United States Patent [19]

Miller et al.

[11] **3,829,948**

[45] **Aug. 20, 1974**

[54] **APPARATUS FOR EXPANDING HEAT EXCHANGER TUBES IN TUBE SUPPORT SHEETS**

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[22] Filed: **Mar. 22, 1973**

[21] Appl. No.: **344,018**

[52] **U.S. Cl.** ..... **29/202 D**

[51] **Int. Cl.** **B23p 15/26**

[58] **Field of Search** ..... 29/202 D, 202 R, 157.3 A, 29/157.5

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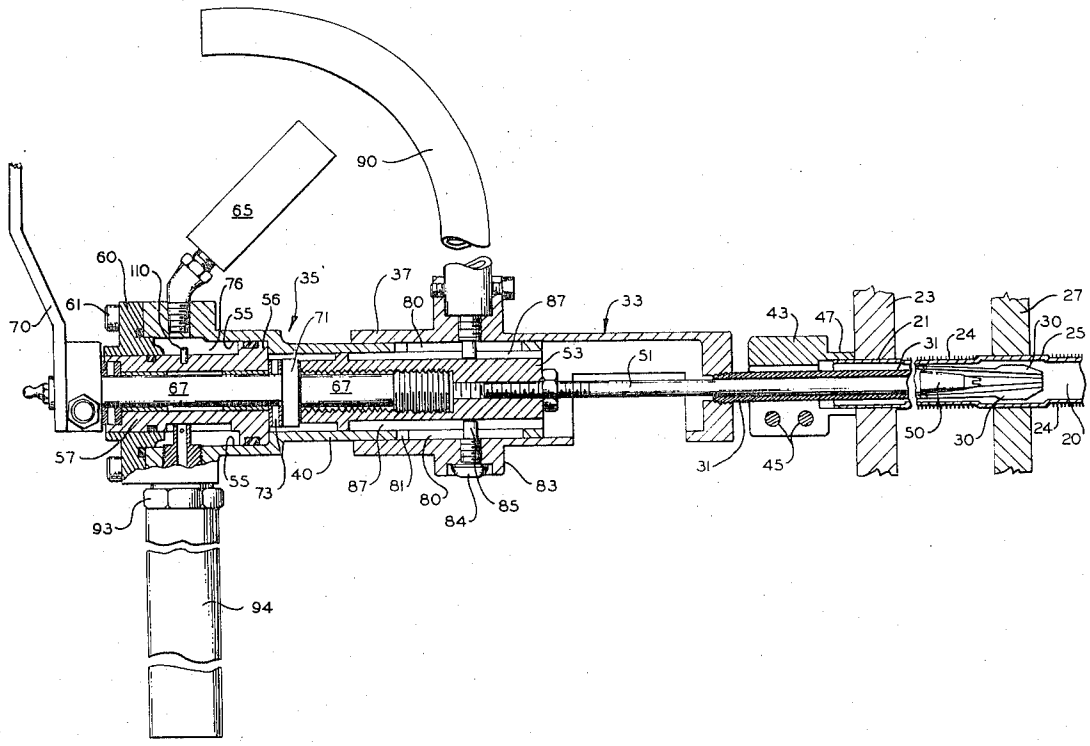
Primary Examiner—Thomas H. Eager

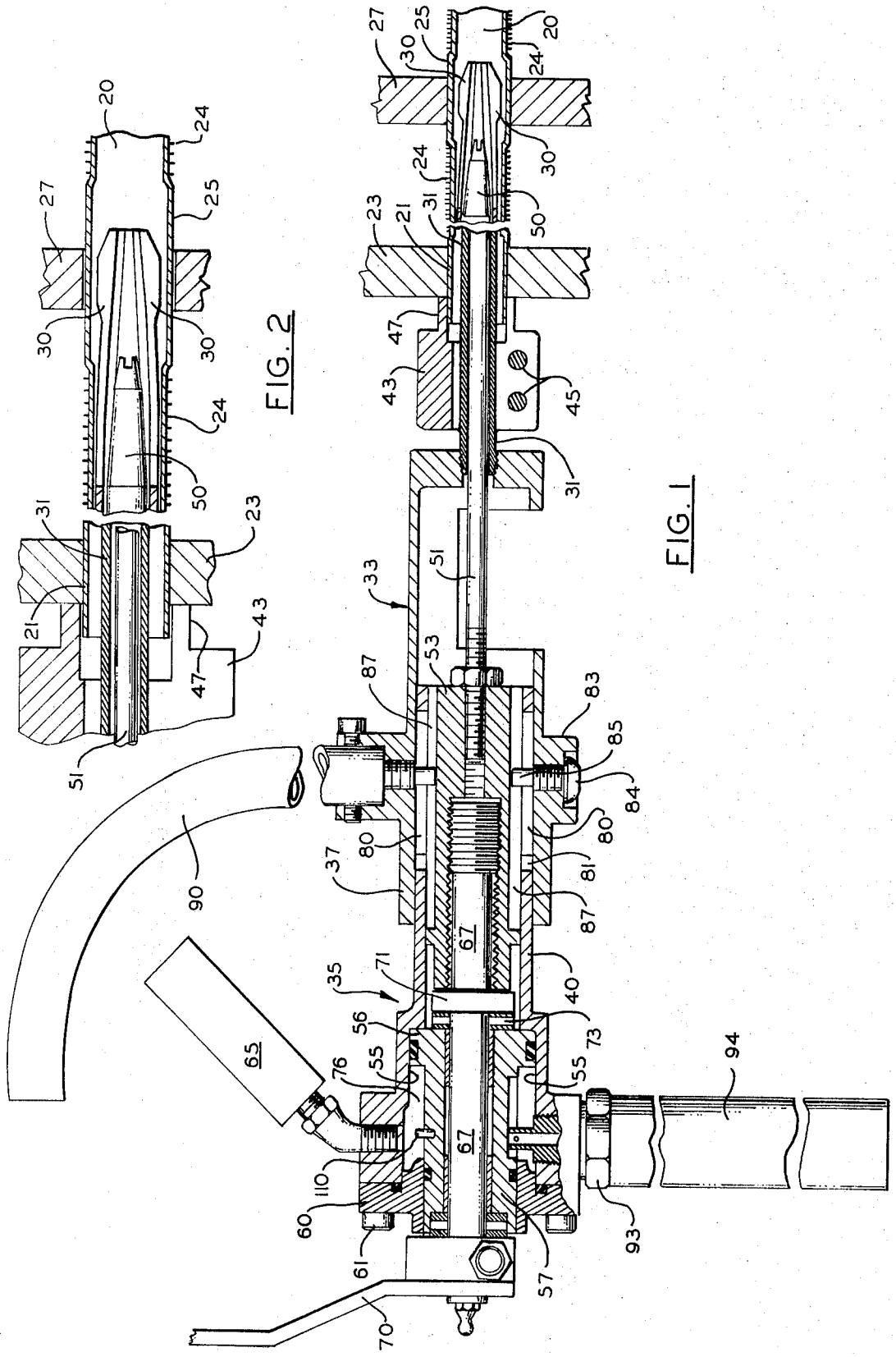
Attorney, Agent, or Firm—J. Raymond Curtin

[57] **ABSTRACT**

A circular series of expandable collet sections is fixed to the inner end of a collet tube positioned in the heat exchanger tube, the collet sections in registration with the tube support sheet. The outer end of the collet tube is fixed to a housing portion connected to a cylinder structure. A rod extends through the tube and has fixed to its outer end a tapered mandrel arranged in juxtaposition to the collet sections. A shaft is journaled in the cylinder structure and is connected to the outer end of the mandrel rod by motion transmitting means operable upon rotation of the shaft to move the rod and the mandrel inwardly to effect expansion of the collet sections in engagement with the heat exchanger tube for expansion of the same in the tube support sheet. The force exerted by the shaft on the mandrel rod is applied directly to a piston arranged in a closed prepressurized air-free hydraulic system. The hydraulic system is further pressurized by movement of the piston, effecting operation of a pressure indicating gauge in the system. Accordingly, the operator can readily expand all tubes in the heat exchanger to precisely the same extent.

9 Claims, 8 Drawing Figures




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FIG. 2
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FIG. 1

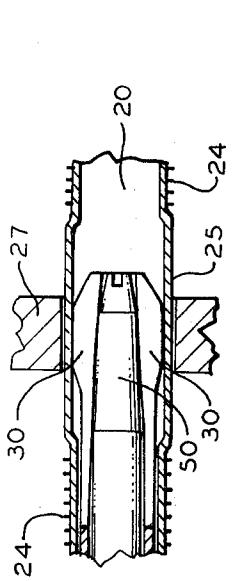

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FIG. 4

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75
93
94
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107
100
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FIG. 3

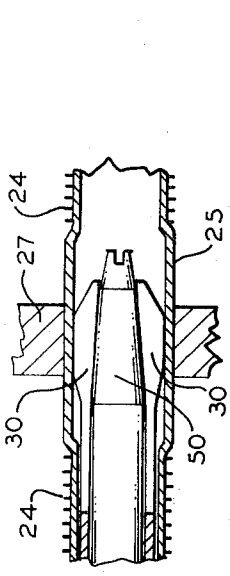

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FIG. 6

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FIG. 5

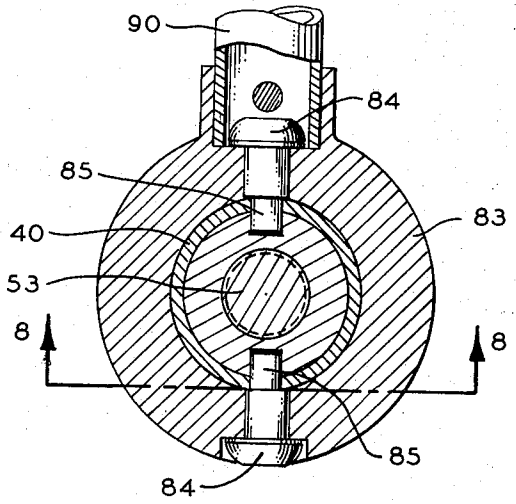


FIG. 7

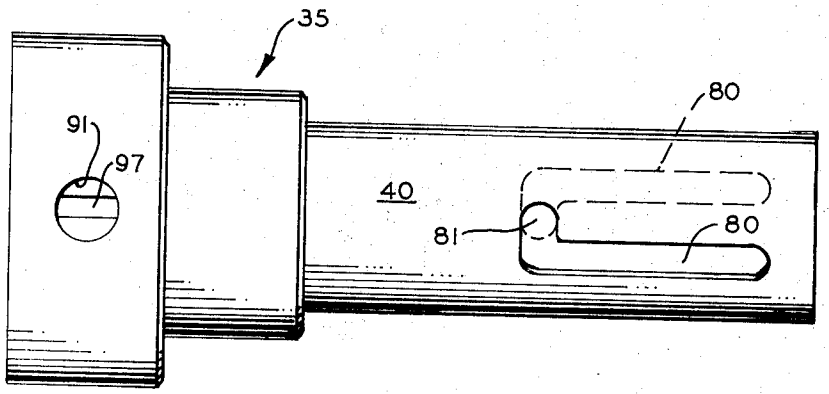


FIG. 8

APPARATUS FOR EXPANDING HEAT EXCHANGER TUBES IN TUBE SUPPORT SHEETS

BACKGROUND OF THE INVENTION

A conventional form of heat exchanger consists of a shell, usually of cylindrical form, provided with end closures. A tube bundle is positioned in the shell, the ends of the tubes being fixed liquid tight in the shell end closures which are referred to as tube sheets. When the heat exchanger is of considerable length, it is necessary to provide one or more support sheets intermediate the ends of the shell. The support sheets serve to prevent the heat exchanger tubes from sagging and also serve to maintain the heat exchanger tubes in uniform spaced relation for efficient operation of the heat exchanger.

It is advantageous to expand the heat exchanger tubes in the support sheets to prevent movement between the tubes and support sheets. To establish such expansion, the conventional procedure is to insert a tubular member in the heat exchanger tube, the tubular member having at its inner end a collet having expandable fingers. A rod is inserted through the tubular member, the end of the rod being formed with a tapered mandrel portion which, when forced against the collet fingers, causes them to expand. The rod is moved inwardly by being manually pounded with a hammer at its outer end.

Examination of many tubes so expanded in the support sheet established the fact that the mechanic has no knowledge as to what extent he has expanded a tube. Actually, examination showed that few if any heat exchanger tubes in the bundle were expanded to a uniform extent.

This invention has as an object an apparatus for expanding heat exchanger tubes in holes in a tube supporting sheet, the apparatus being effective to accomplish the desired union in a highly efficient manner. With our invention, an expanding collet is located in the heat exchanger tube in registration with the support sheet, whereby the heat exchanger tube is not expanded at one side or the other of the support sheet, but in the hole in the sheet. The invention embodies a structural arrangement whereby the collet fingers are initially engaged by the expanding mandrel by simply manually imparting axial movement to the mandrel. Also, the invention employs an arrangement whereby each tube is expanded under the same pressure. Accordingly, with our invention it is made certain that the tubes are expanded in the support sheet and to precisely the same extent for proper engagement therewith.

SUMMARY OF THE INVENTION

A circular series of collet sections are mounted on the inner end of a collet tube and are dimensioned in collapsed or nonexpanded condition for passage through the heat exchanger tube upon insertion of the collet therein. A stop means is provided to locate the collet sections inserted in the heat exchanger tube in registration with the tube support sheet. The collet sections are expanded by a tapered mandrel fixed to the inner end of a mandrel rod extending through the heat exchanger tube for reciprocation therein. The outer ends of the collet tube and the mandrel rod are connected to an operating unit. A shaft is journaled in the unit and is connected to the mandrel rod by motion transmitting means operable upon rotation of the shaft in one direction to effect inward axial movement of the rod and the mandrel to effect expansion of the collet sections in the heat exchanger tube and expansion of the same in proper engagement with the support sheet. Countermovement of the shaft is opposed by a piston mounted in a hydraulic system. The hydraulic system is prepressurized and free from gas and includes a pressure indicating gauge. With this arrangement, the gauge indicates the pressure applied to the expanding mandrel, and accordingly of the pressure or extent to which the heat exchanger tube is expanded in the support sheet. Accordingly, the operator can readily obtain precise, uniform expansion of all the tubes in the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a lengthwise sectional view of a tube expanding apparatus involving our invention and including a portion of a heat exchanger tube expanded in the tube sheet and extending through the tube support sheet;

FIG. **2** is an enlarged view of the structure shown at the right of FIG. **1**;

FIG. **3** is a view similar to FIG. **1** in which the cylinder structure has been advanced to advance the mandrel into initial engagement with the collet sections;

FIG. **4** is an enlarged view of the right portion of FIG. **3**;

FIG. **5** is a view similar to FIGS. **1** and **3** but showing the expanding mandrel moved inwardly for the expansion of the heat exchanger tube in the tube support sheet; it also indicates movement of the piston outwardly in the cylinder structure by countermovement of the power shaft;

FIG. **6** is an enlarged view of the structure shown at the right of FIG. **5**;

FIG. **7** is a view taken on line **7—7**, FIG. **3**; and

FIG. **8** is an enlarged side elevational view of the cylinder structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. **1–6**, the heat exchanger tube is indicated at **20.** The ends **21** of the tube are expanded in fluid tight engagement with the tube sheets **23.** It is customary to form the tubes with heat exchanging fins **24** on the external surface of the tube. The ends **21,** expanded in the tube sheets **23,** are not finned. Also, the intermediate portion **25** of the tube in the area of the support sheet **27** is not formed with fins. The fins **24** are formed by crushing a helical groove in the exterior surface of the tube. In this operation, the internal diameter of the tube in the finned portion is reduced. That is, the internal diameter of the tube in the areas **21, 25** is somewhat greater than the internal diameter of the remainder of the tube. This is clearly shown in FIGS. **2, 4** and **6.** It will be understood that the holes in the tube sheets **23** and the tube support sheets **27** are formed slightly greater in diameter than the external diameter of the tubes **20.** This is to permit the ready insertion of the tubes in the heat exchanger. This clearance is shown in FIG. **2** between the tube support sheet **27** and the tube portion **25.** It is important that the tube areas **25** be expanded into snug engagement with the tube support sheets **27.** However, it is also important that the por-

tions 25 are not overly expanded such as to cause extreme crushing of the tube side walls and substantial reduction of its thickness. Such over expansion would lead to premature tube failure. Also, in the event that it becomes necessary to remove a defective tube, such removal would be made difficult if the sections 25 of the tubes were overly expanded in the tube support sheet 27. The portion 25 of the tube 20 is expanded in the support sheet 27 by a circular series of collet sections 30 mounted on the inner end of a collet tube 31. A housing 33 is connected to a cylindrical cylinder structure 35. The housing 33 is formed with a tubular portion 37, slidably mounted on a tubular portion 40 extending from the cylinder structure 35. The cylinder structure 35 is formed with a cylinder bore 55 in which is mounted a piston 56. The piston is formed in the arrangement shown with an elongated hub portion 57, slidably mounted in and extending through an end tab 60 secured to the cylinder structure 35 by capscrews 61. A shaft 67 is journaled in the cylinder structure, preferably in the piston structure 56, 57. The outer end of the shaft 67 extends outwardly from the piston structure and has affixed thereto a crank 70. The outer end of the plunger 53 is formed with an elongated internally threaded socket to receive the inner externally threaded end of the shaft 67. The shaft 67 is formed intermediate its ends with an integral or fixed collar 71.

The collar 71 is arranged intermediate the outer end of the plunger 53 and a thrust bearing 73 abutting against the inner end of the piston 56. A similar thrust bearing 75 is preferably interposed between the hub of the crank 70 and the outer end of the piston hub 57. The cylinder bore 55 is of greater diameter than the external diameter of the piston hub 57 providing an annular space 76 intermediate the piston and the end cap 60. It is to be noted that the tubular portion 40 of the cylinder structure is formed in opposite sides with axially extending slots 80 terminating at their inner ends in circumferentially extending slots 81, see FIGS. 1 and 8. The housing portion 37 is formed with an enlargement 83 formed in its opposite sides with threaded apertures to receive screws 84 having ends 85 extending into the slots 80, 81. The ends of the screws also extend into slots 87 formed in the periphery of the plunger 53 and extending lengthwise thereof. With this arrangement, there is provided relative axial movement between the housing 33 and the cylinder structure 35. The operator maintains the stop 43 against the tube sheet 23 by means of a handle 90 attached to the housing 33.

Thereupon, the operator pushes the cylinder structure inwardly until the ends 85 of the screws 84 are in registration with the slots 81. He thereupon effects relative rotation between the cylinder structure and the housing, moving the screws in slots 81. The apparatus is now locked in the position shown in FIGS. 3 and 4. In this position, the mandrel 50 has engaged the collet sections 30 and expanded them slightly against the inner surface of the area 25 of the tube. The shaft 67 is then rotated by the crank 70 causing inward movement of the plunger 53 and the mandrel rod 51. This movement results in a reverse pressure against the shaft which is transmitted through the thrust bearing 73 to the piston 56.

Referring to FIGS. 3 and 8, the cylinder structure 35 is formed with an internally threaded aperture 91, communicating with the space 76. An adapter 93 has one end threaded into the aperture 91. The opposite externally threaded end is provided with a tubular member 94. The adapter 93 is formed with an axially extending passage 95 terminating in the area 76. A plug 100 is threaded into the lower end of the tube 94 and is connected to a stem 101 as by pin 102. A piston 103 is mounted in the tube 94 and is formed with a recess 104. The upper end of the stem is formed with an enlargement 105 positioned in the recess and retained therein by a gland nut 106. A helical compression spring 107 encircles the stem 101 intermediate the plug 100 and the nut 106.

With the parts of the apparatus assembled as shown in FIGS. 1, 3 and 5, with the exception of adapter 93 and the structure connected thereto, the apparatus is inverted with the aperture 91 facing upwardly. A charging fixture is threaded into the aperture 91. That fixture is similar to a manifold device used conventionally in charging refrigeration apparatus with refrigeration. It includes a passage extending from a source of vacuum to the area 76. A valve is arranged in that passage. There is another passage extending from the area 76 to a supply of hydraulic fluid. The valve in the supply line is closed; the valve in the vacuum line is opened, whereby the area 76 and the area within the gauge 65, including the Boyden tube, if the gauge is equipped with one, is completely exhausted. Thereupon, the valve in the vacuum line is closed and the valve in the supply line is opened, whereby the hydraulic fluid flows into the hydraulic system completely filling the same.

To prevent movement of the piston hub 57 to the left to move the piston ring 109 out of the cap 60 by application of vacuum to the area 76, the hub 57 is provided with a pin 110 for engagement with the cap 60 to limit outward movement of the piston.

With the apparatus still inverted, the charging device is removed and the adapter 93, with tube 94 attached thereto, is threaded into the aperture 91. The tube 94 is then filled with hydraulic fluid until it escapes through the vent aperture 112, FIG. 3. Thereupon, the piston 103 is pushed into the tube 94 and the plug 100 threaded inwardly. Such action applies pressure on the fluid through spring 107 to put pressure on gauge 65. The plug is threaded inwardly until the enlargement 105 engages the top wall of the recess 104, the compressed spring applies a predetermined pressure on the gauge. The plug is screwed in farther, increasing the pressure on the gauge to some desired higher level.

The elements arranged in the tubular member 94 function as a pressure applying means for prepressurizing the hydraulic system which is free from air, containing only hydraulic fluid. Accordingly, the force applied by the shaft 67 against the piston 56 is transmitted directly to the gauge 65 by the noncompressible fluid.

With a severe change in temperature, the hydraulic fluid may contract sufficiently to eliminate the prepressure with the possibility of air entering the system. The spring 107 functions to prevent such pressure drop. Upon initial movement of the plug 100 in tube 94, the spring 107 will apply a force on the piston 103, which, as the stem enlargement 105 is moved near the top wall of recess 104, effects a pressure on the hydraulic system of, for example, 50 psi. The plug 100 is threaded inward to produce a pressure of say 400 psi, which is

well below that necessary to effect proper expansion of the tube 20 in the support sheet 27.

Reverting now again to FIG. 5, the shaft 67 has been rotated to advance the mandrel rod 51 and the mandrel 50 to expand the collet sections 30. This operation is continued with the result that the counter or outward pressure on the shaft transmitted to the piston 56 moves it outwardly and accordingly increases the pressure on the gauge 65. This occurs because the collet sections, collet tube and housing are then locked against movement relative to the cylinder structure by the screws 84 extending into the slots 81.

The operator knows that when a predetermined pressure is indicated on the gauge 65, the portion 25 of the heat exchanger tube 20 has been expanded to the proper extent in the tube support sheet 27.

Reverse rotation of the shaft 67 will effect outward movement of the plunger 53, withdrawing the mandrel from the collet sections 30. With the release of pressure on the shaft 67, the pressurized hydraulic system will return the piston 56 to its initial prepressurized position.

The structural arrangement disclosed herein is particularly economical to build and is light and compact and very convenient to use. It assures precise, uniform expansion of the heat exchanger tubes in the tube support sheets 27.

While we have described the preferred embodiments of our invention, it is to be understood that the invention is not limited thereto but may be otherwise embodied within the scope of the following claims.

We claim:

1. Apparatus for expanding heat exchanger tubes in tube receiving openings in tube supporting sheets comprising a collet tube, collet means having a circular series of expandable sections fixed to the inner end of said tube, said tube and collet sections, in collapsed condition, being dimensioned for insertion in the heat exchanger tube, a stop member adjustable in a direction axially of said collet tube for engagement with the tube sheet of the heat exchanger to position said collet sections in the heat exchanger tube in registration with the tube support sheet, housing means, the outer end of said collet tube being fixed to the housing, a cylinder structure connected to the housing, a shaft journaled in the cylinder structure, motion transmitting means connecting the inner end portion of said shaft to the outer end of a mandrel rod disposed in said collet tube and extending axially thereof, a collet expanding mandrel fixed to the inner end of said rod, said shaft being operable upon rotation in one direction to move said mandrel rod and the mandrel inwardly in said collet tube for engagement with said collet sections by said mandrel, said mandrel being operable upon such engagement to expand the collet sections against the heat exchanger tube and to expand the latter in a tube receiving opening in the support sheet, said shaft being operable upon reverse rotation to withdraw said mandrel from engagement with said collet sections, and means restraining said shaft against axial countermovement during rotation of the shaft in said one direction.

2. Tube expanding apparatus as set forth in claim 1 wherein said last mentioned means includes a piston in which said shaft is mounted for axial and rotatable movement, a source of fluid pressure and a gauge indicating pressure applied to said source.

3. Tube expanding apparatus as set forth in claim 1 wherein said stop member is mounted on the outer portion of said collet for adjustment axially thereof and means operable to fixedly secure the stop member to said tube in adjusted position.

4. Tube expanding apparatus as set forth in claim 1 wherein said motion transmitting means includes a plunger having one end fixedly secured to the outer end of said mandrel rod, the opposite end of said plunger being formed with an internally threaded socket, the inner end of said shaft having threaded connection with said socket.

5. Tube expanding apparatus as set forth in claim 1 wherein said cylinder structure is connected to said housing for limited adjustment relative thereto in a direction axially of said mandrel rod.

6. Tube expanding apparatus as set forth in claim 2 wherein said shaft is mounted in said piston for axial and rotable movement therein.

7. Tube expanding apparatus as set forth in claim 2 including means operable to restrain rotation of said piston.

8. Tube expanding apparatus as set forth in claim 2 wherein said shaft is formed with an enlargement intermediate the ends thereof for engagement with the inner side of said piston.

9. Apparatus for accurately and repeatably expanding tubes within a tube supporting sheet including

collet means having a circular series of expandable sections affixed to one end thereof, said collet means, in a collapsed condition, being insertable into the tube to be expanded,

a stop member operatively associated with said collet means for engaging the support sheet to preposition said collapsible sections in registration with the support sheet, when the collet is inserted within said tube,

a mandrel slidably extendable into said collet means to expand said collet sections into contact with the tube to expand the sections against the tube sheet, and to collapse said sections upon withdrawal from said collet means,

motion transmitting means being operable to move said mandrel into and out of said collet means whereby the collet sections are expanded and collapsed,

hydraulic means for applying an initial extending reference pressure to said mandrel to expand the collet sections, said pressure being below that required to effect complete tube expansion into contact with the tube sheet, and

gauge means responsive to said hydraulic means to indicate the pressure above said initial pressure exerted by said collet sections upon further movement of said motion transmitting means extending said mandrel into said tube, whereby the tube is expandable to a predetermined pressure against the tube sheet.

* * * * *