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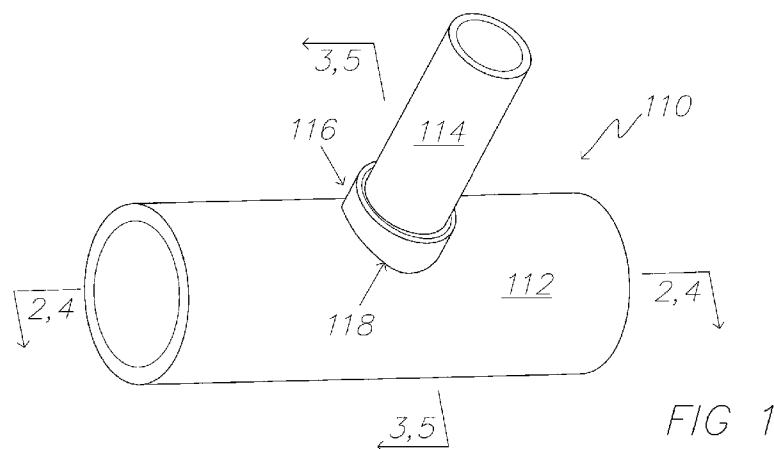
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(54) Title: A PIPE TEE FOR PRESSURE PIPE



(57) Abstract: A method and an apparatus for forming a plastic pipe tee (110) that includes pulling a bullet mandrel through a spigot die with independent actuation of the bullet mandrel and the spigot die. The pipe tee (110) may include a collar (116), about the branch pipe, of a tensile ring (116) with a saddle base (118) formed to abut the main pipe wall when the pipe tee (110) is pressurised.

A PIPE TEE FOR PRESSURE PIPE.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

[0001] The present invention relates to pipe or branch tee fittings or alternatively to a branch pipe fabrication to a length of main pipe for pressurised plastic pipe. In particular to plastic pipe carrying fluids such as water or gas in accordance with ISO 1167 and AS 4129 standards.

[0002] In addition the present invention relates to polyethylene plastic pipe from approximately 110 mm outside diameter up to and beyond 1200 mm outside diameter.

2. Description of the Art:

[0003] A pipe tee or branch tee is a specific form of pipe fitting. Typically one pipe diameter branches off from a continuous main pipe line. The branch or off-take pipe may be the same diameter to the main pipeline, termed an “equal tee”, or of a smaller diameter, termed a “reducing tee”. The branch pipe may also typically be at 90° to the main pipe but may be at other angles depending on the pipe network layout.

[0004] Pipe tees are usually produced as a discrete pipe fitting in a factory and supplied to the customer to be joined into a length of an existing pipe or to form a new pipe network in the field. The tee may be formed in several ways including the following. Injection moulding, however above a diameter of approximately 300 mm plastic pipe injection moulding is often not economical. Alternatively a fusion onto the main pipe with a saddle flange including a short branch pipe, followed by drilling a hole through the main pipe wall via the branch pipe and saddle flange. The fusion is often done by electro-fusion with imbedded electric heating coils in at least one of the surfaces to be fused together. Plastic welding techniques may also be used. Another technique is the fusing of a spigot (a short branch pipe) onto the main pipe followed by drilling the hole through the main pipe wall. A further alternative is butt fusing of mitred assemblies by cutting mitred joints from the main pipe and then butt fusing of a correspondingly mitred branch pipe end. However such mitred assemblies are

inherently weak and require substantial de-rating in pressurised applications. Another technique is machining from a billet of plastic, however this is not particularly economic for very large diameter plastic pipes fittings. A further technique is a heating of the whole of a main pipe length for the fitting then a plastic deformation or forging from the main pipe wall to form a short branch pipe or spigot.

[0005] None of these prior art methods or apparatus provides an entirely satisfactory solution to the provision of a branch pipe or tee fitting for pressurised plastic pipe, nor to the ease and economic of fabrication of tee fittings that are not prone to premature failure.

[0006] Any reference herein to known prior art does not, unless the contrary indication appears, constitute an admission that such prior art is commonly known by those skilled in the art to which the invention relates, at the priority date of this application.

SUMMARY OF THE INVENTION

[0007] The present invention aims to provide an alternative process for making a pipe tee as well as an alternative pipe tee which overcomes or ameliorates the disadvantages of the prior art, or at least provides a useful choice.

[0008] In one form, the invention provides a collar for a plastic pipe tee, comprising: a tensile ring adapted to sleeve a spigot and a branch pipe of the pipe tee; and a base of the collar formed such that two or more portions of the base are adjacent to at least two corresponding portions of a main pipe wall of the pipe tee; wherein when the pipe tee is pressurised an outwardly movement of at least one of the main pipe wall and the spigot is resisted by the collar.

[0009] The collar provides at least one of: preventing a bending moment about a joint between the spigot and the branch pipe and a support to the joint. The outwardly movement of the main pipe wall is at least one of: at and adjacent the junction of the spigot to the main pipe. The outwardly movement of the main pipe wall is resisted by the base of collar.

[0010] The branch pipe and spigot are pressurized a force is caused, via the saddle base of the collar, to resist an outward movement or bending moment of the tee

junction and the main pipe wall approximately about the spigot and branch pipe junction.

[0011] The portions of the main pipe wall are adjacent the junction of the spigot to the main pipe. The portions of the main pipe wall include the transverse and opposing side walls of the main pipe.

[0012] The collar may be clamped to at least one of the branch pipe and the spigot.

[0013] In a further form, the invention provides a force re-distribution collar for a plastic pipe tee of the type comprising a main pipe having a spigot in a main pipe wall adapted to be joined with a branch pipe; the collar comprising a tensile ring adapted to support a circumferential join between the spigot and the branch pipe; the collar further extending to the junction between the main pipe and the spigot so as, in use, to support the main pipe wall adjacent the junction.

[0014] In another form, the invention provides a method for forming a plastic pipe tee including the steps of: providing a main pipe; localising a heating to a portion of a wall of the main pipe; forming an opening, with a projecting tubular lip, in the localised heated portion of the main pipe wall; joining a branch pipe to the projecting tubular lip; and locating a collar about the joint to the branch pipe and substantially adjacent to an outer wall surface of the main pipe.

[0015] The method further includes the step of: independently and simultaneously actuating a saddle die or spigot die and a bullet mandrel when forming the opening and projecting tubular lip wherein the saddle die is located externally to the opening and the bullet mandrel passes through the opening.

[0016] The method further includes the step of: further including the step of: providing a bullet mandrel configured or formed to aid in forming a substantially uniform wall thicknesses for the projecting tubular lip, and pulling the bullet mandrel through the opening such that the projecting tubular lip forms a spigot with a substantially uniform wall thickness.

[0017] The method wherein the steps of providing and pulling through the main pipe wall a configured bullet mandrel, pulls sufficient main pipe wall material from the heated portion to form the spigot with substantially uniform wall thickness.

[0018] The method further includes the step of: inwardly offsetting the saddle die to the main pipe wall whilst forming the projecting tubular lip.

[0019] The method further includes the step of: providing an internal support to the projecting tubular lip whilst the projecting tubular lip cools.

[0020] The method wherein the step of providing internal support further includes: the bullet mandrel providing a removable support ring to the projecting tubular lip as the bullet mandrel exits the projecting tubular lip.

[0021] The method wherein the step for joining the branch pipe includes: supporting from within the main pipe, at least one of the opening and the projecting tubular lip.

[0022] The method further including the steps of: joining a branch pipe to the projecting tubular lip; and locating a collar about the joint to the branch pipe and substantially adjacent to an outer wall surface of the main pipe.

[0023] The method wherein the step for locating the collar includes: sealing or fusing the collar about the joint to the branch pipe.

[0024] The method further including the step of: forming an end of the collar adjacent the main pipe wall such that the collar end abuts and resists the main pipe wall when the pipe tee is pressurised.

[0025] The method wherein the step for locating the collar includes: joining, fusing or sealing the collar end to the main pipe wall.

[0026] The method further including the step of: forming the projecting tubular lip with the same standard diameter ratio as the main pipe.

[0027] The method wherein the plastic is a polyethylene.

[0028] In a further form, the invention provides a pipe tee formed by the method of any one of the preceding claims.

[0029] In another form the invention provides an apparatus for forming a pipe tee in a main pipe comprising: a means for localising a heating to a wall portion of the main pipe; a bullet mandrel initially positioned within the main pipe and adjacent the heated wall portion; and a spigot die applied to the outer surface of the heated wall portion of the main pipe; wherein the pulling of the bullet mandrel through the main pipe wall in opposition to the spigot die forms a spigot in the main pipe wall.

[0030] The bullet mandrel is formed so as to pull through sufficient heated main pipe wall material to form the spigot with a substantially uniform wall thickness.

[0031] The bullet mandrel has a leading first portion of increasing diameter followed longitudinally by a substantially uniform diameter second portion to aid in forming the substantially uniform wall thickness of the spigot.

[0032] The bullet mandrel further includes: a circumferential recess formed by an apex of a second or third portion having a smaller diameter than a base of the preceding portion.

[0033] The bullet mandrel is further formed of successive, longitudinally aligned first or second portions of larger diameter to provide a successive third or fourth portions of the bullet mandrel to further improve the spigot wall thickness uniformity.

[0034] The circumferential recess is formed or located to improve a wall thickness uniformity of the spigot being formed.

[0035] In an alternate form, the invention provides a plastic pipe tee comprising: a main pipe; a branch pipe; an opening formed in the main pipe wall, adapted for a joint between the main pipe and the branch pipe; and a means for transferring a main pipe hoop stress at the opening from one transverse side to the opposing side of the main pipe; wherein the means for transferring the hoop stress is located adjacent an outer surface of the main pipe wall.

[0036] The pipe tee wherein the means for transferring a main pipe hoop stress includes a collar.

[0037] The pipe tee wherein the collar includes a tensile ring.

[0038] The pipe tee wherein an end of the collar adjacent the outer surface of the main pipe wall is shaped such that the collar end abuts the main pipe wall when the pipe tee is pressurised.

[0039] The pipe tee wherein the collar end is substantially conformal with an outer surface of the main pipe wall.

[0040] The collar end resists an outwardly movement of at least one of the outer surface of the main pipe wall and a spigot wall at or adjacent the junction between the spigot and the main pipe

[0041] The pipe tee wherein the collar is sealed about the joint.

[0042] The pipe tee wherein the collar end is joined or sealed to the main pipe wall.

[0043] The pipe tee wherein the opening adapted for the joint includes a projecting tubular lip with substantially the same standard diameter ratio as the main pipe.

[0044] The pipe tee wherein the collar and collar end are shaped and located on the pipe tee so as to resist a bending moment about the joint between the protruding tubular lip or spigot and the branch pipe end.

[0045] The pipe tee wherein the collar and collar end are shaped and located on the pipe tee so as to resist a bending moment about the junction of the branch pipe with the main pipe.'

[0046] The collar and collar end are also shaped and located on the pipe tee so as to resist a bending moment from about approximately the junction of the branch pipe with the main pipe and substantially about a branch pipe joint.

[0047] The pipe tee wherein the opening and the projecting tubular lip or spigot are inwardly offset to the main pipe wall.

[0048] The pipe tee wherein the inward offset is substantially flush to the main pipe wall when the tee fitting is pressurised.

[0049] The pipe tee wherein the dimensions of the collar comprise: a nominal outside diameter DN_2 of the branch pipe; a wall thickness e_2 of the branch pipe; and a standard diameter ratio SDR of the branch pipe, whereby the SDR is determined from the equation: $SDR = DN_2 / e_2$; whereby a nominal outside diameter DN_3 of the collar is determined from the equation: $DN_3 = (DN_2 \times SDR) / 9$.

[0050] The pipe tee whereby a thickness of the collar e_3 is determined from the equation: $e_3 = DN_3 / SDR$.

[0051] The pipe tee whereby a length, a , of an electro-fusion zone of the collar is determined from the equation: $a = 3 \times e_3$.

[0052] The pipe tee wherein the plastic is a polyethylene.

[0053] In yet another form, the invention provides a collar for a plastic pipe tee, comprising: a tensile ring adapted to sleeve a branch pipe of the pipe tee, and a base adapted to substantially conform in use with a main pipe outer wall.

[0054] The base has opposing convex and concave portions

[0055] The collar further including: an electro-fusion heating coil located adjacent the inner surface of the collar.

[0056] The collar wherein the electro-fusion coil extends within the collar sufficiently to seal a joint between the branch pipe and a spigot of a pipe tee.

[0057] The collar wherein the dimensions comprise: a nominal outside diameter DN_2 of the branch pipe; a wall thickness e_2 of the branch pipe; and a standard diameter ratio SDR of the branch pipe whereby the SDR is determined from the equation: $SDR = DN_2 / e_2$; whereby a nominal outside diameter DN_3 of the collar is determined from the equation: $DN_3 = (DN_2 \times SDR) / 9$.

[0058] The collar whereby a thickness of the collar e_3 is determined from the equation: $e_3 = DN_3 / SDR$.

[0059] The collar whereby a length, a , of an electro-fusion zone is determined from the equation: $a = 3 \times e_3$.

[0060] The collar wherein the collar is a substantially formed of a plastic.

[0061] The collar wherein the plastic is a polyethylene.

[0062] In an alternate form, the invention provides a method of localising a heating of a plastic pipe including the steps of: infra-red radiation heating of a portion of a plastic pipe wall; simultaneously with the heating, surface cooling the portion of the wall with a gas; localising the heating of the portion of the wall by partially masking to infra-red radiation heating, the portion of the wall; monitoring at least one of a surface temperature and an internal temperature of the pipe wall portion; and controlling the infra-red radiation heating in response to the at least one monitored temperature and a set temperature for plastically deforming the plastic pipe.

[0063]

[0064] Further including the step of: moving the heating and surface cooling relative to the portion of the pipe wall.

[0065] The step of moving includes at least one of rotating the plastic pipe and moving longitudinally the plastic pipe backwards and forwards relative to the heating and surface cooling.

[0066] The method wherein the masking includes partially shielding or insulating to infra-red radiation heating.

[0067] The method further including the step of: applying the heating and surface cooling to the inner and outer surfaces of the portion of the pipe wall.

[0068] The method further including the step of: controlling the surface cooling in response to the at least one monitored temperature and the set temperature for plastically deforming the plastic pipe.

[0069] The method wherein the plastic is a polyethylene.

[0070] In another form, the invention provides an apparatus for localised heating, for plastic forming of a plastic pipe, comprising: an adjustable frame configured for at least one of a portion of an outer wall surface and a corresponding portion of an inner wall surface of the pipe; at least one of an elongate infra-red radiation heater adjustably mounted on the frame and directed to at least one wall surface portion; at least one surface cooling means adjustably mounted on the frame and directed to at least one wall surface portion; and a mask to localise the heating only to a part of the wall for plastic forming.

[0071] The apparatus further including means for oscillating the position of the plastic pipe with respect to at least one of the heating and the surface cooling means, thereby improving the homogeneity of the localised heating to the part of the wall for plastic forming.

[0072] The apparatus wherein the surface cooling means includes at least one of a gas cooling bar, a fan and an arrangement of fans and vanes.

[0073] The apparatus wherein the plastic is a polyethylene.

[0074] The apparatus further including at least one of a surface temperature sensor and an internal temperature sensor of the pipe wall portion.

[0075] The apparatus wherein at least one of the heater and the surface cooling means are controlled in response to a signal from the at least one temperature sensor and a set temperature for plastically deforming the plastic pipe.

[0076] In a further form, the invention provides a method for forming a plastic pipe tee substantially as described herein. Alternatively the invention provides a plastic pipe tee substantially as described herein. Also the invention provides a collar for a plastic pipe tee substantially as described herein. Furthermore the invention provides a method of localising a heating of a plastic pipe substantially as described

herein. In addition the invention provides an apparatus for localised heating substantially as described herein.

[0077] Further forms of the invention are as set out in the appended claims and as apparent from the description.

DISCLOSURE OF THE INVENTION

BRIEF DESCRIPTION OF THE DRAWINGS

[0078] The description is made with reference to the accompanying drawings, of which:

[0079] FIGURE 1 is a schematic of a perspective view of a pipe tee according to an embodiment of the present invention.

[0080] FIGURES 2 to 6 are sectional views of the pipe tee of FIGURE 1. FIGURES 2 and 3 are respective longitudinal and transverse sectional views through the main pipe. FIGURES 4 and 5 are corresponding elevational views to FIGURES 2 and 3.

[0081] FIGURE 7 is a photograph-perspective drawing of a first bullet shaped mandrel tool.

[0082] FIGURE 8 is a photograph-perspective drawing of a first pulling frame.

[0083] FIGURES 9A and 9B are respective perspective and side views of a saddle die, spigot die or mould.

[0084] FIGURE 10 is a schematic of a transverse sectional view of a pulling arrangement.

[0085] FIGURE 11 is a side elevational view of the pulling arrangement with the independent actuator of FIGURE 10.

[0086] FIGURE 12 is a photograph-perspective drawing of an intermediate step prior to FIGURE 10, where only a partially formed protruding lip is formed in the main pipe wall.

[0087] FIGURE 13 is a side sectional schematic of the bullet mandrel of FIGURE 28 forming a spigot.

[0088] FIGURES 14A and 14B are schematic diagrams to respective perspective and front elevational views of a localised heating apparatus.

[0089] FIGURES 15A and 15B are schematics of perspective views of a cylindrical collar with a saddle base.

[0090] FIGURES 16 and 17 are respective side and front elevational views of the collar of FIGURES 15A and 15B.

[0091] FIGURE 18 is a sectional view of the collar of FIGURE 15A along the lines 18-18.

[0092] FIGURE 19 is a longitudinal cross-section of the collar applied to a pipe tee fitting with dimensioning, design symbols shown.

[0093] FIGURES 20 to 23 are schematics to respective perspective, end elevation, side elevation and plan views of the substantially maximal pipe tee fitting.

[0094] FIGURES 24 to 27 are schematics to respective perspective, end elevation, side elevation and plan views of the substantially minimal reducing pipe tee fitting.

[0095] FIGURES 28 and 29 are schematic diagrams of respective front elevational and perspective views of another bullet mandrel.

[0096] FIGURES 30 and 31 are respective front elevational and perspective views of an alternate, larger, upwardly pulling frame assembly.

[0097] FIGURE 32 is a schematic of a transverse section through a pipe tee 3220 without the collar 114 of the invention.

[0098] FIGURE 33 is a schematic of the pipe tee of FIGURE 32 but with the collar of the invention applied.

[0099] FIGURE 34 is a schematic of a perpendicular, longitudinal section 3420 of the pipe tee with collar of FIGURE 33.

[00100] FIGURE 35 is a schematic perspective cutaway drawing of FIGURES 30 and 31, enlarged to the spigot die area.

[00101] In the figures the reference numerals are prefixed by the figure number. For example FIGURE 1 is the “100” series, FIGURE 2 is the “200” series and so on.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[00102] In the following description the following terms are defined. A Standard Diameter Ratio “SDR” is typically used to define the wall thickness for a given outside diameter of a pipe. The SDR is defined as the ratio of the pipe nominal outside diameter “DN” to the nominal wall thickness “e”. Pipe engineering tables of SDR values with respect to a pressure, a pressure rating, a pipe material, fluids carried and other parameters may be used to determine a wall thickness from a desired pipe diameter.

[00103] There are a number of relevant standards to pipe design and regulatory compliance. The Australian/New Zealand Standard is AS/NZS 4129:2008 “*Fittings for polyethylene (PE) pipes for pressure applications*” the contents of which are incorporated herein by reference. The International Standard is ISO 1167: “*Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure.*” the contents of which are also incorporated herein by reference. Such standards are often used for “type approvals” where the final product is required to pass a series of type approval tests before it can be released for use in certain markets.

[00104] Hydrostatic testing of the invention and prior art was done with respect to the Australian and International standards referenced herein. A screening testing technique used by the inventors for the above prior art techniques for plastic tees was used to accelerate the effects of long term creep as well as slow crack growth simulating lifetime performance under normal operating conditions. Many conventional, prior art tee fittings prematurely fail due to long term creep and slow crack growth. Other pipe tee fittings may also be susceptible to brittle failure with fine fibrils. Another failure mode that also may be seen is ductile failure with longer fibrils and the appearance of tearing of the plastic. The screening test pressurised the pipe fitting for 165 hours (1 week) at approximately 80°C. The large polyethylene pipe fittings tested here were commonly SDR 11 and so were pressurised at approximately

11 Bar for the duration of the test. At the conclusion of the test the pipe tee fittings were then sectioned to document the failure mode/s and wall thicknesses. Not uncommonly for prior art techniques for tee fitting, the test may be concluded early if the tee fitting had failed with loss of pressure or bursting.

[00105] FIGURE 1 is a perspective view of a pipe tee 110 according to the invention. The pipe tee 110 has a main or run pipe 112 and then a perpendicular branch pipe 114 or short spigot projecting from a wall of the main pipe 112. At the junction of the branch pipe 114 and the main pipe 112 a collar 116 or ring is located adjacent the outer surface of the main pipe wall. A saddle base 118 or end of the collar 116 has a lower surface shaped to be substantially conformal with the outer surface of main pipe wall.

[00106] FIGURES 2 to 6 are various sectional views of the pipe tee 110 of FIGURE 1. FIGURES 2 and 3 are respective longitudinal and transverse sectional views through the main pipe 112. FIGURES 4 and 5 are corresponding elevational views to FIGURES 2 and 3. A butt weld fusion joint 220 is shown between a short spigot 222 and an end of the branch pipe 114.

[00107] The short spigot 222 features a protruding lip 224 of an opening 226 formed in the main pipe wall 228. An internal bead 230 of material resulting from the butt weld or fusing jointing 220 may be present within the branch pipe.

[00108] FIGURE 6 is a sectional plan view through the butt weld 220.

[00109] The outside diameter of the plastic main pipe 112 may range from approximately 110 mm up to and beyond 1200 mm. Typical polyethylene pipe outside diameters may be from approximately 200 mm to 1200 mm and beyond. Preferably the plastic main pipe may be in the approximate outside diameter range of 200 to 800 mm or more preferably 400 to 800 mm. In the description below the plastic material preferably used may be polyethylene and in particular polyethylene of grade PE 100 HDPE (high density polyethylene). However it will be readily appreciated that other plastics for pipes may also be substituted appropriately by the person skilled in the art. The typical pressurised plastic pipe applications for the following pipe tees may be pressurised from 1 to 10 bar or more for peak or dynamic pressures.

Pull-Out Process:

[00110] The pipe tee 110 may be first formed by firstly forming a short spigot 222 to the main pipe 112 as follows.

[00111] Firstly a small opening in the main pipe wall 228 may be made which is suitable for the lead in of a bullet or mandrel tool used for the pull out as described below. For example a round or oval shaped initial hole may be drilled through the main pipe wall 228 in the location desired for the branch pipe.

[00112] FIGURE 7 is a photograph-perspective drawing of a bullet shaped mandrel tool 720 that may be used for inserting into the initial hole from within the main pipe 112. The bullet mandrel 720 may then be pulled out as described further below. The bullet mandrel 720 may also advantageously incorporate a removable supporting ring or sleeve 722 which may be left behind in the protruding tubular lip (or short spigot) after the pull out and moulding process of below. The use of the supporting ring is described further below with respect to the pull out process as well as fusing or welding of the branch pipe 114 to the formed spigot 222. The leading face 724 of the bullet mandrel may have a coupling point or bore for a pull rod to be coupled to. The pull rod may be used to extract the bullet mandrel through the main pipe wall as described below.

[00113] The bullet mandrel 720 also features a leading first portion of increasing diameter which is used to expand the opening 226 and begin forming the spigot 222 as described further below. On the longitudinal axis of the bullet mandrel 720 after the leading portion a substantially uniform diameter, cylindrical second portion 728 or section of the mandrel may be used. The second portion 728 of the mandrel 720 may be used during the pulling process to improve the uniformity of the spigot wall thickness during pulling, as described further below. A third portion 730 of increasing diameter may then follow longitudinally to further expand the forming spigot 222 as well as further reduce the wall thickness of the forming spigot 222. The supporting ring 722 may also provide a fourth portion of uniform diameter to also further improve the uniformity of the spigot wall thickness during pulling.

[00114] FIGURES 28 and 29 are schematic diagrams of respective front elevational and perspective views of another bullet mandrel 2820. This bullet mandrel 2820 also features four portions as described above with respect to FIGURE 7. In

addition the bullet mandrel 2820 of FIGURE 28 features a third portion 2822 of expanding diameter where an apex of the conical portion or frustum of the conical section is of a reduced diameter compared with the prior second portion 728 of substantially uniform diameter. That is an overhanging lip 2824 is formed with respect to the direction of travel of the bullet mandrel 2820 through the forming spigot and main pipe wall. A use of such a discontinuity in the bullet mandrel surface may be used improve the spigot wall uniformity during pulling by enabling more heated plastic material to be drawn up into the forming spigot. Additional heated main pipe wall material may be accumulated in the circumferential recess 2824 formed by the overhanging lip 2824, subsequently contributing to the forming spigot wall. Further detail to improving spigot wall uniformity in such a fashion is described with respect to FIGURE 13.

[00115] It will be readily appreciated that a number, a longitudinal length, a diameter expansion or an uniformity of the bullet mandrels described may be varied in order to achieve in the pulling process the spigot length, diameter and wall thickness uniformity desired.

[00116] Localised heating may be advantageously applied only to a portion of the main pipe wall that is to be used for plastically forming the opening 226 and protruding lip 224 of the short spigot 222. Localised heating may be done until the wall portion is heated sufficiently for plastic deformation and forming. A new and advantageous apparatus and method for localised heating is described in detail further below with respect to FIGURE 14.

[00117] After localised heating the main pipe may then be placed in a suitable pulling frame 820 as shown in the photograph of FIGURE 8. An alternate pulling frame is also described below with respect to FIGURES 30, 31 and 35. In FIGURE 8 the heated main pipe is not shown in order to improve the clarity with respect to the pulling frame 820 features. The main pipe may be clamped within a cylindrical clamp 822 made of heat resistant, insulating and low thermal conductivity material, for example a fibreglass or carbon fibre composite or a refractory or ceramic material. The cylindrical clamp 822 may be made of such a material so as to minimise cooling of the heated portion of the main pipe wall during the pull out and spigot forming process. The lower surface of cylindrical clamp may have an aperture or

mounting 824 for receiving a spigot die or saddle mould as described below with respect to FIGURE 9.

[00118] FIGURES 9A and 9B are respective perspective and side views of a saddle die, mould or spigot die 920. The spigot die 920 may also be made of a similar material to the cylindrical clamp to also minimise cooling or heat flow out of the heated portion of the main pipe wall during the pull out and spigot forming process. For example the spigot die 920 material may be a Kevlar fibre and resin composite with a ceramic filler to improve insulation and durability. In addition the material and / or form of the spigot die 920 should be sufficiently rigid to maintain the die form during the pull out process. The spigot die 920 may be advantageously capable of being independently moved relative to the cylindrical clamp 822 in order that the spigot die may be used to also provide an inward force to deform inwardly the localised heated portion of the main pipe wall. The independent movement and actuation of the spigot die 920 is described further with respect to FIGURES 10 and 11. Such an advantageous induced deformation or inward offset of the main pipe wall about the branch pipe junction to the main pipe may be used to allow the main pipe and tee fitting to assume the required form when pressurised in use. For smaller polyethylene pipe of DN 400 mm the deformation or offset of the spigot to the main pipe wall may be in the order of 20 mm.

[00119] For larger and thicker walled pipe of DN 800mm, for example, the offsetting may be done by use of a differential pressure or force between the pull out force applied to the bullet mandrel and the inwardly force applied to the spigot die 920 during the spigot forming process. For example the spigot die may be inwardly forced by approximately 20% more force than the pull out force applied to the bullet mandrel. It will be readily appreciated that the magnitude of the differential force or pressure between pull out of the bullet mandrel and spigot die 920 may be selected as by a person skilled in the art to provide the required deformation of the thicker main pipe wall for the collar optimal functional when in use for a pressurised pipe tee.

[00120] The required form by either offsetting technique to the main pipe wall being such that the collar and saddle base are improved in their co-operation with the main pipe wall when the tee fitting is pressurised as described further below.

Typically at pressurisation the offset may be reduced to be substantially flush with the main pipe wall or as required for the operation of the collar invention.

[00121] The spigot die 920 may be placed into the aperture 824 of the clamp 822 such that the exit 922 of the spigot die 920 is facing outwardly through the aperture 824 of the cylindrical clamp 822. The bullet mandrel 720 being pulled out through the die exit 920. The pull rod 826 for the bullet mandrel is shown in FIGURE 8, below the aperture 824. A shape of the base or face 926 of the saddle or spigot die 920 may be selected as appropriate to mate with and support the main pipe wall during the pulling process with the bullet mandrel.

[00122] A width 924 of the spigot die base 926 may be increased in order to reduce any marking or distortion of the main pipe wall after the pulling process. For example the width 924 of the spigot die face 926 against the main pipe wall may be increased to be in the range of 100 to 150 mm or otherwise as selected to reduce or eliminate marking. That is the contact area may be increased to reduce the surface pressure upon the main pipe wall.

[00123] FIGURE 10 is a transverse sectional view of an advantageous pulling arrangement 1020 together with the bullet mandrel 720 and spigot die 920. The main pipe 112 is also shown, however the cylindrical clamp to the main pipe has been omitted to improve clarity of other features shown in FIGURE 10. The pull rod 826 is shown coupled 724 to the bullet mandrel 720. About the pull rod 826 and bullet mandrel 720 may be an independent actuator 1022 for the spigot die 920. The independent actuator 1022 was not shown in FIGURE 8 for the pulling frame 820 in order to improve the clarity to other features. As the bullet mandrel 720 is pulled through the initial hole in the main pipe wall, the independent actuator 1022 with the spigot die 920 may be advantageously used to support the heated portion of the main pipe wall about the opening 226 being formed. In addition the independent actuator 1022 may be used to advantageously inwardly offset the spigot die 920 as described with respect to FIGURE 9.

[00124] FIGURE 11 is a side elevational view of the pulling arrangement 1020 with the independent actuator 1022. The spigot die 920 is shown against the heated wall portion of the main pipe 112. The spigot die 920 with the

independent actuator 1022 may be moved without hindrance from the cylindrical clamp 822.

[00125] FIGURE 10 also shows a stage of the pull-out process where the bullet mandrel 720 has been pulled clear of the main pipe wall in an outwardly direction as indicated by the arrow 1024. The corresponding independent actuation of the spigot die would be inwardly (upwardly in FIGURE 10) as shown by the arrow 1026. As the bullet mandrel 720 is pulled out: the opening 226 and the protruding lip 224 are formed against the spigot die exit 922 from the heated portion of the main pipe wall.

[00126] FIGURE 12 is a photograph-perspective drawing of an intermediate step prior to FIGURE 10, where only a partially formed protruding lip 1220 has been plastically formed. That is the bullet mandrel 720, 2820 has only partially emerged from the heated portion of the main pipe wall.

[00127] FIGURE 13 is a side sectional schematic diagram of the bullet mandrel 2820 of FIGURE 28 forming a spigot. The spigot die and one side of the forming spigot 222 and main pipe wall 112 have been omitted for clarity. FIGURE 13 shows the pull out process beyond FIGURE 12 where the protruding lip 1220 is progressing to a partially formed spigot 1320. The circumferential recess 2824 is shown with additional plastic pipe wall material within it to aid in forming a substantially uniform spigot wall thickness as the pulling through process with the bullet mandrel and the spigot die progresses. It will be readily appreciated that the circumferential recess or groove 2824 may be varied in cross-sectional shape and location on the bullet mandrel in order to provide the necessary additional plastic pipe wall material to aid in improving wall thickness uniformity of the spigot being formed.

[00128] At the stage of the process shown in FIGURE 10 the internal supporting sleeve 722 may be suitably decoupled from the pull rod 826 such that the supporting sleeve 722 remains within the tubular protruding lip 224 of the short spigot 222 as the plastic cools sufficiently to support itself. Once the spigot has cooled the internal support sleeve 722 may then be removed from the spigot 222, 224.

[00129] For some plastics and for large spigots diameters and wall thicknesses the residual stresses left within the spigot after the pulling process may be

undesirable to long term performance and reliability as well as reversion during re-heating for fusion or butt welding of the branch pipe. The supporting sleeve 722 may incorporate a heating element to heat the spigot to a sufficient temperature and for a sufficient time so that annealing of the spigot wall material may occur. In addition the insulating spigot die 920 may be left in place about the spigot to aid in uniform heating and annealing as well as to improve the wall thickness uniformity and specification if further heating to reversion is done.

[00130] One or more heating elements may also be incorporated into the supporting sleeve 722 to provide a gradient of heating from the terminating end of the spigot for fusion to less heating towards the main pipe wall. Extra heating at the terminating end of the spigot may be used to provide a heat soak of the spigot prior to butt welding to the branch pipe. During the butt welding or fusion process to the branch pipe the supporting sleeve 722 may also be used to provide support as described below.

[00131] The spigot 222 from the pull out process may be butt fused, welded or otherwise joined to a branch pipe 114 as shown herein. During the jointing of the branch pipe 114 to the spigot, the inner wall of the main pipe about the opening 226 of the spigot 222 may be suitably internally supported so as to prevent permanent deformation from the inward forces applied by the branch pipe 114 abutting the spigot during fusion and the like. For example a scissor jack against the opposing inner wall to the opening 226 may have a suitable shaped flange for internally supporting the opening 226 during jointing. The exterior of the main pipe 112 may be supported during jointing as described with respect to FIGURE 8 using the cylindrical clamp 822 and / or the spigot die 920. A protruding external bead 1322 typical from the joining process may be removed as described below before the collar of the invention is applied.

[00132] FIGURES 30 and 31 are respective front elevational and perspective views of an alternate, larger, upwardly pulling frame assembly 3020. A main pipe 112 is shown on a roller bed 3022 so that main pipe diameters above approximately 400 mm may be easily handled. In contrast to the pulling frame 820 of FIGURE 8, no cylindrical clamp to the main pipe may be used. As described herein the localised heating of the main pipe at the spigot forming portion has removed the

necessity for circumferentially supporting the main pipe during the pulling process. A main frame 3024 of the pulling frame 3020 has two opposed hydraulic rams or actuators 3026 which support and actuate an upper frame 3028 to which the spigot die 920 is secured. The spigot die may be secured to an underside of a base 3032 of the upper frame 3028. The upper frame 3028 is moveable within the main frame 3024, running in guide-ways 3034 or rails located in the main frame 3024. The spigot die 920 may be placed upon the upper surface of the main pipe 112, in the region of the localised heated portion 3036 of the main pipe wall by actuating appropriately the two opposed rams 3026. In the example of FIGURES 30 and 31 a third, independent hydraulic ram or actuator 3030 is secured to the base 3032 of the upper frame 3032 by a hollow tower 3038 that may receive the pulled through bullet mandrel 2820. The pull rod 826 from the third ram 3030 passes through the tower 3038 to the bullet mandrel 2820 from the upper frame 3028. Accordingly the spigot die 920 and bullet mandrel 2820 has another means for being independently actuated coaxially and in opposition to each other as described for the prior pulling frame of FIGURES 8, 10 and 11. In addition the spigot die and mandrel may be actuated simultaneously or separately as appropriate. For example the spigot may be applied to the localised heating portion firstly before the mandrel pull through begins.

[00133] FIGURE 35 is a schematic perspective cutaway drawing of FIGURES 30 and 31, enlarged to the spigot die area. In FIGURE 35 the bullet mandrel 2820 is shown emerging from the exit side of the spigot die 920. The operation of the alternate bullet mandrel 2820 during the pulling process and the supporting sleeve decoupling 722 may be as described above with respect to the pulling process for the pulling frame and mandrel of FIGURES 8 to 14B.

[00134] It will be readily appreciated that the use of the independently actuated spigot die with the bullet mandrel pull out is a new supported plastic flow which may provide a superior continuous inner and outer surface of the spigot that results in minimal stress concentration and consequently less failure points when the tee fitting is pressurised.

[00135] In the past the profile of the spigot die exit 922 may be made such that more material is retained at the base of the spigot and only a short length is

then reduced further to form the correct DN and SDR for the spigot pipe that is to be joined to the branch pipe 114. This is the traditional technique of re-enforcement to compensate for the loss of integrity in the main pipe at the base wall and to attempt to re-distribute the hoop stresses through such additional material. Prior mechanical theory suggests that if the material removed by the initial hole in the main pipe is re-distributed within certain confines of the hole, either around the hole in the main pipe or at the base of the spigot, this would be sufficient to compensate for the inherent weakness in hydrostatic strength of the structure. However the inventors surprisingly have found that this approach to be inadequate for the amount of available wall material that can be re-distributed during the plastic flow and moulding in the pull-out process. Pressure testing of prior art large polyethylene pipe tee fittings, to the Australian and ISO standards referenced herein, at elevated temperatures have been found by the inventors to be prone to failure as a result. The use of a new collar 116 as a tensile ring with a saddle base 118 against the main pipe wall has been found to aid in reducing or eliminating these failures. The failure mechanisms and solution to them are described further below.

Localised Heating:

[00136] As described above with respect to FIGURES 7, 8 and elsewhere, localised heating may only be applied to a portion of the main pipe wall that it is to be used in forming the opening 226 with protruding tubular lip 224 to form the spigot 222.

[00137] FIGURES 14A and 14B are schematic diagrams to respective perspective and front elevational views of a localised heating apparatus 1420 that may be applied to the exterior of a main pipe 112. The heating apparatus part shown in FIGURES 14A and 14B has an adjustable frame 1422 that is adjustable for the size of the main pipe 112 as well the positioning of infra-red radiation heating bars 1424 and cooling bars 1426. The infra-red radiation heater bars 1424 may be mounted lengthwise parallel to the longitudinal axis of the main pipe 114 and circumferentially (to the main pipe longitudinal axis) about a sector of the pipe to be locally heated. In FIGURES 14A and 14B three heating bars 1424 are used to heat a sector of about 30

to 90 degrees or as desired when adjusted approximately for the size of the spigot to be formed. Above or outermost to the heating bars 1424 and interposed between the three heating bars are four gas cooling bars 1426, or otherwise surface cooling means, also adjustably mounted to the adjustable frame 1422. The cooling bars 1426 simultaneously direct cooling air or other suitable gas as an elongate jet, knife and / or multiple nozzles onto the surface of the heated portion of the wall so as to prevent excessive surface heating of the main pipe wall 112. The construction of the cooling bars may be optimised so as to provide evenly distributed surface cooling over a desired, controlled area. Alternatively to cooling bars, fans may be used with or without an arrangement of ducting or vanes to direct and evenly distribute the cooling effect across the desired surface area of the pipe wall.

[00138] To further improve the uniformity or homogeneity of heating and surface cooling: the pipe relative to the heaters 1424 and surface cooling 1426 may be oscillated or otherwise moved in position. The oscillatory movement may be longitudinally, with respect to the pipe, backwards and forwards via a roller bed that the main pipe rests upon. Alternatively or in addition the main pipe may be rotated in an oscillatory fashion about its longitudinal axis.

[00139] Infra-red heating with automatic surface temperature closed loop control and forced surface cooling in the heated area may be used to minimise heating time and closely control the localised heating to the desired portion of the pipe wall. Black polyethylene pipe for example may have the infra-red wavelengths chosen to be in the band 1.3 to 1.5 micrometres or as appropriate to obtain the appropriate level of penetration and heating for a particular plastic and wall thickness.

[00140] The heating may be further advantageously localised by masking by a use of paper or similar infra-red attenuation or insulation / reflective masks / shields upon the pipe wall surfaces to further confine the heating of the pipe wall portion to only the part of the pipe wall required for plastically deforming into the opening and protruding lip of the spigot. The use of infra-red radiation heating with masking being particularly preferred as the selection and use of masking templates may be with particular efficiency and accuracy to confining the heating of the main pipe wall to where it is most useful. In FIGURES 14A and 14B the preferred use of metal infra-red shields 1428 is shown between the pipe 112 and the heating

apparatus 1420. The curved metal shield 1428 may extend sufficiently to protect the main pipe from heating, except for the aperture 1430 in the shield 1428 for localised heating of the pipe wall portion.

[00141] In a similar manner to that described for the external localised heating apparatus, an internal localised heating apparatus may also be used so that more uniform heating inside and out of the wall portion for spigot forming may be done. The heating apparatus shown in FIGURES 14A and 14B is particularly suited to larger pipe diameters of over 400 mm. It will be readily appreciated that the heating apparatus may be varied and adjusted to accommodate different main pipe diameters, particularly of the larger diameters.

[00142] Typically for polyethylene pipe the portion of the pipe wall may be more uniformly heated with the above technique to approximately 150°C or as required for plastically deforming the pipe wall. For example when a sharp fillet knife by hand may be used to slice through the pipe wall. The temperature of the pipe wall may be monitored for closed loop controlling purposes by the use of surface contact or optionally imbedded thermocouples, optical pyrometry or as selected by a person skilled in the art. The output from the temperature monitoring may be used to control the amount of heating by the infra-red heaters 1424 and / or the surface cooling 1426 with respect to desired or set point temperature/s. The desired or set point temperatures being those for plastic forming.

[00143] Prior techniques to heating plastic pipe typically involved heating the whole main pipe 114 in a glycerine bath or a microwave oven. Accordingly in such prior immersion heating techniques the whole of the main pipe becomes soft and needs to be protected as the softened material is very prone to damage and distortion. In addition when a short main pipe is originally formed by extrusion, the re-heating process causes reversion of the outside diameter of the pipe such that the outside diameter reduces to be under specification. The shrinkage by reversion may be significant at up to approximately 1%. In other words a wholly reheated pipe may go significantly out of specification and may be rejected / scrapped.

[00144] In addition, heated plastics and in particular polyethylene (PE) are prone to flowing and distortion if not supported during heated or are inadvertently overheated.

[00145] The new and inventive localised heating technique applied here has the further advantage over hot fluid bath immersion techniques that the pipe walls not involved in the pulling / forming operation for the spigot are not heated and do not require supporting. Masking or shielding in conjunction with infra-red radiation heating as described here to further localise the heating of the pipe wall portion is either very difficult or practically not possible in glycerine baths or microwave ovens. In addition wall temperatures more suitable for plastic flow forming of the opening 226 and protruding tubular lip 224 to form the spigot 222 may be used that otherwise may not be used in immersion bath techniques due to the issues with the rest of the main pipe walls not being sufficiently supported. Other issues to heat affected zones of the main pipe wall may also be reduced.

[00146] Furthermore the pulling frames and the pulling arrangements described herein may be operated in air without modification for use in heated immersion fluid baths, a microwave oven and / or without additional support apparatus for all the walls of a fully heated main pipe.

[00147] The apparatus and method for localised heating may be readily applied to plastic pipe of outside diameter 400 mm and SDR 11 as well as the other pipe sizes and specifications described herein.

Collar and Saddle Base:

[00148] FIGURES 15A and 15B are perspective views of cylindrical collar 116 with a saddle base 118. An electro-fusion wire coil 1520 may be inserted or otherwise formed into the inner surface of the collar 116 so that the collar may be fused in place over the joint 220 between the spigot 222 and the branch pipe 114 as shown in FIGURES 1 to 6. In FIGURE 15B the windings of the electro-fusion coil 1520 are shown, whilst in FIGURE 15A the zone where fusion or other joining technique to the branch pipe and spigot is shown as a black band 1520. The fusing in this example only extends along the branch pipe end and the protruding lip or terminating end of the short spigot from the main pipe. The sectional FIGURES of 2

to 5 show the fusion zone formed with the electro-fusion coil 1520 straddling the butt fusion or weld joint between the pulled spigot and the extending pup or branch pipe. The fusion zone further reinforces the joint as well as locating the saddle base 118 adjacent the main pipe wall at the spigot 222 base. The fusion zone is further described with reference to FIGURE 19.

[00149] It will be readily appreciated that other techniques for joint forming may be used, such as socketing. In the case of socketing the inner surface of the collar and the electro-fusion coil may be formed so as to accommodate the external profile of the socketed joint or whatever jointing technique may be used. Where a bead has been formed by butt fusion or welding then de-beading may be done to either both sides or just the outside of the joint so that a continuous surface may be presented for the outer surface when the cylindrical collar is sleeved over the butt weld. De-beading also has the beneficial effect of reducing both a potential stress raiser and removing the sharp notch within the bead line.

[00150] FIGURES 16 and 17 are respective side and front elevational views of the collar 116 showing the respective convex 1620 and concave 1720 portions of the saddle base. The lower end of the collar which abuts the outer surface of the main pipe wall is scalloped to ideally form a saddle base that mates with the curved outer surface of the main pipe wall, as shown in FIGURES 1 to 5 and FIGURES 20 to 27.

[00151] The collar 116 may be installed onto the pipe tee 110 by sliding the collar 116 as a sleeve over the branch pipe 114 until the collar base 118 is adjacent the main pipe wall as described herein. Once the collar has been located correctly on the pipe tee 110 the collar may be held in place by fusing with the electro-fusion coil 1520 or other techniques as described herein or selected by a person skilled in the art. The appropriate dimensions of the collar 116 for installation are described below with respect to FIGURE 19. It will be readily appreciated that the collar may be attached to the pipe tee either in the factory where the pipe tee is formed, at another site prior to use of the pipe tee or in the field during installation of a pipe network. Furthermore retrofitting to a prior pipe tee where the pipe asset owner has lost or reduced confidence in the prior pipe tee's original design, engineering or fabrication may be readily done.

[00152] The collar may be made of a material that is the same plastic as the pipe tee plastic or other suitable plastic or composite as selected by a person skilled in the art. In the example of polyethylene pipe the collar may also be made of a suitable polyethylene. Alternatively the collar could be a steel or other suitable metal or alloy that may be applied as a clamp, described further below, about the branch pipe and located as described herein. In another alternative a composite of a plastic with a steel or other suitable metal/s may be used to provide further reinforcing and / or to reduce the external dimensions of the collar for particular applications. Suitable securing and sealing techniques for the collars of various materials may be selected by a person skilled in the art.

[00153] FIGURE 18 is a sectional view of the collar 116 of FIGURE 15. It will be readily appreciated that the generally rectangular cross-sectional shape of the collar 116 as shown in FIGURE 18 may be varied whilst still allowing the collar to perform the functions described herein. For example the upper, outer chamfer 1820 may be made more pronounced so as to extend along the end face 1822 of the collar to the inner surface at the top of the collar. In addition the chamfer 1820 may extend to the saddle base 118 along the outer surface 1824 of the collar.

[00154] Alternatively the collar may be in sectioned longitudinally two parts so that the alternate collar may be clamped about the spigot and branch pipe. This clamping collar version of the invention may be an advantage when retrofitting the collar to a pipe tee as part of an existing pipe network, as described above. In another alternative a collar may be formed in place upon the pipe tee by the appropriate wrapping and forming of a suitable fibreglass or other reinforcing fabric about the spigot to main pipe junction and then pre and / or post impregnation of the fabric with a suitable resin.

[00155] In FIGURE 18 and other FIGURES the saddle base 118 of the collar is shown to be a continuous surface from the convex portion 1620 to the concave portion 1720 and within each of those portions. It will be readily appreciated that semi-continuous forms of the saddle base may be used to achieve the same function of the collar 116, 118 as described herein.

[00156] Whilst not wishing to be bound by theory the inventors have found a number of critical relationships associated with the performance of the

invention which may be of benefit in calculating the dimensions of the various aspects of the collar with respect to the main pipe, the branch pipe and the protruding lip of the spigot end. FIGURE 19 is a longitudinal cross-section of the collar applied to a tee fitting made in accordance with the above. FIGURE 19 shows dimensioning and symbols to the new design criteria and new equations for the collar parameterized according to the dimensions of the tee by the inventors.

[00157] The Electro-fusion collar 116 has a nominal diameter, " DN_3 ", such that the internal diameter of the collar 116 is sufficient for the collar to slip over and sleeve the spigot 222 at the butt weld 220, with account of the constraint of the desired collar wall thickness " e_3 ". The collar 116 may have a wall thickness e_3 corresponding to the same SDR as the main pipe 112 and spigot 222. Accordingly the collar thickness $e_3 = DN_3/SDR$, where SDR is the Standard Diameter Ratio for the main pipe 112 and the branch pipe 114 as defined above, for example the $SDR = DN_2 / e_2$ for the branch pipe, where " e_2 " is the wall thickness of the spigot 222 and the branch pipe 114. Similarly for the main pipe to obtain the same SDR rating, $SDR = DN_3 / e_3$. The collar outside diameter may be determined by $DN_3 = (DN_2 \times SDR) / 9$. FIGURE 19 also shows that the main pipe and the spigot 222 are to be produced of the same SDR.

[00158] The equation formulated by the inventors to determine an appropriate DN_3 was formulated by firstly considering the internal pipe diameter for the collar whereas it is the usual teaching in pipe design engineering to use the readily available outside diameter and wall thickness of pipe in prior calculations and prior derivations. From that contrary starting point the inventors then proceeded to formulate an equation that allowed for calculation of DN_3 from the usually available pipe parameters and dimensions such as DN_2 and SDR. The example equation given for DN_3 is one example suitable for $SDR=11$ however it will be readily appreciated that a similar equation/s may be formulated for other SDR or a range of SDRs.

[00159] It will be readily appreciated that the dimension DN_2 used in the calculation of DN_3 according to the equation of above, may incorporate a small additional sliding clearance to the DN_2 dimension. This small sliding clearance may be readily determined by a person skilled in the art as appropriate, for example with

respect to: the branch pipe diameter, pipe material and circularity specification for the branch pipe.

[00160] A length of the electro-fusion zone of the collar 116 is represented by the symbol “ a ”. The length “ a ” across the butt weld is proportional to the wall thickness e_3 , but is no smaller than $(e_3 + 50\text{mm})$ for the pipe sizes described herein. Preferably the fusion zone across the joint 220 has a length $a = k \times e_3$ where k may be in the approximate range of 3 to 5 and more preferably approximately 4. More generally the length of the electro-fusion zone, “ a ”, may also depend on the ratio of the diameters of the branch pipe to the main pipe and the absolute diameter of the main pipe.

[00161] The individual upper and lower cold zones of the collar that are adjacent to the fusion zone “ a ” are represented by the symbols “ b ” and “ c ” in FIGURE 19. Therefore the total length or height of the collar may be given by $a + b + c$ as shown in FIGURE 19. The individual cold zones are preferably approximately equal to the collar wall thickness e_3 .

[00162] FIGURES 20 to 23 and 24 to 27 illustrate the proportional differences between a substantially maximal tee 2020 and a minimal reducing tee 2420 with respective collars 2022, 2422.

[00163] FIGURES 20 to 23 are respective perspective, end elevation, side elevation and plan views of the substantially maximal pipe tee fitting 2020. The collar 2022 of the maximal tee fitting 2020 may have an outside diameter substantially equal to the main pipe 112 outside diameter. Correspondingly the maximal saddle base 2024 may substantially extend towards the center-line 2126 of the periphery the main pipe 112, as shown in FIGURE 21, in order to obtain sufficient support as described herein.

[00164] It will also be readily appreciated that the branch pipe 114, with the maximal collar 2020, may be of an outer diameter up to the main pipe 112 diameter less the thickness of the collar in accordance with the relationships described with respect to FIGURE 19. That is the upper limit of the take-off range for the branch pipe 114 is the outer diameter of the main pipe 112 less the wall thicknesses of the collar 2022. Alternatively the off-take or branch pipe 114 may be two pipe classes down from the main pipe class.

[00165] FIGURES 24 to 27 are respective perspective, end elevation, side elevation and plan views of the substantially minimal reducing pipe tee fitting 2420. In comparison to the maximal saddle base 2024 of the maximal tee fitting 2020, a minimal saddle base 2424, of the minimal collar 2422, for the minimal reducing tee fitting 2420 is more planar in order to conform to the main pipe outer wall surface 2426. The end and side elevational views of FIGURES 25 and 26 show the more planar shape of the minimal saddle base 2424 of the collar 2422.

[00166] The relative dimensions of the collars 2022, 2422 between the maximal and minimal pipe tees may also be scaled as per the relationships described with respect to FIGURE 19. It will be readily appreciated that any other dimensions of the collar 2022, 2422 and the saddle base 2024, 2424 with respect to the main pipe 112 and branch pipe 114 may be additionally dimensioned and additionally configured depending on the absolute and relative diameters of the main pipe and branch pipe, the SDR for the pipe fitting, the plastic pipe material and as is normally done for designing and fabricating tee fittings. An example minimal off-take may be a 90mm outside diameter branch pipe from an 800 mm outside diameter main pipe.

[00167] It will be readily appreciated that the above methods and apparatuses may be adapted as required to produce branching pipe at other angles as required. Typical angles for the branch pipe to the main pipe are 45° and 90° however other angles between 45° and 90° may be done, as well as less than 45°. For example the pulling frame 820 and pulling arrangement 1020 of FIGURES 8 to 13 and 30, 31 and 35 may be re-configured so that the angle of pull by the bullet mandrel 720 through a suitable, correspondingly angled and suitably shaped spigot die is an appropriate angle to produce the protruding lip and then short spigot with the desired take-off angle. Similarly the form of the saddle base 118 of the collar 116 and / or the bore through the collar 116 may also be varied so as to accommodate a different take-off angle for the spigot or branch pipe from the main pipe.

[00168] Surprisingly it has been found by the inventors that a pressure tight seal between the inner surface of the collar 116 and branch pipe joint 220 is not necessary. The above described electro-fusing securing of the collar to the branch pipe

joint may be a convenient technique for locating and securing the collar in place for correct positioning of the saddle base adjacent to the main pipe wall. However since the electro-fusing technique described above is convenient and may be applied across the pipe joint 220, the electro-fusion seal may be used to provide a further pressure tight seal and reinforcing in order to increase a margin of safety should the butt joint 220 begin to fail.

[00169] Surprisingly it has also been found by the inventors that a joint or fusing between the main pipe outer wall and the saddle base 118 of the collar 116 is not required. This is in contrast to prior art saddle tee and the like techniques. The saddle base surface of the invention is only required to contact the main pipe wall such that when the tee fitting is pressurised the excessive ballooning tendency at the base of the pressurised short spigot 222 is countered by an outer periphery of the saddle base surface pushing against the pressurised outer wall of the main pipe.

[00170] Optionally the saddle base surface may be fused or otherwise adhered to the main pipe wall as this may be used to at least one of locate the collar to the base of the branch pipe, and may provide a further seal in case of a failure at the branch pipe joint and/or the spigot formed.

[00171] It will also be readily appreciated that a continuous saddle base surface is not necessary, also as described below with respect to FIGURE 18. Rather a sufficient contact/s between the collar saddle base to the outer wall surface of the main pipe wall is only required to prevent excessive ballooning at the base of the short spigot.

[00172] Whilst not wishing to be bound by theory, when a pipe is subjected to an internal pressure the strength to sustain that pressure is achieved via a combination of the material properties and the cylindrical geometry of the pipe. Where the main pipe geometry deviates at a bend or fitting, then the hoop structure that gives the main pipe cylindrical form tensile strength is interrupted or disturbed with a flaw or opening in the pipe wall. Accordingly weaknesses are introduced in the main pipe wall and associated structures of the tee fitting which are prone to failure at pressurisation.

[00173] FIGURE 32 is a schematic of a transverse section through a pipe tee 3220 without the collar 114 of the invention. The hoop strength about the main pipe 112 has been interrupted by the spigot opening 226. When the pipe tee 3220 of FIGURE 32 is pressurised, as indicated by the small solid arrows 3222 within the pipe tee 3220, the pipe tee wall at and about the branch and main pipe junction moves outwardly more as shown by the dashed line 3224 and in a displacement direction indicated by the hatched arrows 3226. The magnitude of the hatched arrows 3224 also providing an exaggerated indication of magnitude of the wall strains. The outward movement of the pipe tee wall at pressurisation is indicated in an exaggerated fashion for illustrative purposes. The failure modes and zones for the pipe tee which were observed by the inventors from testing are given as follows, the more frequent or higher probability failures or issues first.

[00174] The internal pressure and consequent outwardly movement at the junction 3228 of the spigot 222 and the main pipe 112 may cause a bending moment to be applied from the base or junction between the main pipe 112 and the spigot 222 about the butt weld 220 as shown by the arrow 3230. This bending moment may be generally and / or approximately centred about the discontinuity of the butt joint 220 when the collar of the invention is not used. Accordingly the joint 220 may fail due to the application of this bending moment across it.

[00175] In addition to a failure mode at the fusion joint 220, wall thinning failures about the butt fusion weld 220 may also occur or may be progressing to failure if the joint 220 does not fail firstly. The respective wall thinning failure points are shown proximally 3232 and distally 3234 from the pipe tee junction 3228. That is above and below the fusion joint 220 on FIGURE 32.

[00176] A further failure mode observed may be progressive wall thinning, crack propagation and distortion at the junction 3228 of the spigot to the main pipe. This failure mode was observed to be more of a middle to a long term failure point.

[00177] A longer term failure zone or point of vulnerability was also observed to be the main pipe wall thinning and distorting about the junction 3228 as indicated by 3236 on FIGURE 32.

[00178] FIGURE 33 is a schematic of the pipe tee of FIGURE 32 but with the collar of the invention applied. As described above the collar may be secured in place by electro-fusion within the collar ring and / or as the branch pipe pressurizes and expands against the tensile ring of the collar, the collar may be held in position frictionally. In use the convex portion 1620 of the saddle base 118 of the collar when the pipe tee is pressurized typically may not mate with the main pipe side wall due to the usual variations in main pipe wall geometry that may occur. A gap between the saddle base 118 and the main pipe wall may be in the order of approximately 1 to 2 mm for the larger main pipe diameters. When the pipe tee is pressurized and the main pipe side wall creeps, the gap between the saddle base and main pipe wall closes.

[00179] The reactive forces from the collar and saddle base to the pulled tee 3320, 110 are shown by the outlined arrows 3322, 3324, 3326, 3328 shown originating from the collar 116 and the saddle base 118. The arrows 3322 from the tensile ring collar 116 are reactive forces against the pressurization of the branch pipe 114, joint 220 and spigot 222. The arrows 3322 also indicate the normal force applied to the branch pipe and spigot outer surfaces which may provide a substantial frictional force 3324 that resists the collar riding up or slipping along the branch pipe 114 away from the pipe tee junction 3228. In opposition to the frictional and / or fusing of the collar to the branch pipe and spigot the arrows 3326, 3328 indicate the reactive forces respectively applied by the collar against the creep at pressurization at the junction 3228 and the main pipe wall 3236. As described the creep of the main pipe side wall about the junction continues until the reactive forces applied by the collar base convex portion 1620 balance the outward creep.

[00180] Since the outward movement of the junction and main pipe wall about the junction is arrested or at least resisted by the collar and saddle base, the bending moment about joint 220 between the spigot and the branch pipe is removed or substantially reduced. Furthermore the collar 116 as a tensile ring may provide further support across the joint 220 between the spigot and branch pipe.

[00181] In summary for FIGURE 33 the reactive forces 3322, 3324, 3326, 3328 applied by the tensile ring of the collar and the convex portion of the collar base correspond to the failure points and modes observed and identified as above by the inventors. It will also be apparent that the pressurization of the branch

pipe and spigot may cause via the collar of the invention a reactive force which resists a bending moment from junction 3228 and main pipe wall and prevents one or more failure modes at or about the joint 220 between the spigot 222 and the branch pipe 114.

[00182] In other words the collar may act to re-distribute the forces about the junction of the main pipe wall and spigot for 3326, 3328 to other parts of the pipe tee, for example along the branch pipe and spigot 3324 wall. The re-distribution of forces via the collar operates such that the main pipe wall at and adjacent the junction of the main pipe to the spigot is supported by the collar base. Preferably the support may be via the concave portion of the collar base against the side wall of the main pipe when in use, that is when pressurised.

[00183] FIGURE 34 is a schematic of a perpendicular, longitudinal section 3420 of the pipe tee with collar of FIGURE 33. Preferably when the pipe tee is unpressurized the saddle base concave portion 1720 for at least one side of the collar 116 does contact the main pipe wall that is dorsally or lengthways along the main pipe wall. However as described with respect to FIGURE 33, if a small gap between the concave portion 1720 of the saddle base of the collar and the main pipe wall is present at installation, on pressurization, creep of the junction 3228 and the main pipe wall about the junction 3236 may occur until the reactive forces 3326, 3328 balance the outward movement as described above for FIGURE 33. For example the gap at installation for the concave portion 1720 to the main pipe wall on either or both sides may be in the order of approximately 1 to 2 mm or as appropriately determined by a person skilled in the art for the performance of the invention/s described herein.

[00184] Further bending moments about discontinuities or flaws in the main pipe wall about the spigot base may also occur if the collar and pull-out process of the invention are not used. Such bending moments in tee fittings have been observed by the inventors to lead to premature failure of the fitting when tested according to Australian and ISO standards as described above.

[00185] In other words a tee fitting that has not been made according to the invention when pressurised may tend to balloon, with the junction between the branch pipe and the main pipe tending to balloon more than the rest of the main pipe

or the branch pipe due to the interruption of the hoop structure or ring tension inherently present in those cylindrical structures. Surprisingly, as described above, the traditional reinforcement with additional material applied to the main pipe wall outer surface to convey the hoop stress about the opening has been found to be significantly less reliable in practice than the use of a new, inventive collar with a saddle base located adjacent the main pipe wall as described herein. Furthermore the plastic forming of the spigot according to the invention has also been found to be advantageous in reducing flaws and defects in the short spigot and main pipe wall adjacent to the spigot which can lead or contribute to failure under test or in service.

[00186] Further failure mechanisms which may be alleviated or eliminated with the use of the invention are as follows.

[00187] Saddle fusion prior art techniques including those with a flange extending across and fusing with the main pipe outer wall, as well as those only fusing to the wall immediately about the opening in the main pipe wall. Such prior saddle flanges are typically electro-fused or otherwise joined to the main pipe exterior wall and are prone to shear failure across the bond when the pipe fitting pressurises if the electro-fusion or other welding or joining technique is poorly done. Contributing to the shear failure of the bond are components of the hoop stress about the main pipe as well as the bending moment described above and other bending moments that may be applied by the branch pipe to the saddle flange during use. The use of the collar of the invention may allow for a more economic and rapid technique for volume production of large plastic pipe tees than prior art techniques.

[00188] Lack of support and offset during plastic forming of the spigot: another failure mechanism observed by the inventors for the prior art spigots was progressive wall thinning with hydrostatic pressure testing at elevated temperatures. The failure zone was typically about the pulled zone between the branch pipe and the main pipe. Lack of appropriate support during pull out forming as well as lack of support during butt fusion of the branch pipe have been found by the inventors to contribute to defects in the pulled formed spigot which may lead to premature failure. For plastic pipe tees that may be suspected of being prone to failure, an upgrading of

specification and reliability may be obtained by retrofitting the collar of the invention described herein.

[00189] Advantageously the invention/s described herein have changed the failure mechanism/s of plastic pipe tee fittings to that which may be more consistent with continuous main pipe with long service lifetimes. That is the invention restores or at least substantially improves the integrity of the main pipe despite an opening being made in the wall of the main pipe to provide a branch pipe fitting. Furthermore the above process and pipe tee fitting provide a product which is more compliant and robustly exceeds the requirements of the AS/NZS and ISO standards referenced herein. In addition the process provides a more economic, durable and reliable pipe tee product than many of the prior art techniques.

[00190] In this specification, terms denoting direction, such as vertical, up, down, left, right etc. or rotation, should be taken to refer to the directions or rotations relative to the corresponding drawing rather than to absolute directions or rotations unless the context require otherwise.

[00191] Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiments, it is recognized that departures can be made within the scope of the invention, which are not to be limited to the details described herein but are to be accorded the full scope of the appended claims so as to embrace any and all equivalent assemblies, devices, apparatus, articles, compositions, methods, processes and techniques.

[00192] In this specification, the word “comprising” is to be understood in its “open” sense, that is, in the sense of “including”, and thus not limited to its “closed” sense, that is the sense of “consisting only of”. A corresponding meaning is to be attributed to the corresponding words “comprise, comprised and comprises” where they appear.

CLAIMS

1. A collar for a plastic pipe tee, comprising:
a tensile ring adapted to sleeve a spigot and a branch pipe of the pipe tee; and
a base of the collar formed such that two or more portions of the base are
adjacent to at least two corresponding portions of a main pipe wall of the pipe
tee;
wherein when the pipe tee is pressurised an outwardly movement of at least one of at
and adjacent the junction of the main pipe to the spigot, is resisted by the base of the
collar.
2. A collar according to claim 1, wherein the collar provides at least one of:
preventing a bending moment about a joint between the spigot and the branch pipe
and a support to the joint.
3. A collar according to claim 1 or 2, wherein the outwardly movement of the
main pipe wall further includes at least one of the spigot wall adjacent the junction
with the main pipe wall and the spigot wall adjacent the joint with the branch pipe.
4. A collar according to any one of claims 1 to 3, wherein the outwardly
movement of the main pipe wall is resisted by the base of collar.
5. A collar according to any one of claims 1 to 4, when the branch pipe and
spigot are pressurized a force is caused, via the saddle base of the collar, to resist an
outward movement or bending moment of the tee junction and the main pipe wall
approximately about the spigot and branch pipe junction.
6. A collar according to any one of claims 1 to 5, wherein the portions of the
main pipe wall are adjacent the junction of the spigot to the main pipe.
7. A collar according to any one of claims 1 to 6, wherein the portions of the
main pipe wall include the transverse and opposing side walls of the main pipe.

8. A collar according to any one of claims 1 to 7, wherein the collar may be clamped to at least one of the branch pipe and the spigot.

8A. A force re-distribution collar for a plastic pipe tee of the type comprising a main pipe having a spigot in a main pipe wall adapted to be joined with a branch pipe; the collar comprising a tensile ring adapted to support a circumferential join between the spigot and the branch pipe;
the collar further extending to the junction between the main pipe and the spigot so as, in use, to support the main pipe wall adjacent the junction.

9. A collar for a plastic pipe tee, comprising:
a tensile ring adapted to sleeve a branch pipe of the pipe tee, and
a base adapted to substantially conform in use with a main pipe outer wall.

10. A collar according to any one of claims 1 to 9, wherein the base has opposing convex and concave portions.

11. A collar according to any one of claims 1 to 10, further including:
an electro-fusion heating coil located adjacent the inner surface of the collar.

12. A collar according to any one of claims 1 to 11, wherein the electro-fusion coil extends within the collar sufficiently to seal a joint between the branch pipe and a spigot of a pipe tee.

13. A collar according to any one of claims 1 to 12, wherein the dimensions comprise:

a nominal outside diameter DN_2 of the branch pipe;

a wall thickness e_2 of the branch pipe; and

a standard diameter ratio SDR of the branch pipe whereby the SDR is determined from the equation: $SDR = DN_2 / e_2$;

whereby a nominal outside diameter DN_3 of the collar is determined from the equation:

$$DN_3 = (DN_2 \times SDR) / 9 .$$

14. A collar according to claim 13, whereby a thickness of the collar e_3 is determined from the equation:

$$e_3 = DN_3 / SDR .$$

15. A collar according to claim 13, whereby a length, a , of an electro-fusion zone is determined from the equation:

$$a = 3 \times e_3 .$$

16. A collar according to any one of claims 1 to 15, wherein the collar is a substantially formed of a plastic.

17. A collar according to any one of claims 1 to 16, wherein the plastic is a polyethylene.

18. A plastic pipe tee comprising:

a main pipe;

a branch pipe;

an opening formed in the main pipe wall, adapted for a joint between the main pipe and the branch pipe; and

a means for transferring a main pipe hoop stress at the opening from one transverse side to the opposing side of the main pipe;

wherein the means for transferring the hoop stress is located adjacent an outer surface of the main pipe wall.

19. A pipe tee according to claim 18, wherein the means for transferring a main pipe hoop stress includes a collar.

20. A pipe tee according to claim 19, wherein the collar includes a tensile ring.

21. A pipe tee according to claim 19 or 20, wherein an end of the collar adjacent the outer surface of the main pipe wall is shaped such that the collar end abuts the main pipe wall when the pipe tee is pressurised.
22. A pipe tee according to any one of claims 19 to 21, wherein the collar end is substantially conformal with an outer surface of the main pipe wall.
23. A pipe tee according to any one of claim 19 to 22, wherein the collar end resists an outwardly movement of at least one of the outer surface of the main pipe wall and a spigot wall at or adjacent the junction between the spigot and the main pipe.
24. A pipe tee according to any one of claim 19 to 22, wherein the collar is sealed about the joint.
25. A pipe tee according to any one of claim 19 to 24, wherein the collar end is joined or sealed to the main pipe wall.
26. A pipe tee according to any one of claims 19 to 25, wherein the opening adapted for the joint includes a projecting tubular lip or spigot with substantially the same standard diameter ratio as the main pipe.
27. A pipe tee according to claim 26, wherein the collar and collar end are shaped and located on the pipe tee so as to resist a bending moment about the joint between the protruding tubular lip and the branch pipe end.
28. A pipe tee according to any one of claims 19 to 27, wherein the collar and collar end are shaped and located on the pipe tee so as to resist a bending moment from approximately the junction of the branch pipe with the main pipe and substantially about a branch pipe joint.

29. A pipe tee according to any one of claims 26 to 28, wherein the opening and the projecting tubular lip or spigot are inwardly offset to the main pipe wall.

30. A pipe tee according to claim 29, wherein the inward offset is substantially flush to the main pipe wall when the tee fitting is pressurised.

31. A pipe tee according to any one of claims 19 to 30, wherein the dimensions of the collar comprise:

a nominal outside diameter DN_2 of the branch pipe;

a wall thickness e_2 of the branch pipe; and

a standard diameter ratio SDR of the branch pipe, whereby the SDR is determined from the equation: $SDR = DN_2 / e_2$;

whereby a nominal outside diameter DN_3 of the collar is determined from the equation:

$$DN_3 = (DN_2 \times SDR) / 9 .$$

32. A pipe tee according to claim 31, whereby a thickness of the collar e_3 is determined from the equation:

$$e_3 = DN_3 / SDR .$$

33. A pipe tee according to claim 31, whereby a length, a , of an electro-fusion zone of the collar is determined from the equation:

$$a = 3 \times e_3 .$$

34. A pipe tee according to any one of claims 18 to 33, wherein the plastic is a polyethylene.

35. A method for forming a plastic pipe tee including the steps of:

providing a main pipe;

localising a heating to a portion of a wall of the main pipe; and

forming an opening, with a projecting tubular lip, in the localised heated portion of the main pipe wall.

36. A method according to claim 35, further including the step of:
independently and simultaneously actuating a saddle die and a bullet mandrel when forming the opening and the projecting tubular lip.
wherein the saddle die is located externally to the opening and the bullet mandrel passes through the opening.
37. A method according to claim 35 or 36, further including the step of:
providing a bullet mandrel configured or formed to aid in forming a substantially uniform wall thicknesses for the projecting tubular lip, and
pulling the bullet mandrel through the opening such that the projecting tubular lip forms a spigot with a substantially uniform wall thickness.
38. A method according to claim 37, wherein the steps of providing and pulling through the main pipe wall a configured bullet mandrel, pulls sufficient main pipe wall material from the heated portion to form the spigot with substantially uniform wall thickness.
39. A method according to any one of claims 36 to 38, further including the step of:
inwardly offsetting the saddle die to the main pipe wall whilst forming the projecting tubular lip or spigot.
40. A method according to any one of claims 35 to 39, further including the step of:
providing an internal support to the projecting tubular lip or spigot whilst the projecting tubular lip or spigot cools.
41. A method according to claim 40, wherein the step of providing internal support further includes:
the bullet mandrel providing a removable support ring to the projecting tubular lip as the bullet mandrel exits the projecting tubular lip or spigot.

42. A method according to any one of claims 35 to 41, wherein the step for joining the branch pipe includes:
supporting from within the main pipe, at least one of the opening and the projecting tubular lip.

43. A method according to any one of claims 35 to 42, further including the steps of:
joining a branch pipe to the projecting tubular lip; and
locating a collar about the joint to the branch pipe and substantially adjacent to an outer wall surface of the main pipe.

44. A method according to any one of claims 35 to 43, wherein the step for locating the collar includes:
sealing or fusing the collar about the joint to the branch pipe.

45. A method according to any one of claims 35 to 44, further including the step of: forming an end of the collar adjacent the main pipe wall such that the collar end abuts and resists the main pipe wall when the pipe tee is pressurised.

46. A method according to any one of claims 35 to 45, wherein the step for locating the collar includes:
joining, fusing or sealing the collar end to the main pipe wall.

47. A method according to any one of claims 35 to 46, further including the step of:
forming the projecting tubular lip with the same standard diameter ratio (SDR) as the main pipe.

48. A method according to any one of claims 35 to 47, wherein the plastic is a polyethylene.

49. A pipe tee formed by the method of any one of claims 35 to 48.
50. An apparatus for forming a pipe tee in a main pipe comprising:
a means for localising a heating to a wall portion of the main pipe;
a bullet mandrel initially positioned within the main pipe and adjacent the heated wall portion; and
a spigot die applied to the outer surface of the heated wall portion of the main pipe;
wherein the pulling of the bullet mandrel through the main pipe wall in opposition to the spigot die forms a spigot in the main pipe wall.

50A. An apparatus according to claim 50, further including a means for independently actuating the spigot die to the bullet mandrel.

51. An apparatus according to claim 50 or 50A, wherein the bullet mandrel is formed so as to pull through sufficient heated main pipe wall material to form the spigot with a substantially uniform wall thickness.

52. An apparatus according to claim 51, wherein the bullet mandrel has a leading first portion of increasing diameter followed longitudinally by a substantially uniform diameter second portion to aid in forming the substantially uniform wall thickness of the spigot.

53. An apparatus according to claim 51 or 52, wherein the bullet mandrel further includes:
a circumferential recess formed by an apex of a second or third portion having a smaller diameter than a base of the preceding portion.

54. An apparatus according to claim 52 or 53, wherein the bullet mandrel is further formed of successive, longitudinally aligned first or second portions of larger diameter to provide a successive third or fourth portions of the bullet mandrel to further improve the spigot wall thickness uniformity.

55. An apparatus according to claim 53 or 54, wherein the circumferential recess is formed or located to improve a wall thickness uniformity of the spigot being formed.

56. A method of localising a heating of a plastic pipe including the steps of:
infra-red radiation heating of a portion of a plastic pipe wall;
simultaneously with the heating, surface cooling the portion of the wall with a gas;
localising the heating of the portion of the wall by partially masking to infra-red radiation heating, the portion of the wall;
monitoring at least one of a surface temperature and an internal temperature of the pipe wall portion; and
controlling the infra-red radiation heating in response to the at least one monitored temperature and a set temperature for plastically deforming the plastic pipe.

57. A method according to claim 56, further including the step of:
moving the heating and surface cooling relative to the portion of the pipe wall.

58. A method according to claim 57, wherein in the step of moving includes at least one of rotating the plastic pipe and moving longitudinally the plastic pipe backwards and forwards relative to the heating and surface cooling

59. A method according to any one of claims 56 to 58, wherein the masking includes partially shielding or insulating to infra-red radiation heating.

60. A method according to any one of claims 56 to 59, further including the step of:
applying the heating and surface cooling to the inner and outer surfaces of the portion of the pipe wall.

61. A method according to any one of claims 56 to 60, further including the step of:

controlling the surface cooling in response to the at least one monitored temperature and the set temperature for plastically deforming the plastic pipe.

62. A method according to any one of claims 56 to 61, wherein the plastic is a polyethylene.

63. An apparatus for localised heating, for plastic forming of a plastic pipe, comprising:
a frame configured for at least one of a portion of an outer wall surface and a corresponding portion of an inner wall surface of the pipe;
at least one of an elongate infra-red radiation heater mounted on the frame and directed to at least one wall surface portion;
at least one surface cooling means mounted on the frame and directed to at least one wall surface portion; and
a mask to localise the heating only to a part of the wall for plastic forming.

64. An apparatus according to claim 63, wherein at least one of the frame, the heater and the surface cooling means are adjustably mounted.

65. An apparatus according to claim 63 or 64, further including means for oscillating the position of the plastic pipe with respect to at least one of the heating and the surface cooling means,
thereby improving the homogeneity of the localised heating to the part of the wall for plastic forming.

66. An apparatus according to any one of claims 63 to 65, wherein the surface cooling means includes at least one of a gas cooling bar, a fan and an arrangement of fans and vanes.

67. An apparatus according to any one of claims 63 to 66, wherein the plastic is a polyethylene.

68. An apparatus according to any one of claims 63 to 67, further including at least one of a surface temperature sensor and an internal temperature sensor of the pipe wall portion.
69. An apparatus according to claim 68, wherein at least one of the heater and the surface cooling means are controlled in response to a signal from the at least one temperature sensor and a set temperature for plastically deforming the plastic pipe.
70. A collar for a plastic pipe tee substantially as described herein.
71. A plastic pipe tee substantially as described herein.
72. A method for forming a plastic pipe tee substantially as described herein.
73. An apparatus for forming a plastic pipe tee substantially as described herein.
74. A method of localising a heating of a plastic pipe substantially as described herein.
75. An apparatus for localised heating substantially as described herein.

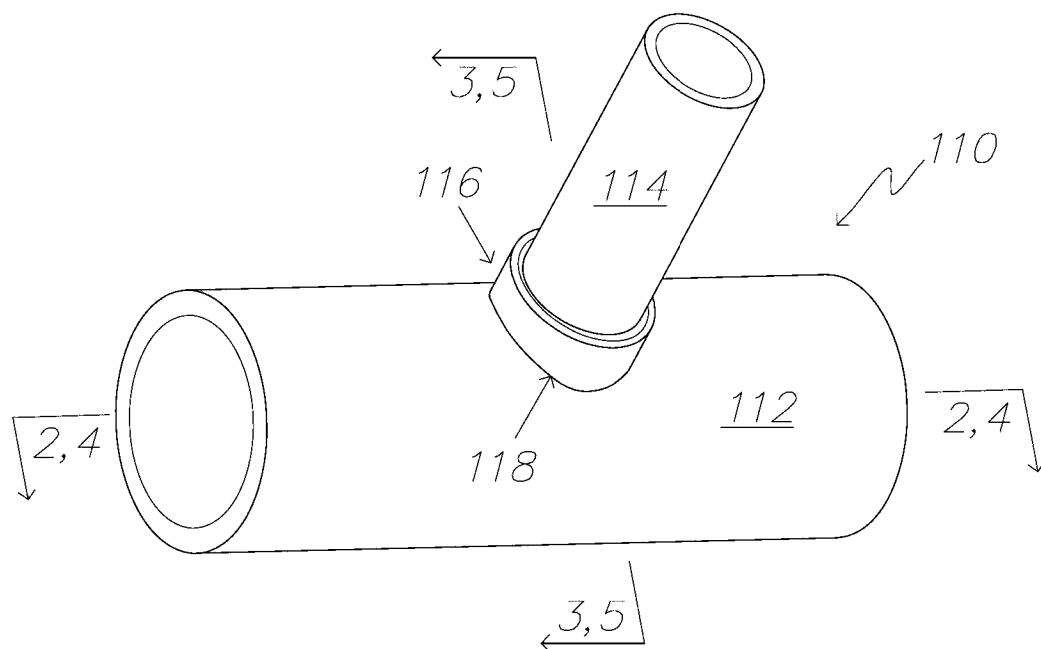


FIG 1

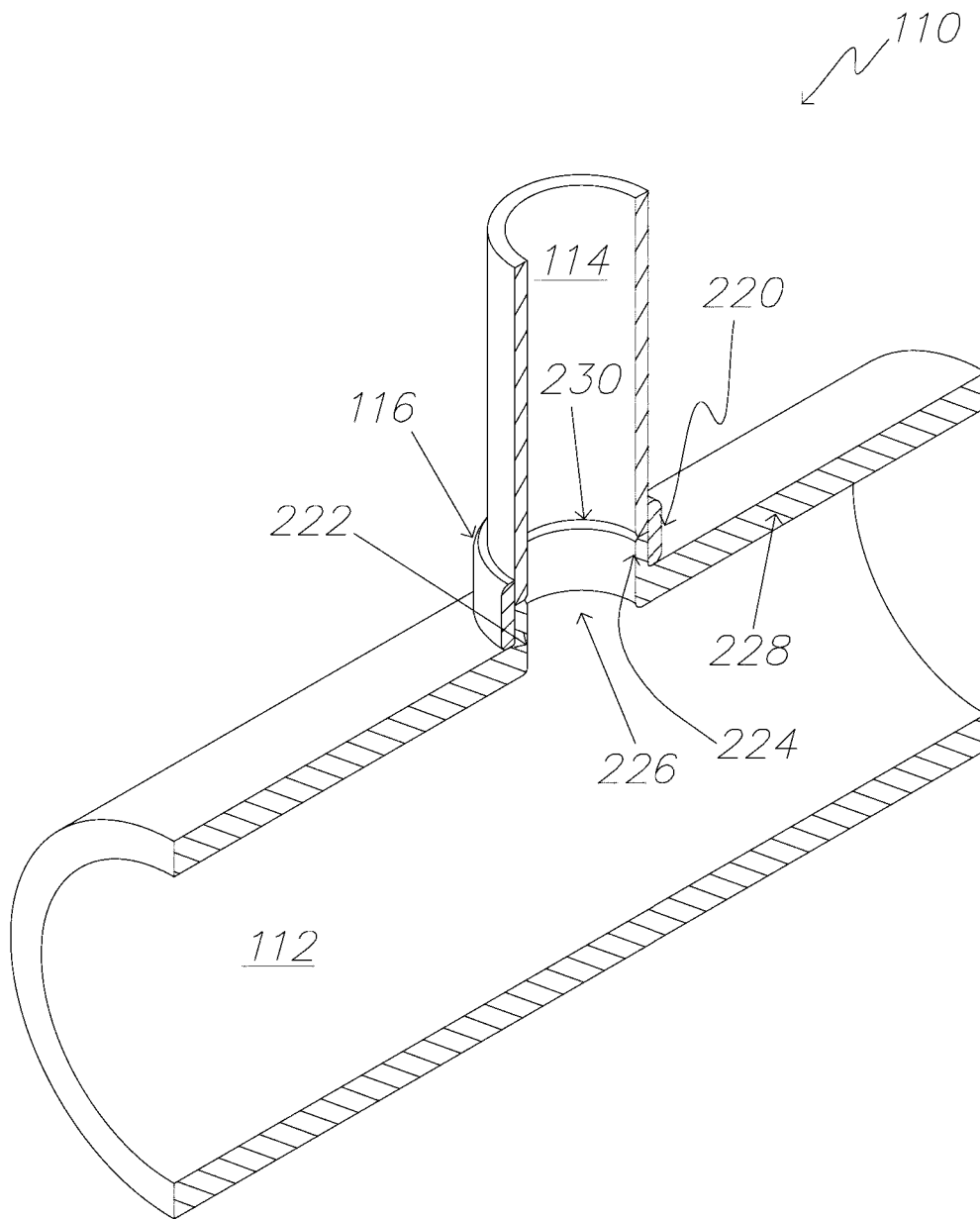


FIG 2

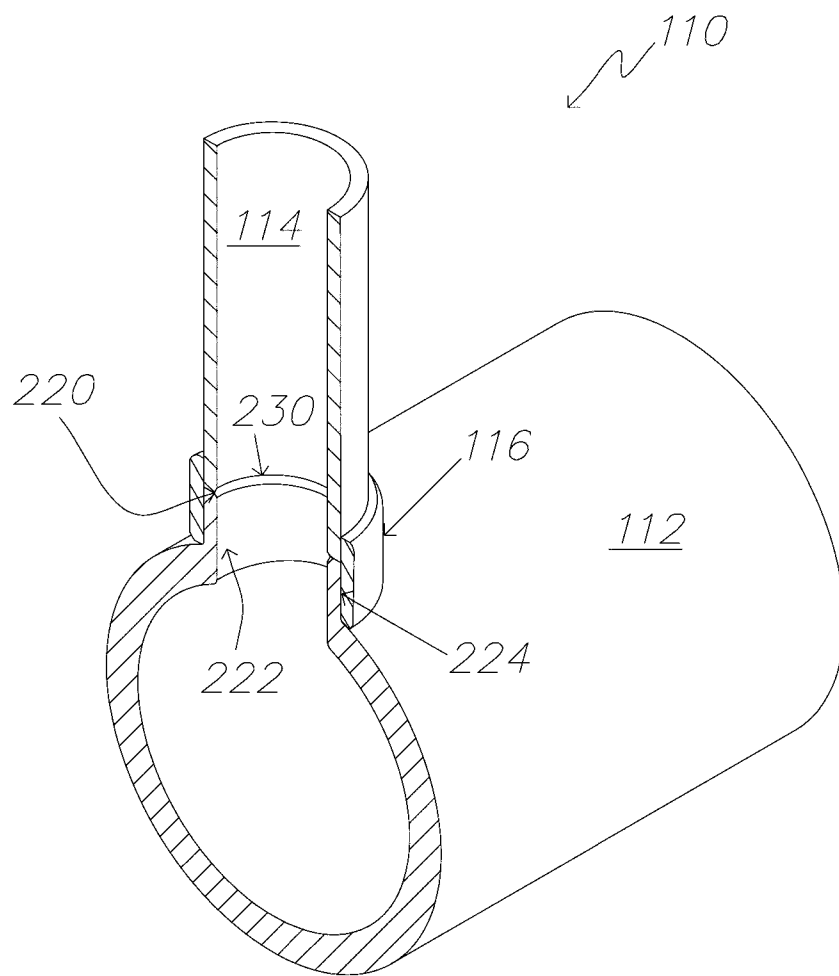


FIG 3

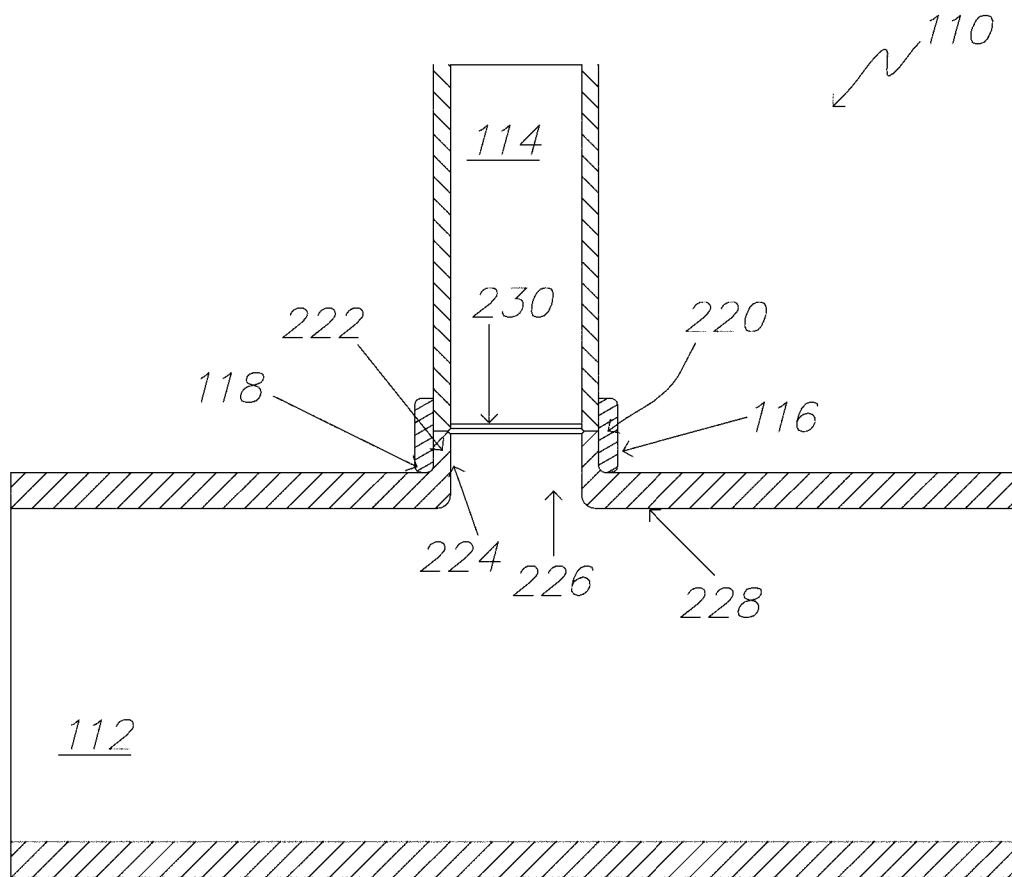


FIG 4

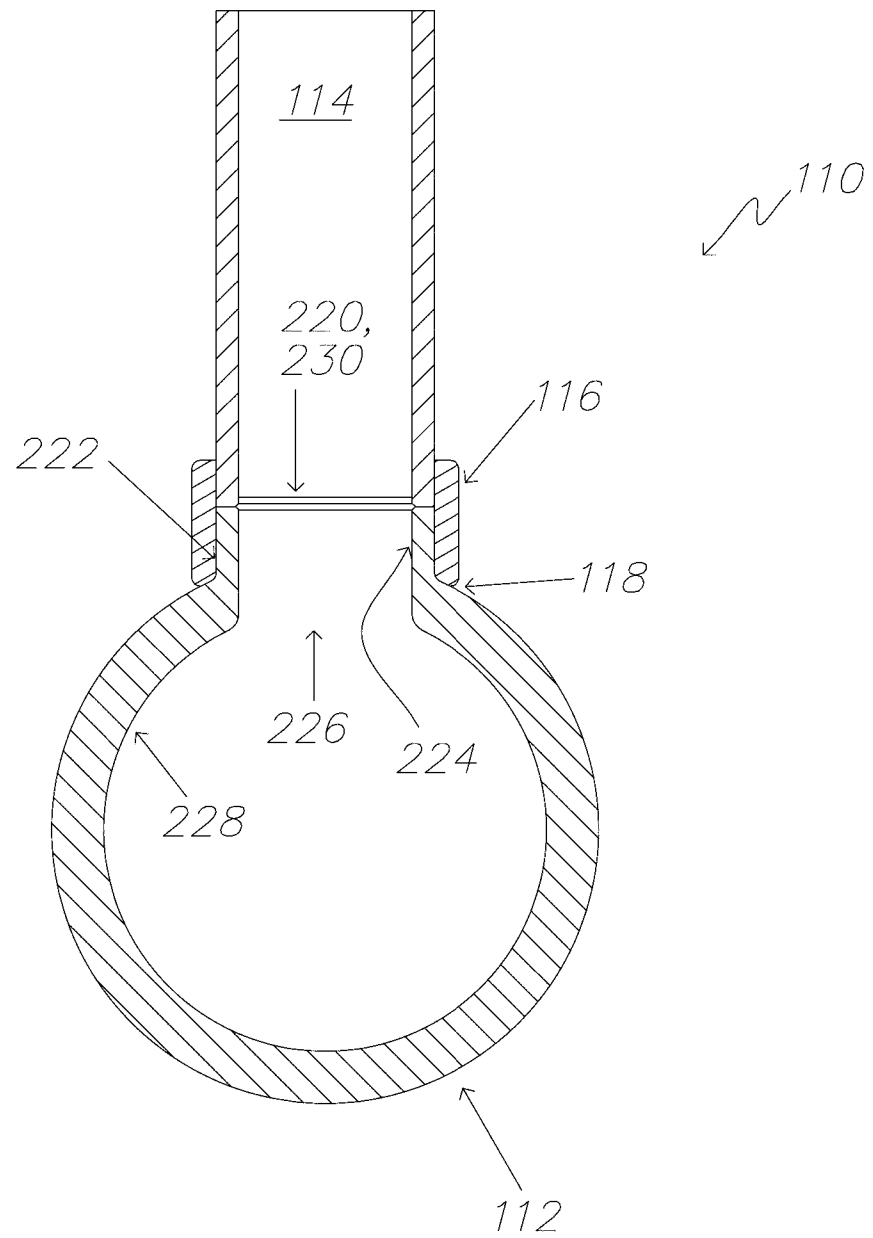


FIG 5

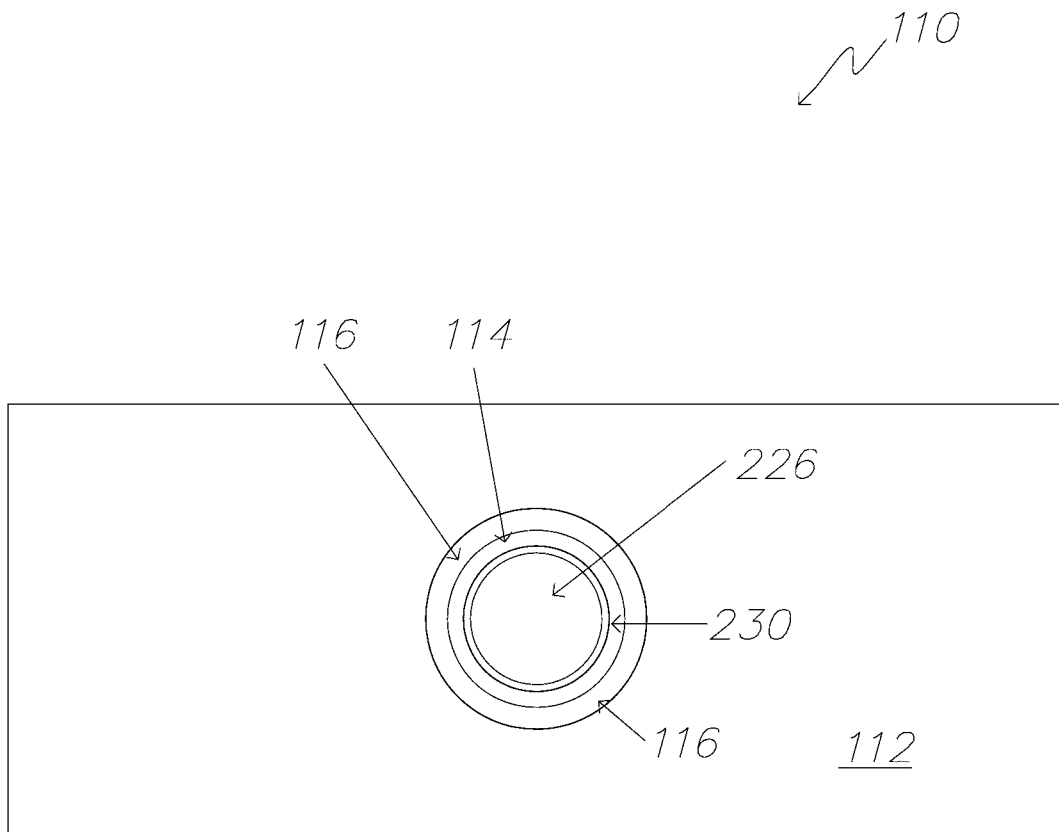
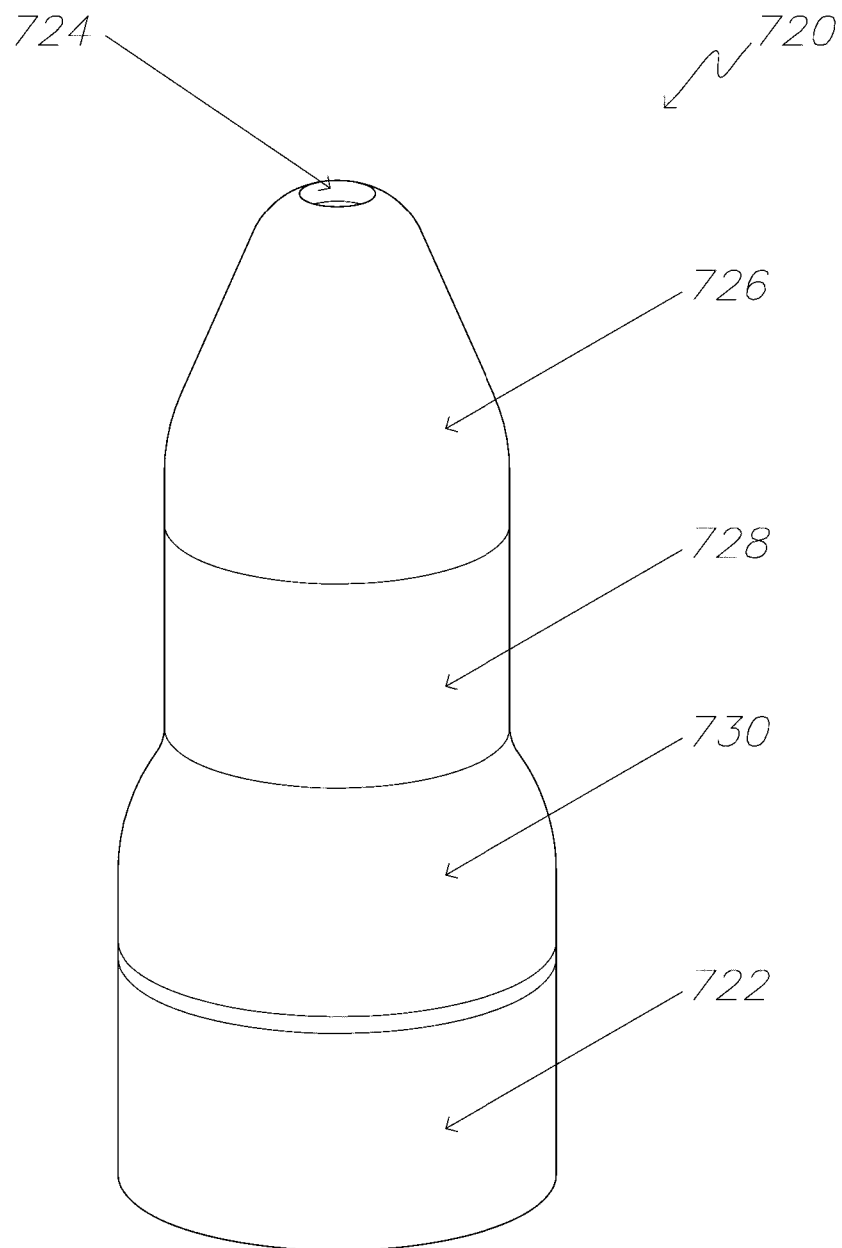


FIG 6

*FIG 7*

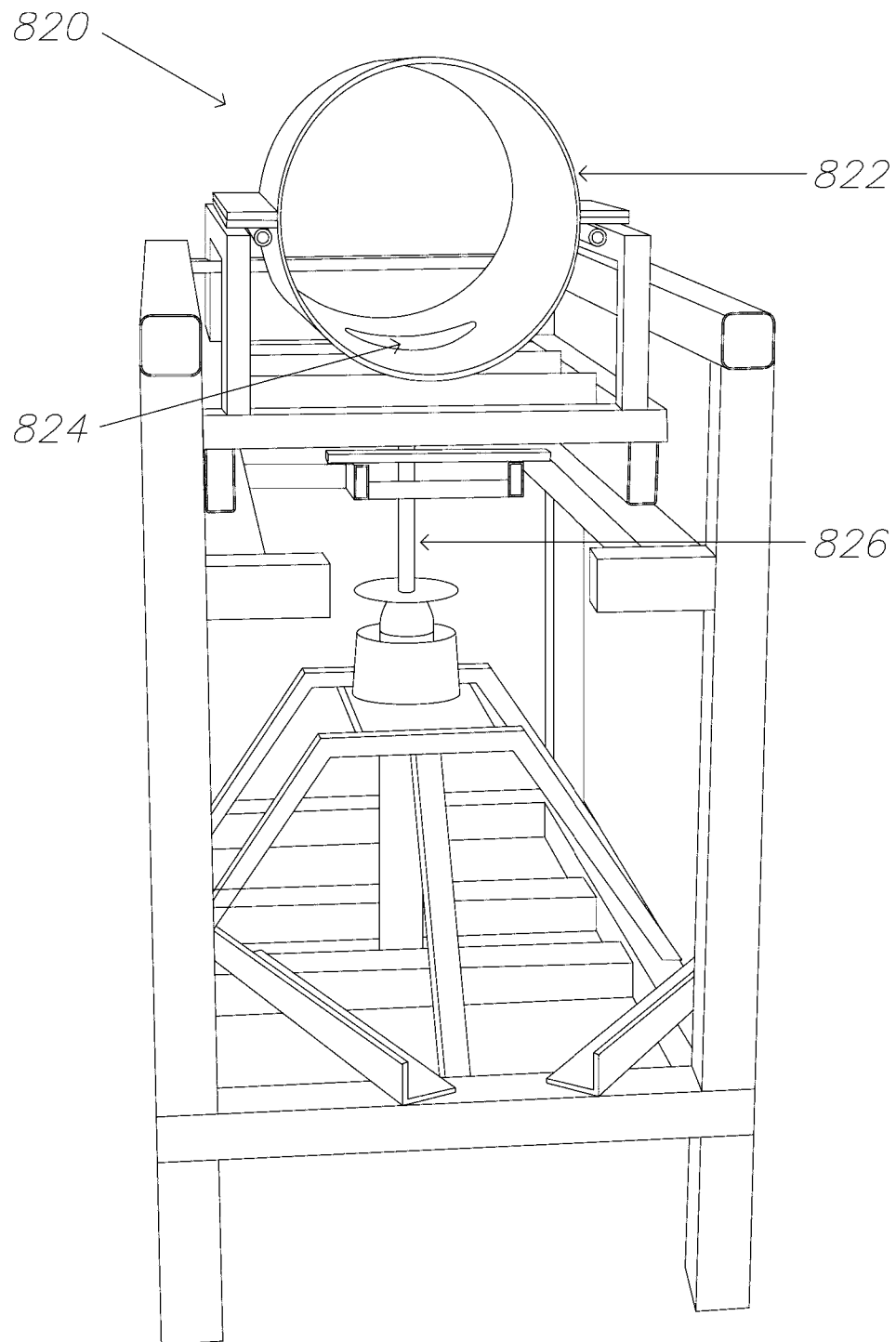


FIG 8

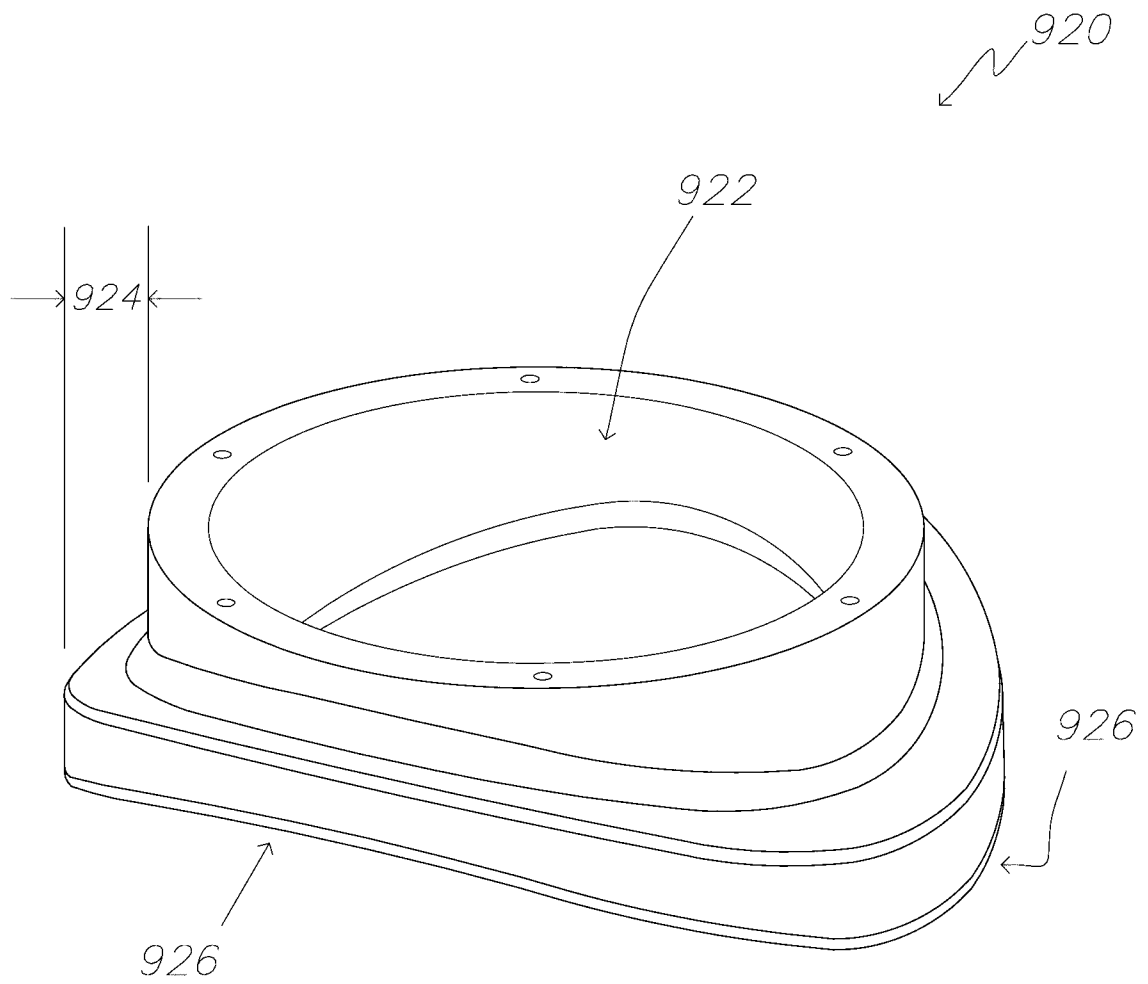


FIG 9A

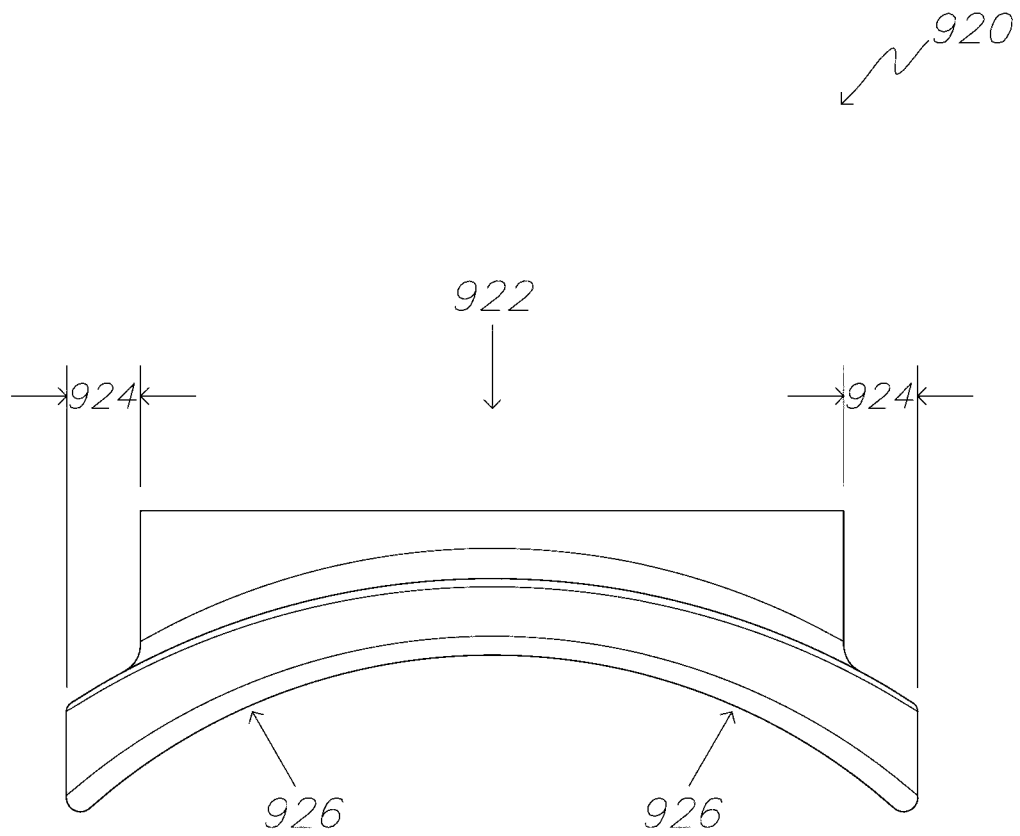
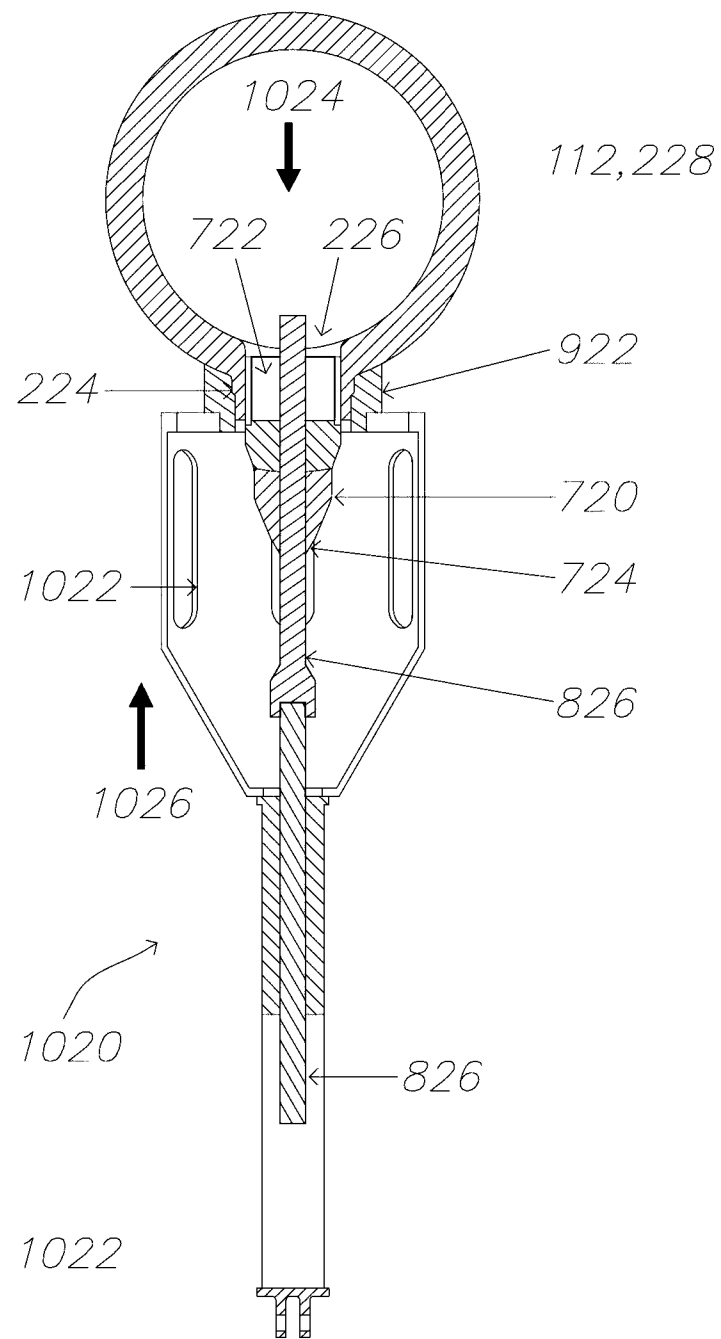


FIG 9B



SECTION A-A

FIG 10

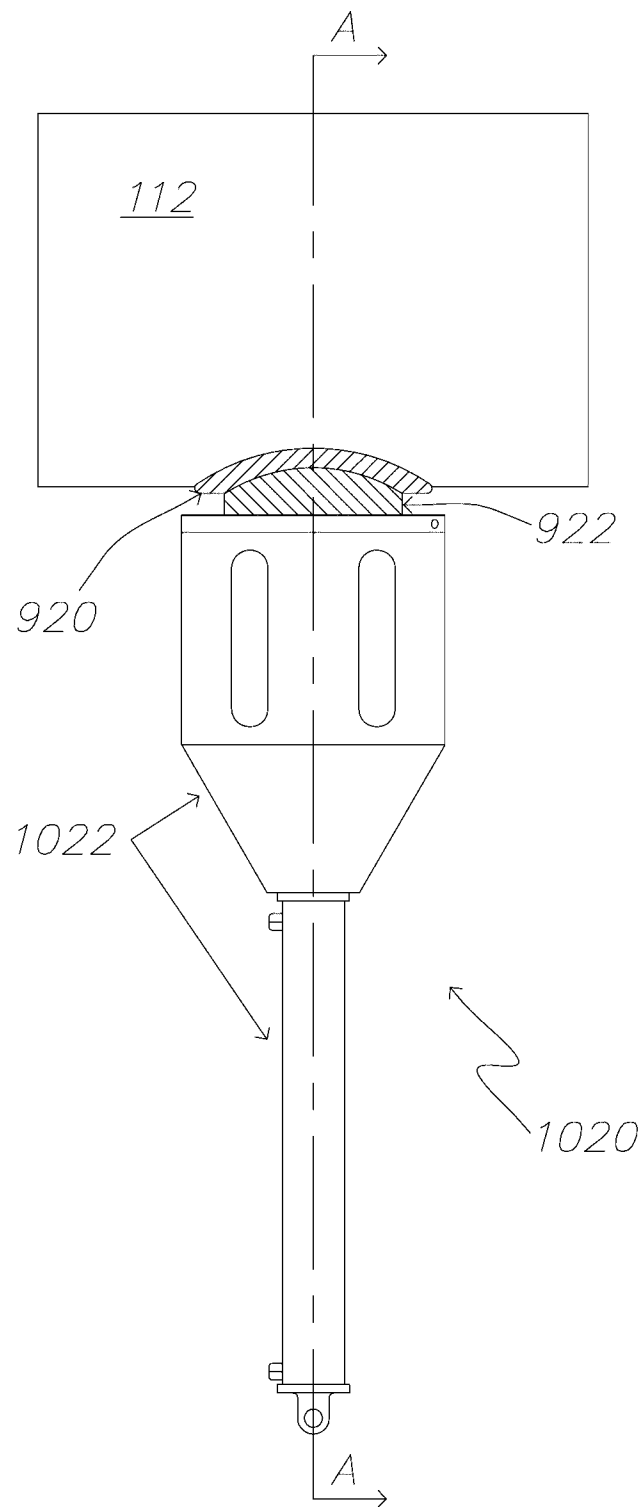


FIG 11

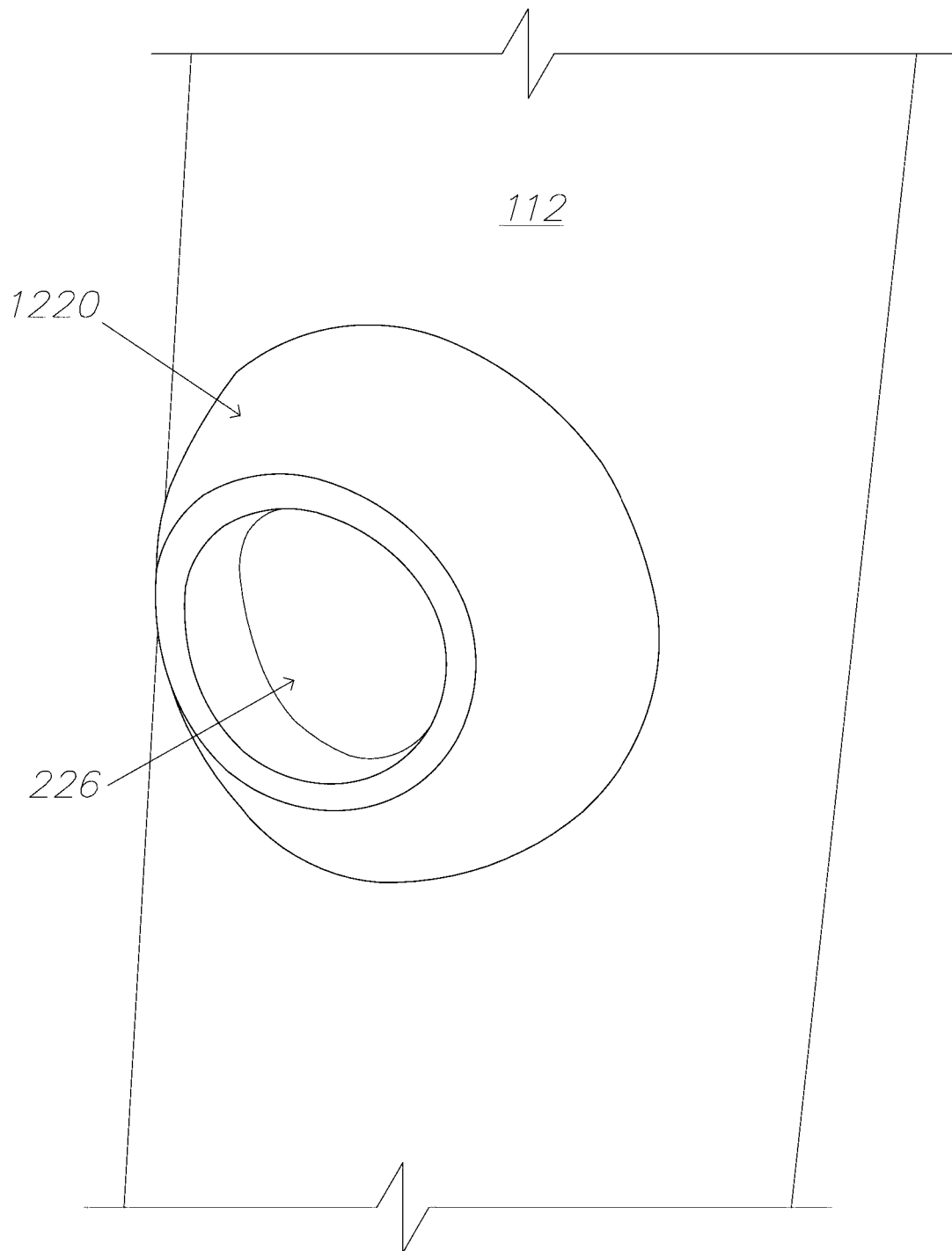


FIG 12

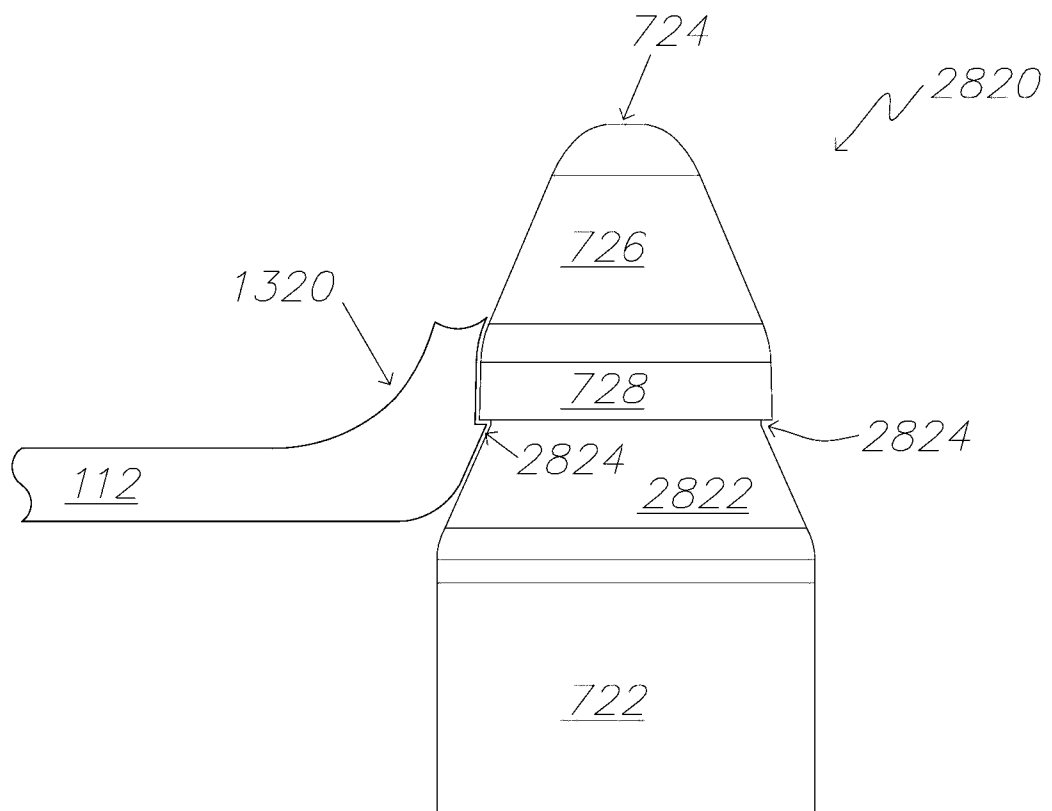


FIG 13

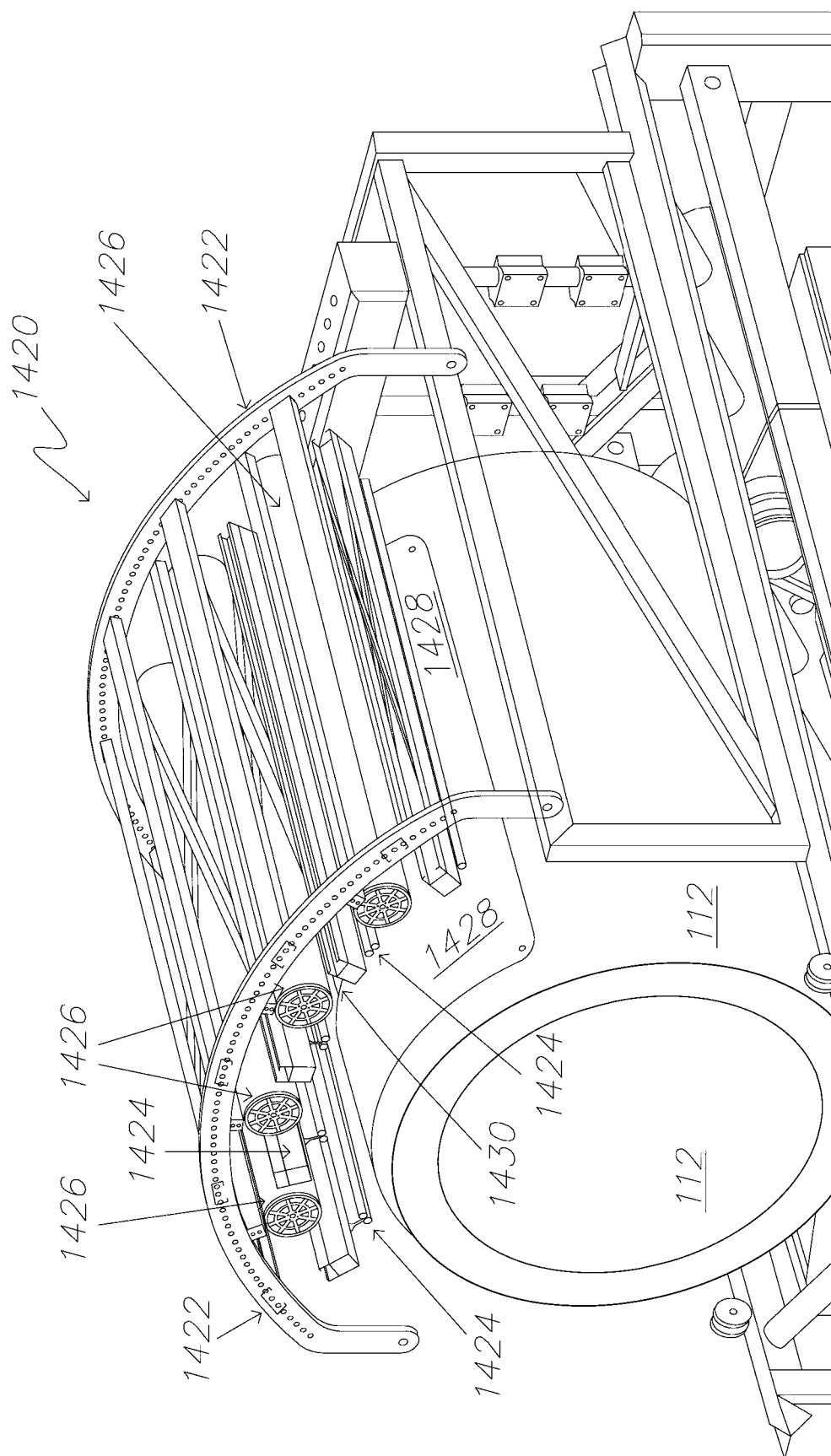


FIG 14A

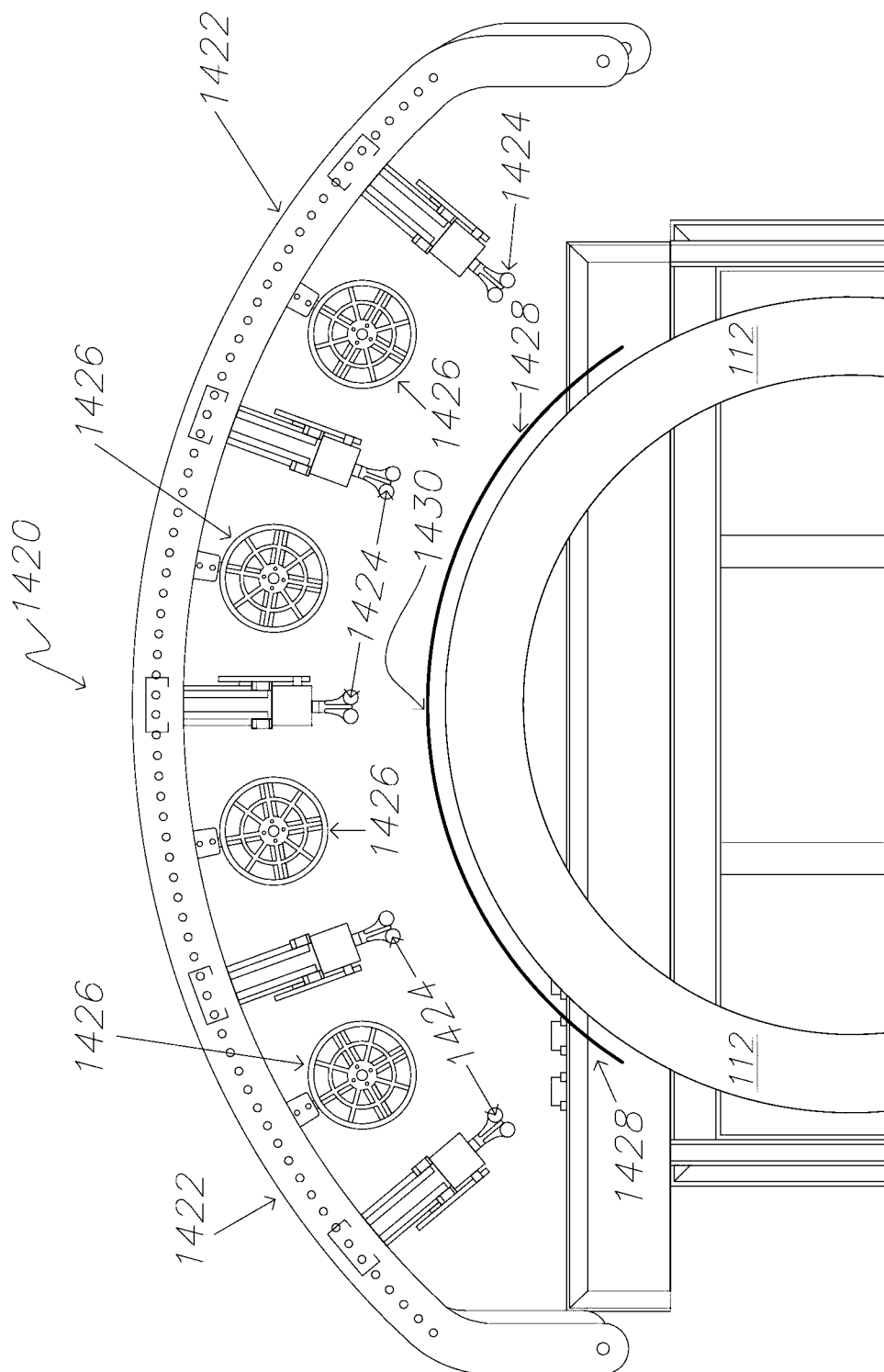


FIG 14B

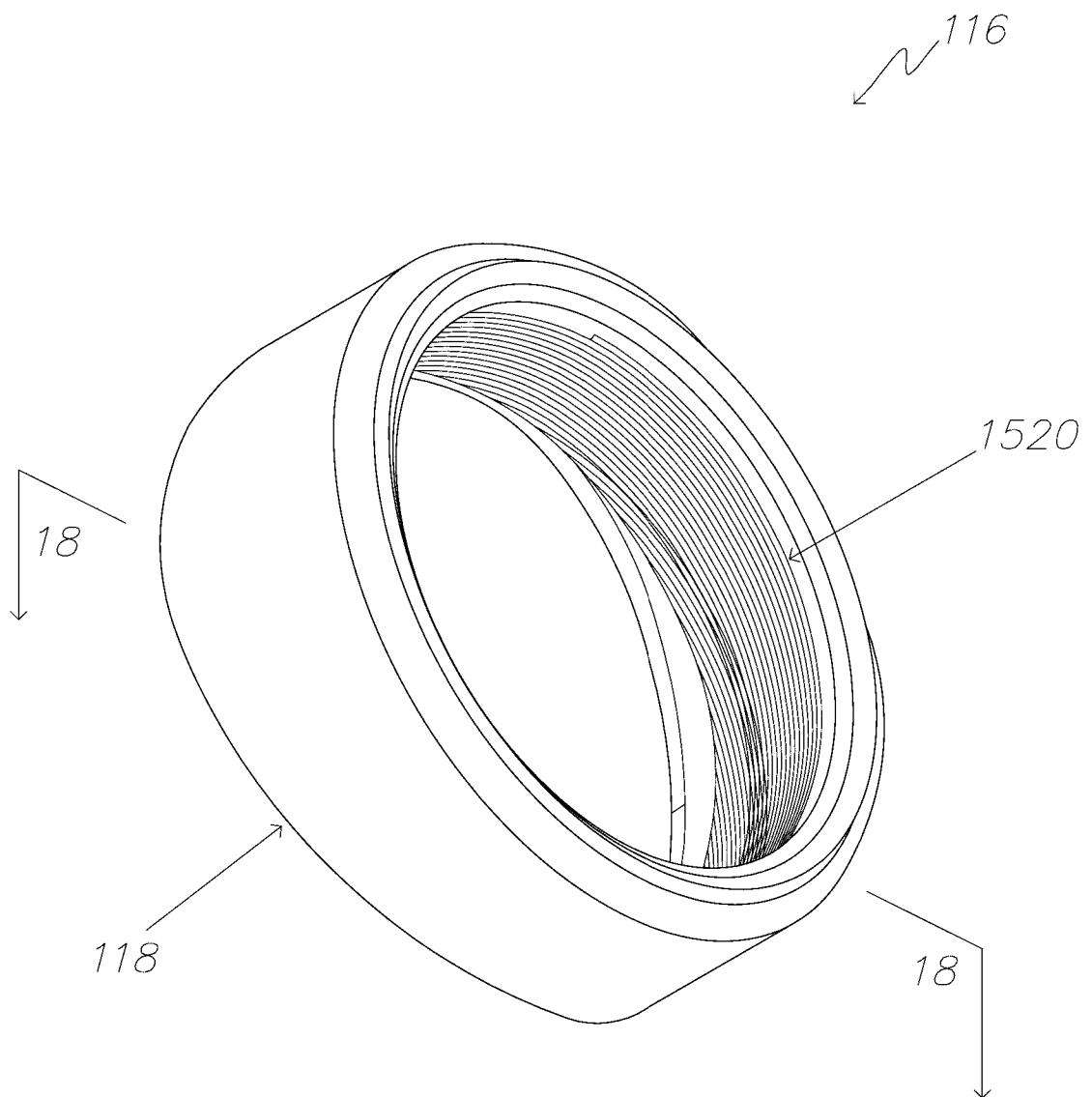


FIG 15A

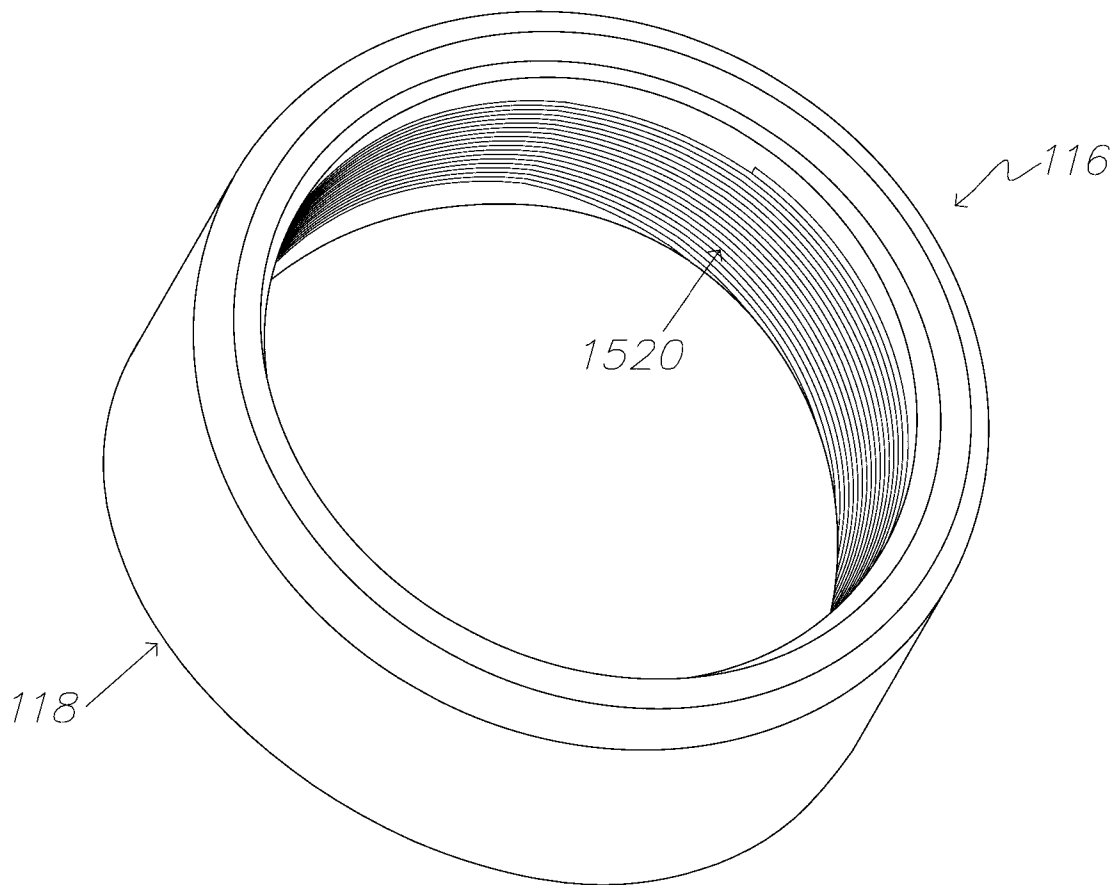


FIG 15B

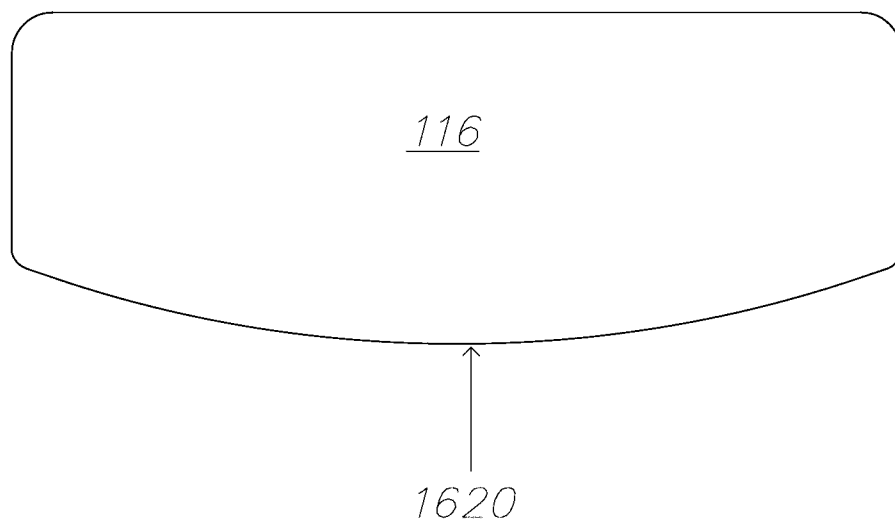


FIG 16

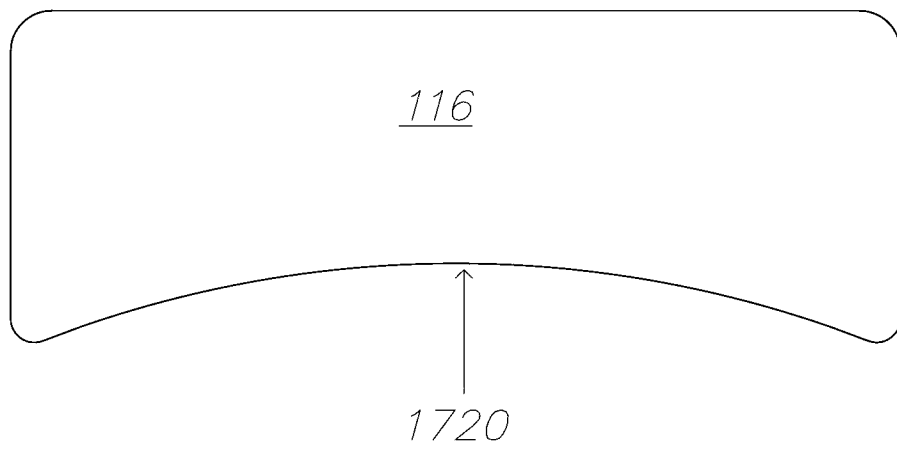


FIG 17

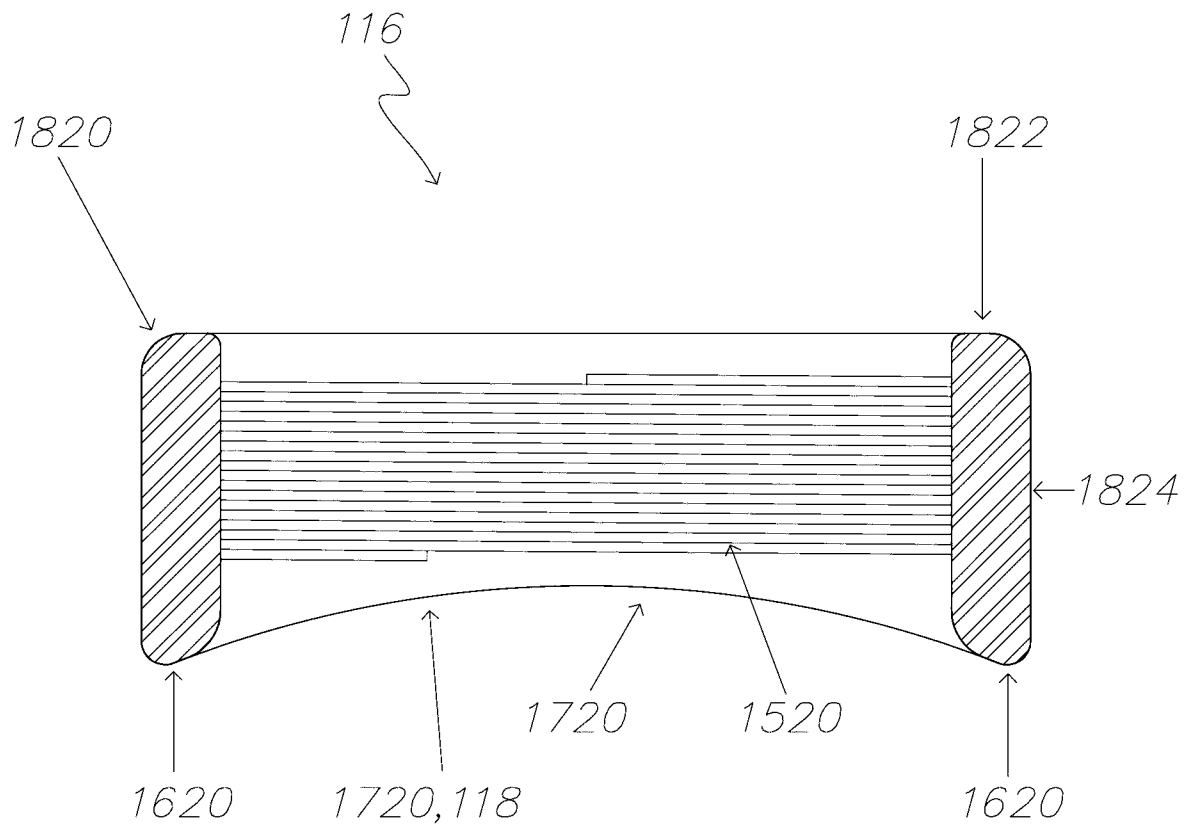
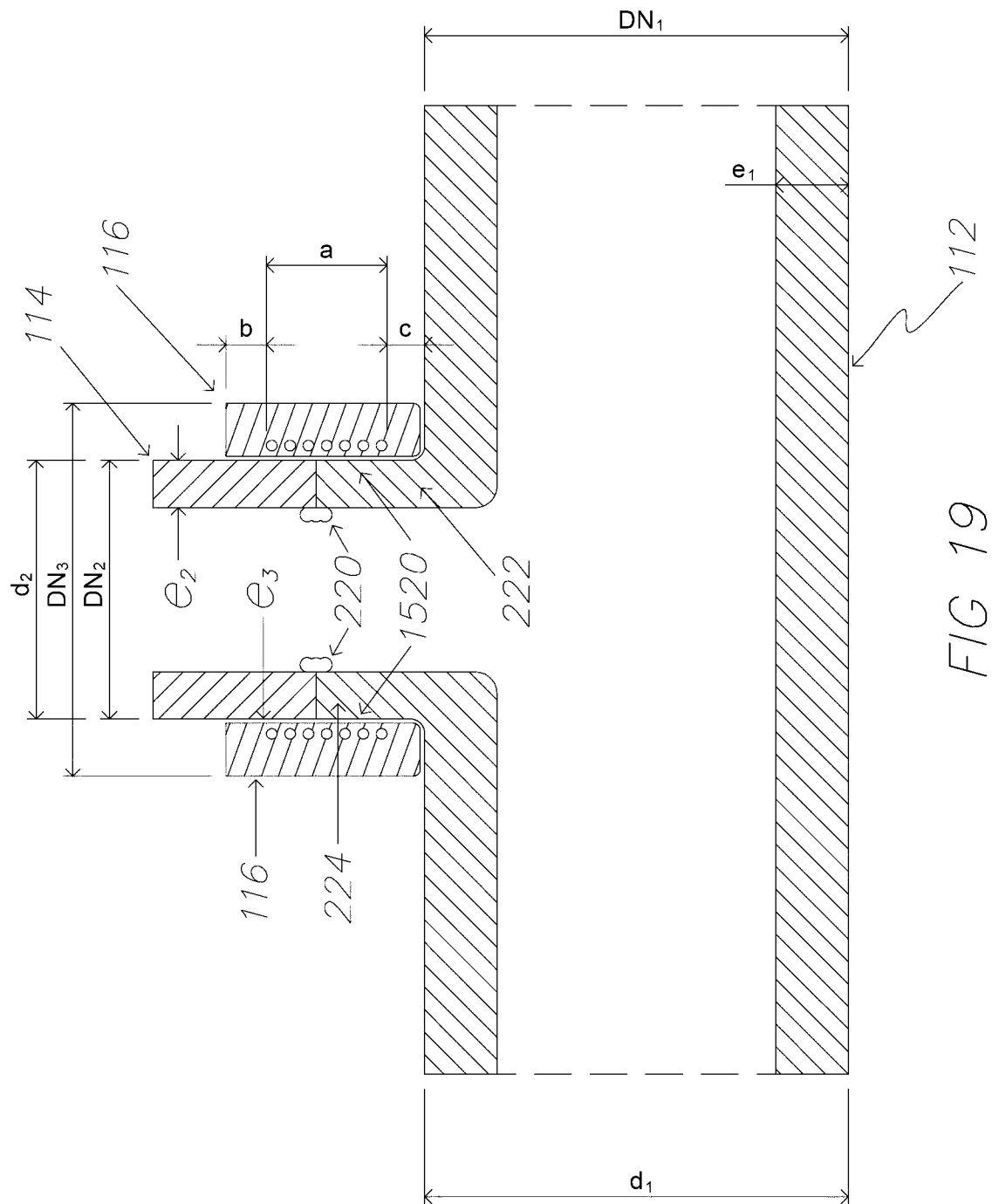


FIG 18



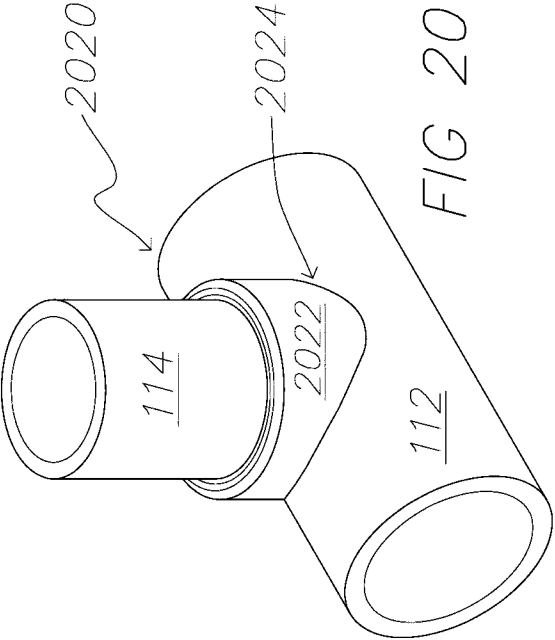


FIG 20

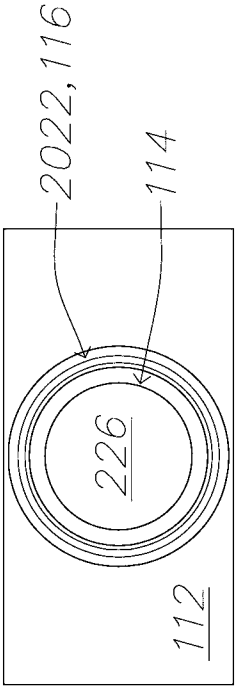


FIG 23

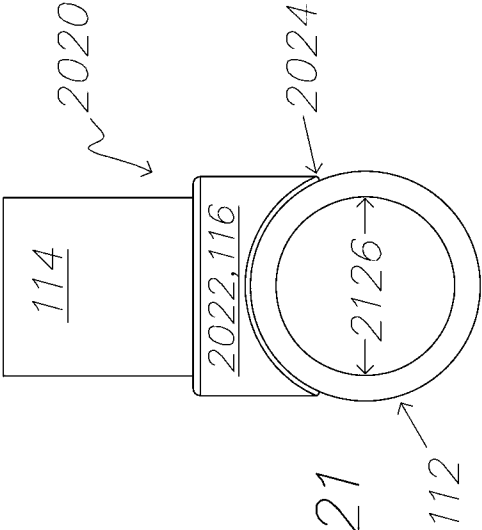


FIG 21

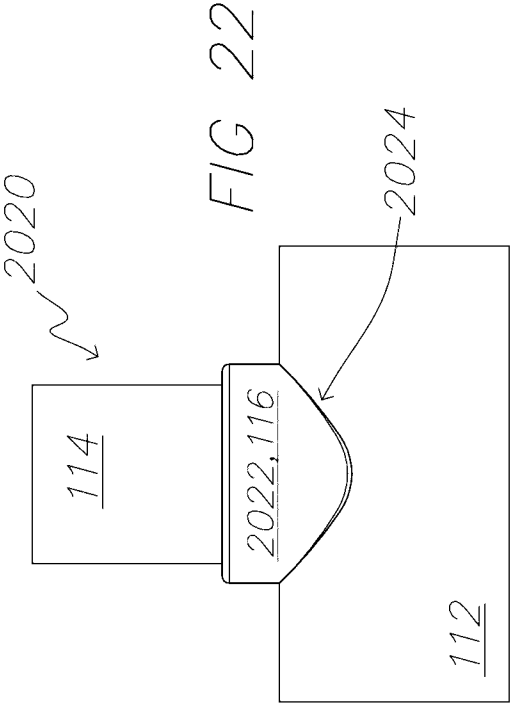
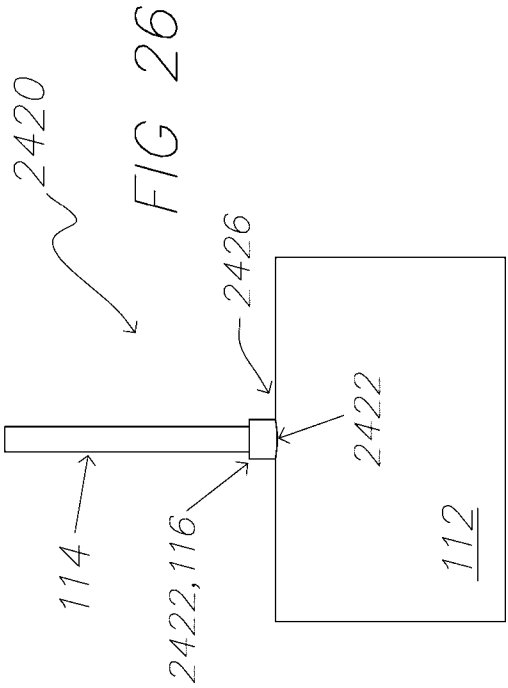
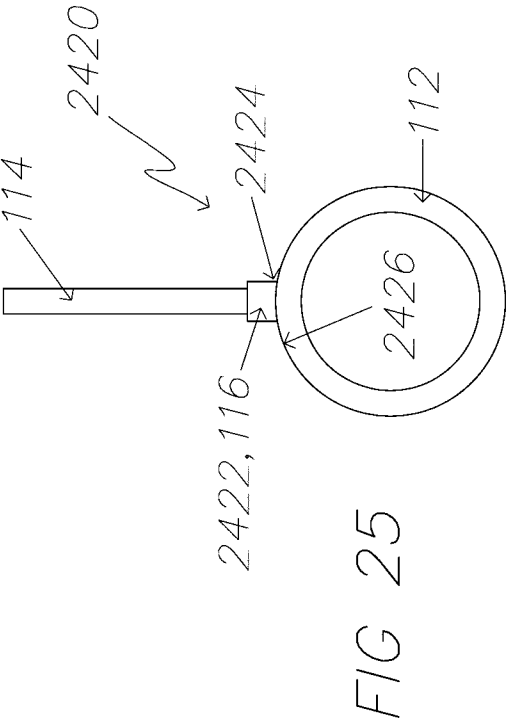
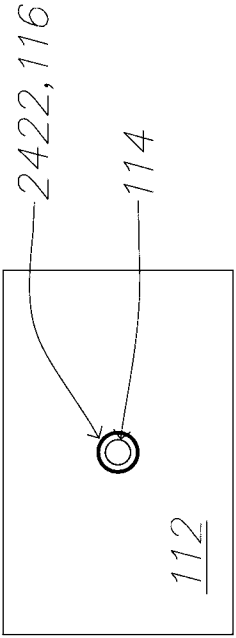
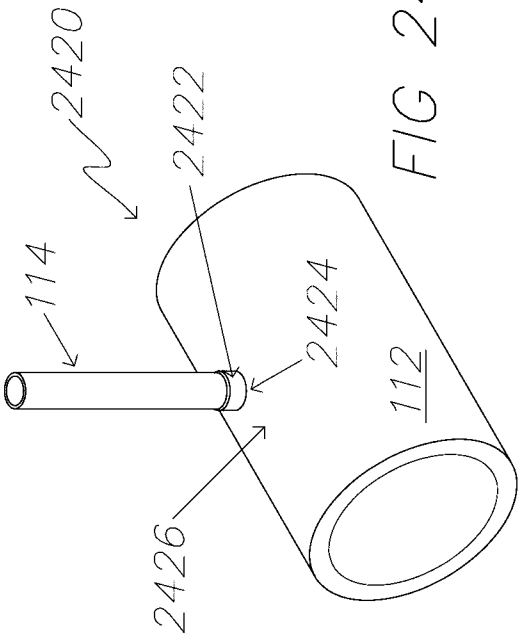


FIG 22



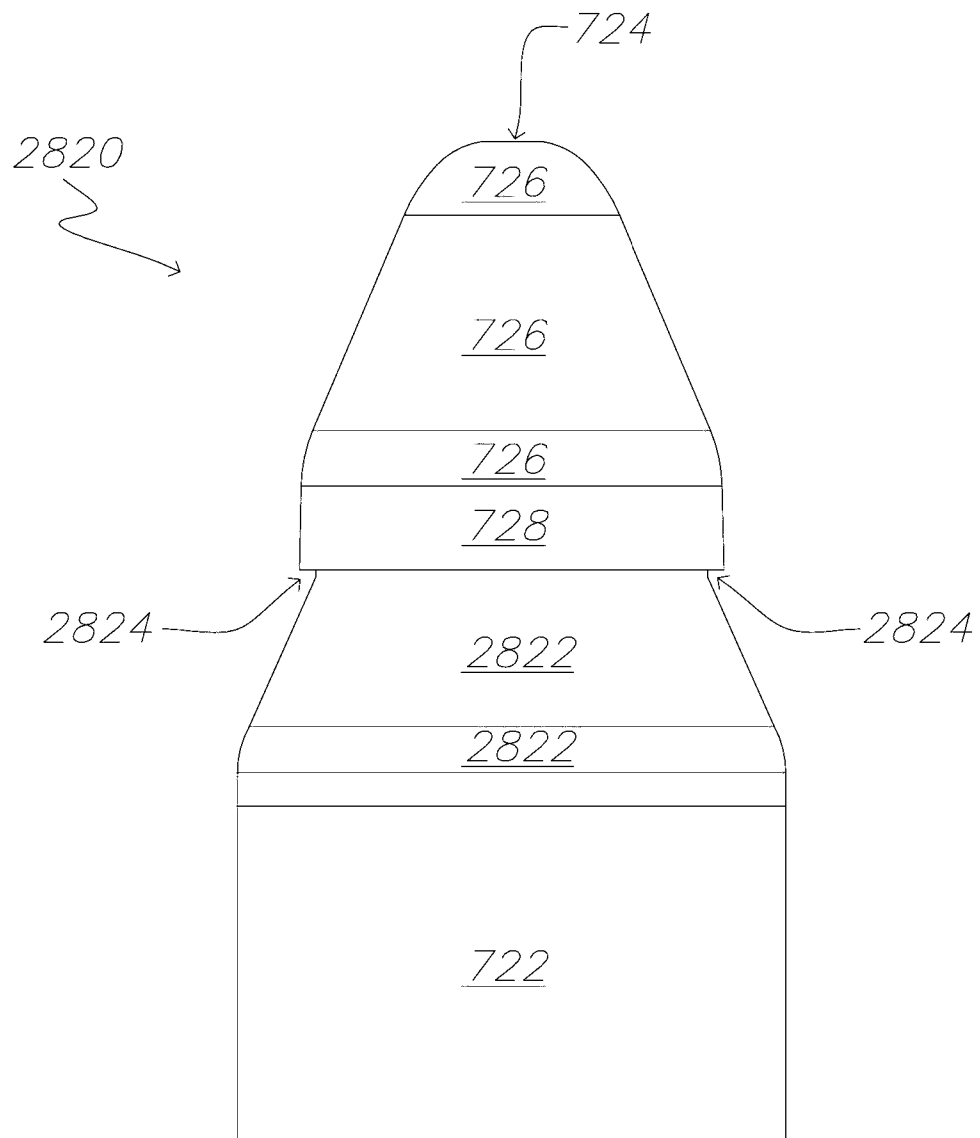
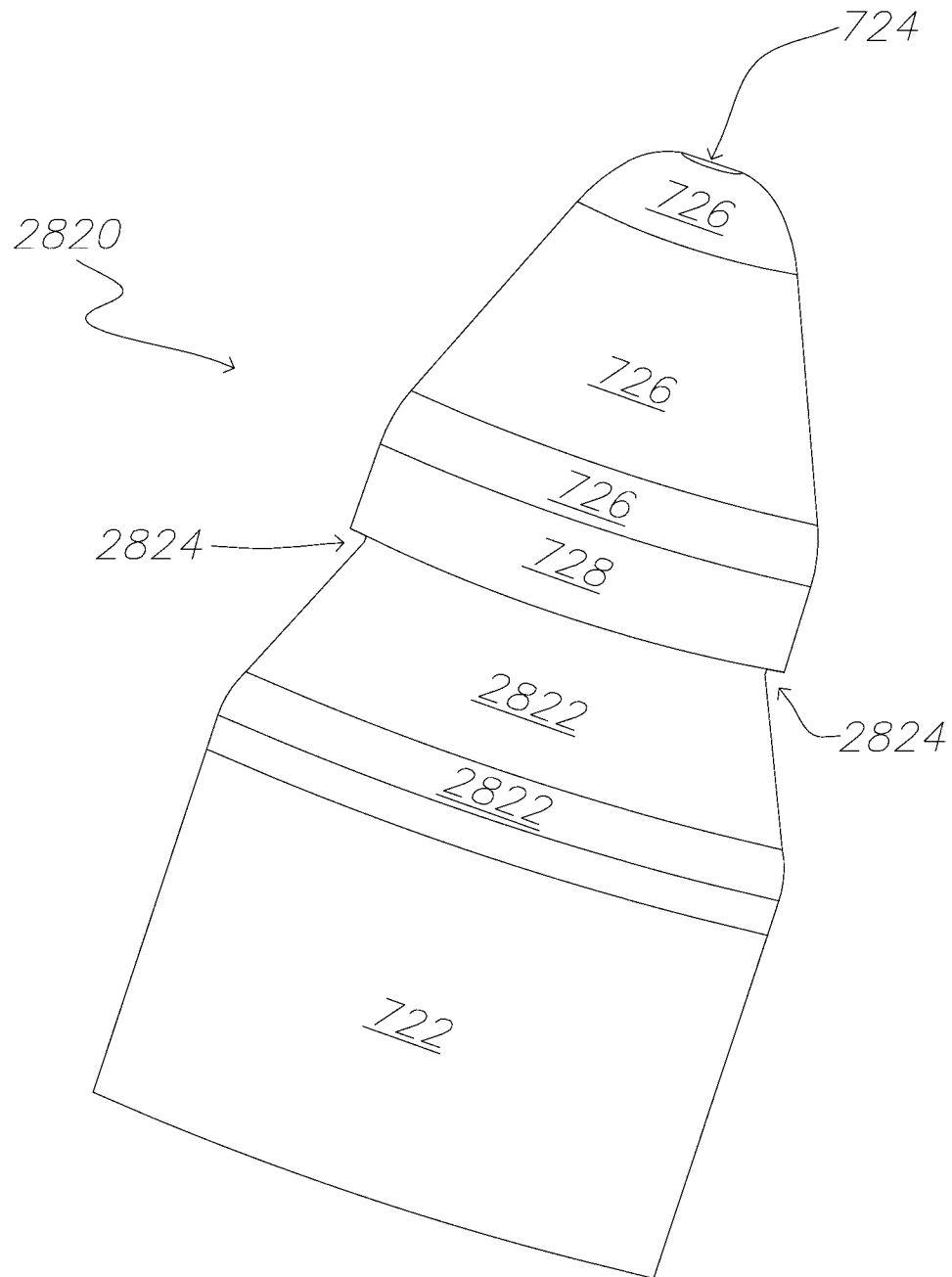


FIG 28



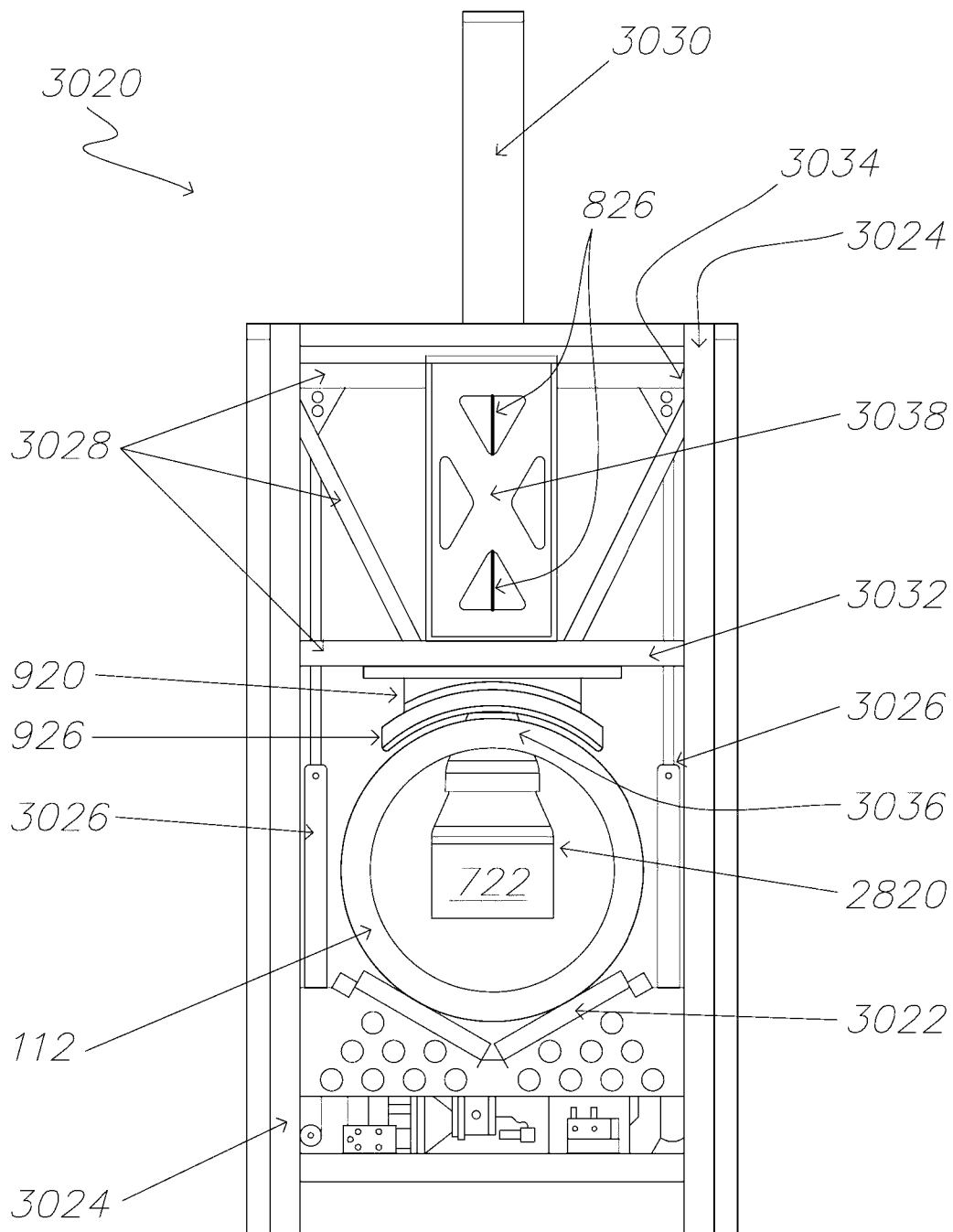


FIG 30

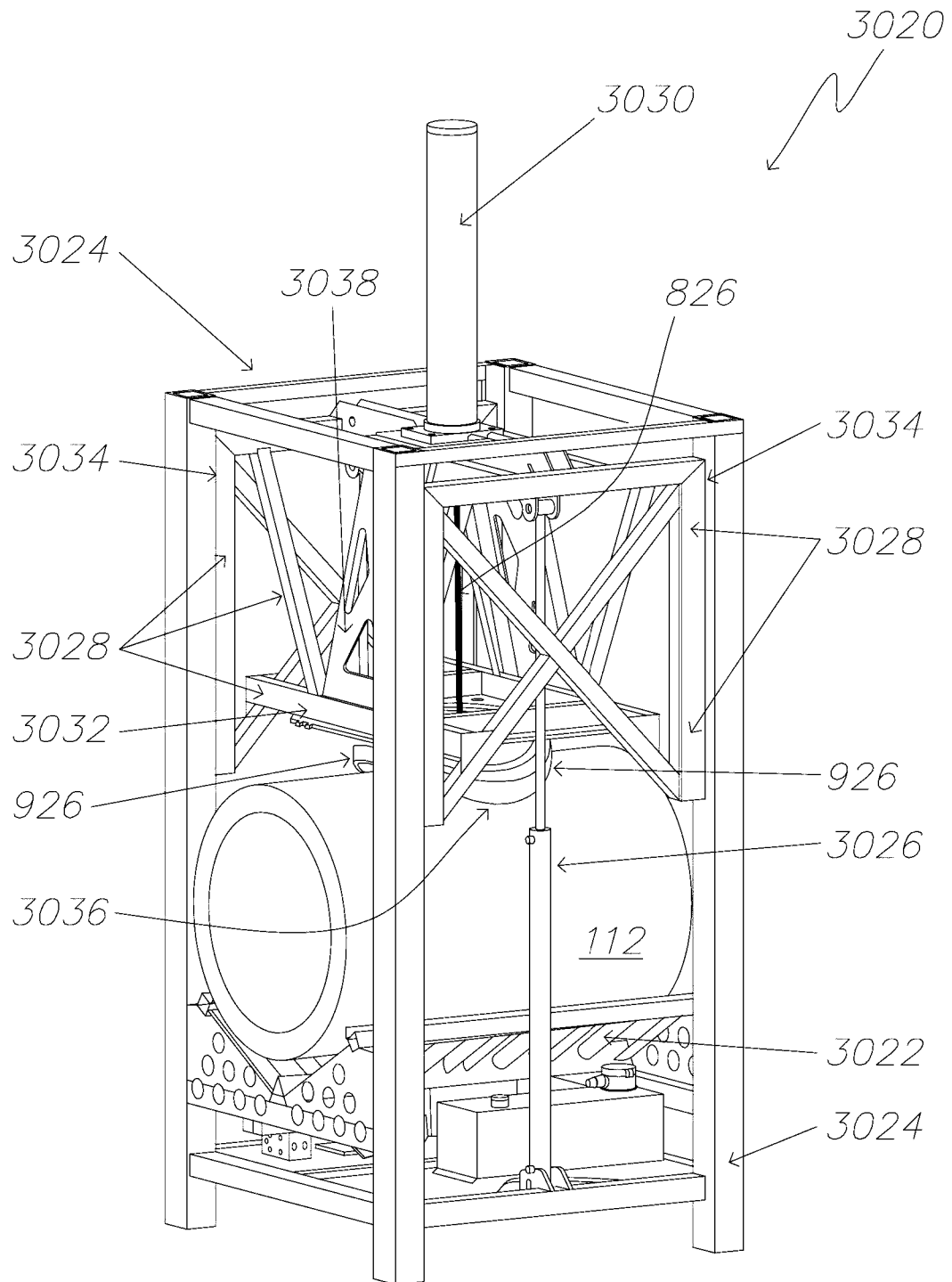


FIG 31

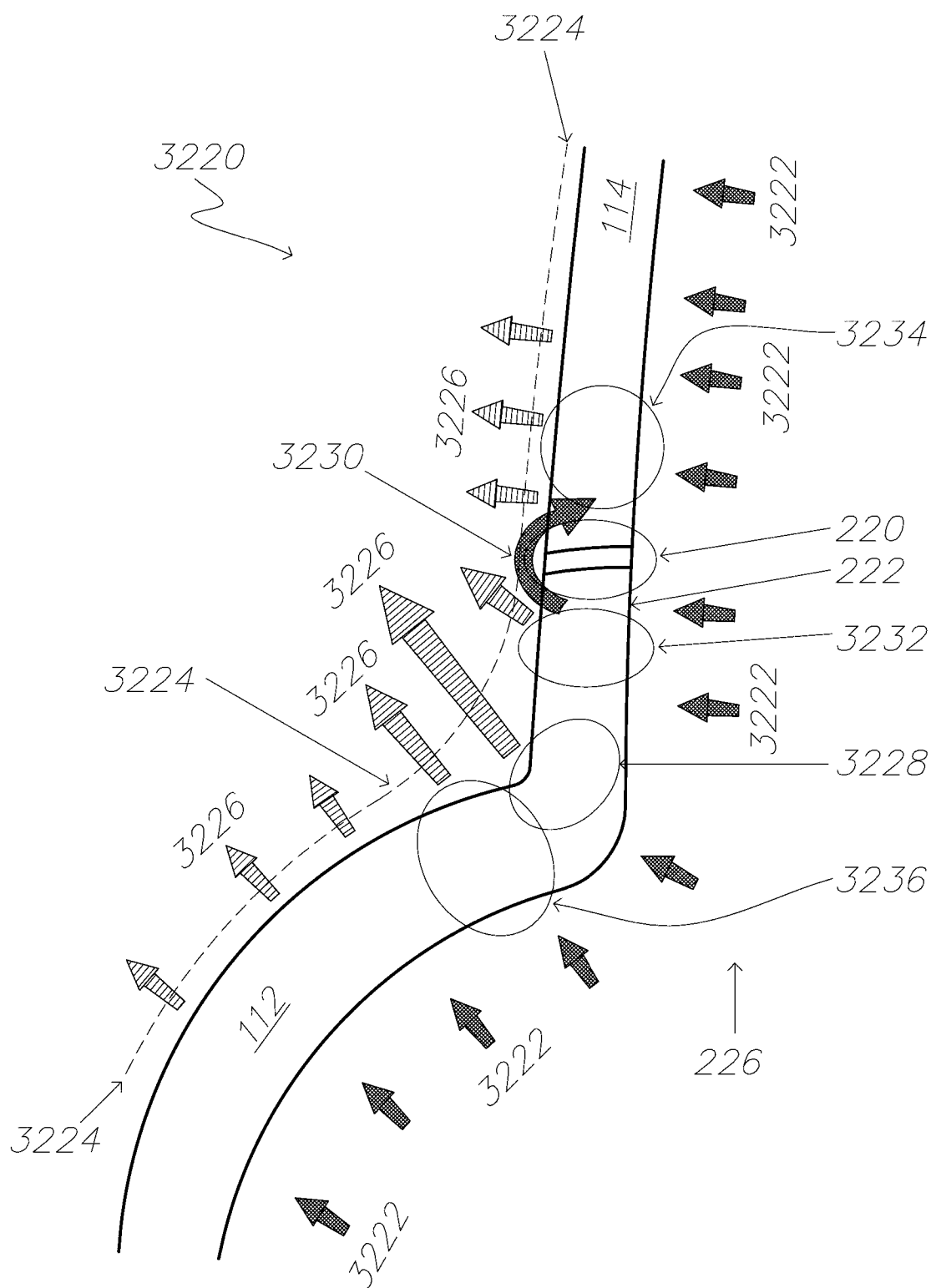


FIG 32

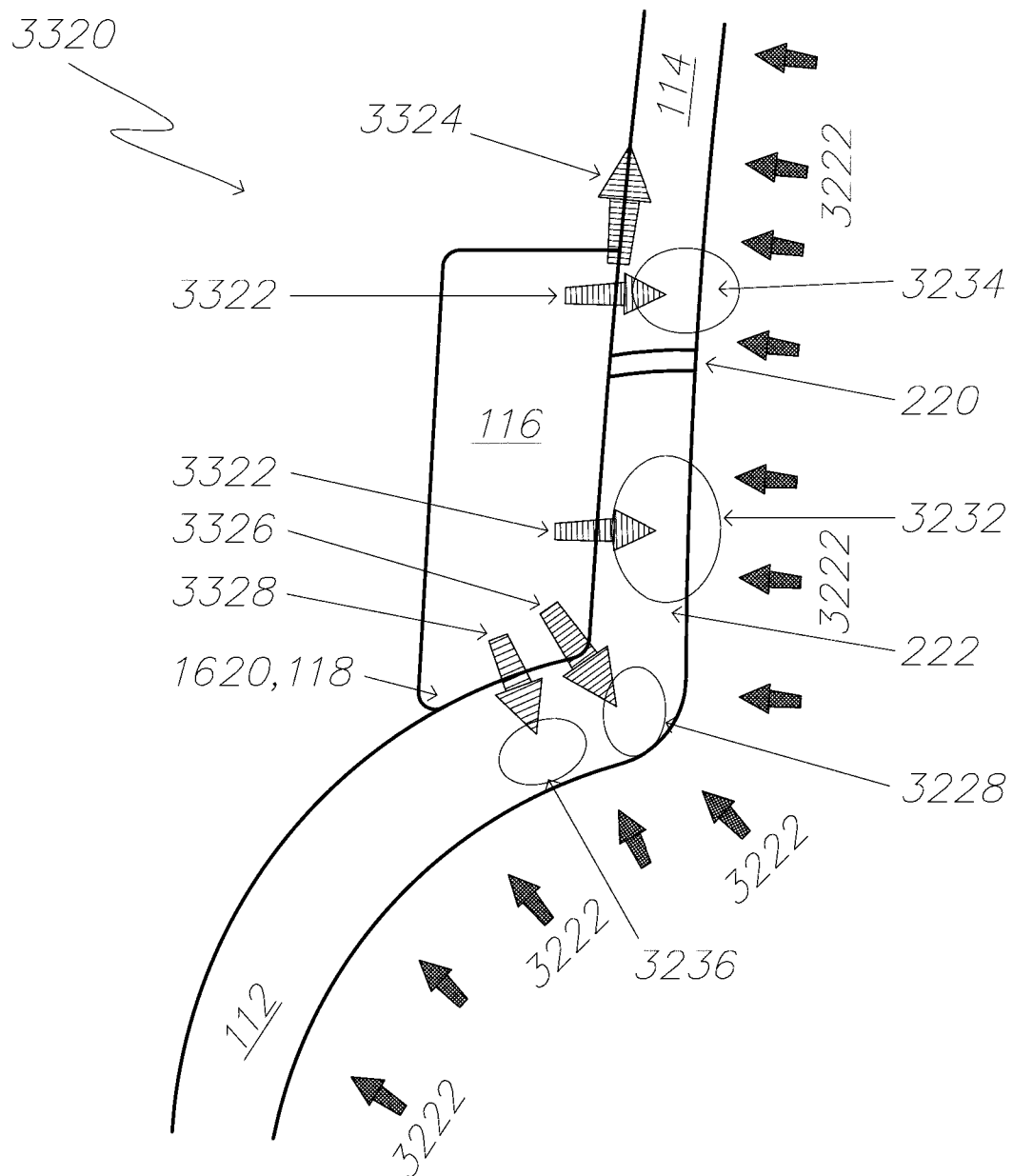


FIG 33

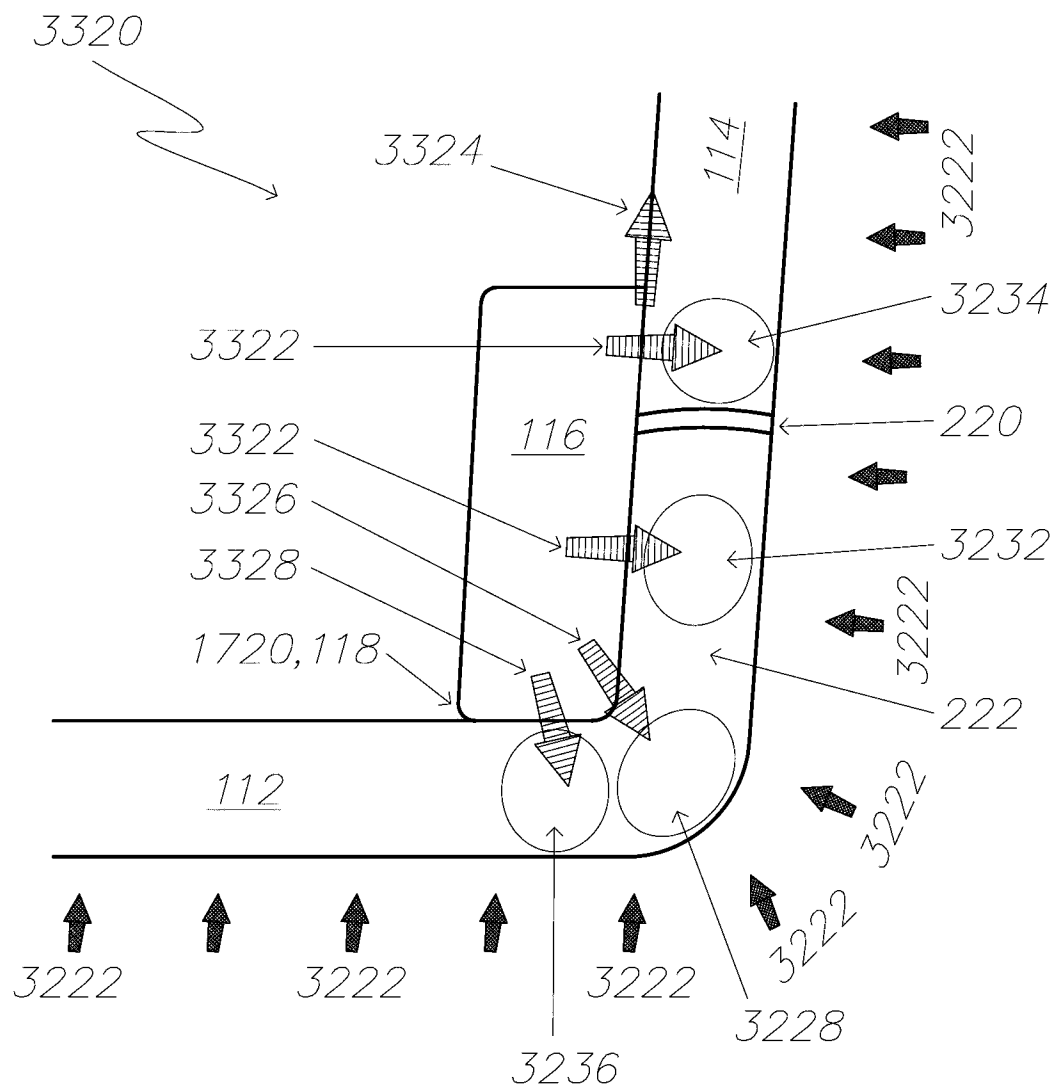


FIG 34

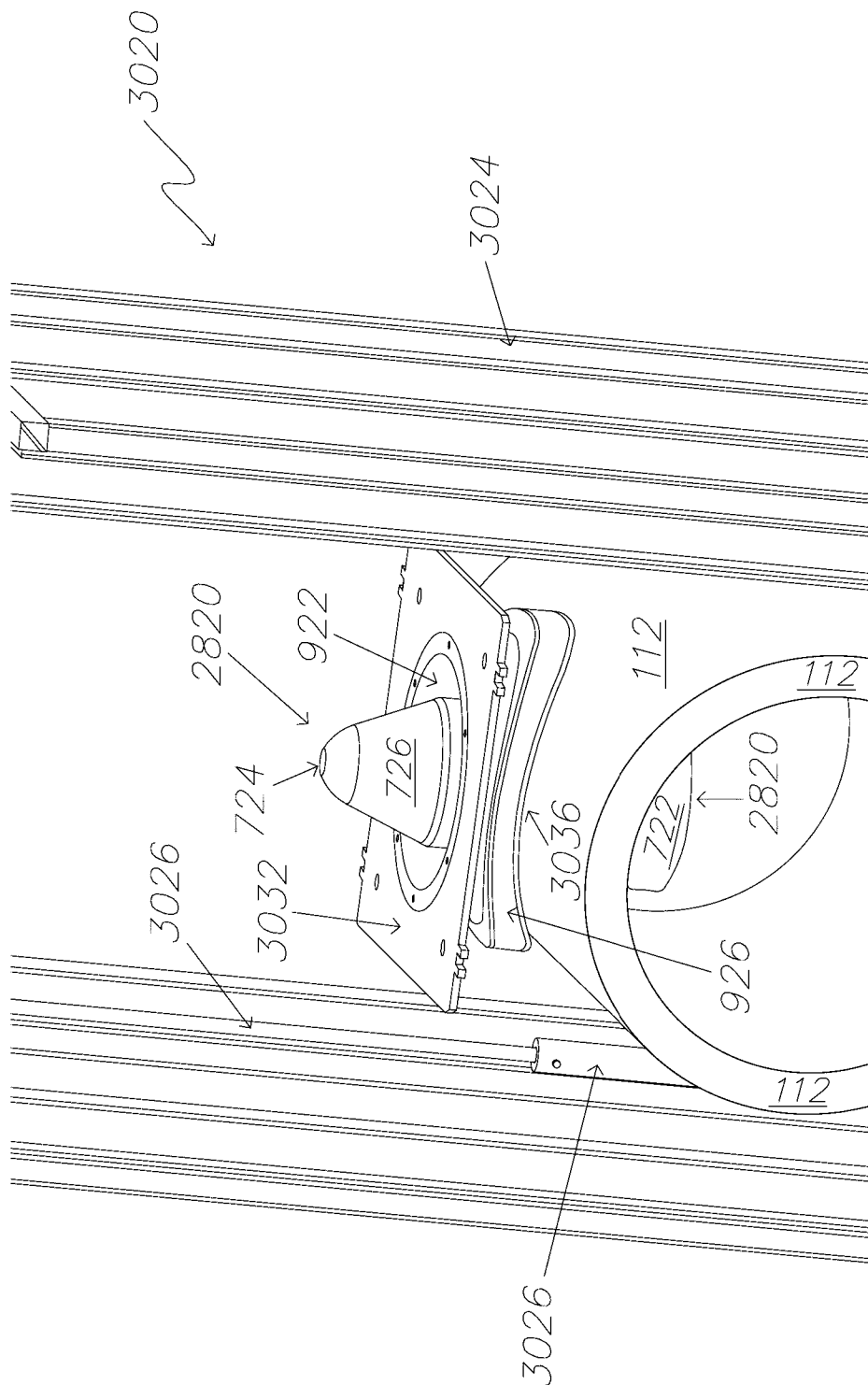


FIG 35

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/AU2016/050583

A. CLASSIFICATION OF SUBJECT MATTER

F16L 47/26 (2006.01) **F16L 47/03 (2006.01)** **F16L 23/04 (2006.01)** **F16L 17/02 (2006.01)** **F16L 21/02 (2006.01)**
F16L 41/08 (2006.01) **F16L 41/12 (2006.01)** **F16L 41/14 (2006.01)** **F16L 58/18 (2006.01)** **F16L 9/12 (2006.01)**
F16L 25/06 (2006.01) **F16L 23/02 (2006.01)**

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)

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)

EPODOC, WPIAP & TXTE (Public Cluster): IPC / CPC (F16L25/06, F16L23/02, F16L23/04, F16L17/02, F16L21/02, F16L41/021, F16L41/08, F16L41/12, F16L41/14, F16L58/18, F16L47/03, F16L47/14, F16L47/04, F16L47/26, F16L33/2073, F16L9/12), keywords (COLLAR, PLASTIC, HDPE, FIRST, SECOND, INTERMEDIATE, SPIGOT, RING, SADDLE, MAIN, BRANCH, TEE, JOINT, PREVENT, BEND, STRETCH, DEFORM, PRESSURE, DISTRIBUTION, ANCHOR, COUPLING) and the like terms; **Applicant(s) and Inventor(s) name search** (Espacenet, AusPat, Internal database)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 28 October 2016	Date of mailing of the international search report 28 October 2016
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au	Authorised officer Kong-Meng Leck AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. (02) 6283 2223

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. PCT/AU2016/050583
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3654008 A (ROGERS et al.) 04 April 1972 Title, Abstract, Fig 1 - 12, Col 3, 7 - 8	1 - 8, 8A, 9 - 34
X	GB 1313069 A (UPO OSAKEYHTIO) 11 April 1973 Fig 4 - 6	1 - 8, 8A, 9 - 25, 28 - 34
X	US 2014/0252763 A1 (GROHE AG) 11 September 2014 Fig 1 - 2, [0025]	1 - 8, 8A, 9 - 25, 28, 31 - 34
X	FR 2518699 A2 (MEGIAS BERNARD) 24 June 1983 Abstract, Fig 1 - 3e	1 - 8, 8A, 9 - 25, 28, 31 - 34
A	US 2008/0001394 A1 (ZIU) 03 January 2008 Title, Abstract, Fig 1 - 6, [0003]	1 - 8, 8A, 9 - 34

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including
2. ☒ Claims Nos.: **70 - 75**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
See Supplemental Box
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1 - 8, 8A, 9 - 34

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Supplemental Box**Continuation of Box II**

The claim/s do/does not comply with Rule 6.2(a) because it/they rely on references to the description and/or drawings.

Continuation of: Box III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1 - 8, 8A, 9 - 34 are directed to a plastic pipe tee comprising a main pipe, a branch pipe, an opening formed in the main pipe wall, a collar to sleeve a spigot formed in the opening joining the main and branch pipe.. The feature of the base of the collar resisting an outwardly movement of at least one of the portion of the wall adjacent the junction of the main pipe to the spigot is specific to this group of claims.
- Claims 35 - 50, 50A, 51 - 55 are directed to a method / apparatus for forming a plastic pipe tee comprising a means for localising a heating to a wall portion of the main pipe.. The feature of a bullet mandrel initially positioned within the main pipe and adjacent the heated wall portion, a spigot die applied to the outer surface of the heated wall portion of the main pipe, wherein the pulling of the bullet mandrel through the main pipe wall in opposition to the spigot die forms a spigot in the main pipe wall is specific to this group of claims.
- Claims 56 - 69 are directed to a method / apparatus of localised heating for plastic forming of a plastic pipe comprising a frame configured for at least one of a portion of an outer wall surface and a corresponding portion of an inner wall surface.. The feature of an infra-red radiation heater and one surface cooling means directed to one wall surface portion and a mask to localise the heating only to a part of the wall for plastic forming is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

The International Searching Authority believes that a search and examination for the second invention will require significant additional search and examination effort over that for the first invention. However it is considered that the search for the third invention will not involve more than negligible additional search and examination effort over that for the second invention, so the third invention can be search together with the second invention.

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2016/050583	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
US 3654008 A	04 April 1972	US 3654008 A	04 Apr 1972
		US 3758255 A	11 Sep 1973
		US 3809737 A	07 May 1974
		US 3861720 A	21 Jan 1975
GB 1313069 A	11 April 1973	GB 1313069 A	11 Apr 1973
		SE 377605 B	14 Jul 1975
US 2014/0252763 A1	11 September 2014	US 2014252763 A1	11 Sep 2014
		DE 102013003818 A1	11 Sep 2014
		EP 2775187 A2	10 Sep 2014
		EP 2775187 B1	20 Apr 2016
FR 2518699 A2	24 June 1983	FR 2518699 A2	24 Jun 1983
		FR 2518699 B2	30 May 1986
		FR 2502736 A1	01 Oct 1982
		FR 2502736 B1	22 Nov 1985
US 2008/0001394 A1	03 January 2008	US 2008001394 A1	03 Jan 2008
End of Annex			