Nov. 12, 1968 D. W. CHRISTENSEN 3,410,581

SHELL-AND-TUBE TYPE HEAT-EXCHANGER

Original Filed May 20, 1965

FIG. 1

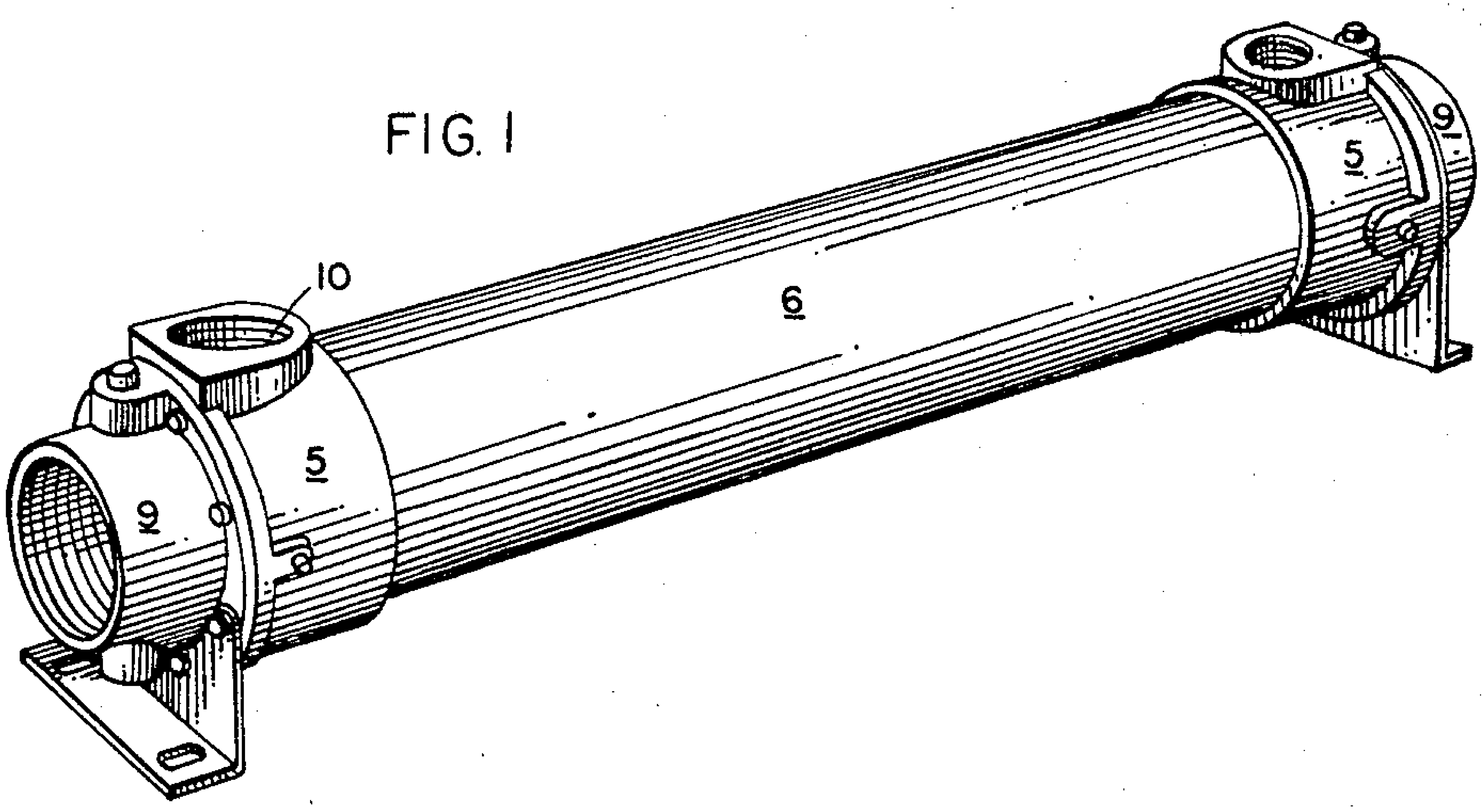
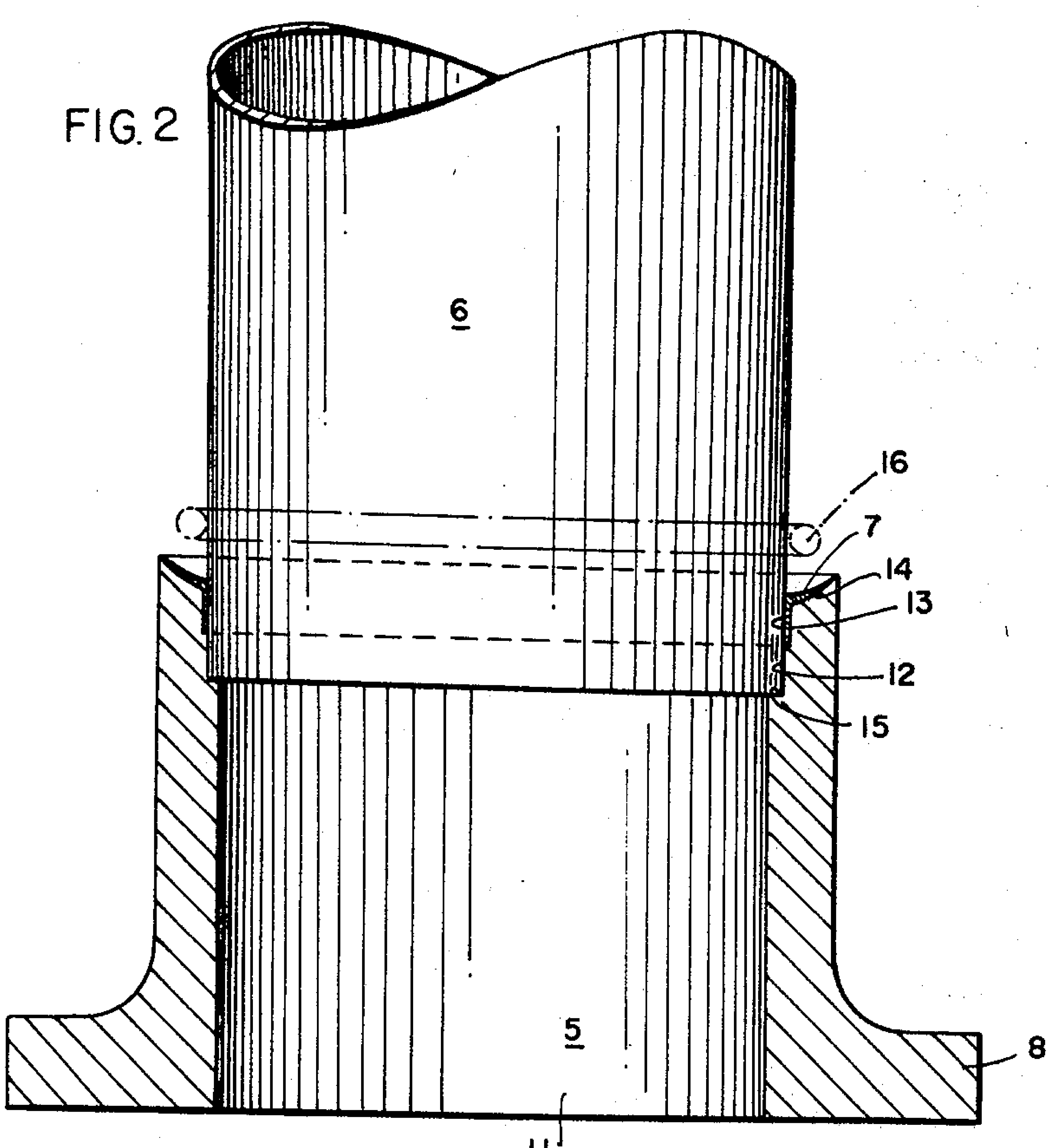


FIG. 2



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SHELL-AND-TUBE TYPE HEAT-EXCHANGER

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Continuation of application Ser. No. 457,459, May 20, 1965, which is a continuation-in-part of application Ser. No. 161,896, Dec. 26, 1961. This application Jan. 26, 1967, Ser. No. 621,090
1 Claim. (Cl. 285—21)

ABSTRACT OF THE DISCLOSURE

The essential concept of this invention involves forming a shell-and-tube heat exchanger wherein hard-metal hubs are machined to form a pair of concentric counter-bores the inner of which bores is dimensioned to effect perfect circularity of the shell end when inserted into the inner counter-bore and provide for so spacing of the adjacent peripheral area of the shell end and the outer counter-bore as will ensure a firm bonding of the shell and the end hubs.

This application is a continuation of a prior application Ser. No. 457,459 filed May 20, 1965 and which was a continuation of the prior application Ser. No. 161,896 filed Dec. 26, 1961, both applications are now abandoned.

This invention relates to the structuring of heat-exchangers of the type commonly referred to as "shell-and-tube."

As is well known, the shell-and-tube type of heat exchanger involves a core-unit embraced within a shell bonded at each end to supporting elements, generally designated as end hubs, formed of hard-metal either as forgings or castings. The core-unit consists of a battery of parallel tubes spanning and bonded at their ends to a pair of header plates. On these tubes is arranged a series of axially-spaced, less than circular-shaped baffles. The diameter of these baffles is just enough less than the interior diameter of the shell to permit telescopic insertion of the core-unit into the shell through the end hubs, after the bonding of the shell to the end hubs. These baffles are staggered circumferentially throughout the length of the shell so as to effect a sort of serpentine flow of the coolant axially through the labyrinth surrounding the battery of tubes through which another fluid flows.

The shell, for such type heat-exchangers, is brass extruded or otherwise structured in cylindrical form. These shells range in length from eight to ninety inches and in transverse diameters from 2⅛" to 8³⁄₁₆". The end hubs, as a rule are brass or malleable iron.

The heretofore conventional practice for producing such heat-exchangers has been to internally machine the end hubs with a single bore of a dimension within a few thousandths of an inch plus or minus, the same as the outside diameter of the shell. Such machining is for the purpose of permitting a "slip" or "push" fit insertion of the shell end into the end-hub bores. Also, it is the practice to chamfer the machined ends of the end hubs to produce a ledge for the temporary seating of a ring of high-temperature bonding-material. Relying upon the phenomenon of capillary action, the molten bonding material is drawn in between the telescopically-opposed surfaces of the machined end hubs and the shell.

It is well known that such a bond is dependent wholly upon securing a uniform spread of the molten bonding material over the entire opposed inner and outer surfaces of the end hubs and the shell. If perchance, conditions are such that at certain points these opposed surfaces present ever-so-slight gaps and/or at other points these opposed surfaces are too firmly in contact, the re-

quired capillary action will not result in a uniform spread of the bonding material over these opposed surfaces.

Also, it is well known, that there have been frequent complaints from users of these conventionally-structured heat-exchangers because of leaks. These leaks are believed to result from imperfect bonding due primarily to the above-indicated diversion in the surface-to-surface opposition of the telescoping shell and hub ends. Obviously such leaks make for increased expense to the manufacturers of these units by either repair or replacements.

A possible contributing factor to this imperfect surface-to-surface bonding of the tube ends to the end hubs has to do with the condition of the shells at the time of bonding. These shells are obtained from concerns whose business it is to provide such for myriads of use. The walls of these shells, of the hereinbefore noted length and diameter ranges, are between 0.049 and 0.125 inch of thickness. The shells come to the plant stacked one on top of another in crates or boxes. These shells remain in storage for considerable periods, pending the need for structuring a particular size of shell-and-tube heat-exchanger. As a result these shells very often are "out-of-round" when they are ready for use. This condition, very often, can be the cause for these deviations in the surface-to-surface relationship of the shell end and the one-bore machined end hub.

Also, it is well known, in the heat-exchanger industry, that there are times when a less-experienced brazer has to be assigned to such brazing operations. He may not be fully aware of the ununiform dissipation of heat that occurs at the hub enlargements and the other thinner portions. Thus, such brazer may fail to "sweat" the operation to make certain of an all-around bond of the shell end to the end hub. The inevitable consequences of this are revealed when these finished units run through the testing tanks. Such units have to be returned to the shop for supplemental brazing operation.

The heat-exchangers of the type whereto this invention relates are used for heating or cooling liquids and gases for equipment wherein these fluids are operating under relatively high pressures and at comparatively high temperatures. Heat-exchangers of this type are used with diesel-type engines, ranging in size from 50 to 1,000 horsepower, for cooling and lubricating oil operations at temperatures ranging as high as 200 degrees Fahrenheit and that is forced through a lubricating network at pressure as high as 100 p.s.i. When such heat-exchangers are used for steam service they may have to operate at pressures up to 75 p.s.i. and temperatures up to 350 degrees Fahrenheit.

The main objects of this invention, therefore, are; to provide an improved machined form of the end hubs for shell-and-tube type heat-exchangers; and to provide such an improved structuring of the end-hubs as will ensure a more complete circumferential bonding of certain of the opposed areas of the machined end hubs and the telescoping shell ends.

In the adaptation shown in the accompanying drawings;

FIG. 1 is a perspective view of a conventional shell-and-tube type of heat-exchanger constructed in accordance with this invention; and

FIG. 2 is a much-enlarged, fragmentary, cross-sectional view of an end hub, formed in accordance with this invention and an elevational view of the shell end bonded to the end hub.

A shell-and-tube heat-exchanger embodying the foregoing concept comprises a pair of hard-metal end hubs **5**, a shell **6**, the telescoping portions of which are secured in permanent assembly by a bond **7** provided by the use of a preformed and tight-fitting bonding ring **16**.

The end hubs **5** are hard metal such as cast or forged of brass or malleable iron. Each such hub **5** has an integrated flange **8** to which a bonnet **9** is attached, generally by bolt-and-nut fasteners, as shown in FIG. 1. Each such end hub **5** is formed with a port **10** for the connection of a pipe (not here shown) for the fluid flow to and from the labyrinth around the core-unit within the shell **6**. Also, each such end hub **5** has a main bore **11** extending therethrough of a diameter, preferably, the same as the inside diameter of the shell **6**.

The end hubs **5**, constructed in accordance with this invention have to be hard metal and the respective ends, opposite the flanges **8**, are machined to provide a pair of counter-bores **12** and **13**. Generally the metal is brass. However it could be malleable iron. The inner bore **12** is machined to a diameter of within .010 to .002 of that of the outside diameter of the shell **6**, depending upon the diameter of the shell. This inner diameter bore **12** is intended to be just enough to permit a "slip" or "push" fit of the extremity of the shell **6** into the full length of the inner bore **12**. The outer bore **13**, generally, is no more than .005 per side greater than the diameter of the inner bore **12**. The axial lengths of the respective bores **12** and **13** is approximately the same. Generally, this would be about 3/32 to 1/8 of an inch, depending upon the diameter of the shell **6** to be used.

The purpose of the two counter-bores **12** and **13**, of such respective diameters, is to cause the entrance of the extremity of the shell **6** into the inner counter-bore **12** to bring the shell end into perfect circularity. This will effect such a uniform spacing of the surface-to-surface opposition of the exterior face of the shell **6** and the interior face of the counter-bore **13** as will ensure a complete and uniform capillary spread of the molten high-temperature bonding-material throughout the axial length and circumference of the outer counter-bore **13**. If, perchance, some of the molten bonding material is drawn down into the surface-to-surface opposition of the shell extremity and the face of the inner counter-bore **12**, the bond of the shell and end hub will be enhanced by just that much. However, it is imperative to ensure a complete bonding within the outer bore **13**.

The adjacent extremity of each end hub **5** is chamfered as shown at **14** in FIG. 2, to provide a seat for the bonding ring **16**, shown in dotted outline in FIG. 2, preparatory to its being heated to a molten state to flow down between the opposed peripheral surfaces of the shell **6** and the end hubs **5**, as will be explained presently. The form and the depth of the chamfer **14** is such as to allow for seating the ring **16** and a requisite amount of flux.

Inasmuch as the main bore **4**, of each end hub **5**, approximates the inside diameter of the shell **6**, the formation of the counterbore **12** creates a shoulder **15** against which the end of the shell **6** rests to provide for the limited telescoping of the shell and a pair of these end hubs **5**. This is imperative to establish the required axial spacing of the end hubs **5** to make certain the proper accommodation of a core-unit of the predetermined length.

The brazing ring **16** is preformed of the requisite kind and amount of high temperature bonding material generally used for these units. In preparation for the bonding, the ring **16** is laid on the chamfer **14** on the end of the end hub **5**. The shell end is inserted through the ring **16** and slipped or pushed into the inner counter-bore **12** of the end hub **5**. Thereupon the requisite heat is applied, preferably by induction equipment. There is enough high temperature bonding material in the ring **16** to leave a small fillet **17**.

The maintaining or restoration of the circularity of the extremity of the shell **6** permits the insertion of a conventional core-unit into one of the end hubs **5** to bring the header plates into position for their bonding to the respective end hubs **5**. Such insertion of the one header plate into the now perfectly circular end of the bonded shell **6** allows for the pushing of the core unit on through the entire axial length of the shell **6**. Should any intermediate portions of the shell **6** be slightly out-of-round, the advancing header plate will tend to so restore the circularity of the shell **6** sufficiently to avoid the likelihood of any of the baffles binding on the shell during this insertion of the core unit and thereby having the axial relationship of the baffles disturbed.

Variations and modifications in the details of structure and arrangement of the parts may be resorted to within the spirit of the appended claims.

I claim:

1. A shell-and-tube heat-exchanger structured for heating and cooling liquids and gases at high temperatures and pressures comprising:

(a) a cylindrical extruded-brass shell of indicated outside diameter, and

(b) a pair of end hubs each with an integrated radially-disposed, external flange at one end for the bolted attachment to a bonnet and internally machined at the other end to form a pair of concentric counter-bores extending axially outward from an internal circumferential shoulder and having a diameter differential of not more than .005", the inner counter-bore being of a diameter within .010" to .002" of the outside diameter of the shell, and

(c) the shell and the end hubs being assembled with the opposite ends of the shell fitted into the respective inner counter-bore and seating the end of the shell on the shoulder with such a surface-to-surface contact of the shell and the inner counter-bore as to effect perfect circularity of each shell end and thereby provide a uniform spacing of the adjacent opposed peripheral portions of the shell and the respective outer counter-bore and thereat bonded together by capillary action of molten high-temperature bonding material.

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