

PATENT SPECIFICATION

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(54) METHOD AND APPARATUS FOR JOINING THE ENDS OF PIPES

(71) We, HYDROTECH SERVICES, INC., a Corporation organized under the laws of the State of Texas, United States of America, of P.O. Box 55364, Houston, Texas, United States of America, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to method and apparatus for connecting the ends of two pipes which may be misaligned. More particularly, this invention relates to method and apparatus for connecting two pipes which are misaligned and which may be in a hostile environment, such as under water.

In making a connection between two pipes, such as a pipeline under water which has been severed, it is usually not too difficult a problem to place the two terminal ends of the pipe in a position such that their ends are in close proximity to each other and in certain instances where the center lines of the two ends have a common point of intersection. However, in some situations it is quite difficult to bring the two center lines of the pipes into complete incident. For example, in a situation where one of the ends of one of the pipes is immovable and the second end a terminal end of a long pipeline, the problem is considerably more difficult. The difficulty and the cost of making this match are tremendously high in a difficult environment such as under water, particularly in water depths deeper than 20 to 30 feet in open sea conditions.

It is therefore an object of this invention to provide an improved method and apparatus for connecting the ends of two pipes in a manner which overcomes the problems of the prior art.

The present invention therefore provides an apparatus for connecting the ends of two pipes which are misaligned, said apparatus including a first connector having one end arranged for mounting over a first one of said pipes in axial and rotational sliding relationship therewith, a

second connector having one end arranged for connection with a second one of said pipes in co-axial alignment therewith, means for joining the other ends of said connectors together in fixed relationship, means including a resilient seal for rigidly attaching said one end of said first connector to said first pipe, and means including a resilient seal for rigidly attaching said one end of said second connector to said second pipe.

The present invention also provides apparatus for connecting the ends of two pipes which may be positioned to have intersecting center lines, said apparatus including a pair of connectors, each connector having one end arranged for rotatable and axially slidable positioning over the end of either one of said pipes, the second ends of said connectors having means for joining together said connectors at said center line intersection, and means including resilient seals for rigidly attaching said connectors to said pipes.

The present invention further provides a method of joining the ends of two pipes which are misaligned, the steps of said method including slidably positioning one end of a first coupling over the end of one of said pipes, moving said coupling axially until the second end of said first coupling approaches the end of the second pipe, slidably positioning a second coupling over the end of the second one of said pipes so that the second end of said second coupling is adjacent the second end of said first coupling, rigidly and sealingly joining the second ends of said couplings, and rigidly and sealingly joining each of said couplings to the respective pipes therein.

Reference to the drawings will further explain the invention wherein like numerals refer to like parts and in which:

Figure 1 is a top plan view showing one apparatus embodiment of this invention mounted on two pipes which are misaligned with respect to each other.

Figure 2 is a top plan view showing the apparatus of Figure 1 installed on two pipes

[Price 25p]

Price 33p

which are in alignment, but which, nevertheless, may be joined by the apparatus of this invention.

Figure 3 is a top plan view similar to Figure 1, but showing the apparatus of Figure 1 connecting two pipes misaligned in the opposite direction.

Figure 4 is a partial central sectional view of one form of the connecting means for joining the flanges of the couplings as shown in Figures 1—3, and showing the rotatability of the flanges.

Figures 5A and 5B are plan view of alternative forms of the flanges which may be utilized in connection with the apparatus shown in Figures 1—3.

Figure 6 is a side elevation view, partially in central section, showing one preferred form of the means for attaching each of the couplings to one of the pipes.

Figure 7 is a side elevation view, partially in central section, of an alternative means for connecting the couplings together.

Figure 8 is a top plan view, partially in central section, of an alternative embodiment of the invention wherein the means for connecting the couplings together takes the form of a ball joint.

Figure 9 is a top plan view of a still further alternative embodiment of the invention wherein the means for connecting the couplings together includes flange means and a pair of ball joints.

Figure 10 is a top plan view of a further alternative embodiment which is similar to that shown in Figure 9, having flange means mounted at angles to accommodate greater misalignment.

Referring now in Figure 1, coupling 11 is shown mounted over the end of pipe 12 and sealingly connected thereto as described below. The other end of coupling 11 is provided with an annular flange 14 which is connected thereto as by welding and is arranged such that it lies in a plane which is intersected by the central axis of coupling 11, such that the minor angle is less than 90° and preferably in the range from about 89° to about 60° .

The invention also includes another coupling 18 mounted over the end of pipe 19 and sealingly attached thereto as described below. The other end of coupling 18 has another flange 21 attached thereto as by welding or the like and is similarly arranged at an angle with respect to the central axis of coupling 18, such that the minor angle is less than 90° and preferably matches the angle that flange 14 forms with coupling 11.

Flanges 14 and 21 are attached together by a plurality of circumferentially spaced bolts 23 passing therethrough as shown.

Referring now to Figures 5A and 5B, one form of flanges 14 and 21 are shown. For example, flange 14 may be provided with a plurality of arcuate bolt slots 24 and flange

21 may be provided with a plurality of circumferentially spaced bolt holes 25. Bolts 23 are arranged to pass through bolt holes 25 and bolt slots 24. This arrangement permits the rotation of one of the couplings, as for example coupling 11, relative to the other coupling, as for example coupling 18, such that the couplings 11 and 18 may be adjusted to fit to the misaligned sections of pipes, which have a misalignment angle different from the angle of alignment of each of the flanges 14 and 21 to its respective coupling. Stated another way, it is desirable that flanges 14 and 21 are preferably attached to their respective couplings at an angle which is equal to or greater than one-half the angle existing between the center lines of the two pipes, as for example pipes 12 and 19. This permits any two pair of couplings, such as couplings 11 and 18, to be adjustable to join a wide range of misaligned pipes wherein the misalignment angles vary over a rather wide range.

Couplings 11 and 18 are installed on pipes 12 and 19 in the manner shown by first lifting or otherwise moving the end of pipe 19 away from pipe 12 sufficiently that coupling 18 may be slide over pipe 19. Thereafter coupling 11 is similarly installed on pipe 12. Couplings 11 and 18 are then slid axially back to the general position shown in Figure 1 and rotated relative to each other such that flanges 14 and 21 are bolts 23 are installed as shown and couplings caused to lie in the same plane. Thereafter 11 and 18 are attached respectively to pipes 12 and 19, by means of the attaching means to be described with respect to Figure 6.

Referring now to Figure 2, the same two couplings 11 and 18 are shown mounted on pipes 27 and 28 with flanges 14 and 21 connected by bolt 23, as before. However, in this instance couplings 11 and 18 have been rotated relative to each other such that the relative angles of flanges 14 and 21 match to form a straight line connection. It is to be understood that couplings 11 and 18 are connected to pipes 27 and 28 by attachment means as will be described hereinafter. This arrangement of couplings 11 and 18 shows the great versatility of the apparatus of this invention showing that the apparatus of this invention is arranged for connecting not only misaligned pipes, but pipes which are in alignment, although it is particularly useful in connecting misaligned pipes.

Referring now to Figure 3, couplings 11 and 18 are shown mounted on pipes 30 and 31, respectively, and are connected thereto by attachment means which will be described hereinafter. Again flanges 14 and 21 are connected by bolt 23, and couplings 11 and 18 are located relative to each other to accommodate a different angular relationship between pipes 30 and 31.

This again demonstrates the great versatility of the apparatus of this invention to accommo-

date the connection of two pipes having different alignment relationships.

Referring now to Figure 4, an alternative embodiment of the flange portions of the couplings will be described in detail. In this embodiment, couplings 34 and 35 are shown joined by rotatable flange means as will be described. However, it is to be understood that couplings 34 and 35 are arranged for attachment to the pipes which are to be joined by means which are to be described hereafter with respect to Figure 6. Further, while each of the couplings 34 and 35 is shown in Figure 4 as having a rotatable flange means, it is to be understood that the invention is operable with only one of the flange means being rotatable. Coupling 34 is shown having an enlarged hub portion 37 which is connected thereto as by butt-weld line 38. Hub portion 37 is provided with an annular radially enlarged lug portion 39 about which is mounted rotatable flange ring 40 having a plurality of bolt holes therein arranged to receive bolts 41 therethrough. Lug portion 39 is also provided with an annular recess in the axial end thereof which is arranged to receive annular seal 42 therein. It will be noted that flange ring 40 is mounted in a plane which is intersected at an angle of less than 90° by the central axis of coupling 34, the same as with flanges 14 and 23 shown and described in connection with Figures 1—3.

Coupling 35 is similar to coupling 34 and is provided with an enlarged hub portion 44 which is attached thereto as by weld line 45 and has an annular lug 46 which is similar to lug 39, and similarly has an annular recess in the axial end thereof to accommodate annular seal 42. Annular lug 46 supports another rotatable flange ring 47 having bolt holes therein which are arranged to receive bolts 41.

Installation of the apparatus embodiment shown in Figure 4 is accomplished by first installing one of the couplings, as for example coupling 35, over one of the pipes to be joined and sliding it axially therealong. Thereafter coupling 34 is slid over the other pipe to be joined and the two couplings 34 and 35 are then moved axially together and rotated relative to each other so that flange rings 40 and 47 lie in the same plane. Then flange rings 40 and 47 are rotated relative to each other to align the bolt holes therethrough and are then joined by bolts 41. While the embodiment in Figure 4 is shown in the straight aligned condition, it is to be understood that they are particularly useful for joining misaligned pipes, in which instance one of the couplings 34 and 35 would be rotated relative to the other to adjust the angular alignment therebetween such that it matches the angular misalignment of the pipes to be joined. Moreover, only one of the flange rings 40 need be rotatable but two rotatable flange rings have been shown for

convenience purposes to illustrate the invention.

Referring now to Figure 6 an embodiment of means for attaching the couplings to the pipes which are to be joined is shown. In this embodiment a pair of couplings 50 and 51 are shown respectively mounted over and sealingly attached to misaligned pipes 52 and 53. The means for connecting couplings 50 and 51 is shown in the form of flanges 54 and 55 which are connected by bolts 56. Again, it is to be noted that flanges 54 and 55 are connected as by welding or otherwise to their respective couplings at an angle with respect to the center line of the couplings, as with the previous embodiments. It is to be further understood that the means for connecting couplings 50 and 51 may be in the form of those shown in Figures 5A and 5B, or in Figure 4, or in Figure 7—9 which are to be described hereinafter. In this embodiment, the means for attaching each of the couplings 50 and 51 to pipes 52 and 53 include fluid actuated means for frictionally engaging the outside surfaces of pipes 52 and 53. Referring first to coupling 50, it includes a tubular casing 58 which is attached to flange 54 at one end and is arranged to have a fluid chamber 59 therein which communicates with inlet opening 60 which is arranged for connecting to a line which in turn connects to a source of a pressurized fluid, as for example an epoxy resin which is arranged to cure to a hard state after a short period of time. This embodiment also includes an annular sleeve-shaped piston 61 which is adjacent to chamber 59 and is arranged for actuation by fluid pressure in chamber 59, so as to move piston 61 to the left as shown in Figure 6.

The embodiment also includes a plurality of annular packing elements 62 which abut against piston 61 on one side and annular spacing ring 63 on the opposite axial end thereof. Spacer ring 63 is arranged to abut against a plurality of circumferentially spaced slips 65 having a radially outward tapered surface which is arranged to be engaged by annular tapered bowl 66 which is mounted inside of casing 58, as shown, and arranged such that upon actual movement of slip 65 to the left as shown in Figure 6, slips 65 are caused to frictionally engage external surface of pipe 52. Couplings 50 and 51 are initially installed on pipes 52 and 53 in the same manner as with respect to the couplings described in the embodiment shown in Figures 1—3. That is, coupling 50 is first installed on pipe 52 and is slid axially therealong. Thereafter coupling 51 is mounted on pipe 52. Couplings 50 and 51 are then moved axially together and rotated relative to each other such that flanges 54 and 55 lie in parallel planes. Thereafter flanges 54 and 55 are joined or otherwise connected by the use of bolts 56 or by other connector means. With couplings 50 and 51 so installed,

each of the couplings 50 are sealingly and frictionally engaged with their respective pipes, as will be described hereinafter.

When fluid pressure is applied to chamber 59, piston 61 is caused to move to the left, thereby compressing packing elements 62, and urging slips 65 into engagement with pipe 52. Further, actuation of piston 61 causes slips 65 to frictionally engage pipe 52 to thereby provide a sealing and frictional engagement of coupling 50 with pipe 52. It is preferred that the fluid pressure in fluid chamber 59 be applied by an epoxy resin which will set up or cure after a short period of time to thereby provide a permanent connection of couplings 50 and 51 to pipe 52.

Coupling 51 is identical to coupling 50 and includes the same casing 58, fluid chamber 59, inlet opening 60, packing elements 62, spacer ring 63, slips 65, and tapered bowl 66. One advantage of the embodiment shown in Figure 6 is that it is arranged to be used in a hostile environment such as an under water installation where it may be difficult or impossible to otherwise connect the couplings 50 and 51 to pipes 52 and 53 as by welding or otherwise. Nevertheless, this attaching means provides a sealing engagement with pipes 52 and 53 and thereby couples the two pipes together in a fluid tight relationship.

Referring now to Figure 7 an alternative embodiment of the invention will be described. In this embodiment a pair of couplings 71 and 72 are shown mounted respectively on misaligned pipes 73 and 74. The couplings 71 and 72 are attached to pipes 73 and 74 by the attachment means described in connection with the embodiment shown in Figure 6, utilizing the fluid actuated means described therein. In this embodiment coupling 71 is shown attached to a butt-welded hub 80 having an externally enlarged flange portion 81.

Similarly coupling 72 has attached thereto a butt welded hub 82 having a radially enlarged flange portion 83. It will be noted that flange portions 81 and 83 in the installed condition lie in common or parallel planes and each are in a plane which is intersected by the central axes of the respective coupling at an angle of less than 90°, the same as with the previous embodiments. In this embodiment coupling 71 is fitted over pipe 73 and slid axially therealong. Thereafter coupling 72 is mounted over the end of pipe 74 and then the two couplings 71 and 72 are brought together in the relationship shown in Figure 7. The couplings 71 and 72 are rotated relative to each other until the axial misalignment therebetween matches the axial misalignment of pipes 73 and 74 in the position shown in Figure 7 and flange portions 81 and 83 lie in parallel planes. Thereafter couplings 71 and 72 are connected together by clamp ring 84 which is of conventional design and may include two semi-circular halves joined together

by bolts (not shown). It is to be understood that a seal ring 85 may be installed between flange portions 81 and 83 to provide a fluid tight seal. Upon the installation of clamp ring 84, couplings 71 and 72 are effectively connected together, thereby completing the connection of pipes 73 and 74. As with the previous embodiments, flange portions 81 and 83 are respectively connected to couplings 71 and 72 at an angle which is equal to or greater than one-half of the angle existing between the central axes of the two pipes 73 and 74. Moreover, by having the angle of connection of flange portions 81 and 83 the same with respect to couplings 71 and 72, coupling 71 may be rotated relative to coupling 72 to obtain the desired misalignment and match the misalignment of pipes 73 and 74, the same as with the previous embodiments described.

With the embodiments shown in Figures 1-7, the angle of alignment of the flanges or flange portions with respect to the coupling to which each is attached is such that the central axis of the coupling intersects the plane in which the flange or flange portion lies such that the minor angle lies in the range of from about 89° to about 60°. However, in the most preferred embodiment it is desirable that this angle be about 79° which angle has been found to accommodate the widest range of pipe misalignment with a minimum amount of acceptable interference or restriction in the passageway through the connection formed by the couplings.

Referring now to Figure 8, a still further alternative embodiment of the invention will be described. This embodiment, which is also arranged for connecting the ends of two separated sections of pipe, such as pipes 86 and 87, includes mating couplings 88 and 89. Couplings 88 and 89 are provided with means for sealingly and frictionally engaging the external surfaces of the pipes 86 and 87, which means are of the same general type as described in connection with the embodiment shown in Figure 6. For example coupling 88 includes a cylindrical casing 91 having an inlet opening 92 communicating with fluid chamber 93 therewithin.

An annular sleeve type piston 94 is mounted within casing 91 and arranged for actuation by fluid pressure in chamber 93. Upon actuation of piston 94, it is arranged to engage the thrust radially outward a plurality of annular packing elements 95 which are held generally in place by spacer ring 96. Spacer ring 96 abuts against a plurality of slips 97 having teeth on the radially inward sides thereof which are arranged to frictionally engage pipe 86 upon actuation. In addition, slips 97 have a tapered radially outward surface which is arranged to engage and be cammed radially inward by an annular tapered bowl 98.

Upon application of fluid pressure through

inlet opening 92 to chamber 93, piston 94 is urged axially against packing element 95 and spacer ring 96 whereby packing elements 95 are enlarged in radial directions to thereby provide sealing engagement between pipe 86 and casing 91. In addition, pressure is applied to spacer ring 96 which thereby urges slips 97 to engagement with bowl 98 and are thereby cammed into frictional engagement with the external surface of pipe 86. In certain instances it is desirable that the fluid applied to chamber 93 be of the type which will set up or otherwise cure to a hardened state so as to provide a permanent seal for coupling 88.

The other end of coupling 88 is provided with an enlarged annular socket portion 99 which forms a portion of the ball connection which will be described hereinafter and is provided with a plurality of threads about the axial end thereof as shown. Socket portion 99 is provided with a counterbore in the end thereof which is arranged to receive ball-shaped portion 101 of coupling 89. Coupling 89 is also provided with means for attaching to pipe 87, and these means are similar to those described with respect to coupling 88. These sealing and frictional engagement means include a casing 103 having an inlet opening 104 leading to fluid chamber 105 arranged such that the fluid pressure therein urges annular sleeve-shaped piston 106 into engagement with a plurality of packing elements 107 which abut against spacer ring 108 which in turn engages a plurality of slips 109 which are arranged to be cammed radially inward by tapered bowl 110, the same as with coupling 88. Again, it is often desirable to use pressurized fluid resin as the actuating medium, which resin will subsequently cure or set up to provide a permanent seal.

In operation, one of the couplings, as for example coupling 88, is slid over the end of pipe 86 and moved axially therealong a short distance. Thereafter coupling 89 is installed over the end of pipe 87, and the ends of the two couplings 88 and 89 are thereafter brought together. It is to be understood that socket portion 99 of coupling 88 will have mounted therein an annular inner gasket 112 and an outer gasket 113, the latter of which may be inserted after ball-shaped portion 101 is generally fitted inside socket portion 99, as shown. Coupling 89 has loosely mounted thereon a flange nut 114 having an axial opening therein sufficient to permit rotation of the central axis thereof relative to the central axis of coupling 89 a substantial distance, as for example as much as 30° in some instances. Nut 114 thereafter may be threaded onto the threads of socket portion 99, thereby compressing gasket 112 and 113. Once flange nut 114 is placed in position and tightened to the desired extent, thereafter the attachment means, heretofore described with respect to both couplings 88

and 89, may be actuated by the application of fluid pressure thereto to complete the setting of the apparatus. Thus, couplings 88 and 89 are joined together and a fluid tight seal is provided therebetween. This particular embodiment permits the connection of two pipes which are substantially misaligned with respect to each other, which alignment is accommodated for by the ball connection described above.

In certain environments it may be difficult to connect the ball socket type apparatus described above in a particular environment, in which case it may be desirable to have the ball connection pre-assembled whereby the two couplings are joined together before application to the two pipes which are to be connected. In this instance it will be desirable for the over-all axial length of coupling 89, inclusive of ball portion 101, to be greater than the shortest distance between the two ends of pipe which are to be joined. This is necessary in order to allow coupling 89 and the ball joint sufficient freedom to move to the aligned condition. In addition, the axial length of coupling 88, inclusive of socket portion 99, must be equal to or greater than the shortest distance between the ends of the two pipes which are to be joined plus the active or sealing and engaging means of coupling 88, which active means includes packing elements 95 and slips 97. This dimensioning will permit the coupling 88, for example, to be slid axially toward the end of the pipe over which it is mounted after the coupling 89 has been aligned as described above.

Referring now to Figure 9, a further alternative embodiment of the invention will be described which utilizes two ball connections such as that described with respect to Figure 8. This embodiment includes two couplings which may in all respects be the same as coupling 88 shown in Figure 8 and hence are given the same numeral designation and are shown mounted on two pipes 116 and 117. The socket portions 99 are each arranged to receive the ball portion 119 of a pair of connector couplings 120, each of which is provided with an annular flange 121 at the opposite ends thereof, which flanges are shown held together by a plurality of bolts 122.

In this embodiment flanges 121 lie in planes which are generally perpendicular to the central axes of the couplings 120 to which each is attached. Any misalignment between pipes 116 and 117 is accommodated by the ball and socket connection as described above. This apparatus is installed on pipes 116 and 117 in the same manner as the embodiment shown in Figure 8, in that after the same are installed in position, flange nuts 114 are appropriately tightened. Thereafter fluid pressure is applied through inlet openings 92 to thereby sealingly and frictionally engage the apparatus with pipes 116 and 117, thus completing the coupling operation.

Referring now to Figure 10, a further embodiment of the invention will be described. In this invention the apparatus is shown adjoining the two pipes 124 and 125. The apparatus also includes a pair of pipe couplings which are also identical with pipe coupling 88 shown in Figure 8 and are hence designated by the same numeral. However, in this instance the two couplings 88 are arranged for connecting together by two connecting couplings 126 and 127 having ball-shaped portions 128 and 129 respectively connected thereto and arranged to be received and held in socket portions 99 of couplings 88. Connector coupling 126 is provided with an annular flange 130 which lies in a plane which is intersected by the central axis of coupling 126 at an angle of less than 90° at the minor angle. Similarly connector coupling 127 is provided with flange 131 of similar configuration. Flanges 130 and 131 are arranged to be held together by a plurality of bolts 132.

In operation of the embodiment shown in Figure 10, couplings 88 and their respective connection couplings 126 and 127 may be pre-assembled. Thereafter the couplings 88 are slid over the ends of pipes 124 and 125, connector couplings 126 and 127 rotated to the aligned position such as that shown in Figure 10 and flanges 130 and 131 joined by bolts 132. Thus installed, fluid pressure can thereafter be applied to couplings 88 in the manner previously described to provide a permanent sealing and frictional engagement of the couplings to their respective pipes. The embodiment shown in Figure 10 is arranged to accommodate greater misalignment between the pipes which are to be connected since connector couplings 126 and 127 may be rotated relative to each other, such that the central axes thereof meet at an angle rather than a straight line as shown.

It will thus be apparent that the art has been provided with a novel and highly useful means for connecting pipe such as misaligned pipe, located in a hostile environment, as for example in a sub-sea location. Further modifications and alternative embodiments will be apparent to those skilled in the art in view of this description; and accordingly, this description is to be construed as illustrative only.

WHAT WE CLAIM IS:—

1. Apparatus for connecting the ends of two pipes which are misaligned, said apparatus including a first connector having one end arranged for mounting over a first one of said pipes in axial and rotational sliding relationship therewith, a second connector having one end arranged for connection with the second one of said pipes in co-axial alignment therewith, means for joining the other ends of said connectors together in fixed relationship, means including a resilient seal for rigidly attaching said one end of said first connector to said first pipe, and means including a resilient seal for rigidly attaching said one end of

said second connector to said second pipe.

2. Apparatus according to claim 1, wherein said means for attaching said first connector includes fluid actuated means for frictionally engaging the outside surface of said pipe about which said first coupling is mounted.

3. Apparatus according to claim 1 or 2, including means for sealing the connection between said first connector and said pipe on which said first connector is mounted.

4. Apparatus according to claim 1, 2 or 3, wherein the means for joining said other ends of said connectors include flanges connected to each of said connectors, with each of said flanges lying in a plane which is intersected by the central axis of the connector to which said flange is attached such that the minor angle is less than 90°, and means for fixedly connecting said flanges together.

5. Apparatus according to claim 4, wherein the minor angle of the respective plane of said flanges with the connector axis is in the range of 60° to 89°.

6. Apparatus for connecting the ends of two pipes which may be positioned to have intersecting center lines, said apparatus including a pair of connectors, each connector having one end arranged for rotatable and axially slidable positioning over the end of either one of said pipes, the second ends of said connectors having means for joining together said connectors at said center line intersection, and means including resilient seals for rigidly attaching said connectors to said pipes.

7. Apparatus according to claim 6, wherein said means for attaching said connectors to said pipes includes fluid actuated means for frictionally engaging the outside surfaces of said pipes about which said connectors are mounted.

8. Apparatus according to claim 6 or 7, wherein said means for connecting the second ends of said connectors include flanges attached to each of said connectors with each of said flanges lying in a plane which is intersected by the center line of the connector to which said flange is attached such that the minor angle is less than 90°.

9. Apparatus according to claim 8, wherein the minor angle of the respective plane of said flanges with the connector axis is in the range of 60° to 89°.

10. Apparatus according to any of claims 6 to 9, wherein the means connecting the second ends of said connectors includes a ball and socket joint.

11. Apparatus according to any of claims 7 to 10 wherein said seal means are actuatable to the sealing condition in response to actuation of said fluid actuated means.

12. Apparatus for connecting the spaced apart proximate ends of two misaligned pipes, said apparatus including a first generally tubular connector having means including a resilient seal for rigidly attaching one end thereof



Referring now to Figure 10, a further embodiment of the invention will be described. In this invention the apparatus is shown adjoining the two pipes 124 and 125. The apparatus also includes a pair of pipe couplings which are also identical with pipe coupling 88 shown in Figure 8 and are hence designated by the same numeral. However, in this instance the two couplings 88 are arranged for connecting together by two connecting couplings 126 and 127 having ball-shaped portions 128 and 129 respectively connected thereto and arranged to be received and held in socket portions 99 of couplings 88. Connector coupling 126 is provided with an annular flange 130 which lies in a plane which is intersected by the central axis of coupling 126 at an angle of less than 90° at the minor angle. Similarly connector coupling 127 is provided with flange 131 of similar configuration. Flanges 130 and 131 are arranged to be held together by a plurality of bolts 132.

In operation of the embodiment shown in Figure 10, couplings 88 and their respective connection couplings 126 and 127 may be pre-assembled. Thereafter the couplings 88 are slid over the ends of pipes 124 and 125, connector couplings 126 and 127 rotated to the aligned position such as that shown in Figure 10 and flanges 130 and 131 joined by bolts 132. Thus installed, fluid pressure can thereafter be applied to couplings 88 in the manner previously described to provide a permanent sealing and frictional engagement of the couplings to their respective pipes. The embodiment shown in Figure 10 is arranged to accommodate greater misalignment between the pipes which are to be connected since connector couplings 126 and 127 may be rotated relative to each other, such that the central axes thereof meet at an angle rather than a straight line as shown.

It will thus be apparent that the art has been provided with a novel and highly useful means for connecting pipe such as misaligned pipe, located in a hostile environment, as for example in a sub-sea location. Further modifications and alternative embodiments will be apparent to those skilled in the art in view of this description; and accordingly, this description is to be construed as illustrative only.

WHAT WE CLAIM IS:—

1. Apparatus for connecting the ends of two pipes which are misaligned, said apparatus including a first connector having one end arranged for mounting over a first one of said pipes in axial and rotational sliding relationship therewith, a second connector having one end arranged for connection with the second one of said pipes in co-axial alignment therewith, means for joining the other ends of said connectors together in fixed relationship, means including a resilient seal for rigidly attaching said one end of said first connector to said first pipe, and means including a resilient seal for rigidly attaching said one end of

said second connector to said second pipe.

2. Apparatus according to claim 1, wherein said means for attaching said first connector includes fluid actuated means for frictionally engaging the outside surface of said pipe about which said first coupling is mounted.

3. Apparatus according to claim 1 or 2, including means for sealing the connection between said first connector and said pipe on which said first connector is mounted.

4. Apparatus according to claim 1, 2 or 3, wherein the means for joining said other ends of said connectors include flanges connected to each of said connectors, with each of said flanges lying in a plane which is intersected by the central axis of the connector to which said flange is attached such that the minor angle is less than 90° , and means for fixedly connecting said flanges together.

5. Apparatus according to claim 4, wherein the minor angle of the respective plane of said flanges with the connector axis is in the range of 60° to 89° .

6. Apparatus for connecting the ends of two pipes which may be positioned to have intersecting center lines, said apparatus including a pair of connectors, each connector having one end arranged for rotatable and axially slidable positioning over the end of either one of said pipes, the second ends of said connectors having means for joining together said connectors at said center line intersection, and means including resilient seals for rigidly attaching said connectors to said pipes.

7. Apparatus according to claim 6, wherein said means for attaching said connectors to said pipes includes fluid actuated means for frictionally engaging the outside surfaces of said pipes about which said connectors are mounted.

8. Apparatus according to claim 6 or 7, wherein said means for connecting the second ends of said connectors include flanges attached to each of said connectors with each of said flanges lying in a plane which is intersected by the center line of the connector to which said flange is attached such that the minor angle is less than 90° .

9. Apparatus according to claim 8, wherein the minor angle of the respective plane of said flanges with the connector axis is in the range of 60° to 89° .

10. Apparatus according to any of claims 6 to 9, wherein the means connecting the second ends of said connectors includes a ball and socket joint.

11. Apparatus according to any of claims 7 to 10 wherein said seal means are actuatable to the sealing condition in response to actuation of said fluid actuated means.

12. Apparatus for connecting the spaced apart proximate ends of two misaligned pipes, said apparatus including a first generally tubular connector having means including a resilient seal for rigidly attaching one end thereof



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to one of said pipes; a second generally tubular connector; means for joining together the other end of said first connector and one end of said second connector, said joining means being adjustable for accommodating a plurality of misalignment positions between the axes of said two connectors; and, means including a resilient seal for rigidly connecting the other end of said second connector to the other of said pipes, said connecting means including means for accommodating a plurality of substantially different distances between said one end of said second connector and the end of said other pipe.

15 13. Apparatus as claimed in claim 12, wherein said attaching, joining and connecting means each includes seal means, whereby fluid may flow through said pipes and through said connectors.

20 14. Apparatus as claimed in claim 12 or 13, wherein said attaching means includes means for accommodating a plurality of substantially different distances between said other end of said first connector and the end of said first one of said pipes.

25 15. Apparatus as claimed in claim 12, 13 or 14, wherein any one of said attaching means and said connecting means includes means for

accommodating a plurality of different angles between the members being connected.

16. A method of joining the ends of two pipes which are misaligned, the steps of said method including slidably positioning one end of a first coupling over the end of one of said pipes, moving said coupling axially until the second end of said first coupling approaches the end of the second pipe, slidably positioning a second coupling over the end of the second one of said pipes so that the second end of said second coupling is adjacent the second end of said first coupling, rigidly and sealingly joining the second ends of said couplings, and rigidly and sealingly joining each of said couplings to the respective pipes therein.

17. Apparatus for connecting the ends of two pipes which are misaligned constructed substantially as herein described with reference to the embodiments disclosed in the accompanying drawings.

18. A method of joining the ends of two pipes substantially as herein described.

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