture, each of said seating surfaces having a coating of silver thereon compressed against the associated tube seat to form a pressure-tight seal therewith.

2. In a high pressure heat exchanger, the combination of a stainless steel alloy pressure element having apertures for receiving the ends of tubes, the peripheries of the apertures forming tube seats for the tubes; and stainless steel alloy tubes each having a seating surface on at least one end inserted in an aperture of the pressure element and expanded into tight seating engagement with the tube seat formed by the associated aperture, each of said seating surfaces having a coating of silver thereon compressed against the associated tube seat to form a pressure-tight seal therewith.

3. In a high pressure heat exchanger, the combination of a pressure element of 18-8 Cb alloy steel having apertures therein forming tube seats; and tubes of 18-8 Cb alloy steel each having a seating surface on at least one end and inserted in an aperture of the pressure element and expanded into tight seating engagement with the tube seat formed by the associated aperture, each of said seating surfaces having a plating of silver thereon compressed against the associated tube seat to form a pressure-tight seal therewith.

4. In the formation of a heat exchanger, the method of forming a pressure-tight connection between a tube and a pressure element having a tube seat, such method comprising coating a seat engaging end of a tube with silver, inserting the silver coated tube end into the tube seat, and expanding the coated tube end into pressure-tight engagement with the seat.

5. In the formation of a high pressure heat exchanger, the method of forming a pressure-tight connection between a tube of 18-8 Cb alloy steel and a pressure element of 18-8 Cb alloy steel having a tube seat, such method comprising coating a seat engaging end of the tube with silver, inserting the silver coated tube end into the tube seat, and expanding the coated tube end into pressure-tight engagement with the seat.

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