May 11, 1937. A. R. McALLISTER 2,080,374

METHOD OF MAKING PRESSURE VESSELS

Filed April 25, 1933

Fig. 1

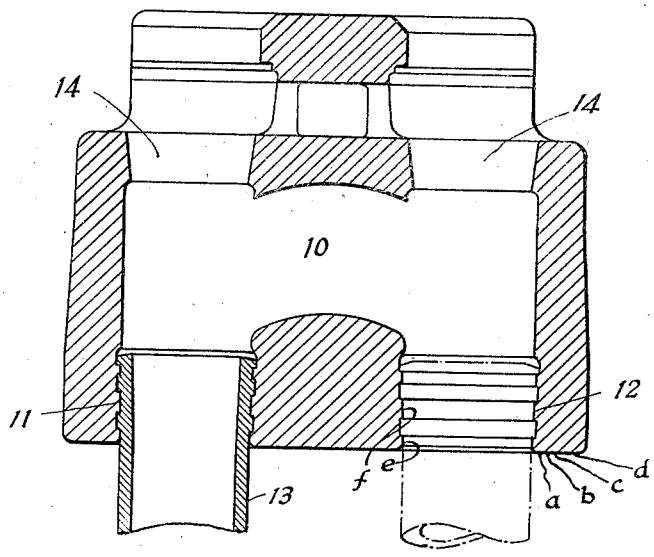


Fig. 2

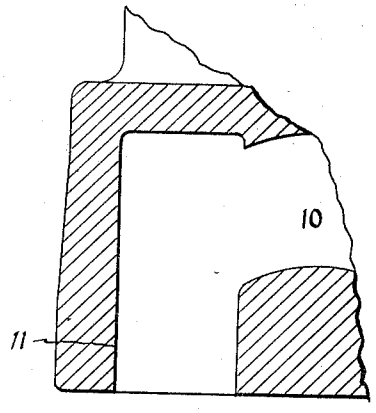
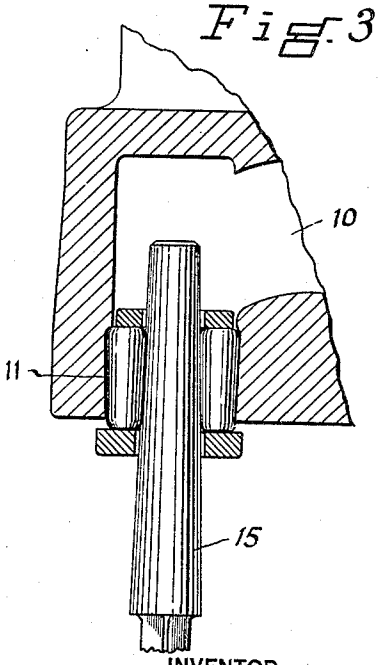


Fig. 3



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METHOD OF MAKING PRESSURE VESSELS

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6 Claims. (Cl. 29—157.5)

The present invention relates to the manufacture of metallic pressure vessels, which in use have a tube connected thereto by expanding one end of the tube into a tube seat formed in the pressure vessel.

In forming fluid passages by expanding tube ends into tube seats formed in metallic pressure vessels, it has been found that the portion of the pressure vessel surrounding the tube seat may also be enlarged to some extent during the tube expanding operation, even though that portion of the pressure vessel be made of substantial thickness. The amount of deformation will depend primarily upon the yield point of the metal forming the tube seat. Any enlargement of the tube seat during the tube expanding operation is disadvantageous, and particularly so where periodic replacement of such tubes is contemplated; as an increased amount of expansion and thereby thinning of the end of the replacement tube will then be required to insure a fluid tight joint. Where the pressure vessel is to be subjected to the effect of a corrosive fluid at high temperatures and pressures, such as a return bend in an oil heater, it has been found desirable to use alloy steels for the pressure vessel because of their higher resistance to corrosion and great strength at high temperatures. Chrome nickel austenitic steels have been found especially suitable from a corrosion resistant standpoint. Such alloy steels however have a relatively low yield point and are therefore easily deformable. For example, an alloy steel casting having 18% chromium, 8% nickel, and .12% max. carbon will have a yield point of approximately 25,000 lbs. per sq. in. This yield point value is comparatively low when considered with respect to alloys of lower chromium and nickel content or carbon steels.

It has been found that the corrosion resistance property of the metal forming a tube end is considerably lessened when the tube is subjected to excessive cold working, such as would occur in expanding a tube into a tube seat of a pressure vessel formed of metal having a low yield point. It is believed that this change in the corrodibility of the tube end is due to overstressing of the metal during the cold working operation by which changes are made in the grain structure of the metal. Corrosion of the tube ends will result in rapid leakage at the tube joints, with the consequent liability to dangerous fires or explosions.

The general object of my invention is the provision of an improved pressure vessel of the character described and a method of manufacturing the same. More specifically, the object of my invention is an improved method of forming a tube seat in a pressure vessel adapted to be exposed in operation to the deteriorating effects of a corrosive fluid.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described one form of pressure vessel in the manufacture of which my invention may advantageously be followed.

Of the drawing:

Fig. 1 is a somewhat diagrammatic sectional elevation of a pressure vessel having a tube end expanded therein;

Fig. 2 is a partial view of the pressure vessel shown in Fig. 1 at an intermediate stage of manufacture; and

Fig. 3 is a view similar to Fig. 2 illustrating a subsequent stage.

My invention is illustrated in the drawing as embodied in the manufacture of a return bend formed from a casting of alloy steel of the compositions described. The return bend is cast in a well known form having an internal U-shaped passage 10, the parallel legs of which terminate in tube seats 11 and 12, into each of which one end of a tube 13 is adapted to be expanded to provide a fluid tight joint between each tube and the return bend. The portion of the return bend in alignment with each tube seat is formed with a hand hole opening 14 to permit the insertion of a tube expanding tool or tube cleaning device, and normally closed in operation by a closure member (not shown).

In accordance with my invention, the steps employed in making the return bend tube seats 11 and 12 will include one or more cold working operations by which the yield point of the metal forming the tube seats will be substantially increased, thereby minimizing the amount of deformation of the tube end and tube seat in subsequently expanding the tube therein. The return bend is first cast with its tube seat openings considerably under-size. Each tube seat opening is then machined to a diameter somewhat less than its desired final diameter, resulting in the form shown in Fig. 2. The return bend is then securely clamped in position and each tube seat portion cold rolled with an expanding tool 15 of a well known type, as shown in Fig. 3. The expanding operation is preferably

carefully regulated so that the line of demarcation between the worked and unworked portions of the header will not be sharply defined. For this reason, the outer end portion of each tube seat is rolled to a greater degree than the remaining portion. The cold rolling operation is continued until the diameter of the opening is only slightly less than the desired final tube seat diameter. During the cold rolling operation, the yield point of the metal surrounding each tube seat opening will be substantially increased, and will thus offer increased resistance to further deformation. Each tube seat opening is then machined to the desired final form shown in Fig. 1. The Brinell hardness of the metal treated will vary with changes in the yield point and will thus be a measure thereof.

As a further illustration of the operations described heretofore, I have formed a tube seat for a 4 in. O. D. tube in a return bend of the character described by machining the openings in the casting to 3¾ in. diameter. The opening was then expanded to approximately 3 13/16 in. diameter by a cold rolling operation, as shown in Fig. 3. The tube seat opening was then machined to the desired final diameter of 4 1/64 in. and form shown in Fig. 1. The Brinell hardness of the cast metal was originally 140, and after the described series of operations, tests showed that the hardness of the metal forming the tube seat had been increased at the point *a* (⅛ in. from the seat) to 184, at the point b (¼ in. from the seat) to 179, at the point *c* (⅝ in. from the seat) to 149, while at the point *d* (1 in. from the seat) no increase was noted. Axially of the tube seat, the hardness at the first land *e* (¼ in. from the end) was increased to 241 and at the second land *f* (1¼ in. from the end) to 202.

With the tube seats formed as heretofore described, each tube 13 may be connected to the header in the usual way by inserting a tube expanding tool through the corresponding opening 14 and expanding the end of the tube until a tight joint is attained. Substantially no deformation of the return bend will occur during the tube expanding operation, and therefore a minimum expansion of the tube ends. The tube may be subsequently replaced with little, if any, increase in the amount of expanding required to form a tight joint. The increase in hardness of the metal will thus be confined to the return bend portions immediately surrounding the tube seats, whereby the corrodibility of the metal in the remaining portion of the return bend, which will be directly exposed to the corrosive fluid in operation, will not be affected.

While in accordance with the provisions of the statutes I have illustrated and described herein the best embodiment of my invention now known to me, those skilled in the art will understand that changes may be made in the process of manufacture disclosed without departing from the spirit of the invention covered by my claims.

I claim:

1. The method of forming a tube seat in a pressure vessel formed of metal having a relatively low yield point which comprises casting the pressure vessel with a tube seat of less diameter than the desired final diameter, then cold rolling the tube seat to increase its diameter and the hardness of the locally surrounding metal but without changing its form or exceeding the desired final diameter, and then machining the tube seat to the desired final form and diameter.

2. The method of forming a tube seat in a pressure vessel formed of a temperature and corrosion resistant alloy steel having a relatively low yield point and adapted to receive in operation a fluid having a corrosive action proportional to the hardness of the exposed metal surface which comprises casting the pressure vessel with a tube seat of less diameter than the desired final diameter, then cold rolling the tube seat to increase its diameter and the hardness of the locally surrounding metal but without changing its form or exceeding the desired final diameter, and then machining the tube seat to the desired final form and diameter.

3. The method of forming a tube seat in a pressure vessel formed of a temperature and corrosive resistant alloy steel having a relatively low yield point and adapted to receive in operation a fluid having a corrosive action proportional to the hardness of the exposed metal surface which comprises casting the pressure vessel with a tube seat of less diameter than the desired final diameter, then machining the tube seat without exceeding the desired final diameter, then cold rolling the tube seat to increase its diameter and the hardness of the locally surrounding metal but without changing its form or exceeding the desired final diameter, and then machining the tube seat to the desired final form and diameter.

4. The method of connecting a tube into a return bend formed of a temperature and corrosive resistant alloy steel having a relatively low yield point and adapted for the passage therethrough in operation of a fluid having a corrosive action proportional to the cold working of the exposed metal surface which comprises forming a tube seat in the return bend of less diameter than its desired final diameter, then machining the tube seat to increase its diameter without exceeding its desired final diameter, then cold rolling the tube seat to increase its diameter and the hardness of the locally surrounding metal but without changing its form or exceeding its desired final diameter, then machining the tube seat to its desired final form and diameter, and expanding one end of the tube into the tube seat so formed with substantially no deformation of the return bend and a minimum expansion of the tube end.

5. The method of connecting a tube into a return bend formed of a temperature and corrosive resistant alloy steel having a relatively low yield point and adapted for the passage therethrough in operation of a fluid having a corrosive action proportional to the cold working of the exposed metal surface which comprises forming a tube seat in the return bend of less diameter than its desired final diameter, then machining the tube seat to increase its diameter without exceeding its desired final diameter, then cold rolling the tube seat to increase its diameter and progressively increase the hardness of the locally surrounding metal toward its outer end but without changing its form or exceeding its desired final diameter, then machining the tube seat to its desired final form and diameter, and expanding one end of the tube into the tube seat so formed with substantially no deformation of the return bend and a minimum expansion of the tube end.

6. The method of connecting a tube into a pressure vessel formed of a temperature and corrosive resistant alloy steel having a relatively low yield point and adapted for the passage therethrough in operation of a fluid having a corrosive action proportional to the cold working of the exposed metal surface which comprises

forming a tube seat in the pressure vessel of less diameter than its desired final diameter, subsequently cold rolling the tube seat to increase its diameter and progressively increase the hardness of the locally surrounding metal toward its outer end but without changing its form or exceeding its desired final diameter, then machining the tube seat to its desired final form and diameter, and expanding one end of the tube into the tube seat so formed with substantially no deformation of the pressure vessel and a minimum expansion of the tube end.

ALEXANDER R. McALLISTER.