Oct. 11, 1932. A. M. NELSON 1,881,867

METHOD OF ATTACHING ANNULAR ELEMENTS TO SUPPORTING STRUCTURES

Filed Sept. 22, 1930 2 Sheets-Sheet 1

Fig. 1.

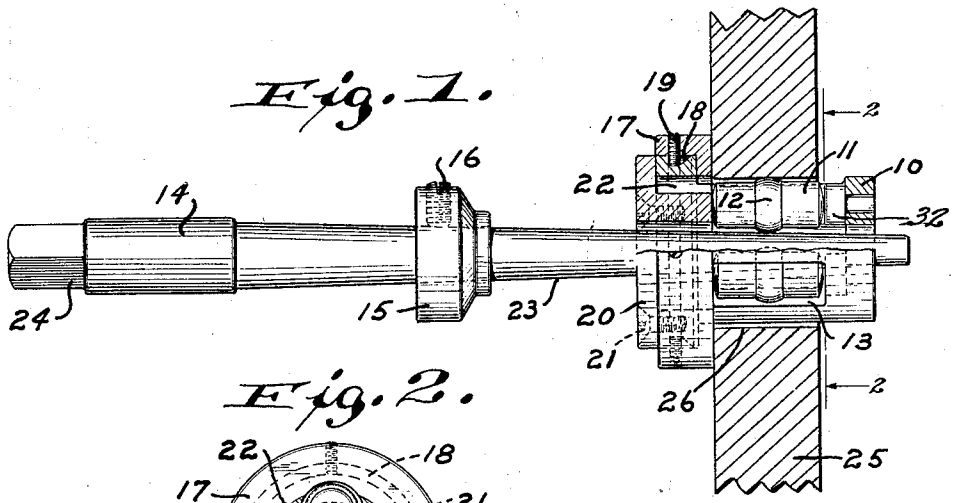


Fig. 2.

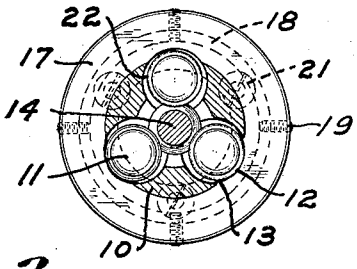
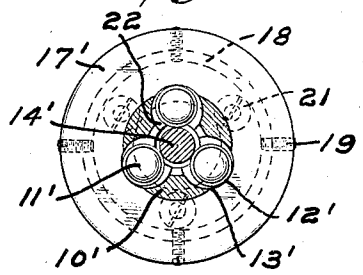


Fig. 3.

Fig. 4.



INVENTOR.

A. M. Nelson

BY

Morsell & Morsell

ATTORNEY.

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Fig. 5.

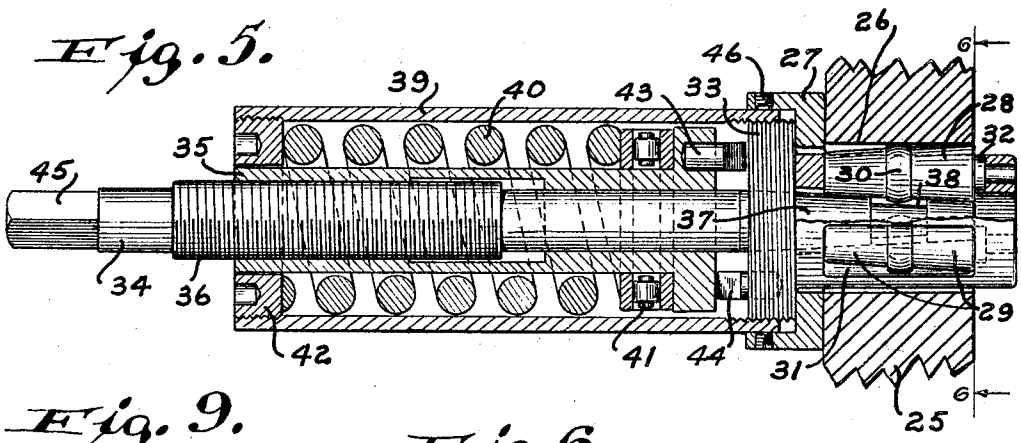


Fig. 9.

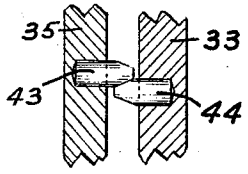


Fig. 6.

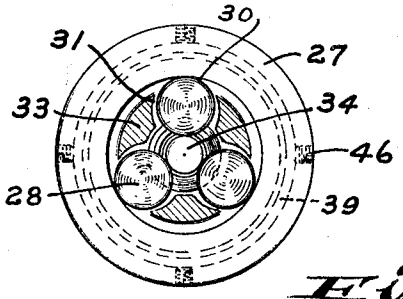


Fig. 7.

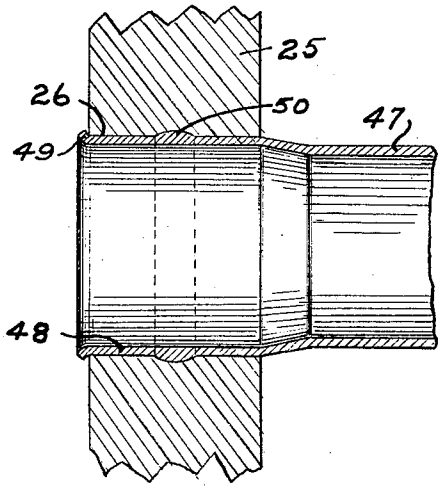
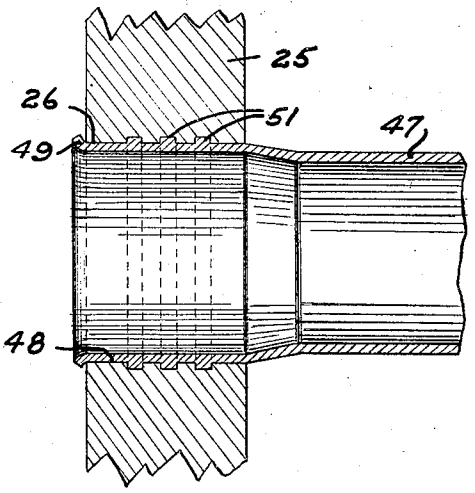


Fig. 8.



INVENTOR.

A. M. Nelson

BY

Morsell & Morsell

ATTORNEY.

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UNITED STATES PATENT OFFICE

ALFRED M. NELSON, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO THE VILTER MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF WISCONSIN

METHOD OF ATTACHING ANNULAR ELEMENTS TO SUPPORTING STRUCTURES

Application filed September 22, 1930. Serial No. 483,740.

The present invention relates in general to an improved method of attaching annular elements to supporting structures, and relates more specifically to an improved process of rigidly fastening the ends of tubes to tube-sheets and to improved mechanism for effecting such fastening.

An object of the invention is to provide a new and useful method for effecting rigid attachment of one element to another.

It has heretofore been common commercial practice in the boiler, condenser, and refrigeration industries, to attach the end of each of a bank of tubes to an adjacent tube-sheet, by inserting the tube end into a hole formed in the sheet and by subsequently expanding the inserted tube end into intimate contact with the bounding surface of the receiving hole.

It has also been customary in some cases to cut an annular groove of greater diameter than that of the hole itself, intermediate the ends of each hole, and to subsequently expand the tube into this groove in order to prevent axial displacement of the tube relative to the sheet. With this prior construction, a groove was left within the tube adjacent to the groove in the sheet, such grooves being objectionable in that they tend to accumulate dirt and prevent ready cleaning of the interior of the tubes. The tube-receiving holes are formed by drilling through the sheet, and in the prior grooved construction the grooves were formed by cutting away the metal, the tube ends being expanded into direct engagement with the surfaces of the finished holes and grooves, with the aid of a rotary expander cooperable with the interior of the tube ends.

In order to prevent accumulation of dirt within the tube ends and to permit ready cleaning of the tubes, it is desirable to avoid internal grooving of the tube ends as in the prior construction wherein grooves were provided between the ends of the holes. The drilling of these holes and the cutting of the grooves to accurate diameter, has also introduced frequent breakage of drills and of the grooving tools, and the prior construction did not provide leak-proof final unions.

A more specific object of the present invention is to provide an improved method of securing a more rigid and tighter union between a tube and a supporting tube-sheet, while retaining all of the advantages of the prior constructions. In accordance with the improvement the metal adjoining the tube-receiving holes of the tube-sheets, is compressed by providing one or more rolled annular grooves therein, the tube ends being subsequently expanded to fill these annular grooves while avoiding the formation of depressions in the interiors of the tube ends. This produces a fastening in which the metal at the tube ends, as well as in the adjacent portions of the tube-sheet, is properly conditioned to resist destruction of the joint, and wherein the tube is effectively locked against longitudinal displacement relative to its support. The invention further contemplates improved mechanism for facilitating commercial exploitation of the improved process by quickly and effectively rolling the grooves in the support preparatory to final fastening of the elements and without breakage of tools.

A clear conception of the several steps of the improved process and of the construction and mode of manipulating several forms of the improved mechanisms during commercial exploitation of the process, may be had by referring to the drawings accompanying and forming a part of this specification, in which like reference characters designate the same or similar parts in the various views:

Fig. 1 is a part-sectional side elevation of one form of tool for conditioning the holes in a tube-sheet preparatory to attaching the ends of the tubes thereto;

Fig. 2 is a transverse section through the tool disclosed in Fig. 1, the section being taken along the line 2—2 of Fig. 1 looking in the direction of the arrows;

Fig. 3 is a part-sectional side elevation of another type of tool for conditioning the holes in tube-sheets preparatory to attaching tube ends thereto;

Fig. 4 is a transverse section through the tool of Fig. 3, the section being taken along

the line 4—4 of Fig. 3 looking in the direction of the arrows;

Fig. 5 is a part-sectional side elevation of still another form of tool for conditioning the holes in tube-sheets preparatory to the fastening of tubes thereto;

Fig. 6 is a transverse section through the tool of Fig. 5, the section being taken along the line 6—6 of Fig. 5 looking in the direction of the arrows;

Fig. 7 is an enlarged sectional view through the end of a tube attached to a fragment of a tube-sheet, the hole within the tube-sheet having been conditioned with a tool of the form shown either in Fig. 1 or Fig. 5;

Fig. 8 is a similarly enlarged section through the end of a tube and through a fragment of a tube-sheet, wherein the fastening has been effected with the aid of a tool such as shown in Fig. 3; and

Fig. 9 is a fragmentary section through the portion of the implement adjoining the chamfered driving pins.

Referring specifically to Figs. 1 and 2, the improved groove-rolling implement shown therein, comprises in general a cage member 10 having one or more elongated radiating recesses 13 of substantially circular cross-section; a roller 11 freely rotatably supported in each of the recesses 13; and a spindle 14 having a tapered portion 23 cooperable with the rollers 11 to urge the latter outwardly and to simultaneously rotate the rollers during rotation and longitudinal advancement of the spindle 14.

Each of the rollers 11 is of substantially cylindrical formation, except that it has an enlarged medial portion 12 adapted to coact directly with the tapered portion 23 of the spindle 14, and the corresponding ends of the rollers 11 are adapted to coact with thrust blocks 32 mounted in the cage member 10 at the corresponding ends of the recesses 13. While the recesses 13 are formed to permit free rotation and limited outward movement of the rollers 11 therein, the outermost portions of these recesses 13 are constricted so as to prevent the rollers from falling out of the recesses. The rollers 11 are insertable endwise into the recesses 13, through openings 22, and a retaining cap 20 secured to the end of the cage member 10 by means of screws 21, serves to prevent excessive endwise movement of the rollers away from the thrust blocks 32. The peripheral portion of the cage member 10 adjacent to the cap 20, is provided with a flange having a continuous groove 18 therein, and a bearing ring 17 coacts with the outer and side portion of this flange and carries a series of radial set-screws 19 which extend into the groove 18 in order to hold the ring 17 in place while permitting free rotation of the ring relative to the cage member 10. The medial portion of the driving spindle 14 is provided with a stop collar 15 which may be locked in any desired position along the taper 23 by means of a set-screw 16, and the end of the spindle beyond the taper 23 is provided with a square shank 24 for imparting rotation thereto.

Referring specifically to Figs. 3 and 4, the modified groove-rolling implement shown therein is somewhat similar to that previously described, comprising in general a cage member 10′ having one or more radiating recesses 13′ of substantially circular cross-section; a roller 11′ freely rotatably supported in each of the recesses 13′; and a spindle 14′ having a tapered portion 23 cooperable with the rollers 11′ to urge the same outwardly and to simultaneously rotate the rollers 11′ during rotation and longitudinal advancement of the spindle 14′.

Each of the rollers 11′ of the modified implement, is of slightly tapered formation, except that a series of enlarged portions 12′ are formed thereon, these enlarged portions being adapted to coact directly with the tapered portion 23 of the spindle 14′. While the recesses 13′ are formed to permit free rotation and limited outward movement of the rollers 11′, the outermost portions of the recesses 13′ are likewise constricted to prevent the rollers from falling out of the recesses. The rollers 11′ are insertable endwise into the recesses 13′ through openings 22, and a retaining cap 20′ secured to the end of the cage member 10′ by means of screws 21, again serves to prevent excessive endwise movement of the rollers within the recesses 13′. The peripheral portion of the cage member 10′ adjacent to the cap 20′, is provided with a flange having a continuous groove 18′ therein, and a bearing ring 17′ coacts with this flange and carries a series of set-screws 19 which extend into groove 18′ for the purpose of holding the ring 17′ in place, while permitting free rotation of this ring relative to the cage member 10′. The medial portion of the driving spindle 14′ is likewise provided with a stop collar 15 having a set-screw 16 for the purpose of locking the collar in various positions of adjustment along the taper 23, and the end of the spindle 14′ is also provided with a square shank 24 for imparting rotation thereto.

During normal operation of the implement illustrated in Figs. 1 to 4 inclusive, the tube sheet 25 to which the tubes 47 are to be fastened, is provided with drilled holes 26 properly spaced and positioned. These drilled holes 26 are of slightly greater diameter than the outer diameters of the tubes 47 which are to coact therewith. Either of the implements of Figs. 1 or 3 may be utilized for the purpose of grooving and of simultaneously compressing the metal at the grooves in each of the holes 26, the implement of Fig. 1 being adapted to form a single groove in each hole 26 intermediate its ends and the implement

of Fig. 3 being adapted to compress a plurality of grooves into each of the holes 26.

After the roller-supporting cage 10, 10′ has been inserted within one of the holes 26 and the bearing collar 17, 17′ thereof has been provided with an abundance of lubrication and has been brought into contact with the face of the sheet 25, rapid rotation may be imparted to the spindle 14, 14′ which may be simultaneously urged into the space between the rollers 11, 11′. The collar 15 may be set to limit the longitudinal movement of the spindle, so that when the spindle has been advanced to the position where the collar 15 engages the adjacent cap 20, 20′, the formation of the grooves within the holes 26 and the compression of the metal bounding the holes, has been completed. As the rapidly rotating portion 23 of the spindle advances longitudinally between the rollers 11, 11′, the rollers are simultaneously rapidly rotated and forced outwardly within their radial confining recesses 13, 13′ thus rolling the grooves and simultaneously compressing the metal within and adjoining the rolled grooves. The bearing ring 17, 17′ serves to permit free rotation of the cage 10, 10′ during the rolling operation, while creating minimum resistance to such rotation of the cage member. When the rolling operation has been completed, the spindle 14, 14′ may be withdrawn and the rollers 11, 11′ will then recede into the recesses 13, 13′ and will permit free withdrawal of the cage member 10, 10′ from the finished hole 26.

Referring specifically to Figs. 5 to 9, the improved groove-rolling implement shown therein, is of somewhat different construction and operates in a slightly different manner, from the implements shown in Figs. 1 to 4 inclusive. The modified implement of Fig. 5 comprises in general a cage 33 having one or more radiating recesses 31 of substantially circular cross-section; a roller 28 freely rotatably supported in each of the recesses 31; and a spindle 34 having a tapered end portion 37 cooperable with tapered end portions 29 of the rollers 28, to urge these rollers outwardly and to simultaneously rotate the same during rotation and longitudinal advancement of the spindle 34.

Each of the rollers 28 besides having the tapered end portions 29, has a medial enlarged portion 30, the spindle 34 being provided with a recess 38 for permitting rotation and longitudinal displacement of the spindle without engagement thereof with the roller enlargements 30. The larger ends of the rollers 28 are adapted to coact with thrust blocks 32 mounted in the cage member 33 at the corresponding ends of the recesses 31. While the recesses 31 are formed to permit free rotation and limited radial displacement of the rollers 28 therein, the outermost portions of the recesses are constricted to prevent the rollers from falling out of the recesses. The rollers 28 are insertable into the recesses 31 through the central opening in the cage member 33, when the spindle 34 has been removed, and are retained within the recesses by the spindle after insertion thereof. The cage 33 is provided with a threaded flange to which a spring housing 39 is directly attached, and this flange is provided with a chamfered pin 44 extending parallel to the spindle 34. The bearing ring 27 is secured to the casing 39 adjacent to the cage member 33 by means of set-screws 46, and this bearing ring coacts with the flange at the end of the cage member 33. The spindle 34 is provided with a threaded portion 36 and has a square driving shank 45 at the end thereof, and a push member 35 coacts with the threaded portion 36 and is adapted to ride therealong. The end of the push member 35 adjacent the cage member 33 is likewise provided with a chamfered pin 43 adapted to coact with the pin 44 under certain conditions of operation. A relatively stiff compression spring 40 coacts with a roller bearing 41 interposed between one end of the spring and the flange on the member 35, and the opposite end of the spring 40 reacts against an end ring 42 secured to the end of the housing 39.

During normal operation of the implement illustrated in Figs. 5, 6 and 9, the tube-sheet 25 to which the tubes 47 are to be attached, is provided as before with drilled holes 26 properly spaced and positioned and of slightly greater diameter than the external diameters of the ends of the tubes 47. The roller-supporting cage 33 after having been inserted in one of the holes 26 as shown in Fig. 5, engages one side of the bearing ring 27, the other side of which is in direct engagement with the outer face of the tube-sheet 25. The rollers and the various bearings should be supplied with an abundance of lubrication, whereupon relatively rapid rotation may be imparted to the spindle 34 through the shank 45. As the spindle 34 rotates, the screw-threads coacting with the push member 35, cause the spindle to slowly travel forwardly between the rollers 28, thereby simultaneously rotating these rollers and forcing them outwardly against the wall of the hole 26. The rollers 28 are driven by virtue of the coaction between the taper 37 of the spindle 34 with the tapered end portions 29 of the rollers, and as the rollers 28 are forced outwardly, the enlargements 30 thereof simultaneously form a groove in the medial portion of the hole 26 by compressing the metal of the tube-sheet 25. During the relative rapid rotation of the spindle 34, the cage member 33 is slowly rotated and the chamfered pin 44 engages the pin 43 carried by the push member 35 and causes similar

slow rotation of the member 35 and of the spring 40.

When the groove has been formed, reverse rotation of the spindle 34 will withdraw the taper 37 from the space between the rollers 28, and the pin 43 is then swung about the axis of the spindle 34 and impinges against the opposite side of the pin 44 thus imparting a blow and subsequent reverse rotation to the cage 33, which quickly releases the rollers 28 from the formed groove and permits withdrawal of the implement from the tube-sheet.

After the grooves have thus been rolled into the holes 26 of the tube-sheet 25, the tubes 47 may be finally fastened to the sheet 25. The end of each tube 47 is inserted within a grooved hole 26, and a rolling device is then applied within the tube end 48, and this end is expanded as indicated in Figs. 7 and 8 to snugly coact with the wall of the hole 26 and with the grooves 50 or 51 formed in the tube-sheet. The compression of the metal in the tube end by rolling is continued until the grooves are entirely filled with metal and the extreme end 49 of the tube is rolled out to form a slight flange which assists the enlargement coacting with the grooves 50 or 51, in positively preventing endwise displacement of the tube. In Fig. 7, the single groove 50 has been formed with an implement of the type shown in Fig. 1 or Fig. 5, and in Fig. 8 the grooves 51 have been formed with an implement of the type shown in Fig. 3.

From the foregoing description it will be apparent that the present invention provides a simple and highly effective method of fastening tubes to tube-sheets, without danger of breakage of cutting tools such as formerly used to provide the grooves. The holes 26 may be formed by an ordinary drilling operation, and the rolled grooves 50, 51 being formed by compression of the metal, provide perfect seatings for the tube ends and eliminate possible leakage of fluids past the joints. The rolled grooves can also be formed much quicker than the cut grooves, and commercial exploitation of the present improved process has resulted in the production of superior fastenings in much less time than has heretofore been possible. The final fastenings are also devoid of internal grooves within the tube ends, thereby facilitating cleaning of the tubes 47.

It should be understood that it is not desired to limit the invention to the exact steps of the improved method herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

What I claim as my invention is:

1. The method of attaching a tube to a sheet, which comprises forming in the sheet a hole having a diameter approximating that of the exterior of the tube, enlarging the diameter of part of the hole to form a groove and compressing the bounding wall of the hole and groove, inserting the tube end within the hole, and expanding the tube end into intimate contact with said compressed wall of the hole and groove.

2. The method of attaching a tube to a sheet, which comprises forming in the sheet a hole having a uniform diameter approximating that of the exterior of the tube, enlarging the diameter of part of the hole by rolling a groove in the bounding wall thereof and compressing the bounding walls of the hole and groove, inserting the tube end within the hole, and expanding the tube end into intimate contact with said compressed wall and groove while avoiding complementary grooving of the interior of the tube end.

3. The method of attaching a tube to a sheet, which comprises forming in the sheet a hole having a uniform diameter approximating that of the exterior of the tube, enlarging the diameter of part of the hole by compressing the bounding wall to form a series of local annular grooves therein and also compressing the bounding wall of the hole adjoining said grooves, inserting the tube end within the hole, and expanding the tube end into intimate contact with said compressed wall and grooves while avoiding complementary grooving of the interior of the tube end.

In testimony whereof, I affix my signature.

ALFRED M. NELSON.