CONNECTOR ASSEMBLY FOR AN EXPANDABLE SLOTTED PIPE

This invention relates to a connector assembly for use in connecting sections of an expandable tubing string, and in particular but not exclusively for use in the connection of sections of an expandable slotted tubing (EST) string as utilised in downhole applications in the oil and gas exploration and extraction industries.

Expandable slotted tubing (EST) is used in various downhole applications. The tubing comprises lengths of tube which have been machined to create a large number of longitudinal slots. Thus, it is relatively easy to expand the tube radially outwardly by, for example, running a mandrel through the tubing. The expansion causes the slots to extend to create diamond-shaped apertures. The tubing is useful where it is desired to, for example, line a bore below a restriction without further reducing the diameter of the bore. Using conventional tubing, the outer diameter of the tubing must, by necessity, be of smaller diameter than the restriction, to permit the tubing to be passed through the restriction. This reduction in the bore diameter has a number of significant effects, primarily in reducing the production capabilities of the bore. Using EST, the tubing may pass through a restriction into a reamed section of bore below the restriction. The tubing may then be expanded to a diameter larger than the restriction.

EST is supplied in lengths which are, at present, made up into a string by welding the lengths to one another. This is relatively time consuming and expensive and in many situations, for example in an off-shore operation in bad weather, it may be difficult to maintain consistent weld quality. Safety problems may also arise due to the high temperatures and exposed flames or sparks

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created by a welding operation. Further, in the event of a "mis-run", requiring the welded lengths of tubing forming the EST string to be separated, the tubing must be cut, and the cut tubing cannot be reused.

It is among the objects of the present invention to provide a means of connecting sections of EST which obviates or mitigates these difficulties.

According to the present invention there is provided a connector assembly for interconnecting sections of an expandable slotted tubing string, the assembly comprising a male part and a female part for mounting on the ends of respective tubing sections, each part being slotted and being adapted to co-axially engage the other part to permit expansion of the coupled parts in a corresponding manner to the tubing string.

As used herein, the term "slots" is intended to encompass any cutting, machining or weakening of a tubular structure intended to facilitate radial expansion, including: slots which extend only partially through the tube wall and which permit the remaining thinned wall sections to fracture or extend; and lines of drilled holes.

Preferably, the male part is formed by an end of one of the interconnected tubing sections of which the outer surface has been machined away over a selected distance and the female part is formed by an end of the other of the interconnected tubing sections of which the inner surface has been machined away over a similar distance.

In such case it is preferred that the free end of the male and female part fits within an annular groove formed at the other end of the corresponding part such that if the parts co-axially engage each other said free ends are locked in a radial sense inside said grooves to prevent flaring of said free ends when the tubing string is expanded.

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This minimizes the possibility of the free ends flaring on expansion of the tube. Such flaring of the male end would create an irregularity in the tubing bore on which tools could become snagged.

The slotted free ends of the parts will define fingers and in a preferred arrangement mechanical fasteners are provided for coupling the respective overlapping fingers to one another. This prevents the ends of the parts from separating when the connected tubing is expanded. Preferably, each fastener is located substantially in the middle of a node and halfway between a pair of adjacent slots. The fasteners may be releasable, for example short screws for location in appropriate holes provided in the parts, such that the tubing may be separated in the event of a mis-run. The use of screws and the like, and the associated screw-holes, also provides a convenient means for ensuring that the parts are properly aligned.

It is therefore preferred that the mechanical fasteners consist of short screws that pass through radial holes drilled through the walls of the male and female parts and the head of each screw is sunken within a recess formed in the outer surface of the female part and the shank of each screw engages a screw thread formed in the radial hole passing through the male part.

It is also preferred that a series of circumferentially spaced screws is arranged near the free end of the male part and another series of circumferentially spaced screws is arranged near the free end of the female part, to reduce the risk of flaring of the ends of the male and female parts of the connector assembly on the tubing being expanded. In such case it is also preferred that at least the series of circumferentially spaced screws that are arranged near the free end of the male part protrude over a selected distance into the interior of the male part.

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When an expansion cone engages the protruding screws, the cone will create a slightly higher expansion force to the free end of the male part than to other parts of the expanding tubing string. This will further reduce the risk of inward flaring of the free end of the male part during expansion.

The cone will also squeeze the protruding screw ends during the expansion process so that after expansion the screw ends protrude only over a minimal, if any, distance into the interior of the expanded tubing string.

The parts may be formed integrally with the respective tubing lengths, or may be welded or otherwise secured thereto.

Furthermore, the female part may be formed by the free end of an expandable slotted tubing section which is slightly expanded before arranging the female part co-axially around the male part.

Alternatively, the assembly may comprise two male parts that are formed by the ends of the interconnected tubing sections and the female part comprises a sleeve which co-axially surrounds the male parts.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a length of expandable slotted tubing (EST), shown in an expanded configuration;

Figure 2 is a sectional view on line 2-2 of Figure 1, and in addition showing the EST in unexpanded configuration;

Figure 3 is a half section of a connector assembly in accordance with a preferred embodiment of the present invention, with the parts of the assembly shown separated; and

Figure 4 is a half section of the connector assembly of Figure 3, showing the parts connected.

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Reference is first made to Figures 1 and 2 of the drawings, which illustrate a length of expandable slotted tubing (EST) 10. In its initial configuration, the tubing 10 is simply a length of pipe in which a series of longitudinal slots 12 have been machined (shown as 12a in Figure 2). Applying a radially outward force to the tubing wall, for example by passing a cone or mandrel through the tubing, causes the tube to expand such that the slots 12a become diamond shaped openings 12b.

The tubing 10 is supplied in lengths suitable for transportation and handling and these are joined to one another to create a tubular string. The connector assembly 20 as illustrated in Figures 3 and 4 of the drawings is used to connect such tubing lengths. The assembly 20 comprises a male part 22 and a female part 24, which are mounted on the ends of the respective tubing lengths. In this particular example the parts 22, 24 are adapted to be welded to the tubing ends. The parts 22, 24 are intended to expand in a similar manner to the tubing 10, and as such are provided with similar longitudinal slots 26.

The free end of the male part 22 is machined to form a male portion 28 having a reduced outer diameter and the free end of the female part 22 defines a corresponding female portion 30 having a reduced and enlarged inner diameter to receive the male portion 28, as will be described. Each part 22, 24 defines a respective annular groove in the form of an undercut ledge 34, 35 for engaging the free end 36, 37 of the other part which is of corresponding form. This serves to prevent the free ends of one part separating from the other part on expansion of the tubing. To permit the free end 36 of the male part to be deflected inwardly and thus pass within the female part, the male part 22 defines a living hinge 38. It will be noted that the hinge 38 is spaced a relatively long distance from the free end 36, such that

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only small degree of deflection is necessary at the hinge 38 to allow the free end 36 to slide into the female part 24.

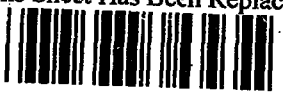
The slots 26 in the parts 22, 24 are arranged such that the free ends 36, 37 of the parts each define fingers 40, 41, and each of these fingers defines a hole 42, 43. The holes 43 in the female part are countersunk, whereas the holes 42 in the male part 22 are threaded such that the fingers 40, 41 may be secured to one another using a number of short screws 44. The screws 44 are located adjacent the free end of the female part, as the fingers 41 will have a tendency to flare outwardly on expansion of the tubing. In addition, a line of screws may also be provided on the other side of the threads 32, 33.

To connect two lengths of tubing provided with the tubing connector assembly 20, the parts 22, 24 are brought together such that the free end 36 of the male part passes inside the free end 37 of the female part, the end 36 being deflected inwardly to ride under the free end 37. The screws 44 are then secured in the holes 42, 43.

The desired number of tubing sections is connected in this manner to form a string and run downhole to the desired location within the bore. The tubing and the connector assemblies may then be expanded to the desired diameter. However, in the event of a mis-run, requiring the tubing to be withdrawn and disassembled, this may be achieved relatively easy by removing the screws 44 and then unscrewing the male and female parts 22, 24.

It will be clear to those of skill in the art that the above-described embodiment is merely exemplary of the present invention, and may be subject to various modifications and improvements without departing from the scope of the invention.

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C L A I M S

1. A connector assembly for interconnecting sections of an expandable slotted tubing string, the assembly comprising a male part and a female part for mounting on the ends of respective tubing sections, each part being slotted and being adapted to co-axially engage the other part to permit expansion of the coupled parts in a corresponding manner to the tubing string.

2. The connector assembly of claim 1, wherein the male part is formed by an end of one of the interconnected tubing sections of which the outer surface has been machined away over a selected distance and the female part is formed by an end of the other of the interconnected tubing sections of which the inner surface has been machined away over a similar distance.

3. The connector assembly of claim 2, wherein the free end of the male and female part fits within an annular groove formed at the other end of the corresponding part such that if the parts co-axially engage each other said free ends are locked in a radial sense inside said grooves to prevent flaring of said free ends when the tubing string is expanded.

4. The connector assembly of claim 1, 2 or 3, wherein the male and female parts are interconnectable by at least one series of circumferentially spaced mechanical fasteners.

5. The connector assembly of claim 4, wherein the mechanical fasteners consist of short screws that pass through radial holes drilled through the walls of the male and female parts and the head of each screw is sunken within a recess formed in the outer surface of the female part and the shank of each screw engages a screw

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thread formed in the radial hole passing through the male part.

6. The connector assembly of claim 5, wherein a series of circumferentially spaced screws is arranged near the free end of the male part and another series of circumferentially spaced screws is arranged near the free end of the female part.

7. The connector assembly of claim 6, wherein at least the series of circumferentially spaced screws that are arranged near the free end of the male part protrude over a selected distance into the interior of the male part.

8. The connector assembly of claim 4, wherein each fastener is located substantially in the middle of a node and halfway between a pair of adjacent slots.

9. The connector assembly of claim 1, wherein the female part comprises an expandable slotted tubing section which is slightly expanded before arranging the female part co-axially around the male part.

10. The connector assembly of claim 9, wherein the assembly comprises two male parts that are formed by the ends of the interconnected tubing sections and the female part comprises a sleeve which co-axially surrounds the male parts.

11. The connector assembly of any preceeding claim, wherein at least some of the slots of the male and female parts of the connector are substantially aligned.

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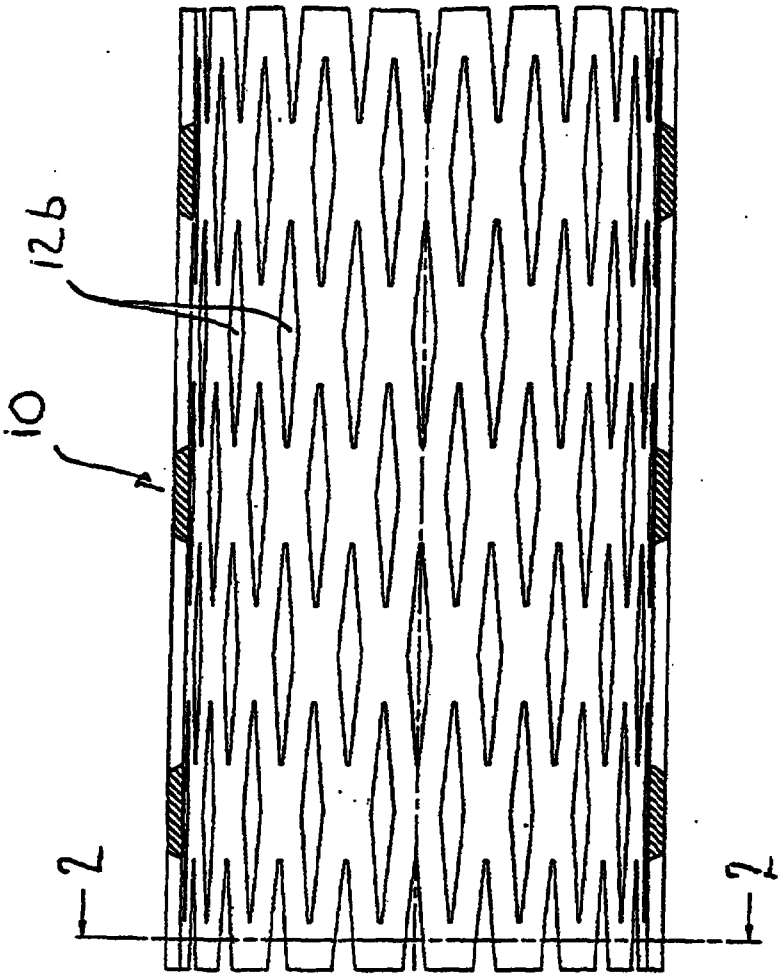


Fig 1

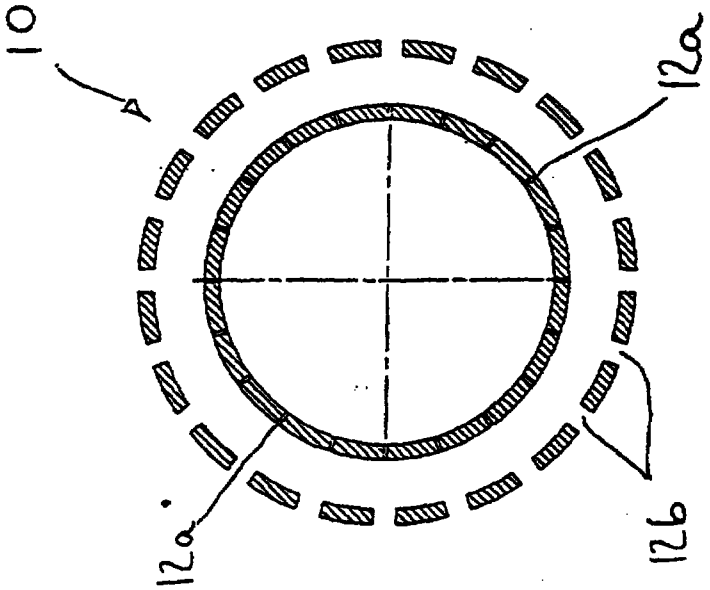


Fig 2

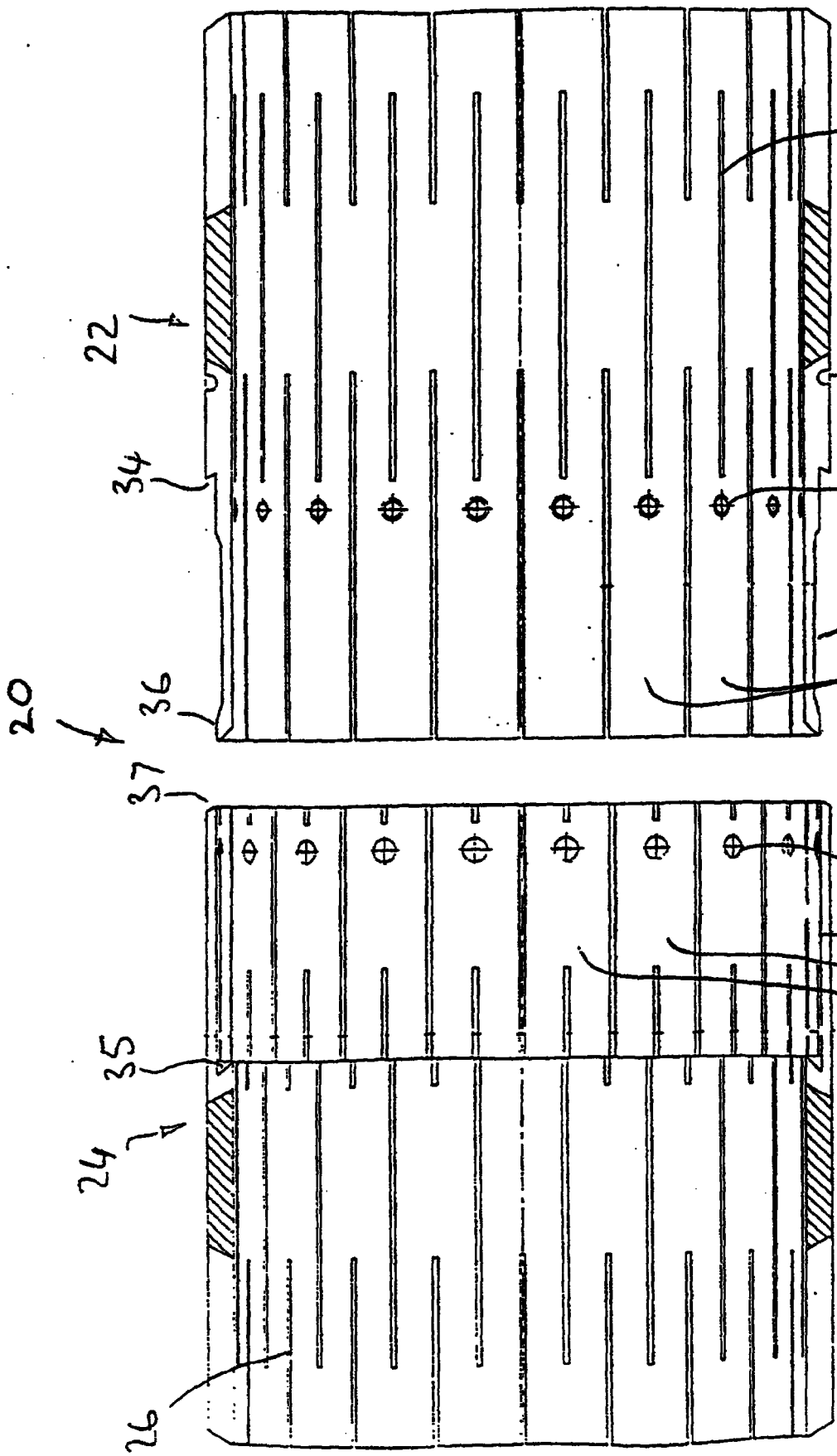


Fig 3

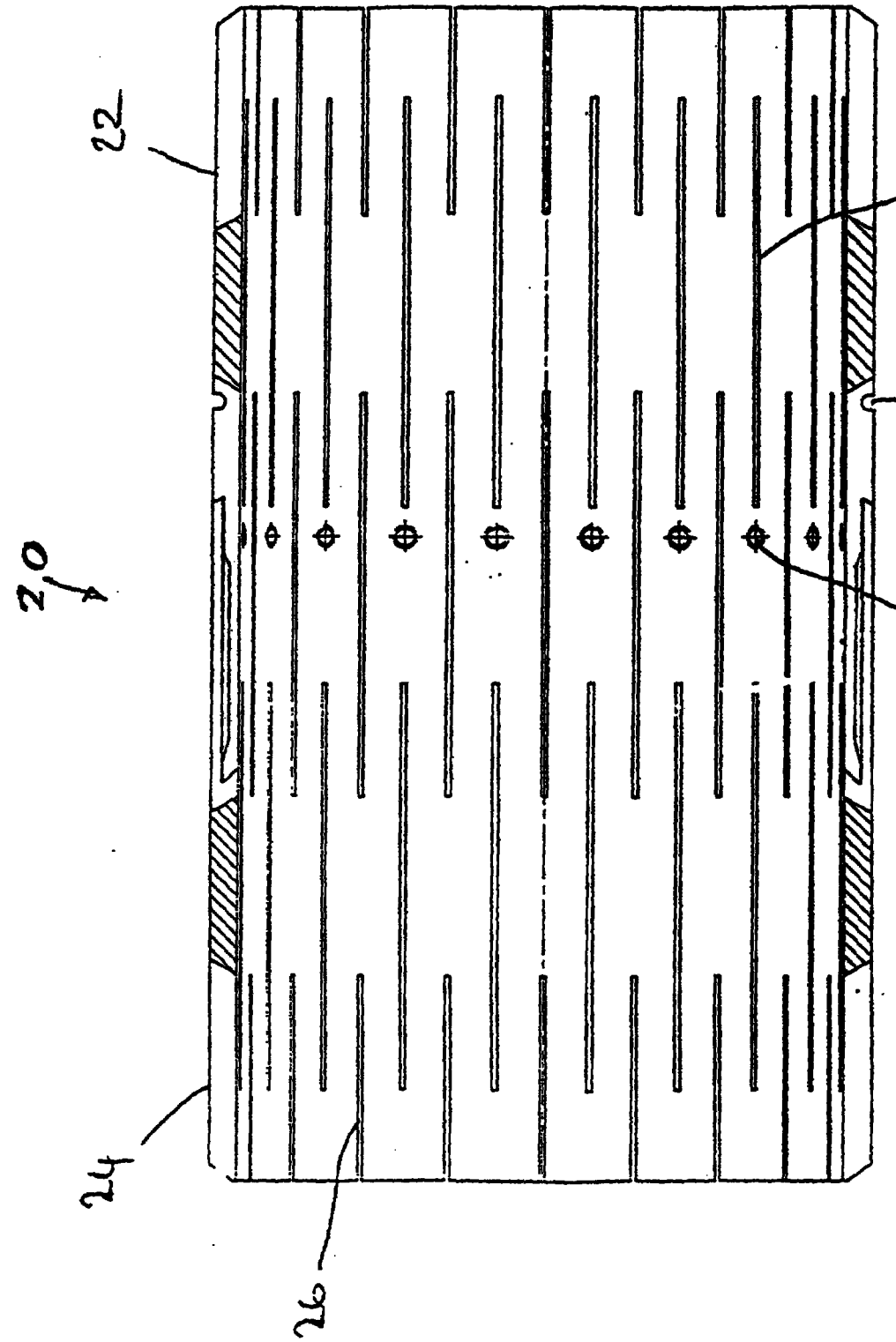


Fig. 4

created by a welding operation. Further, in the event of a "mis-run", requiring the welded lengths of tubing forming the EST string to be separated, the tubing must be cut, and the cut tubing cannot be reused.

It is among the objects of the present invention to provide a means of connecting sections of EST which obviates or mitigates these difficulties.

According to the present invention there is provided a connector assembly for interconnecting sections of an expandable slotted tubing string, the assembly comprising a male part and a female part formed integrally with the ends of respective tubing sections, each part being slotted and being adapted to co-axially engage the other part to permit expansion of the coupled parts in a corresponding manner to the tubing string, wherein the male and female part are interconnectable by one series of circumferentially spaced mechanical fasteners.

Preferably, the male part is formed by an end of one of the interconnected tubing sections of which the outer surface has been machined away over a selected distance and the female part is formed by an end of the other of the interconnected tubing sections of which the inner surface has been machined away over a similar distance.

In such case it is preferred that the free end of the male and female part fits within an annular groove formed at the other end of the corresponding part such that if the parts co-axially engage each other said free ends are locked in a radial sense inside said grooves to prevent flaring of said free ends when the tubing string is expanded.

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The slotted free ends of the parts will define fingers and in a preferred arrangement mechanical fasteners are provided for coupling the respective overlapping fingers to one another. This prevents the ends of the parts from separating when the connected tubing is expanded. Preferably, each fastener is located substantially in the middle of a node and halfway between a pair of adjacent slots. The fasteners may be releasable, for example short screws for location in appropriate holes provided in the parts, such that the tubing may be separated in the event of a mis-run. The use of screws and the like, and the associated screw-holes, also provides a convenient means for ensuring that the parts are properly aligned.

It is therefore preferred that the mechanical fasteners consist of short screws that pass through radial holes drilled through the walls of the male and female parts and the head of each screw is sunken within a recess formed in the outer surface of the female part and the shank of each screw engages a screw thread formed in the radial hole passing through the male part.

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Furthermore, the female part may be formed by the free end of an expandable slotted tubing section which is slightly expanded before arranging the female part coaxially around the male part.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

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The slots 26 in the parts 22, 24 are arranged such that the free ends 36, 37 of the parts each define fingers 40, 41, and each of these fingers defines a hole 42, 43. The holes 43 in the female part are countersunk, whereas the holes 42 in the male part 22 are threaded such that the fingers 40, 41 may be secured to one another using a number of short screws 44.

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It will be clear to those of skill in the art that the above-described embodiment is merely exemplary of the present invention, and may be subject to various modifications and improvements without departing from the scope of the invention.

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2. The connector assembly of claim 1, wherein the male part is formed by an end of one of the interconnected tubing sections of which the outer surface has been machined away over a selected distance and the female part is formed by an end of the other of the interconnected tubing sections of which the inner surface has been machined away over a similar distance.

3. The connector assembly of claim 2, wherein the free end of the male and female part fits within an annular groove formed at the other end of the corresponding part such that if the parts co-axially engage each other said free ends are locked in a radial sense inside said grooves to prevent flaring of said free ends when the tubing string is expanded.

4. The connector assembly of claim 1, 2 or 3, wherein the mechanical fasteners consist of short screws that pass through radial holes drilled through the walls of the male and female parts and the head of each screw is sunken within a recess formed in the outer surface of the female part and the shank of each screw engages a screw thread formed in the radial hole passing through the male part.

5. The connector assembly of claim 1, wherein each fastener is located substantially in the middle of a node and halfway between a pair of adjacent slots.

6. The connector assembly of any preceding claim, wherein at least some of the slots of the male and female parts of the connector are substantially aligned.

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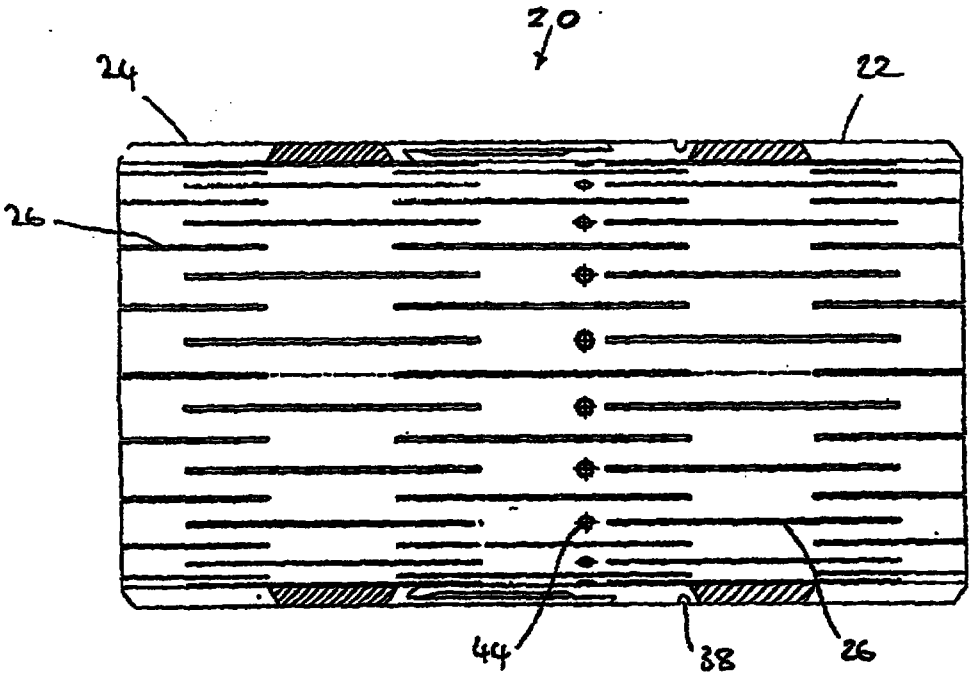
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(57) Abstract

A connector assembly for interconnecting sections of an expandable slotted tubing string (10) comprises a male part (22) and a female part (24) for mounting on the ends of respective tubing sections. Each part is slotted and adapted to co-axially engage the other part to permit expansion of the coupled parts in a corresponding manner to the tubing string without flaring of the coupled parts.