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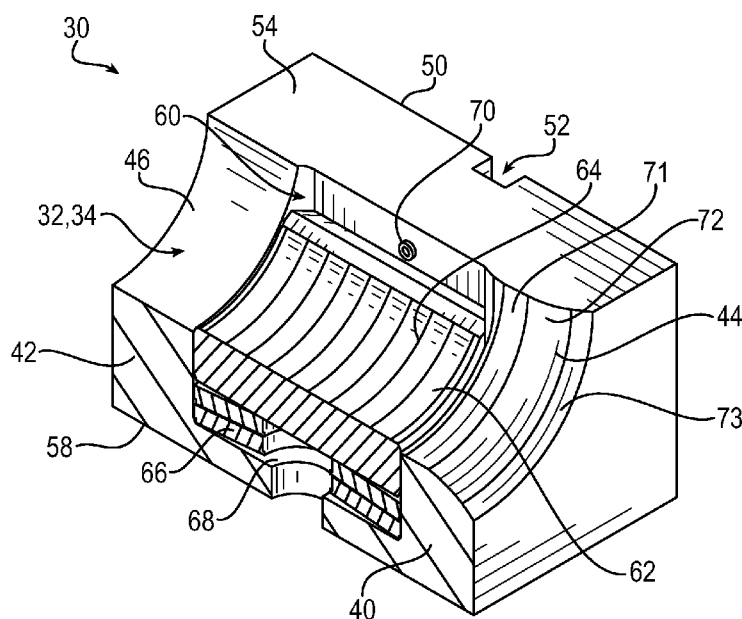


FIG. 3

(57) Abstract: A forming die system and method is used in end forming a pipe or tube for connecting the pipe or tube with a fitting without a sleeve therebetween. The forming die system includes engageable outer dies that together define a bore having a longitudinal axis, die forming surfaces formed on each outer die, grip dies supported in each of the outer dies and configured to hold the pipe or tube, a biasing member that is engageable between a corresponding one of the outer dies and a corresponding one of the grip dies, and a forming pin that is configured to roll around the longitudinal axis in a circular motion at a predetermined angle relative to the longitudinal axis.

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A FORMING DIE FOR FORMING AN END OF A TUBE AND A METHOD FOR FORMING AN END OF A TUBE

Field of Invention

5 The present invention relates to pipe or tube connections, and more particularly to flanged connections and end forming methods for connecting pipes and face seal type fittings.

Background

10 Various applications require connecting axially opposing tubes or pipes. For example, metal tubes or stainless steel (scheduled) pipes are commonly used in the oil and gas industry. In particular applications, tubes or pipes may be connected with fittings, such as face seal type fittings that include a nut, a fitting body, an o-ring, and a sleeve. Prior attempts at connecting the fitting and a tube include end
15 forming or flanging the tube end. When the fitting is assembled, the fitting compresses the o-ring within a groove of the fitting body to form a leak tight seal. As the nut is tightened onto the fitting body, the o-ring seal is compressed between the fitting body and the flat face of the tube flange to form a positive seal.

 However, due to the outside diameter of a scheduled pipe and the required
20 tolerances between the components to be connected, prior flanging methods may not be suitable for connecting scheduled pipes, or large tubes, and face seal type fittings. Conventional methods may be deficient in that reaching the preferred dimensions may cause undesirable end forming of the pipe or tube when the pipe or tube is irregular or improperly set. One disadvantage of the conventional end
25 forming and connection methods is that the sleeve or lap piece is welded and exerts a high force on the pipe or tube end. Still another disadvantage is that conventional forming dies may not be able to fully close and adequately grip larger pipes and tubes for end forming.

Summary of Invention

The present invention is directed towards a forming die system and method that ensures consistent end forming of pipes or tubes in a sleeveless and non-welded connection with a face seal type fitting having a seal, such as an o-ring, and a nut. The forming die system includes a forming die having die halves that each have a die forming surface, grip dies that are configured to hold the pipe or tube, and a biasing member that biases the grip dies towards the pipe or tube supported in the forming die. Advantageously, the biasing member enables the forming die to completely close when accommodating differently sized pipes or tubes, and also enables the pipe or tube to be more easily removed from the forming die after the die forming process. The grip dies include surfaces having protrusions that bite into the pipe or tube for improved support of the pipe or tube, and the die forming surfaces are complementary in shape to a contour of the nut such that the end forming is consistent regardless of varying sizes of the pipe or tube and the nut.

The forming die system and method further includes a forming pin that is shaped to ensure consistent end forming and is configured to roll in a circular motion around the longitudinal axis of the pipe or tube at a predetermined angle with an axial force. The forming pin includes an axially protruding or positive stop surface that is engageable against the forming die to maintain a consistent thickness of the formed or flanged end of the pipe or tube. A captive surface is formed radially adjacent the stop surface and is used to maintain a consistent inside diameter and outside diameter of the formed end. The forming pin also includes a biasing surface that biases a portion of the formed end during the end forming process to ensure a precise pressure point on the o-ring and an improved sealing capability when mating the formed end and o-ring. Using the forming die system and method enables consistent end forming and sleeveless connections between larger pipes or tubes with face seal type fittings as compared with conventional end forming systems and methods that are only suitable for smaller tubes having low tolerances.

According to an aspect of the invention, a forming die is used in end forming a pipe or tube for connecting the pipe or tube with a fitting. The forming die includes

engageable outer dies that each have a die forming surface, grip dies supported in each of the outer dies and configured to hold the pipe or tube, and a biasing member that is engageable between a corresponding one of the outer dies and a corresponding one of the grip dies.

5 According to another aspect of the invention, a forming die system is used in end forming a pipe or tube for connecting the pipe or tube with a fitting. The forming die system includes engageable outer dies that together define a bore having a longitudinal axis and each have a die forming surface, grip dies supported in each of the outer dies and configured to hold the pipe or tube, a biasing member that is
10 engageable between a corresponding one of the outer dies and a corresponding one of the grip dies, and a forming pin that is configured to roll around the longitudinal axis in a circular motion at a predetermined angle relative to the longitudinal axis.

 According to still another aspect of the invention, a method of end forming a
15 pipe or tube for connecting the pipe or tube with a fitting includes providing complementary outer dies that each have a die forming surface, engaging the outer dies together to define a longitudinal axis, holding the pipe or tube using grip dies supported in each of the outer dies, and radially biasing the grip dies toward each other.

20 Other systems, devices, methods, features, and advantages of the present invention will be or become apparent to one having ordinary skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present invention, and be protected by the
25 accompanying claims.

Brief Description of the Drawings

Fig. 1 is a schematic drawing showing an isometric view of a forming die used in end forming a pipe or tube for connecting the pipe or tube with a fitting.

30 Fig. 2 is a schematic drawing showing an isometric view of one of an outer die, or die halves, of the forming die of Fig. 1.

Fig. 3 is a schematic drawing showing a sectional view of the outer die of Fig. 2.

Fig. 4 is a schematic drawing showing a side view of a forming die system using the forming die of Fig. 1 and further including a forming pin.

5 Fig. 5 is a schematic drawing showing an isometric view of the forming die system of Fig. 4.

Fig. 6 is a schematic drawing showing an isometric view of the forming pin of Fig. 4.

10 Fig. 7 is a schematic drawing showing a sectional view of the forming pin of Fig. 6.

Fig. 8 is a schematic drawing showing a side view of the forming pin of Fig. 6.

Fig. 9 is a schematic drawing showing a side view of the forming die system of Fig. 4 during the end forming process.

15 Fig. 10 is a schematic drawing showing a side sectional view of the forming die system of Fig. 4 during the end forming process.

Fig. 11 is a schematic drawing showing a side sectional view of a connection formed between the pipe or tube and the fitting using the forming die system of Fig. 4.

20 Fig. 12 is a schematic drawing showing an isometric view of the connection of Fig. 11.

Fig. 13 is a schematic drawing showing a side sectional view of the connection of Fig. 11 with the fitting being disassembled from the pipe or tube and the nut.

25 Fig. 14 is a schematic drawing showing an isometric view of the connection of Fig. 13.

Fig. 15 is a schematic drawing showing an isometric view of the pipe or tube and the nut of the connection of Fig. 11.

30 Fig. 16 is a schematic drawing showing another isometric view of the pipe or tube and the nut of the connection of Fig. 11.

Fig. 17 is a schematic drawing showing a side sectional view of the connection of Fig. 16.

Detailed Description

5 Aspects of the present invention relate to systems and methods of connecting pipes or tubes with fittings such as a face seal type fitting that include a nut, a fitting body, and an o-ring. The forming die system and method described herein may be used in any application that uses metal pipes or tubes. Exemplary applications include applications in the oil and gas industry and power generation
10 such as in turbines. Many other applications may be suitable. The forming die system and method may be suitable for end forming stainless steel (scheduled) pipes with large diameters. Piping or tubing that is formed of other materials may also be suitable for use with the forming die system and method. For example, piping or tubing that is formed of steel materials other than stainless steel, other
15 metals, or plastic materials may be suitable.

Referring first to Figs. 1-3, a forming die 30 used in end forming a pipe or tube is shown. The forming die 30 includes outer dies 32, 34 that are formed as engageable die halves. Each of the outer dies 32, 34 may have any suitable shape, such as rectangular, and the outer dies 32, 34 may form one rectangular body when
20 assembled together for holding the pipe or tube during the end forming process. The outer dies 32, 34 may be formed of any suitable material, such as a metal material. When the outer dies 32, 34 are assembled, a parting line 36 is defined between the outer dies 32, 34 as the location where the outer dies 32, 34 meet, and the outer dies 32, 34 are symmetrical relative to each other along the parting line
25 36. As best shown in Fig. 1, the outer dies 32, 34 together define a pipe or tube receiving bore 38 that extends along a longitudinal axis L. The end of the pipe or tube to be formed is retained within the receiving bore 38 during the end forming process and extends along the longitudinal axis L such that the pipe or tube is concentrically arranged within the forming die 30. Advantageously, the outer dies
30 32, 34 may be identical or nearly identical in shape and contain identical or nearly identical components such that replacement and replication of the outer dies 32, 34

is less complex as compared with forming die halves that may have different shapes or components contained within the die half.

Each outer die 32, 34 includes four walls that may be integrally formed to define the rectangular shape of the outer die 32, 34. Each outer die 32, 34 includes
5 a first sidewall 40 and a second sidewall 42 that are axially spaced and parallel with each other. The sidewalls 40, 42 may have a similar thickness and each sidewall 40, 42 defines an arched or annular surface 44, 46, respectively, that are coaxially arched along the longitudinal axis L. A third sidewall 48 and a fourth sidewall 50 extend between the first sidewall 40 and the second sidewall 42. The third sidewall
10 48 and the fourth sidewall 50 are spaced from the longitudinal axis L and parallel with each other. The third sidewall 48 and the fourth sidewall 50 may have a similar thickness and may be identical in shape. An outer die retaining feature, such as a notch 51, is formed in each of the third sidewall 48 and the fourth sidewall 50 for aligning the outer dies 32, 34 with an external tool or end forming machine, such as
15 a press, and for retaining the outer dies 32, 34 in engagement during the end forming process. The outer dies 32, 34 may be secured to each other using any suitable fastening mechanism, such as any type of latch, fastener, or clamp. For example, the outer dies 32, 34 may be clamped together by the end forming machine. The notch 51 may be rectangular in shape and extend along an entire
20 height of the corresponding sidewall 48, 50.

The third sidewall 48 and the fourth sidewall 50 each define engaging surfaces 52, 54, respectively, for engagement with the corresponding engaging surfaces of the third and fourth sidewalls of the other outer die 32, 34 such that the engaging surface 52, 54 define the parting line 36 when the outer dies 32, 34 are
25 assembled together. The engaging surfaces 52, 54 may be planar and arranged in a plane that extends normal to the longitudinal axis L. In other exemplary embodiments, the engaging surface 52, 54 may have protrusions or other locking-type features that are complementary for locking the outer dies 32, 34 together. The engaging surfaces 52, 54 may extend widthwise and lengthwise, whereas the
30 notch 52 extends along an end surface 56 of the outer die 32, 34 that is perpendicular to the corresponding engaging surfaces 52, 54. The engaging

surfaces 52, 54 also extend axially between the first sidewall 40 and the second sidewall 42. Opposing the engaging surfaces 52, 54 is an outer surface 58 of the outer die 32, 34 that extends in a plane parallel with the plane in which the engaging surfaces 52, 54 are arranged. The outer surface 58 may be planar. All of the walls 40, 42, 48, 50 together define a grip die receiving cavity 60. The grip die receiving cavity 60 extends between the outer surface 58 and the engaging surfaces 52, 54, and between the first sidewall 40 and the second sidewall 42.

A grip die 62 is arranged within the grip die receiving cavity 60 and is housed or supported by the outer die 32, 34. The grip die 62 is configured to hold the pipe or tube within the forming die 30 to prevent axial movement of the pipe or tube during the end forming process. Advantageously, each grip die 62 is formed separately from the corresponding outer dies 32, 34 such that the grip dies are radially moveable inwardly and outwardly to accommodate pipes or tubes with different diameters. The grip dies enable the outer dies 32, 34 to close completely together such that the parting line 36 between the outer dies 32, 34 is gapless or nearly gapless. As best shown in Figs. 2 and 3, the grip die 62 is annular in shape and is supported axially between the first sidewall 40 and the second sidewall 42 of the corresponding outer die 32, 34, such that the grip die 62 is axially held in place by the sidewalls 40, 42. The grip die 62 is configured to face the receiving bore 38 and engage the pipe or tube. The grip die 62 may be formed to be flush with the annular surfaces 44, 46 such that the end of the pipe or tube is uniformly or nearly uniformly engaged along an entire length of the forming die 30.

A grip die surface 64 is formed on each grip die 62, and the grip die surface 64 includes at least one protrusion or a plurality of protrusions that increase the surface area hold of the pipe or tube. The grip die surface 64 may be configured to bite into or penetrate an outer diameter of the pipe or tube and has any suitable textured surface or protrusion pattern. The grip die surface 64 may be formed of any suitable material and is formed to have a ridged or toothed surface. For example, the grip die surface 64 may be textured with carbide deposit. The grip die surface 64 and protrusion pattern may be formed using any suitable manufacturing process, such as machining. The ridges or teeth may extend radially along the grip

die 62 and a plurality of ridges or teeth may be arranged axially adjacent one after another. Any suitable number of ridges or teeth may be used, and the protrusion pattern of the grip die surface 48, such as the number of ridges or teeth, may be dependent on the size of the grip die 62 and the grip die surface 64. In an
5 exemplary embodiment, the grip die surface 48 may have between 15 and 30 teeth.

As best shown in Fig. 3, the movable grip die 62 is biased by a biasing member 66 toward the opposite grip die of the opposite outer die 32, 34 to ensure that the outer dies 32, 34 close completely. The biasing member 66 is supported within the grip die receiving cavity 60 of the corresponding outer die 32, 34 and is
10 interposed between the outer die 32, 34 and the grip die 62. A width of the biasing member 66 extends between the sidewalls 40, 42. On one side, the biasing member 66 may be engageable against a planar surface 68 that opposes the outer surface 58 of the corresponding outer die 32, 34 and faces the grip die 62. On an opposing side of the biasing member 66, the biasing member 66 acts on a surface
15 of the grip die 62 that opposes the grip die surface 64 ensuring that the grip die surface 64 contacts the outer diameter of the pipe or tube. The corresponding outer die 32, 34 may further include a retaining mechanism 70 that protrudes from the outer die 32, 34 to retain the grip dies and the biasing members within the grip die receiving cavity 60 of the respective outer die 32, 34 during the end forming
20 process. The retaining mechanism 70 may protrude from one of the sidewalls of the outer die 32, 34 and radially inwardly. Any suitable retaining mechanism may be used, such as a spring pin.

The biasing member 66 may be any biasing member formed of a material that is suitable to deliver a predetermined force to hold the pipe or tube during the
25 end forming process. In exemplary embodiments, the biasing member 66 may be configured to provide several tons of force to balance the outer dies 32, 34 and center the pipe or tube. The biasing member 66 is arranged to exert the force in a radially inward direction such that the biasing member 66 exerts force on the corresponding grip die 62 and towards the other biasing member of the other outer
30 die 32, 34. Suitable biasing members include disc springs and Bellville washers, but other types of springs and biasing members may also be suitable. Providing the

biasing members to engage the grip dies is further advantageous in that after the pipe or tube has undergone the end forming process and the outer dies 32, 34 are separated from each other, the biasing members may be used to push the held pipe or tube out of the forming die 30. In contrast, conventional forming methods may
5 require a manual leverage tool such as a hammer for removing the pipe or tube from the forming die due to the pipe or tube sticking to the dies.

The forming die 30 further includes a die forming surface that is used to reduce forces during the end forming process by way of the die forming surface being shaped to match a natural flow of the material being end formed. Providing
10 the die forming surface is particularly advantageous in the end forming of the pipe or tube with a face seal type fitting that includes a nut in that the die forming surface is shaped to match a contour of the nut, or the nut interface, such that the end forming may be consistent regardless of the size of the pipe or tube and the nut. The die forming surface may be formed as the annular surface 44 of the first
15 sidewall 40 and is arranged axially adjacent to each grip die 62. Each die forming surface 44 may have a plurality of adjacent conically angled surfaces that are used to ensure the die forming surface 44 matches the nut. The die forming surface 44 is configured to receive an end most portion of the pipe or the tube and has axially adjacent conically angled surfaces 71, 72, 73.

Any suitable number of conically angled surfaces may be provided. For
20 example, three adjacent surfaces may be provided that are gradually and progressively inclined radially outwardly relative to the longitudinal axis L. A first conically angled surface 71 of the die forming surface 44 may be arranged proximate the grip die 62 and extend parallel or substantially parallel with the
25 longitudinal axis L. A second conically angled surface 72 of the die forming surface 33 may be adjacent the first conically angled surface 71 and extend slightly radially outwardly from the first conically angled surface 71. A third conically angled surface 73 is a distal most surface relative to the grip die 62 and extends slightly radially outwardly from the second conically angled surface 72, such that the conically
30 angled surfaces 71, 72, 73 progressively curve radially outwardly relative to the longitudinal axis L of the forming die 30.

Referring now to Figs. 6-10, the forming die 30 is part of a forming die system 76 used in the end forming process that further includes a forming pin 78. The forming pin 78 is engageable with a pipe or tube end 80 of the pipe or tube 82 that is held within the forming die 30, as shown in Figs. 4 and 5. The forming pin 78 includes features that enable the forming die system 76 to produce a formed end of the pipe or tube end 80 having a consistent thickness and inside and outside diameter, and reduces the resistance to pipe or tube tolerance variation during the end forming process. Advantageously, the forming pin 78 prevents over-flanging of the pipe or tube end 80 to ensure the pipe or tube end 80 fits within the nut of the connection with the fitting. The forming pin 78 has a pin head 84 and a longitudinal body 86 that extends from the pin head 84 and includes an attachment end 88 that enables the forming pin 78 to be attached to the end forming machine or press. For example, the attachment end 88 may have a recessed portion 90 that is a groove configured to hold an o-ring in providing friction and preventing the forming pin 78 from slipping out of the end forming machine. Opposite the attachment end 88, the pin head 84 has a knob-shaped protrusion 92 that extends longitudinally from the pin head 84 opposite the longitudinal body 86. The knob-shaped protrusion 92 may be formed of conically angled surfaces 94 having different curvatures.

As shown in Fig. 4, the forming pin 78 is configured to roll around the longitudinal axis L in a circular motion at a predetermined angle relative to the longitudinal axis L. Movement of the forming pin 78 may be controlled using the end forming machine that supports and enables the forming pin 78 to roll during the end forming process. Any suitable predetermined angle may be used. In exemplary applications, the predetermined angle may be between 4 and 20 degrees, and more particularly, 18.5 degrees. Other angles may also be suitable. As best shown in Figs. 6-8, the pin head 84 includes annular surfaces or grooves that define different contours of the forming pin 78. A protruding stop surface 96 may be formed as a radially outer annular surface of the pin head 84 and is used to maintain a consistent thickness of the pipe or tube 82. The stop surface 96 is used to set a predetermined amount or length of how much of the end 80 of the pipe or tube 82 protrudes or sticks out of the die 30 during the die forming process. The

stop surface 96 is engageable against the corresponding outer die 32, 34 during circular movement of the forming pin 78. The stop surface 96 may be angled relative to an axially extending peripheral surface 98 of the pin head 84 and may extend radially inwardly and axially outwardly from the peripheral surface 98 to an edge 100 of the stop surface 96, as best shown in Fig. 7.

Adjacent the edge 100 of the stop surface 96, a captive surface 102 is formed for controlling the inside and outside diameters of the end form of the pipe or tube 82. The captive surface 102 is concentrically arranged with the stop surface 96 and may be recessed inwardly from the stop surface 96. The captive surface 102 may be formed as a groove and radially interposed between the stop surface 96 and a biasing surface 104 that extends radially inwardly and axially outwardly. The biasing surface 104 is also used to enable increased pressure capability by biasing a flat portion of the pipe or tube flange inwardly to obtain a precise pressure point on the o-ring of the pipe or tube and face seal connection. Thus, using the biasing surface 104 provides improved sealing capability between the formed end and the o-ring. The biasing surface 104 extends radially inwardly to a base 106 of the knob-shaped protrusion 92. The knob-shaped protrusion 92 extends axially and radially outwardly from the base 106 such that the knob-shaped protrusion 92 is curved outwardly from the base 106.

Operation of the forming die system 76 is best shown in Figs. 9 and 10. During the end forming process, the end 80 of the pipe or tube 82 is inserted within the outer dies 32, 34 of the forming die system 76, and the outer dies 32, 34 are secured to each other to close the forming die 30 around the pipe or tube 82. As shown in Fig. 10, each grip die 62 of the corresponding outer die 32, 34 is biased radially inwardly by the biasing member 66 to bite into an outer surface 107 of the pipe or tube 82. Using the spring-assisted outer dies 32, 34 also ensures that the outer dies 32, 34 are completely closed and the parting line 36 is gapless or nearly gapless. When the forming die 30 and pipe or tube 82 are secure, the knob-shaped protrusion 92 of the forming pin 78 of the forming die system 76 is inserted in the end 80 of the pipe or tube 82 such that the knob-shaped protrusion 92 is also received within the receiving bore 38 of the forming die 30. The forming pin 78 rolls

around the longitudinal axis of the pipe or tube 82 in the circular motion at a predetermined angle relative to the longitudinal axis.

During the rolling movement of the forming pin 78, the contoured surfaces of the forming pin 78 are used to ensure consistency in a flanged or formed end 108 of the pipe or tube end 80. The stop surface 96 is engageable against the outer dies 32, 34 to ensure that the formed end 108 of the pipe or tube end 80 has a consistent thickness. The stop surface 96 determines the length of the pipe or tube end 80 that protrudes out of the forming die 30. The captive surface 102 is engageable against the formed end 108 to control the inside and outside diameter of the formed end 108. Using the captive surface 102 enables the inside and outside diameters of the formed end 108 to be reduced as compared with conventional end forming methods. The captive surface 102 may also be used to smooth the inside diameter edge of the formed end 108.

Referring now to Figs. 11-17, the end forming process using the forming die system 76 and end forming method described herein produces a connection 110 between the pipe or tube 82 and a fitting body 112. The assembled connection 110 is shown in Figs. 11 and 12 and includes any suitable seal, such as an o-ring 114 and a nut 116. Figs. 13 and 14 each show the formed end 108 of the pipe or tube 82 assembled with the nut 116 and the fitting body 112 disassembled from the pipe or tube 82 and the nut 116. Figs. 15-17 show further details of the connection between the pipe or tube 82 and the nut 116. The selected fitting body, nut, and o-ring may be dependent on the application. The o-ring 114 and the formed end 108 may form a flat face seal, or an angled seal, such as a face seal having an angle between 30 and 50 degrees relative to the longitudinal axis of the connection 110. For example, the seal face may be angled at 37 degrees or 45 degrees. The size of the fitting body and the nut may be dependent on the application and the forming die system 76 and end forming method ensures that any size of the fitting body and the nut may be suitable for connection.

As best shown in Figs. 11 and 13, the fitting body 112 may have a threaded outer surface 118 that is configured for threaded engagement with a corresponding internal threaded diameter of the nut 116. The nut 116 and the fitting body 112 may

also be secured using any other suitable connection. As best shown in Fig. 11, 13 and 17, the nut 116 also receives the formed end 108 is radially received within the nut 116 by way of a contour 120 of the nut 116 being complementary with or matching the contour of the formed end 108 of the pipe or tube 82. Using the forming die system 76 and end forming process described herein enables the formed end 108 to match any contour of any suitable nut. When both the formed end 108 and the fitting body 112 are engaged within the nut 116, the o-ring 114 is matingly engageable and compressed against the formed end 108, as best shown in Fig. 11.

Advantageously, the forming die system 76 and method described herein results in a consistently formed and sleeveless connection 110 that may be used for pipes and tubes and fittings of any size. Eliminating the welded joints and sleeves is advantageous in that the forces acting on the pipe or tube 82 due to the welding are reduced and the number of components in the connection 110 are reduced as compared to conventional pipe or tube-to-fitting connections. Providing a forming die system 76 and method that is suitable for use with variably sized pipes and fitting is advantageous in that the connection 110 may be suitable for use with large pipes or tubes. For example, the forming die system 76 and method may be suitable for applications in which the pipes or tubes have diameters between 1 and 8 centimeters (0.5 to 3 inches). The forming die system 76 and method may also be suitable for applications in which the pipes or tubes have larger diameters, such as greater than 7 centimeters.

The connection 110 of the present application is consistently formed by the features of the forming die 30 (shown in Figs. 1-5) and of the forming pin 78 (shown in Figs. 4-10). Using the spring-assisted grip in the forming die 30 enables the parting line between the outer dies (die halves) to have a minimal or no gap such that the pipe or tube 82 is securely held within the forming die 30 during the end forming process. The spring-assisted grip also enables the pipe or tube 82 to be easily removed from the forming die 30 after the end forming process. The forming pin 78 has the protruding or positive stop surface that is engageable against the forming die 30 to maintain a consistent thickness of the formed end 108. With

reference to Fig. 15, the captive surface of the forming pin 78 is used to smooth an inside diameter edge 122 of the formed end 108 and maintain a consistently-formed inside diameter edge 122 and outside diameter 124. The biasing surface of the forming pin 78 also provides improved sealing capability when mating the formed
5 end 108 and the o-ring 114.

A forming die is used in end forming a pipe or tube for connecting the pipe or tube with a fitting. The forming die includes engageable outer dies that each have a die forming surface, grip dies supported in each of the outer dies and configured to hold the pipe or tube, and a biasing member that is engageable between a
10 corresponding one of the outer dies and a corresponding one of the grip dies.

The forming die may include grip die surfaces that are formed on each of the grip dies and have protrusions for holding the pipe or tube.

The protrusions may be teeth or ridges.

The grip die surfaces may be toothed and have between 15 and 30 teeth.

15 The grip die surfaces may be formed of a carbide deposit material.

The outer dies may be identical in shape and rectangular, with the outer dies defining a bore having a longitudinal axis when the outer dies are engaged.

The die forming surface of each outer die may be axially adjacent the grip dies and each die forming surface has axially adjacent conically angled surfaces.

20 The biasing member may include disc springs or Bellville washers.

The outer dies may form a gapless parting line therebetween when engaged, with the outer dies being symmetrical to each other along the parting line.

The forming die may include spring pins that are configured to retain the grip dies within the outer dies.

25 A forming die system is used in end forming a pipe or tube for connecting the pipe or tube with a fitting. The forming die system includes engageable outer dies that together define a bore having a longitudinal axis and each have a die forming surface, grip dies supported in each of the outer dies and configured to hold the pipe or tube, a biasing member that is engageable between a corresponding one of
30 the outer dies and a corresponding one of the grip dies, and a forming pin that is configured to roll around the longitudinal axis in a circular motion at a predetermined

angle relative to the longitudinal axis.

The forming pin may have a captive surface formed as an annular groove.

The forming pin may have a protruding stop surface that is radially adjacent the captive surface and configured to contact the outer dies.

5 The protruding stop surface may be axially angled relative to a longitudinal axis of the forming pin.

The predetermined angle of the forming pin may be between 4 and 20 degrees relative to the longitudinal axis.

10 The grip die surfaces may be formed on each of the grip dies and have protrusions for holding the pipe or tube.

The protrusions may be teeth or ridges.

The grip die surfaces may be formed of a carbide deposit material.

The die forming surface of each outer die may be axially adjacent the grip dies and each die forming surface may have conically angled surfaces.

15 The biasing member may include disc springs or Bellville washers.

The outer dies may be engageable to form a gapless parting line between the outer dies, with the outer dies being symmetrical to each other along the parting line.

20 The forming die system may include spring pins that are configured to retain the grip dies within the outer dies.

25 A method of end forming a pipe or tube for connecting the pipe or tube with a fitting includes providing complementary outer dies that each have a die forming surface, engaging the outer dies together to define a longitudinal axis, holding the pipe or tube using grip dies supported in each of the outer dies, and radially biasing the grip dies toward each other.

The method may include rolling a forming pin in a circular motion around the longitudinal axis at a predetermined angle relative to the longitudinal axis.

The method may include forming grip die surfaces on each of the grip dies that have protrusions for holding the pipe or tube.

30 Forming the grip die surfaces may include using a carbide deposit material and forming the protrusions as teeth or ridges.

Engaging the outer dies together may include forming a parting line without gaps between the outer dies and symmetrically arranging the outer dies along the parting line.

The method may include forming the die forming surface of each outer die to be axially adjacent the grip dies and have conically angled surfaces.

The method may include retaining the grip dies within the outer dies using a retaining pin.

The method may include externally clamping the outer dies to close the outer dies.

Although the invention has been shown and described with respect to a certain embodiment or embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In particular regard to the various functions performed by the above described elements (components, assemblies, devices, compositions, etc.), the terms (including a reference to a "means") used to describe such elements are intended to correspond, unless otherwise indicated, to any element which performs the specified function of the described element (i.e., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary embodiment or embodiments of the invention. In addition, while a particular feature of the invention may have been described above with respect to only one or more of several illustrated embodiments, such feature may be combined with one or more other features of the other embodiments, as may be desired and advantageous for any given or particular application.

Claims

What is claimed is:

- 5 1. A forming die used in end forming a pipe or tube for connecting the pipe or tube with a fitting, the forming die comprising:
engageable outer dies that each have a die forming surface;
grip dies supported in each of the outer dies and configured to hold the pipe or tube; and
10 a biasing member that is engageable between a corresponding one of the outer dies and a corresponding one of the grip dies.
- 15 2. The forming die according to claim 1 further comprising grip die surfaces that are formed on each of the grip dies and have protrusions for holding the pipe or tube.
3. The forming die according to claim 2, wherein the protrusions are teeth or ridges.
- 20 4. The forming die according to claim 3, wherein the grip die surfaces are toothed and have between 15 and 30 teeth.
5. The forming die according to any of claims 2-4, wherein the grip die surfaces are formed of a carbide deposit material.
- 25 6. The forming die according to any preceding claim, wherein the outer dies are identical in shape and rectangular, the outer dies defining a bore having a longitudinal axis when the outer dies are engaged.
- 30 7. The forming die according to claim 6, wherein the die forming surface of each outer die is axially adjacent the grip dies and each die forming surface has

axially adjacent conically angled surfaces.

8. The forming die according to any preceding claim, wherein the biasing member includes disc springs or Bellville washers.

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9. The forming die according to any preceding claim, wherein the outer dies form a gapless parting line therebetween when engaged, the outer dies being symmetrical to each other along the parting line.

10. The forming die according to any preceding claim further comprising spring pins that are configured to retain the grip dies within the outer dies.

11. A forming die system used in end forming a pipe or tube for connecting the pipe or tube with a fitting, the forming die system comprising:
engageable outer dies that together define a bore having a longitudinal axis and each have a die forming surface;
grip dies supported in each of the outer dies and configured to hold the pipe or tube;
a biasing member that is engageable between a corresponding one of the outer dies and a corresponding one of the grip dies; and
a forming pin that is configured to roll around the longitudinal axis in a circular motion at a predetermined angle relative to the longitudinal axis.

12. The forming die system according to claim 11, wherein the forming pin has a captive surface formed as an annular groove.

13. The forming die system according to claim 12, wherein the forming pin has a protruding stop surface that is radially adjacent the captive surface and configured to contact the outer dies.

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14. The forming die system according to claim 13, wherein the protruding

stop surface is axially angled relative to a longitudinal axis of the forming pin.

15. The forming die system according to any of claims 11-14, wherein the predetermined angle of the forming pin is between 4 and 20 degrees relative to the longitudinal axis.

16. The forming die system according to any of claims 11-15 further comprising grip die surfaces that are formed on each of the grip dies and have protrusions for holding the pipe or tube.

17. The forming die system according to claim 16, wherein the protrusions are teeth or ridges.

18. The forming die system according to claim 16, wherein the grip die surfaces are formed of a carbide deposit material.

19. The forming die system according to any of claims 11-18, wherein the die forming surface of each outer die is axially adjacent the grip dies and each die forming surface has conically angled surfaces.

20. The forming die system according to any of claims 11-19, wherein the biasing member includes disc springs or Bellville washers.

21. The forming die system according to any of claims 11-20, wherein the outer dies are engageable to form a gapless parting line between the outer dies, the outer dies being symmetrical to each other along the parting line.

22. The forming die system according to any of claims 11-21 further comprising spring pins that are configured to retain the grip dies within the outer dies.

23. A method of end forming a pipe or tube for connecting the pipe or tube with a fitting, the method comprising:

providing complementary outer dies that each have a die forming surface;
engaging the outer dies together to define a longitudinal axis;

5 holding the pipe or tube using grip dies supported in each of the outer dies;
and

radially biasing the grip dies toward each other.

24. The method of end forming according to claim 23 further comprising
10 rolling a forming pin in a circular motion around the longitudinal axis at a
predetermined angle relative to the longitudinal axis.

25. The method of end forming according to claim 23 or 24 further
comprising forming grip die surfaces on each of the grip dies that have protrusions
15 for holding the pipe or tube.

26. The method of end forming according to claim 25, wherein forming the
grip die surfaces includes using a carbide deposit material and forming the
protrusions as teeth or ridges.

20

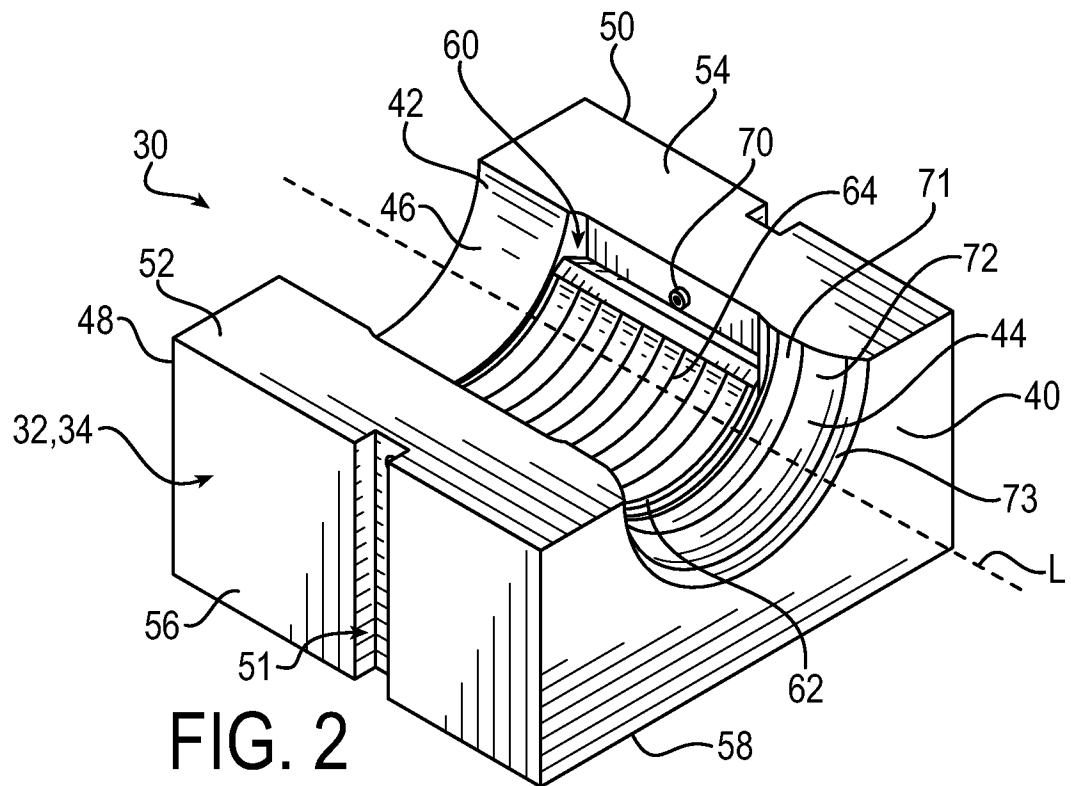
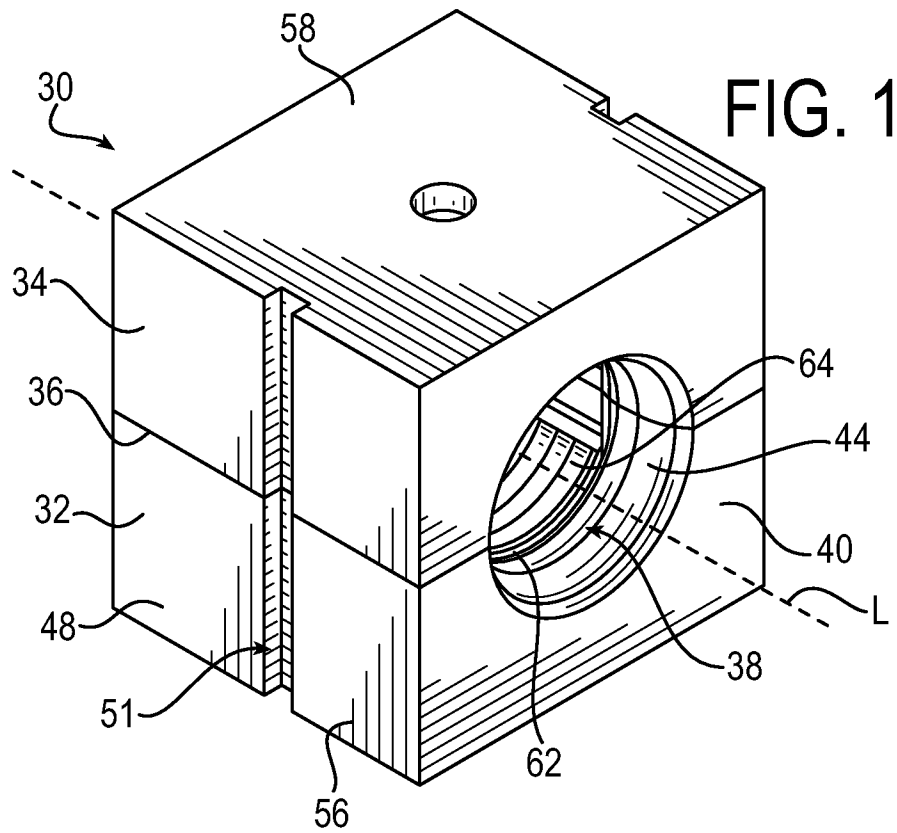
27. The method of end forming according to any of claims 23-26, wherein
engaging the outer dies together includes forming a parting line without gaps
between the outer dies and symmetrically arranging the outer dies along the parting
line.

25

28. The method of end forming according to any of claims 23-27 further
comprising forming the die forming surface of each outer die to be axially adjacent
the grip dies and have conically angled surfaces.

29. The method of end forming according to any of claims 23-28 further
30 comprising retaining the grip dies within the outer dies using a retaining pin.

30. The method of end forming according to any of claims 23-29 further comprising externally clamping the outer dies to close the outer dies.



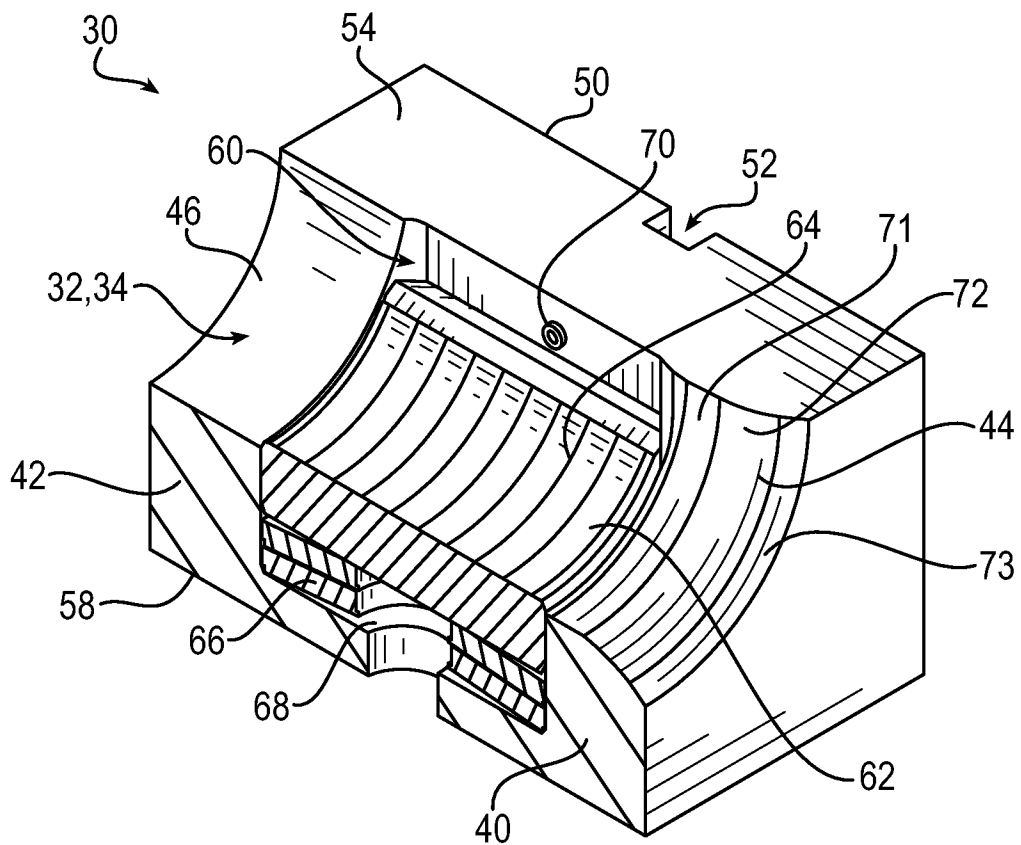


FIG. 3

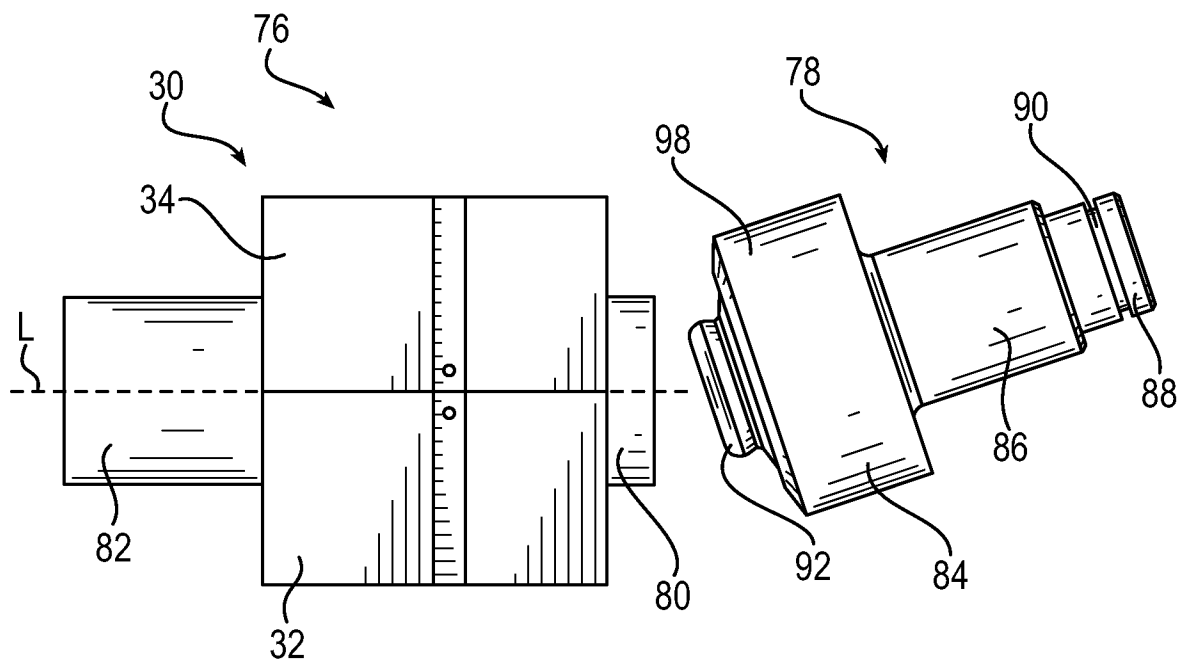


FIG. 4

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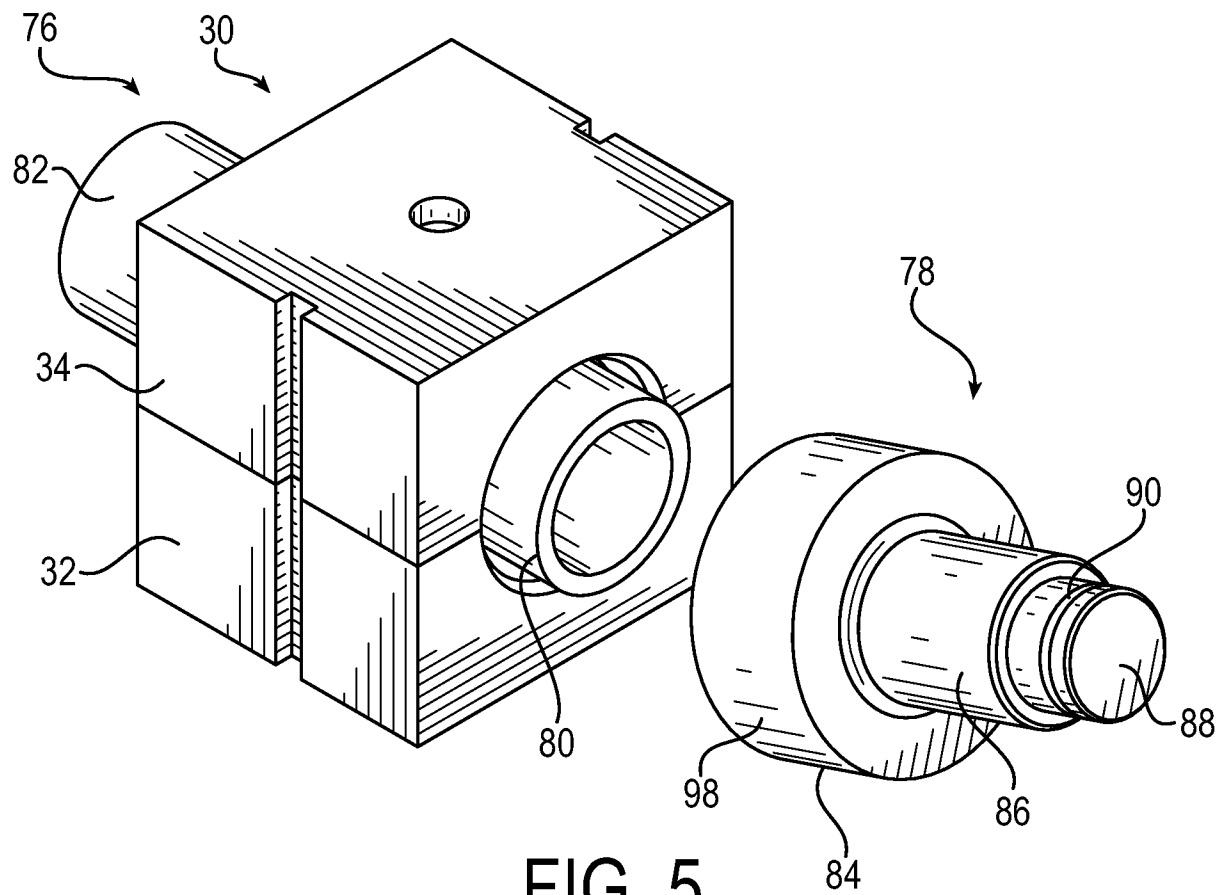


FIG. 5

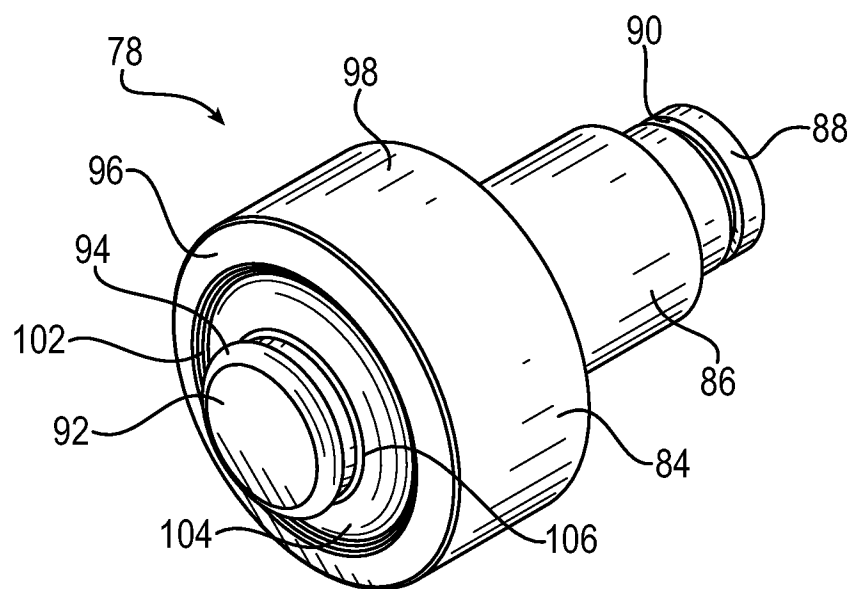


FIG. 6

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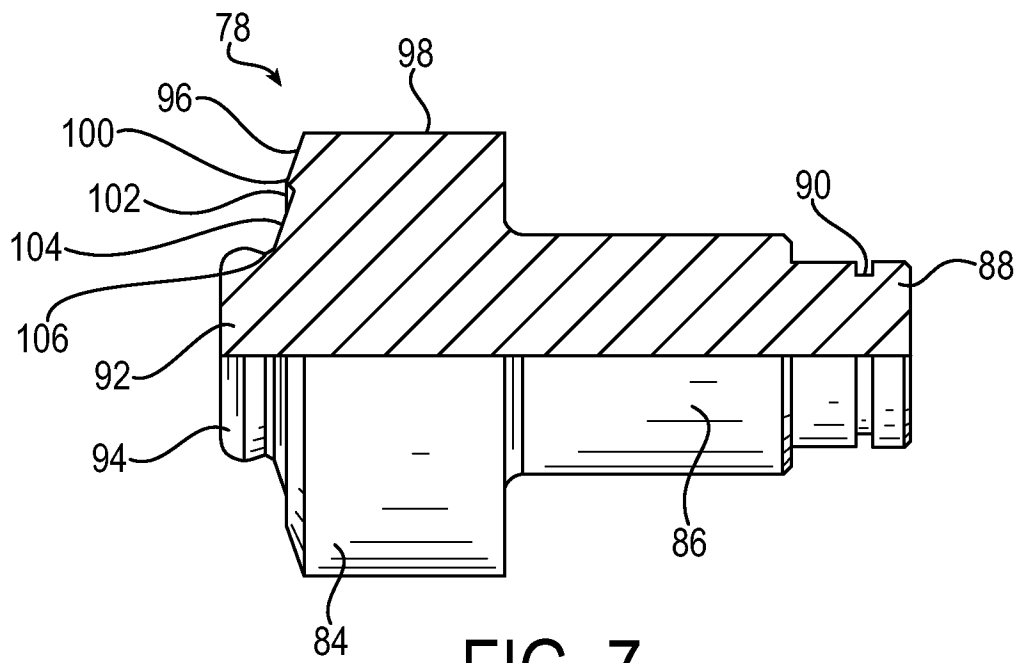


FIG. 7

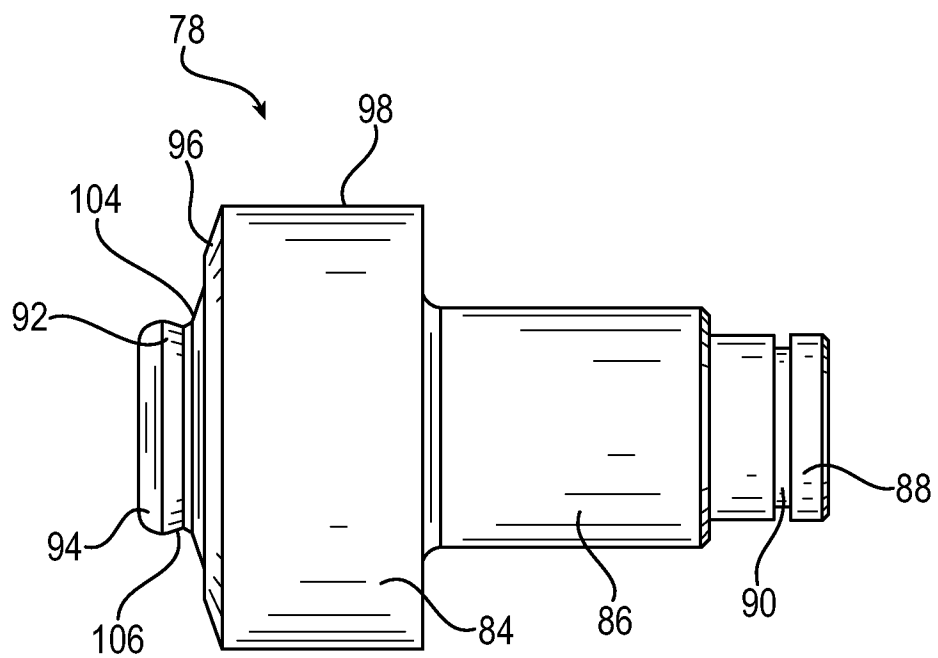


FIG. 8

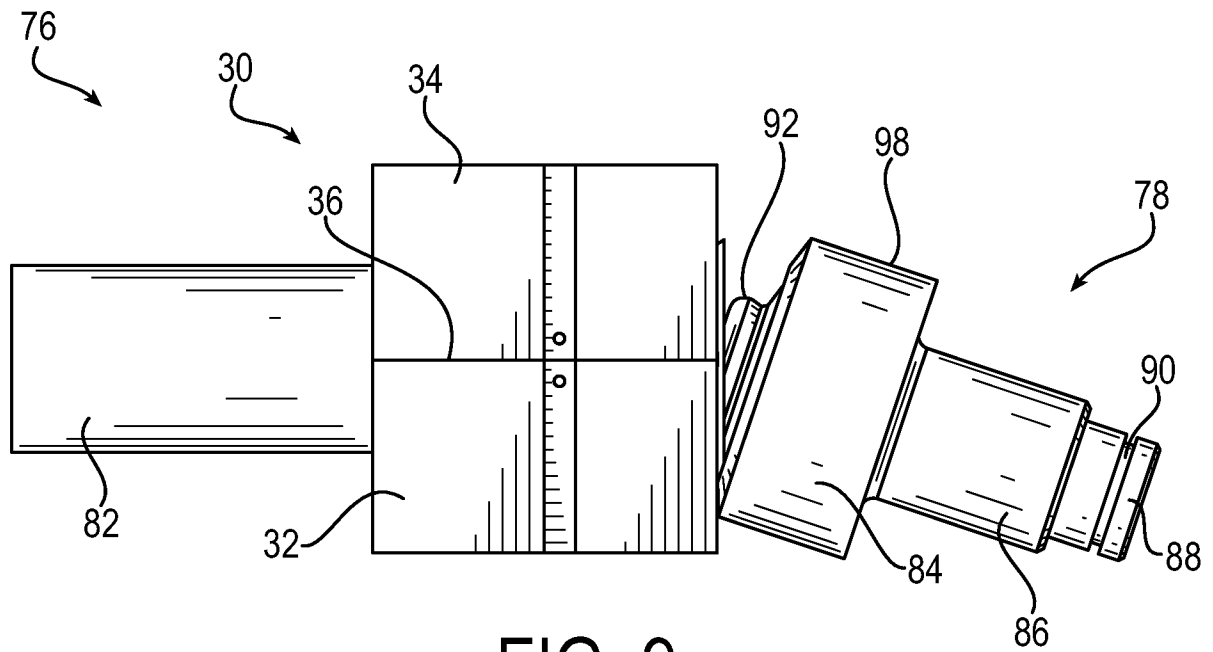


FIG. 9

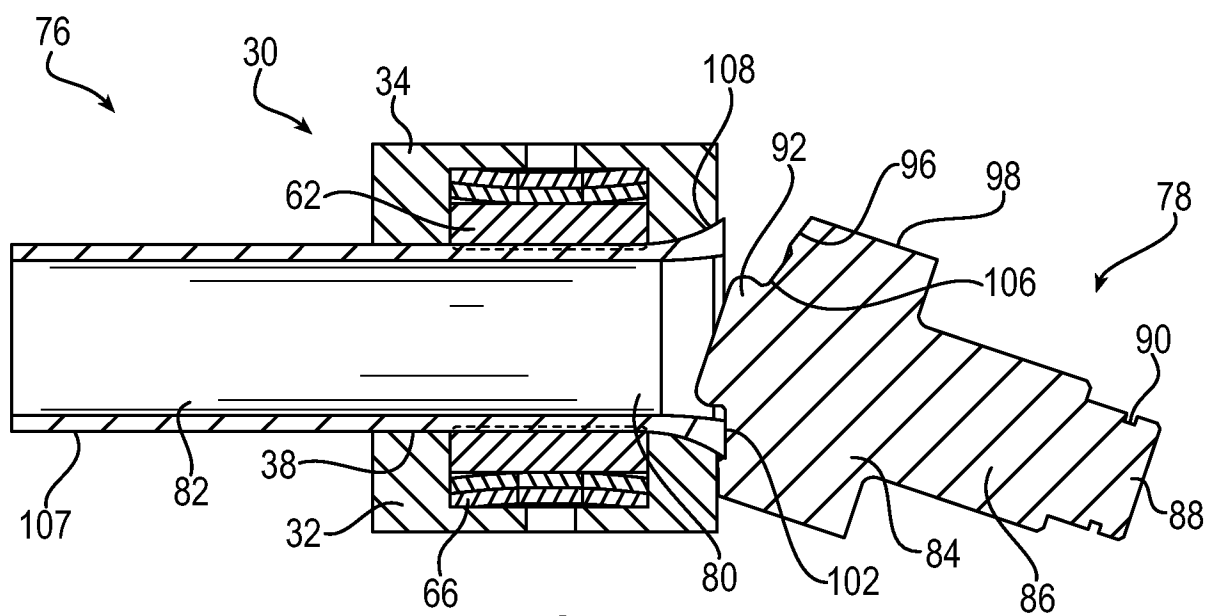


FIG. 10

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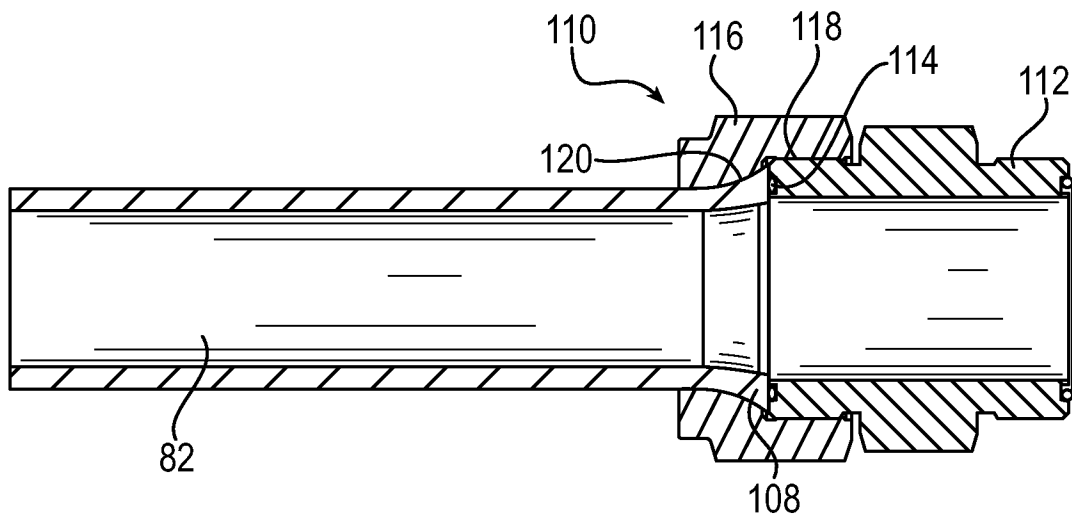


FIG. 11

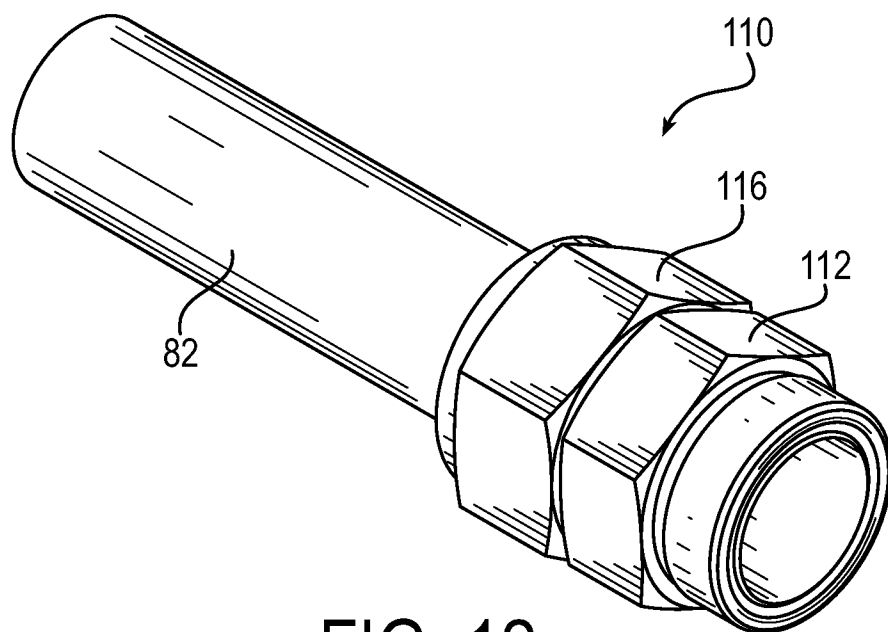


FIG. 12

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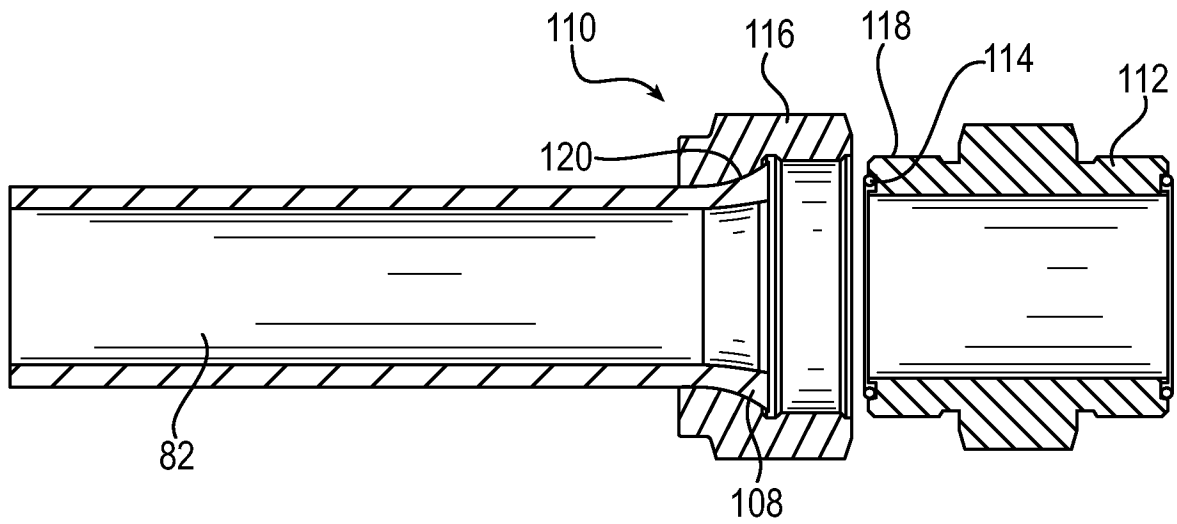


FIG. 13

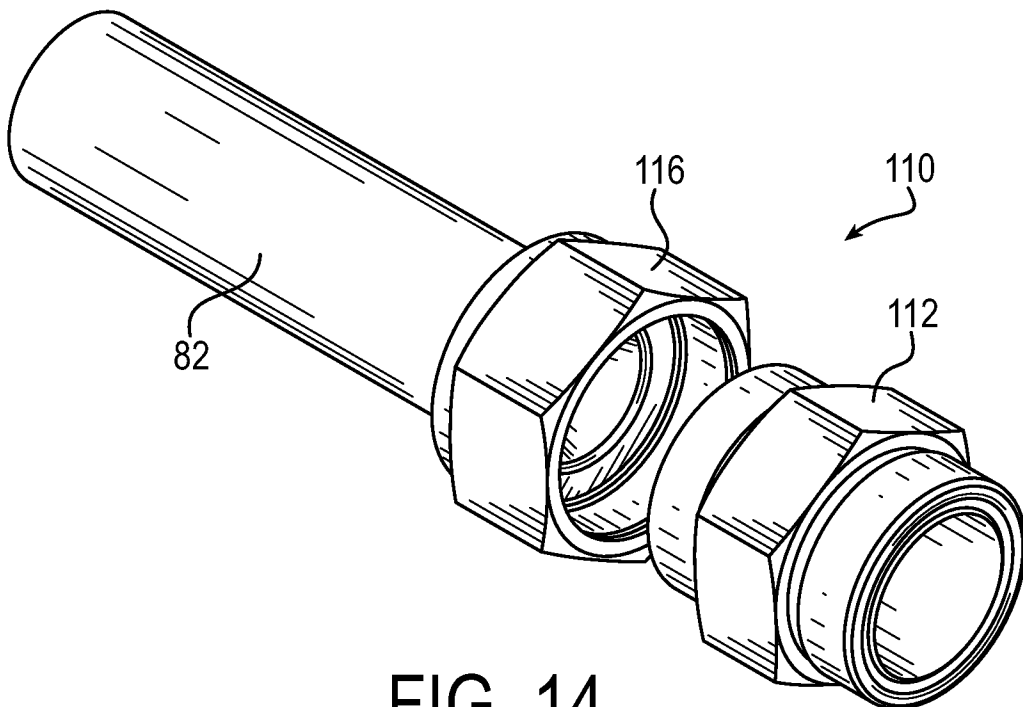
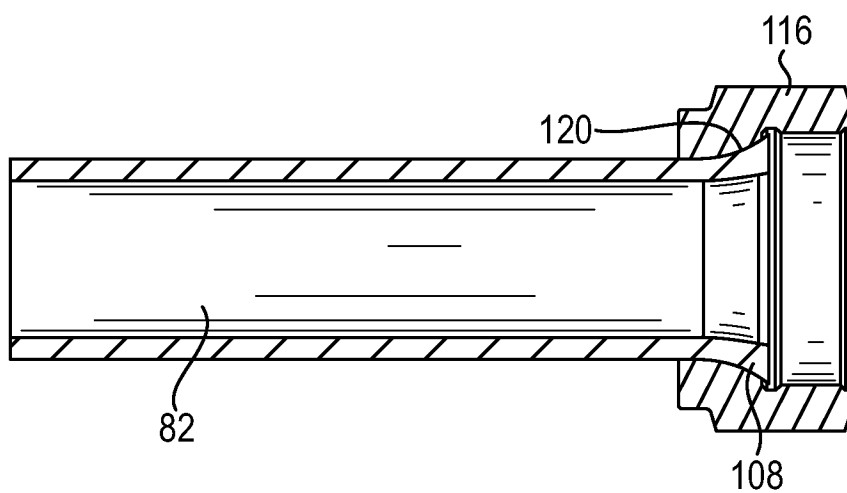
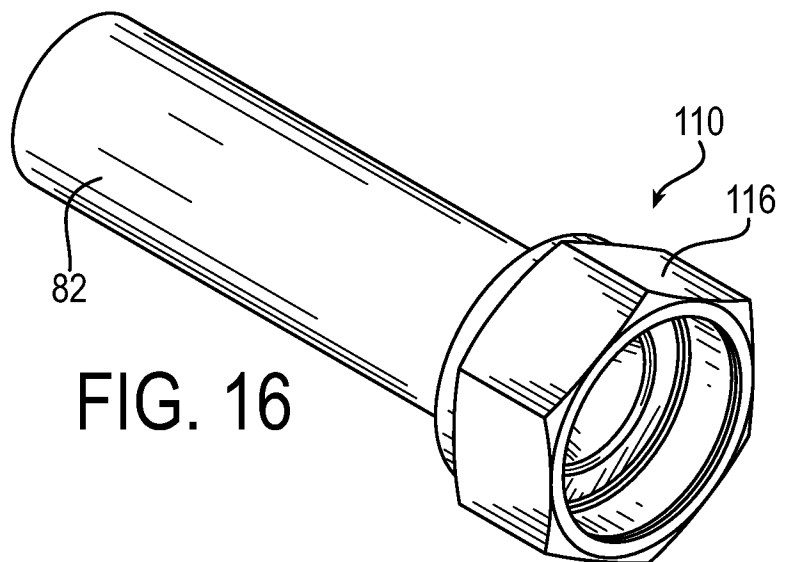
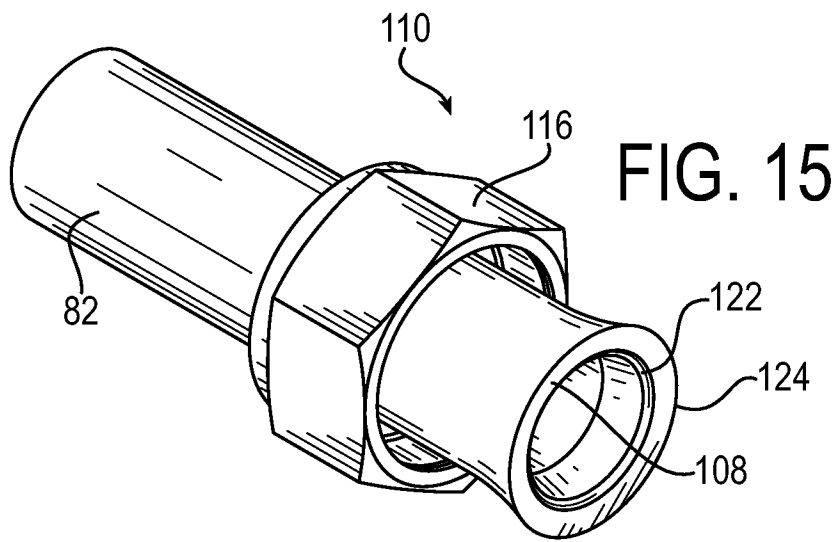


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/018100

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21D41/02 B21D37/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 497 132 B1 (MACKAY GARY [CA] ET AL) 24 December 2002 (2002-12-24)	23,25-30
A	column 4, line 29 - column 5, line 8; figures 4,5	1-22
X	US 3 083 755 A (WILSON FRANK R) 2 April 1963 (1963-04-02)	23-30
A	column 3, line 1 - line 12; figure 5	1-22
X	DE 299 12 996 U1 (EVER COMFORT CORP [TW]) 18 November 1999 (1999-11-18)	23-30
A	page 7, line 12 - line 28; figure 3	1-22



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search

5 May 2020

Date of mailing of the international search report

20/05/2020

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Authorized officer

Vesterholm, Mika

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2020/018100

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6497132	B1	24-12-2002	NONE
US 3083755	A	02-04-1963	NONE
DE 29912996	U1	18-11-1999	NONE