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VENTED DUPLEX HEAT EXCHANGER TUBES

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Fig. 1

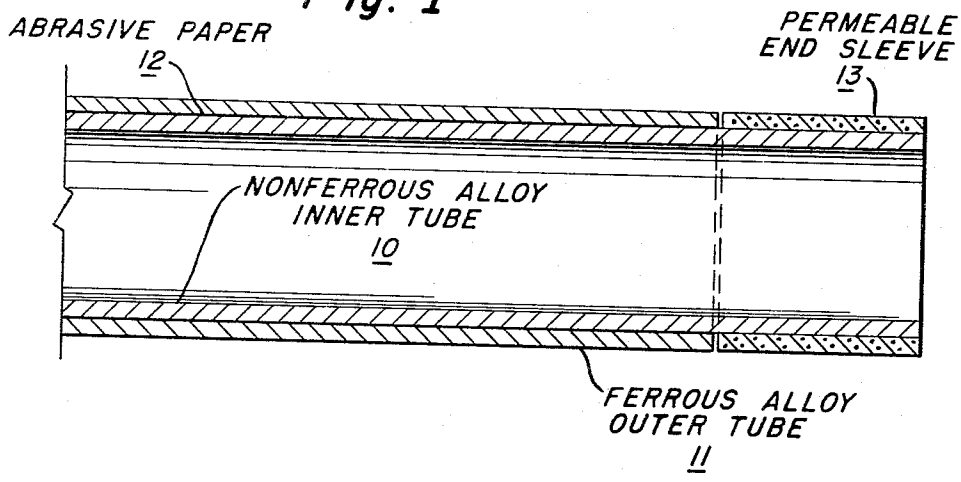
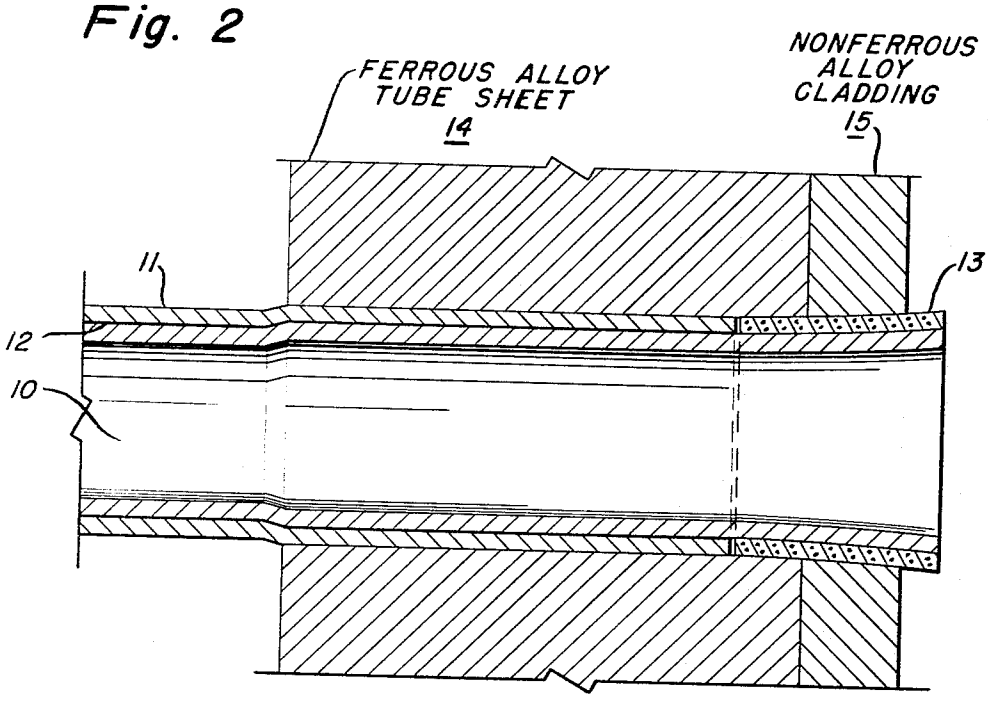


Fig. 2



INVENTOR.
Cecil B. Heith
BY Manford R. Haston
ATTORNEY

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VENTED DUPLEX HEAT EXCHANGER TUBES

Cecil B. Heith, Yorktown, Va., assignor to Standard Oil Company, Chicago, Ill., a corporation of Indiana

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This invention relates to improved bi-metallic duplex heat exchanger tubes. More particularly, the invention relates to improved tubes of this type which provide for venting gas from within the interfaces between the elements of the duplex tubes.

In refineries and chemical plants, heat is exchanged between process streams by passing one stream through tubes and passing another stream at a different temperature over the outside surface of the tubes. A common piece of equipment for effecting transfer of heat between process streams is the well known shell and tube heat exchanger. One of the main problems associated with the use of these heat exchangers is the choice of a suitable alloy, from the corrosion standpoint, from which to form the tubes. Various process streams have varying corrosion characteristics. For example, in hydrocarbon processing units steel or other ferrous alloy tubes possess sufficient corrosion resistance to the hydrocarbon streams; however, cooling water, especially sea water, is highly corrosive to ferrous alloys. Non-ferrous alloys, such as copper-nickel alloys, possess satisfactory corrosion resistance to cooling water, but are corroded by most hydrocarbon streams which usually contain contaminants such as sulfur compounds. Therefore, it has become common practice to form duplex heat exchanger tubes by a drawing process in which a non-ferrous alloy tube such as brass is encased within an outer tube of ferrous alloy such as steel. The ferrous metal tube can also be placed within the non-ferrous alloy tube, but the common practice is to pass the water cooling medium inside the tubes, therefore the non-ferrous alloy is normally the inside tube of the duplex unit.

In order to protect the tube sheet, into which the ends of the heat exchanger tubes are fitted by rolling, it is standard practice to clad the tube sheet, on the side exposed to water, with a non-ferrous alloy, such as Monel. Since the non-ferrous alloy is relatively expensive as compared to steel, the cladding is normally applied as a relatively thin layer usually less than one-half inch thick. With a tube bundle constructed in this manner, non-ferrous metal alloy is exposed to the sea water flowing on the tube side of the exchanger, while ferrous metal alloy is exposed to the hydrocarbons flowing on the shell side of the exchanger. This has been found to be the optimum use of materials of construction for units of this type in sea water-hydrocarbon service because the ferrous metal alloys are more resistant to corrosion by the hydrocarbon stream while the non-ferrous alloys possess more corrosion resistance to cooling water.

A serious problem encountered with the use of such duplex tubes has been collapse or buckling of the inner non-ferrous alloy tubing resulting from hydrogen pressure build-up at the interface between the two metal surfaces. This tube collapse not only restricts flow of cooling water through the tubes, but also lowers heat transfer across the gap created between the steel tube and the non-ferrous liner. Ultimately, decreased efficiency of the unit necessitates shut down and retubing of the exchanger with new tubes. Hydrogen pressure builds up at the interface between the two metal surfaces because monatomic hydrogen, generated during corrosion of steel surface, diffuses through the steel tube wall and collects at the interface between the two tubes. The hydrogen then recombines into molecular form. Because there is no escape

route for the hydrogen gas, pressure builds up until the weaker of the two tubes, usually the non-ferrous inner tube, collapses.

Attempts have been made to solve the tube collapse problem by placing a material, such as sandpaper, between the two metal tubes to provide a network of passages which would allow the hydrogen gas to escape at the end of the tube. Tubes of this type are known to the art as vented duplex tubes. Several problems have been encountered during attempts to use tubes constructed in this manner. One of the problems is corrosion of the ferrous metal outer tube at the end where it is exposed to the cooling water. Another problem is that during the rolling in to seal the tube ends into the tube sheet, the rolling pressure inside the tube is sufficient to cause the non-ferrous metal inner tube to conform to the grains of sand effectively sealing the interface between the tubes at the ends thus preventing the escape of hydrogen gas.

The present invention solves this problem by providing a rolled duplex tube having a sandpaper-like material between the tubes and an outer rolled end with a gas-permeable sleeve to permit the venting of the gas from between the inner and outer portions of the duplex tube. A preferred gas-permeable bushing or sleeve is a non-ferrous alloy of about 75 to 95% of theoretical maximum density. The invention further provides, in a heat exchanger having a tube sheet and rolled duplex tubes therein, the improvement which comprises a gas-permeable sleeve fitted over the extended inner portion of said duplex tube and after rolling being in contact with both said inner tube and said sheet.

FIGURE I shows a section through the end portion of a preferred embodiment of a heat exchanger tube of the present invention. In this embodiment a non-ferrous alloy tube **10**, such as admiralty brass, is fitted inside a ferrous alloy outer tube **11**. Paper **12** coated with a hard substance such as corundum, similar to sandpaper, is located between the tubes in order to provide sufficient space between the tubes for gas to pass. This coated paper may be along the entire length or just at the ends, e.g. about two feet at each end. The end of a non-ferrous metal alloy inner tube **10** extends a short distance, normally about one-half to one inch, beyond the end of the outer tube **11**. A gas-permeable sintered compact sleeve **13** is fitted over the exposed end of the inner tube. The length of the sleeve is conveniently twice the thickness of the alloy cladding on the tube sheet of the heat exchanger into which the tube is to be installed. This sleeve length is normally about ⅝ of an inch. The outside diameter of the sleeve corresponds to the ouside diameter of the outer tube **11** with the inside diameter of the sleeve providing about 0.004 inch interference fit on the ouside diameter of the inner tube **10**. These dimensions are not critical, however the length of the sleeve should be selected so that the sleeve does not extend completely through the tube sheet of the heat exchanger into which the tube is to be installed. Such a sleeve would provide a flow path for fluid to pass between the shell side of the exchanger and the tube side through the permeable sleeve, the direction of flow depending upon the difference in pressure between the shell and tube sides.

FIGURE II shows a cross section through a portion of a tube sheet into which a tube of the present invention has been installed by rolling to expand the tube and provide a liquid-tight seal between the outer tube wall and the heat exchanger tube sheet. In this embodiment, steel tube sheet **14** is clad with a non-ferrous alloy cladding **15**, such as Monel, to protect the outer surface of the tube sheet against corrosion from cooling water. The use of Monel is particularly applicable where sea water is used as a heat exchange medium.

The permeable end sleeve is preferably made of metal. Any metal capable of being in a powder form but having some ductility is useful to make the gas-permeable sleeve. Powdered metal sleeves are conveniently made by pouring the powdered metal into a mold, then pressing the powdered metal into the desired form and sintering the resulting shape to fuse the metal particles without destroying the pores. The particle size of the powdered metal particles from which the sleeve is formed are in the range of about 5 to 5000 microns, preferably in the range of 100 to 200 microns. Suitable corrosion resistant metals for forming permeable sintered metal compact sleeves include stainless steel, Monel, brass, etc.

The end sleeves should be permeable enough to permit the flow of gas through the sleeve without undue pressure build-up, however the porosity, i.e. the pore size, should be low enough to prevent back-flow of fluid such as water from the tube side of the exchanger into contact with the outer steel tube end and the tube sheet. The porosity of sintered metal compacts is normally designated as a per cent of the maximum theoretical density of the base metal itself. That is, the apparent bulk density of the sintered metal material as compared with the actual density of the base metal from which the compact is formed. Sleeves having 75 to 95% of theoretical maximum density are satisfactory, the preferred range of density being in the range of about 80 to 90%. It has been determined experimentally that permeable sintered metal and sleeves of Monel having an apparent density of 80% of the theoretical maximum density are satisfactory. The pressure required to collapse inner tubes three-fourth inch in diameter made from brass is about 1500 p.s.i.g. Experiments have shown that adequate venting occurs through gas-permeable sleeves of tubes of this invention at interface pressures of only 100 p.s.i.g. and lower.

The end sleeves may be formed in any shape such as cylinders, and then machined to the proper desired inside and outside daimeters, or the sleeves may be formed in molds which will produce the desired size and shape upon sintering.

While the invention has been described with reference to particular embodiments thereof, it is to be understood that equivalents apparent to those skilled in the art are deemed to be within the scope of the invention.

Having thus described the invention, what is claimed is:

1. In a heat exchanger, a tube sheet, said tube sheet having a rolled duplex tube extending therethrough and terminating in an end, said duplex tube including an inner tubular portion and an outer tubular portion, said extending end having a gas-permeable metal sleeve over said inner portion, said sleeve being in contact with said tube sheet, said sleeve permitting the venting of gas from between said inner and outer portions of the duplex tube.

2. In a heat exchanger having a tube sheet through which a duplex heat exchanger tube passes and terminates in an end, said tube having an inner portion and an outer portion, the improvement comprising a gas-permeable sleeve fitted over the inner portion of said tube, said sleeve in contact with said sheet.

3. A duplex heat exchanger tube having an outer tubular portion fitted over an inner tubular portion, said outer and inner tubular portions being fabricated of dissimilar metals, said tube having an end with the inner tubular portion extending from said outer tubular portion, and a gas-permeable sleeve fitted over said extended end of said inner tubular portion to permit the venting of gas from between the inner and outer portions of said duplex tube through said sleeve when the tube is installed in a heat exchanger.

4. A rolled duplex heat exchanger tube having an inner tubular portion and an outer tubular portion, said tube having an extended tubular portion at an outer rolled end with a gas-permeable sleeve to permit the venting of gas between the inner and outer portions, said sleeve having an apparent density between about 75 and about 95 percent of theoretical maximum density.

5. A rolled heat exchanger tube with an inner tubular portion and an outer tubular portion, said tube having an outer rolled end fitted with a gas-permeable sleeve to permit the venting of gas from between the inner and outer portions of the tube, said sleeve having apparent density between about 75 and about 95 percent of theoretical maximum density.

6. A duplex heat exchanger tube having a steel outer tubular portion fitted over a brass inner tubular portion, a Monel gas-permeable sleeve fitted over an extended end of said inner tubular portion to permit the venting of gas from between the inner and outer portions of said duplex tube through said sleeve when said duplex tube is installed in a heat exchanger.

7. A duplex heat exchanger tube having a ferrous metal outer tubular portion fitted over a non-ferrous metal inner tubular portion, and a non-ferrous metal gas-permeable sleeve fitted over an extended end of said inner tubular portion to permit the venting of gas from between the inner and outer portions of said duplex tube through said sleeve when said tube is installed in a heat exchanger.

8. In a heat exchanger having duplex tubes with outer tubular portions fitted over inner tubular portions with ends of said inner portions extended beyond said outer portions, said outer and said inner tubular portions being fabricated of different metals, gas-permeable sintered metal sleeves fitted over the extended ends of said inner tubular portions to permit the venting of hydrogen gas from between the inner and outer portions of said tubes through said sleeves.

References Cited

UNITED STATES PATENTS

504,871	9/1893	Forsyth	138—148 X
1,714,703	5/1929	Walton	285—211
2,157,596	5/1939	Davis	28—182 X
2,394,402	2/1946	Penella	165—178 X
2,448,315	8/1948	Kunzog	165—154 X
3,123,133	3/1964	Pels et al.	165—178
3,127,668	4/1964	Troy	29—182

FOREIGN PATENTS

432,230	7/1935	Great Britain.

ROBERT A. O'LEARY, *Primary Examiner.*

MEYER PERLIN, *Examiner.*

N. R. WILSON, T. W. STREULE, JR.,
Assistant Examiners.