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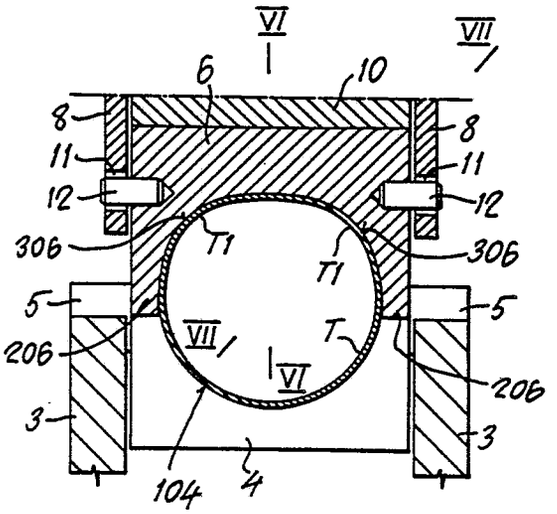
(54) Metal pipe bending apparatus.

(57) The object of the invention is an apparatus for bending metal pipes, particularly pipes having a means and a great diameter. The apparatus is associated with a vertical press (1,2) and comprises two lower pipe-bearing cradle members (4) with their upper surface (104) being semi-circular in cross-section, and an upper pipe-bending saddle member (6) arranged between the two cradle members (4), with its lower surface (106) corresponding to an intrados part of a tore. At least the pipe-bending saddle member (6) and preferably also the pipe-bending cradle members (4) have each in the central region of their surface in contact with the pipe (T), two opposite lateral depressions (306,304) which are provided in symmetrical positions with respect to the longitudinal median vertical plane of the saddle

member (6) or of the cradle member (4) in areas at 45° of the said saddle member (6) or cradle member (4). The said depressions (306,304) are so sized that a slight pressure applied by means of the pipe-bending saddle member (6) on the pipe (T) to be bent on starting the bending thereof, causes an expanding of said pipe into the lateral depressions (306,304), so that conforming protuberances (T1,T2) are formed in said pipe, and a contact surface between pipe (T) and the pipe-bending saddle member (6) and between pipe (T) and the pipe-bearing member (4) is thus obtained, the said surface being of such a width that on subsequent by increasing the pressure as applied by means of the pipe-bending saddle member (6) up to obtain the moment of flexure which is required for bending the pipe (T), any specific pressure is prevented from being reached, which would be apt to produce the narrowing of said pipe.

Fig.3



"Metal pipe bending apparatus".

The object of the invention is an apparatus for bending metal pipes, comprising two lower pipe-bearing cradle members with their internal surface being semi-circular in cross section, which are set in an axially aligned spaced apart relation, and are each pivotably mounted around a transversal axis, while an upper pipe-bending saddle member with an internal surface corresponding to an intrados part of a tore, is provided intermediately between the two pipe-bearing cradle members intended for receiving and supporting from below the pipe to be bent, and is designed for causing the bending of the pipe by straddling it and by being forced downward by a vertical press having the said pipe-bending saddle member secured to the movable plate thereof.

In the known apparatus of this type, the pipe-bending saddle member has a simple toric profile, while the two pipe-bearing cradle members have a simple semi-cylindrical profile. On starting the bending, the toric surface of the pipe-bending saddle member and the cylindrical surface of the pipe to be bent are caused to contact each other in correspondence of a point or of an extremely small area. The result is that an excessive specific pressure will be generated, which determines the sinking of the pipe-bending saddle member into the pipe to be bent and, as a consequence, a corresponding narrowing of the pipe and a reduction of its diameter which becomes still more noticeable in the sequence of the various beinding steps.

The said inconvenience particularly occurs in bends with a rather reduced radius, as well as in connection with pipes of a mean and a great diameter, having then a wall of a very limited thickness in relation to the pipe diameter. The same inconvenience occurs in correspondence of the pipe-bearing cradles when an already partly bent pipe is supported on a cradle member. In fact, in this instance, the contact surface between the bent pipe and the cylindrical pipe-bearing cradle member is limited to a very narrow area, with the result of an excessive specific pressure being generated on starting the bending, and of a consequent narrowing of the pipe.

The main object of the invention is to eliminate or at least to sensibly reduce the above disclosed inconvenience, as well as any defect in the bends made by using the known apparatus of the aforementioned type.

This problem is solved by the invention by the feature that at least the pipe-bending saddle member and preferably also the pipe-bearing cradle members, have each in the central area of their pipe-contacting surface, at least one lateral depression preferably provided in a zone at about 45° of the saddle member or the cradle member cross-section, and which is smoothly connected to the remaining toric surface of the pipe-bending saddle member or to the remaining semi-cylindrical surface of the pipe-bearing cradle member. Preferably, according to the invention, two opposite lateral depression of the above stated type are provided, which are symmetric with respect to the longitudinal median vertical plane of the pipe-bending saddle member or of the pipe-bending saddle member or of the pipe-bearing cradle member.

In the implementation according to the invention, a slight pressure applied by means of the pipe-bending saddle member on the pipe to be bent on starting the bending thereof, produces a yielding and an expanding of said pipe into the lateral depression or depressions in the saddle member and may be also in the pipe-bearing cradle member, so that in correspondence of the zone of the said depression or depressions a contact surface between the pipe and the pipe-bending saddle member and may be also between the pipe and the pipe-bearing cradle member is thus determined, the said surface being of such a width that on subsequently increasing the pressure up to obtain the moment of flexure as required for bending the pipe, any such specific pressure is prevented from being reached, that would cause the narrowing of said pipe. The slight deformation of the pipe at the beginning of the bending, due to the lateral depression or depressions, produces only a correspondingly slight change in the shape of the originally circular profile of the pipe to be bent, and not a reduction of the peripheral development thereof, and the said deformation will be automatically rectified and eliminated when after a bending step, the movable plate of the press is lifted up together with the pipe-bending saddle member, and the pipe is advanced by one step of a length not much shorter than the just bent pipe section, whereupon the bending step is repeated. In this subsequent bending step, the previously bent section of the pipe is actually subjected to the action of a portion of the pipe-bending saddle member or of the pipe-bearing cradle member having no depressions, so that it is a fully toric or semi-cylindrical portion, whereby the said pipe section will have its originally circular profile restored. The wide contact surface thus obtained by means of the lateral depression or depressions, between a pipe and the pipe-bending saddle member in the central area of the section affected by the bending, facilitates the bending and reduces the risk of wrinkles, laps, and any other undesired distortion

being formed in a bend. Therefore, by using the apparatus according to the invention, highly accurate bends can be obtained in the pipes, with a distortion of their diameter (reduction and ovalization) being, for example, contained within a limit of 0,5-1,5%.

The apparatus according to the invention is generally used for cold bending, although it may be also used for hot bending. Moreover, the apparatus according to the invention can be used for bending pipes only in one step of in two or more steps, depending on the bending radius, the thickness of the pipe wall, the pipe diameter, the pipe material, and the like. The apparatus according to the invention can be used for bending pipes of any diameter, although it is particularly adapted for bending pipes of a mean and a great diameter, especially pipes for oil and methane pipelines and generally, for liquid and gas ducts, for example pipes of 54" and even of 60" and more. In fact, pipes of a means and a great diameter have a very low thickness/diameter ratio, so that they are particularly exposed to the risk of being narrowed as a result of any excessive specific pressure at the starting of each bending step. On the other hand, just in the instance of pipes having a low thickness/diameter ratio, in order to avoid the forming of wrinkles on the intrados of the bending, the distance between the swing centers of the two pipe-bearing cradle members needs to be a relatively small one, and to be, for example, maintained within a value of about 3.3 times the diameter of the pipe. Consequently, the force needed for reaching the moment of flexure as required for bending is quite important in relation to the pipe diameter, and just as much important therefore is the extent of the surfaces affected by any excessive specific pressure that produces the narrowing of the pipe cross-sectional opening.

These and other features of the invention will become apparent from the claims and the following specification of one preferred embodiment thereof, diagrammatically shown in the accompanying drawings, in which:

Figure 1 is a side elevational view showing a pipe bending apparatus according to the invention.

Figure 2 is a vertical cross-sectional view taken on line II-II of figure 1, in correspondence of the pipe-bending saddle member, before starting the bending pressure on the pipe.

Figure 3 is a cross-sectional view similar to that of figure 2, at the beginning of the bending pressure on the pipe.

Figures 4 and 5 are two longitudinal sectional views taken on lines IV-IV and V-V of figure 2, showing the pipe-bending saddle member before starting the bending pressure on the pipe.

Figures 6 and 7 are two longitudinal sectional views taken on lines VI-VI and VII-VII of figure 3, showing the pipe-bending saddle member at the beginning of the bending pressure on the pipe.

Figure 8 is a vertical cross-sectional view showing a pipe-bearing cradle member before starting the bending of a pipe resting with an already bent section thereof on the said pipe-bearing cradle member.

Figure 9 is a cross-sectional view similar to that of figure 8, at the beginning of the bending of a pipe.

Figures 10 and 11 are two longitudinal sectional views taken on lines X-X and XI-XI of figure 8, showing the pipe-bearing cradle member before starting the bending pressure on the pipe.

Figures 12 and 13 are two longitudinal sectional views taken on lines XII-XII and XIII-XIII of figure 9, showing the pipe-bearing cradle member at the beginning of the bending pressure on the pipe.

Figure 14 is a vertical cross-sectional view taken on line XIV-XIV of figure 15, showing a pair of sizing dies for ovalized bends.

Figures 15 and 16 are top views according to arrows XV-XV in figure 14 of the lower sizing die in two different operative steps.

The illustrated pipe bending apparatus comprises a vertical press of which the base 1 and the movable plate 2 are shown. Arranged on the base 1 of the press is a support comprising two spaced apart side members 3 between which two pipe-bearing cradle members 4 are mounted, the upwardly turned surface 104 thereof being substantially of a semi-cylindrical configuration, so that this surface has over almost the whole of its extent a semicircular profile. The two pipe-bearing cradle members 4 are axially and horizontally in line with each other, and are made so as to contain the lower half of a pipe T supported thereon. Each pipe-bearing cradle member 4 is mounted in the support 3-3 so as to be swingable around a transverse horizontal axis. Therefore, in the shown embodiment, each pipe-bearing cradle member 4 has two co-axial side pins 5 by means of which it is pivotably supported in respective upper seats provided in the side members 3 of the support. The axis of pins 5 forming the swing axis of each pipe-bearing cradle member 4, is located below the axis of the semicircular profile of the said pipe-bearing cradle member 4. The upper longitudinal edges 204 of the pipe-bearing cradle members 4 are rectilinearly extended in the upward direction beyond the horizontal plane passing through the axis of the semicircular profile of said cradle members 4.

In one preferred embodiment, which is disclosed merely by way of a non-limiting example,

the length of each pipe-bearing cradle member 4 is approximately 1.2 times the diameter of the pipe T.

The distance between the swing axes of the two pipe-bearing cradle members 4, i.e., between the pins 5 for the support and the pivoting of said cradle members 4 is approximately 3.3 times the diameter of the pipe. The upward extension of the upper longitudinal edges 204 of each pipe-bearing cradle member 4 beyond the horizontal axial plane of said cradle member 4 is approximately 1/10 of the diameter of the pipe T. Also the distance of the axis of pins 5 for each pipe-bearing cradle member 4 from the overlying horizontal axial plane of said cradle member 4 corresponds approximately to 1/10 of the diameter of the pipe T.

Arranged intermediately between the two pipe-bearing cradle members 4 is the pipe-bending saddle member 6 which is secured to the movable plate 2 of the press. Preferably, the pipe-bending saddle member 6 is connected to the movable plate 2 of the press through an articulated joint or a knuckle having a transverse horizontal axis of articulation.

In the shown embodiment, the said articulated joint consists of a plate 7 which is secured to the plate 2 of the press, such as by means of bolts, and has two downwardly extending side ears 8. Welded below the securing plate 7 is an articulation member 9 having a concave lower surface that corresponds to a cylindrical surface segment with a transverse horizontal axis. The mating convex upper surface of an articulation member 10 bears against the said concave lower surface of the articulation member 9, and the said member 10 has its lower planar horizontal surface bearing against the upper planar horizontal surface of the pipe-bending saddle member 6. In the ears 8 extending sideways of the articulation members 9,10 and the pipe-bending saddle member 6, bores 11 are made which are co-axial to each other and to the centre of curvature of the mating, concave and convex surfaces of the two superposed articulation members 9,10.

The transverse horizontal axis which is common to the two bores 11 and to the curved mating surfaces of the two articulation members, preferably lies only a little above the horizontal plane passing through the barycenter of the pipe-bending saddle member 6. The pipe-bending saddle member 6 is secured to the side ears 8 by means of two pins 12 having a diameter which is sensibly smaller than the bores 11, so that the said pins are passed with a correspondingly great play through the said bores 11, to be driven in the pipe-bending saddle member 6. The sensible play between the pins 12 and the bores 11 in the ears 8 guarantees that the pressure of the press will be applied on the pipe-bending saddle member 6 solely through the two mating articulation members 9,10, and not through the pins 12 that mainly perform the task of holding together the assembly formed by the pipe-bending saddle member 6 and the two articulation members 9,10, when this assembly is suspended from the uplifted movable plate 2 of the press.

The lower surface 106 of the pipe-bending saddle member 6, which is turned toward the pipe T, is substantially formed by a tore segment intrados part of 180, with a cross-section like that of the pipe T to be bent, and with a radius being slightly shorter than that of the bend to be made in said pipe. The longitudinal edges 206 of the pipe-bending saddle member 6 are rectilinearly extended downwards, tangentially to the cross-section of the tore, for example over a length of about 1/10 of the diameter of the pipe.

According to the invention, two lateral depressions 306 are provided in the lower tore intrados part surface 106 of the pipe-bending saddle member 6, at the central region of said member 6, and are situated on opposite sides of the longitudinal median vertical plane of the pipe-bending saddle member 6, in correspondence of areas at about 45 from the said plane, and are symmetrical with respect to the said plane. More particularly, each one of these depressions 306 has a maximum depth at its central area, i.e., in correspondence of the median transversal plane of the saddle member 6, at about 45 of the cross-section of the said member 6. Such a depth gradually decreases from the central area of the depression in all direction, so that a smooth connection is obtained of the depression 306 to the remaining toric surface 106 of the saddle member 6.

The extent of each depression 306 in the longitudinal direction of the pipe-bending saddle member 6 preferably corresponds to the arc chord of the impression produced in pipe T by a pipe-bending saddle member 6 having no depressions 306, as a result of the excessive specific pressure at the beginning of the bending. In one preferred embodiment, the extent of each depression 306 in the longitudinal direction of the pipe-bending saddle member 6 is of about 0.6 times the diameter of pipe T. The maximum depth of each depression 306 preferably corresponds substantially to the maximum camber of the said impression arc.

Also in the central region of the semi-circularly profiled upper surface 104 of each pipe-bearing cradle member 4 two lateral depressions 304 are provided, which are situated on opposite sides of the longitudinal median vertical plane of the pipe-bearing cradle member 4 in correspondence of areas at about 45° from the said plane, and which are symmetrical with respect to the said plane. Each one of these depressions 304 has a maximum depth in its central region, i.e., in correspon-

dence of the median trans versal plane of the pipe-bearing cradle member 4, at about 45° of the semi-circular cross-section of said member 4. Such a maximum depth of the depression 304 preferably corresponds to about one quarter of the maximum depth of the depressions 306 in the pipe-bending saddle member 6, and gradually decreases in all directions, so that a smooth connection is effected of the depression 304 to the remaining semi-cylindrical surface 104 of the cradle member 4. The extent of each depression 304 in the longitudinal direction of the pipe-bearing cradle member 4 may be defined as previously disclosed in connection with the depression 306 in the pipe-bending saddle member 6 and, for example, it may corresponds to about 0.3 times the diameter of pipe T.

The pipe T to be bent is fitted between the raised pipe-bending saddle member 6 and the pipe-bearing cradle members 4 and is accomodated in the two cradle members 4. By lowering the pipe-bending saddle member 6 so as to cause the same to contact the pipe T, however without any pressure being yet applied thereon, the conditions shown by solid lines in figures 4 and 2 and - only for the pipe-bending saddle member 6, in figures 4 and 5, are obtained. Subsequently, by means of the pipe-bending saddle member 6 a slight pressure is applied on the pipe T, such that this pipe will be squeezed and will be forced to expand in correspondence of the two depressions 306 in the pipe-bending saddle member 6 whereby it is so deformed that it fills the said depressions 306 and has two conforming protuberances T1 formed in the same, as shown in figures 3,6, and 7. Thus, a wide contact surface is obtained between the pipe-bending saddle member 6 and the pipe T, over a zone extending substantially throughout the length of the depressions 306. This contact surface is of such a width that when the pressure as applied on the pipe T by means of the pipe-bending saddle member 6 will be subsequently increased up to attain the moment of flexure as required for the bending of said pipe, no excessive specific pressure will occur, which would be apt to cause a sinking of the pipe-bending saddle member 6 into the pipe T, and so a consequent narrowing of said pipe. The pipe T is therefore bent without substantially reducing its diameter and its cross-sectional opening.

During the bending of pipe T, the two pipe-bearing cradle members 4 are pivoting in opposite directions about the pins 5, as shown by dash lines in figure 1. Since the pins 5 for the pivoting of the pipe-bearing cradle members 4 are situated below the longitudinal axis of pipe T, the pipe-bearing cradle members 4 are drawn near to each other and bring about a strong compressive stress on the axis of pipe T. This limits the tendency to being stretched of the pipe extrados and the consequent reducing of the thickness of the extrados wall of the pipe.

The above-described extension of the longitudinal edges 204 and 206 of the pipe-bearing cradle members 4 and the pipe-bending saddle member 6 beyond the horizontal plane passing through the longitudinal median axis of pipe T, is in order to laterally cover the pipe and the bend in the course of being made, and to hold the respective sidewalls tending to spread apart, thus avoiding the deforming action of the cradle members and particularly of the saddle member 6 on the median zon of the pipe profile, especially in pipes having a wall of a relatively small thickness.

The articulation 9,10 interposed between the movable plate 2 of the press and the pipe-bending saddle member 6 permits the said member to be inclined when the underlying pipe T is already partly curved and then it is not tangent to the central point of the saddle member 6 between the lateral depressions 306 thereof. In the particular embodiment of said articulation 9,10, which is described by way of an example by referring to figures 1,2, the swing center is preferably situated substantially at the top side of pipe T, in order to avoid any sideward displacement.

After the above-described bending step, the pipe-bending saddle member 6 is lifted up and the partly bent pipe T is advanced rightward or leftward as seen in figure 1, by one step of a length not much shorter that the length of the already bent section. The above-described bending step is then repeated, and on carrying out this step, the previously bent pipe section provided with lateral protuberances T1 conforming to the depressions 306 in the pipe-bending saddle member 6, comes to be located in correspondence of a portion thereof, in which the cross-section of the toric surface 106 of the saddle member 6 is semi-circular in shape, with no lateral depressions. Therefore, this semi-circular portion in cross-section of the pipe-bending saddle member 6 promotes the re-sizing of the already bent section of the pipe, by eliminating its protuberances T1 due to the depressions 306.

When the section of pipe T which is received in a pipe-bearing cradle member 4 is rectilinear, the bearing surface therefor extends over the whole semi-cylindrical surface of the cradle member 4, and the lateral depressions 304 in said member have no effect on the said pipe section since there is no risk of any excessive specific pressure. However, as shown in figures 8 to 13, when a previously bent pipe T is received in the pipe-bearing cradle member 4, then on having the said pipe T bent by means of the pipe-bending saddle member 6, an operating condition occurs in correspondence of the pipe-bearing cradle member 4, which is

similar to the operating condition, as described above for the pipe-bending saddle member, in connection with a straight pipe. The initial position of the previously bent pipe T section in a pipe-bearing cradle member 4 is shown in figures 8,10, and 11, in which it clearly appears that the contact between the semi-cylindrical surface of the cradle member 4 and the toric surface of the previously bent pipe T is limited to a very narrow area. Owing to the slight pressure as applied on the previously bent pipe T by means of the pipe-bending saddle member 6 on starting the bending, the said pipe is so deformed that it fills the two depressions 304 in the pipe-bearing cradle member 4 and has two conforming protuberances T2 formed in the same, as shown in figures 9,12, and 13. Thus, the contact area between the previously bent pipe T and the pipe-bearing cradle member 4 is widened to such an extent as to prevent any excessive specific pressure from being generated, which would cause the narrowing of the pipe when the pressure of the pipebending saddle member 6 on the previously bent pipe T is increased to cause a further or the final bending thereof.

The pipe bending apparatus comprises also two sizing dies 14,16 shown in figures 14 to 16, which are meant for eliminating any ovality of the pipe T in correspondence of the bend TC. It is ascertained that the said ovality always appears in such a manner that the major axis of the ovalized cross-section of the pipe bend TC is perpendicular to the plane of said bend TC. Each one of the two sizing dies 14,16 has a concave surface 114,116 corresponding to a part slightly smaller than 180 of a toric surface segment. The load of this toric surface substantially corresponds to the load of the pipe bend TC.

The cross-section of the said toric surface part is slightly lesser than a semicircle and has a radius that is slightly longer than the radius of the cross-section of the pipe bend TC. The said two sizing dies 14,16 are arranged the one over the other with their concave toric surfaces 114,116 facing each other, and one of them is secured to the press base 1 and the other to the movable plate 2 of the press. The whole in such a manner that when the two sizing dies 14 and 16 are caused to bear the one upon the other by their longitudinal side edges, the said sizing dies 14,16 delimit in cross-section a substantially oval opening having its major axis horizontal and slightly longer than the diameter of the cross-section of the pipe bend TC, and its minor axis vertical and slightly shorter than the diameter of the cross-section of the bend TC. Each one of the said sizing dies 14,16 is prolonged at least one and preferably at both ends thereof tangentially to the pipe bend TC, and so to the toric surface, by a substantially rectilinear section 214,216 having its maximum extent in correspondence of the extrados of the pipe bend TC, and being reduced to nothing in correspondence of the intrados of said bend.

To size an ovalized pipe bend TC, the said bend is inserted between the two sizing dies 14,16 so as to have the plane of the bend arranged horizontally. Thus, the major axis of the oval cross-sectional shape of the pipe bend TC is arranged vertically, i.e., in correspondence of the minor axis of the oval opening between the two sizing dies 14,16, as shown by a dash-and-dot line in figure 14. By compressing by means of the press the pipe bend TC between the two dies 14,16, and by suitably adjusting the pressure, the major axis of the cross-section of the ovalized bend is shortened and the minor axis of the said cross-section grows longer, thus restoring the circular cross-sectional shape of the pipe bend TC. The operation is repeated by successive steps over the whole length of the pipe bend TC (figure 15).

Thanks to the rectlinear end prolongations 214,216 of the two sizing dies 14,16, these dies can effect the sizing even of any rectilinear extremity or extremities TC' of the pipe bend TC. Therefore, the rectlinear extremity TC' of the pipe bend TC is inserted into, and compressed within one of the two end sections of the opening between the two dies 14,16, in correspondence of the rectilinear respective tangential prolongations 214,216 of said dies (figure 16). The annulment of these rectilinear tangential prolongations 214,216 of the sizing dies 14,16 in correspondence of the intrados of their toric surface 114,116 is foreseen in order to not hinder the sizing of the bent pipe section TC.

The invention may be applied also to the bending of pipes having been preliminarily filled with water, after the tight sealing of their ends by means of welded plugs. In this instance, according to the invention, the water contained in the pipe before bending under pressure, preferably under a pressure of about 1/4 of the pressure that the pipe can withstand. Such an initial pressure of the water in the pipe is controlled, for example, by means of a pressure gauge connected to the water inflow union, and is restored in the course of the first bending steps, during which it tends to change owing to the alteration in the extrados portion of the bend. This control is effected until the water pressure in the pipe will be maintained in a practically constant condition.

In any case, by using the apparatus according to the invention, bends can be obtained with a radius starting from about two or three times the diameter of the pipe, and the bends thus obtained present a very slight reduction of the pipe diameter, and a very slight ovality and distortion, so that they meet the strictest technological requirements.

Of course the invention is not limited to the just described and shown embodiments, and the same may be widely changed and modified, the more so as for what concerns the geometrical shape and/or the position and/or the number of the depressions 306,304 in the pipe-bending saddle member 6 and in the pipe-bearing cradle members 4, without however departing from the leading principle as set forth above, and as claimed hereinafter.

Claims

1. An apparatus for bending metal pipes, comprising two lower pipe-bearing cradle members (4) with their upper surface (104) being semicircular in cross section, which are set in an axially aligned, spaced apart relation, and are each swingably mounted around a transversal axis (5), while an upper pipe-bending saddle member (6) with its lower surface (106) corresponding to an intrados part of a tore, is provided intermediately between the two pipe-bearing cradle members (4) intended for receiving and supporting from below the pipe (T) to be bent, and is designed for producing the bending of the pipe (T) by straddling it and by being forced downwardly by a press (1,2), characterized in that at least the pipe-bending saddle member (6), and preferably also the pipe-bearing cradle members (4) have each in the central area of their surface in contact with the pipe (T), at least one lateral depression (306,304) preferably located in a zone at about 45 of the cross-section of the saddle member (6) or the cradle member (4), and which is smoothly connected to the remaining toric surface (106) of the pipe-bending saddle member (6) or to the remaining semi-cylindrical surface (104) of the pipe-bearing cradle member (4).

2. The apparatus according to claim 1, characterized in that in the toric surface (106) of the pipe-bending saddle member (6) and preferably also in the semi-cylindrical surface of each pipe-bending cradle member (4), two opposite lateral depressions (306,304) are provided, which are symmetric with respect to the longitudinal median vertical plane of the saddle member (6) or the cradle member (4).

3. The apparatus according to any one of claims 1 or 2, characterized in that the depression or depressions (306,304) are so sized that a slight pressure as applied by means of the pipe-bending saddle member (6) on the pipe (T) to be bent on starting the bending thereof, produces an expanding of said pipe into the lateral depression or depressions (306,304) so that conforming protuberances (T1,T2) are formed in said pipe, whereby a contact surface between the pipe and the pipe-bearing saddle member (6) and between the pipe and the pipe-bearing cradle member (4) is obtained, the said surface being of such a width that on subsequently increasing the pressure as applied by means of the pipe-bearing saddle member (6), up to obtain the moment of flexure as required for bending the pipe (T), any such specific pressure is prevented from being reached, that would be apt to cause the narrowing of said pipe.

4. The apparatus according to any one or more of the preceding claims, characterized in that each depression (306 or 304) has a maximum depth at its central area, in correspondence of the median transversal plane of the pipe-bending saddle member (6) or of the pipe-bearing cradle member.

5. The apparatus according to any one or more of the preceding claims, characterized in that the maxim depth of each depression (306) in the pipe-bending saddle member (6) substantially corresponds to the maximum camber of the arcuate impression which owing to an excessive specific pressure would be produced in pipe (T) by a pipe-bending saddle member (6) having no depressions (306).

6. The apparatus according to any one or more of the preceding claims, characterized in that the extent of each depressions (306) in the pipe-bending saddle member (6) in the longitudinal direction thereof, substantially corresponds to the chord of the arcuate impression which owing to an excessive specific pressure would be produced in pipe (T) by a pipe-bending saddle member (6) having no depressions (306).

7. The apparatus according to any one or more of the preceding claims, characterized in that the extent of each depression (306) in the pipe-bending saddle member (6) in the longitudinal direction thereof, is of about 0.6 times the diameter of pipe (T).

8. The apparatus according to any one or more of the preceding claims, characterized in that the maximum depth and/or the longitudinal extent of each depression (304) in each pipe-bearing cradle member (4) substantially correspond to one quarter of the respective values of a depression (306) in the pipe-bending saddle member (6).

9. The apparatus according to the preamble of claim 1 or according to any one or more of the preceding claims, characterized in that the pipe-bending saddle member (6) is swingably mounted around a transversal axis which is substantially located at the top side of pipe (T) and/or not much above the horizontal plane passing through the barycenter of the said member (6).

10. The apparatus according to any one or more of the preceding claims, characterized in that between the movable plate (2) of the press and the pipe-bending saddle member (6) two articulation members (9,10) are interposed, which are placed

the one over the other and mate in correspondence of a cylindrical contact surface with its axis of curvature coinciding with the swing axis of the pipe-bending saddle member (6), this latter member being suspended from two side ears (8) which are integral with the upper articulation member (9), and being fastened to said ears so as to be pivotable around the axis of curvature of the said cylindrical contact surface, with a great play transversely to the said axis.

11. The apparatus according to the preamble of claim 1, or according to any one or more of the preceding claims, characterized in that it comprises two superposed sizing dies (14, 16) for eliminating any ovality in the cross-section of bends (TC) provided at least one end of a rectilinear section (TC"), the facingly arranged surfaces (114,116) of the two sizing dies (14,16) consisting each of a part slightly lesser than 180° of a toric surface segment with a radius substantially corresponding to the radius of the bend (TC) of the pipe, so that the two superposed sizing dies (14,16) delimit therebetween an opening having a substantially oval cross-section, the major axis of which is horizontal and parallel to the plane of the pipe bend (TC) and is slightly longer that the diameter of the cross-section of said bend (TC), while the minor axis of the said opening is vertical and is slightly shorter than the diameter of the cross-section of the pipe bend (TC), the said sizing dies (14, 16) having each at one and preferably at both of their extremities, in correspondence of the extrados side, a tangential rectilinear prolongation (214,216) which is reduced to nothing at the intrados side, and serves for the sizing of any rectilinear end sections (TC') of the pipe bend (TC).

12. The apparatus according to the preamble of claim 1, or according to any one or more of the preceding claims, which is applied for the bending pipes being tightly sealed at their ends and being filled with water, characterized by means for generating in the water contained in the pipe an initial pressure, preferably an initial pressure of about 1/4 the pressure that the pipe can withstand, means being also provided for controlling and substantially restoring the initial value of said pressure during the bending of the pipe.

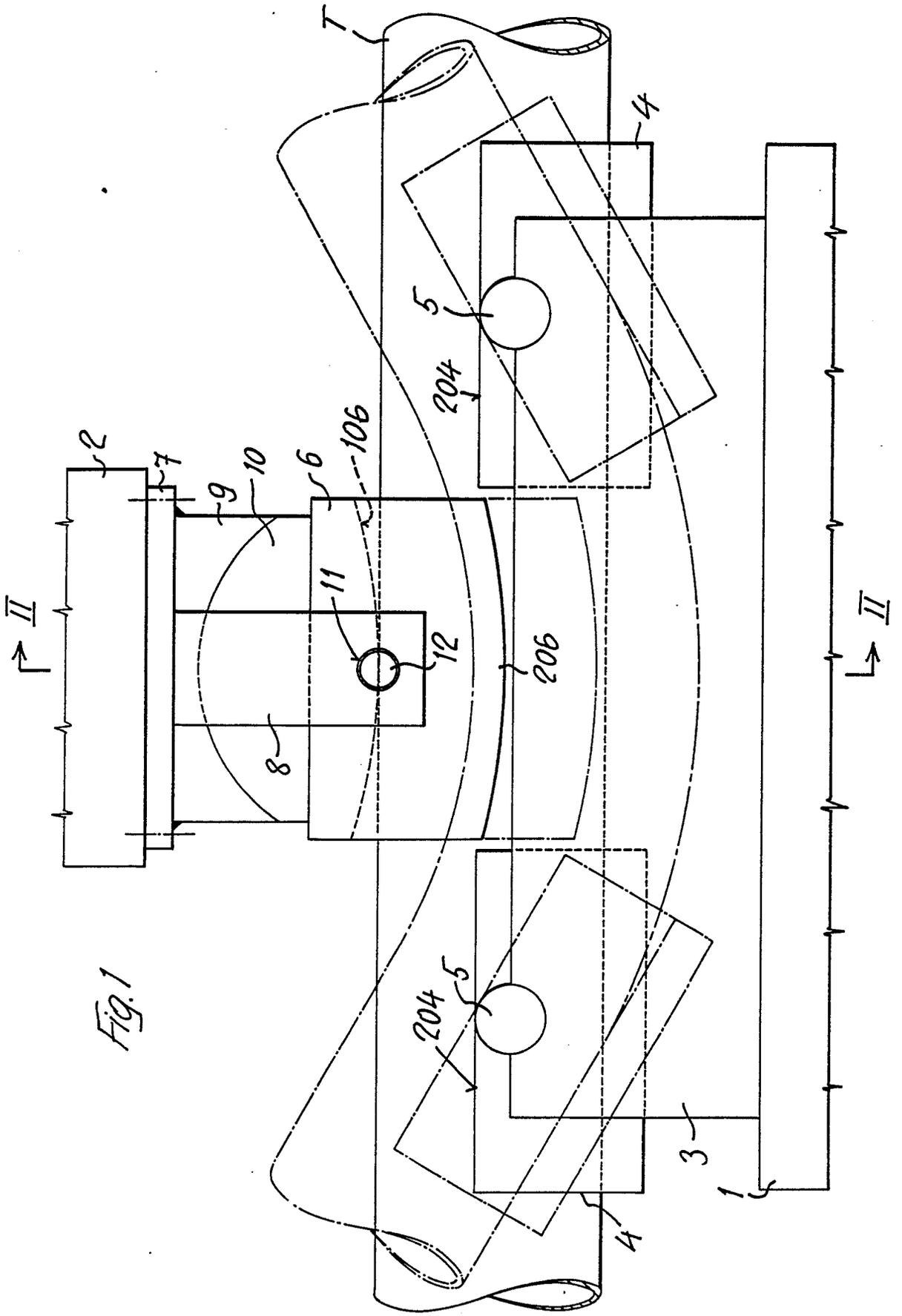


Fig.1

Fig.3

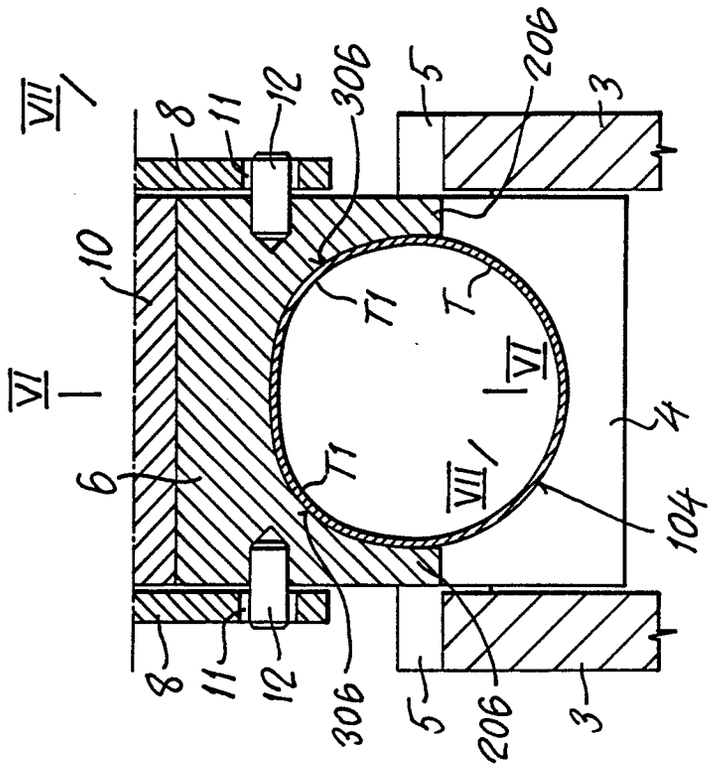
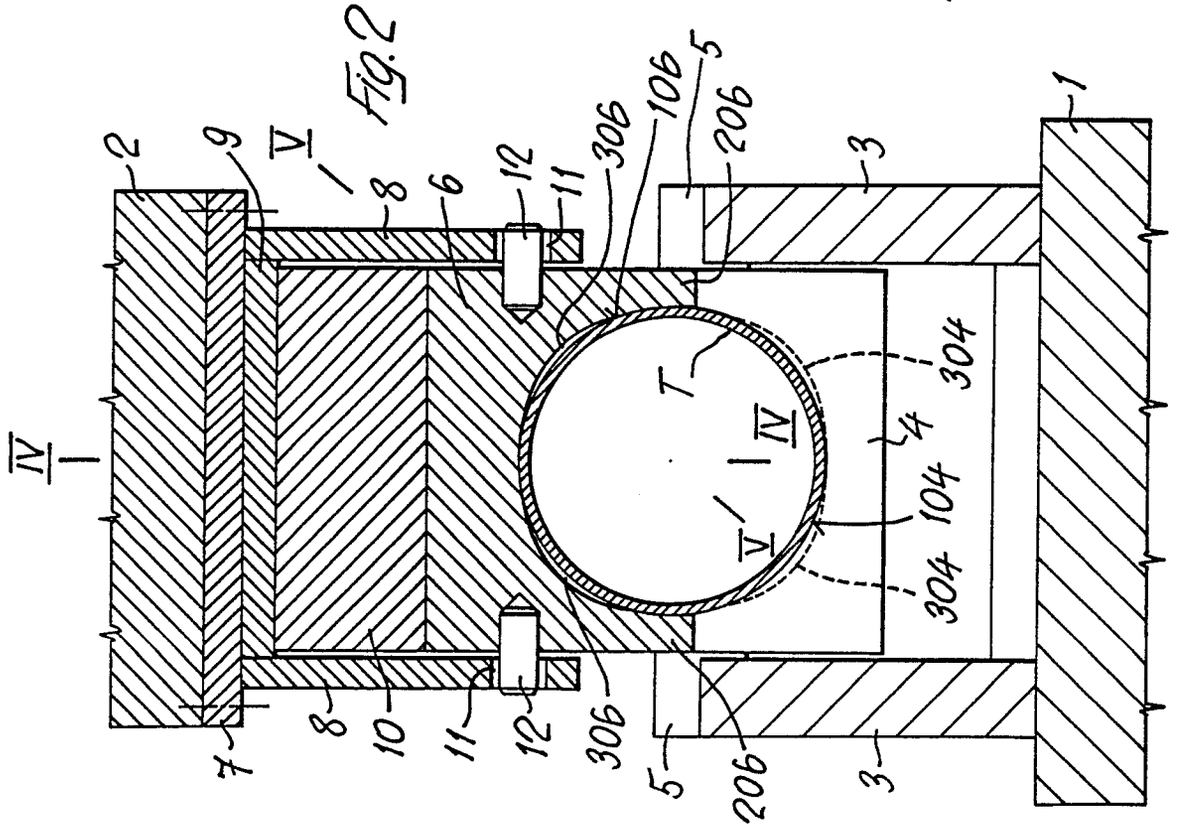

VIII
8
11
12
306
5
206
3
10
T1
T
VI
VII
6
4
104

Fig.2


2
9
V
8
6
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11
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3
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IV
T
304
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10
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Fig.6

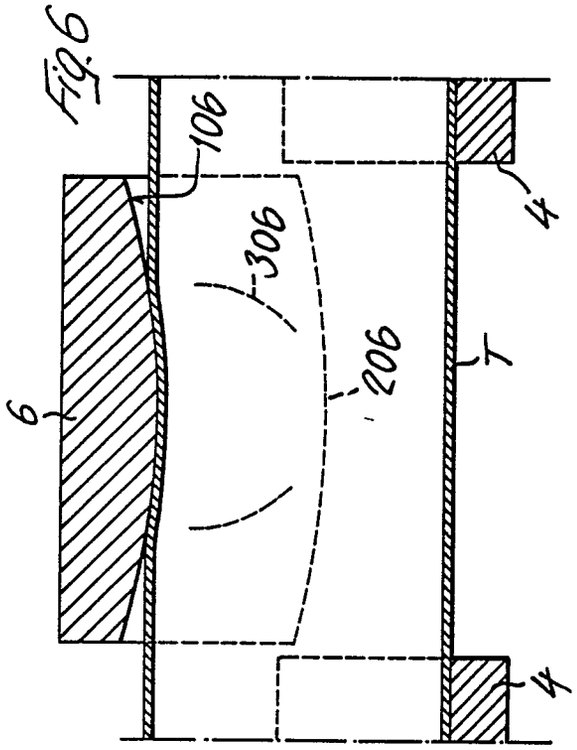


Fig.7

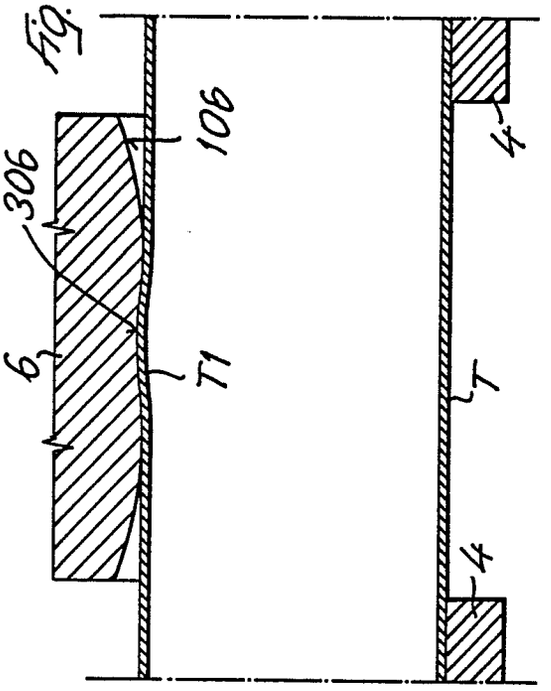


Fig.4

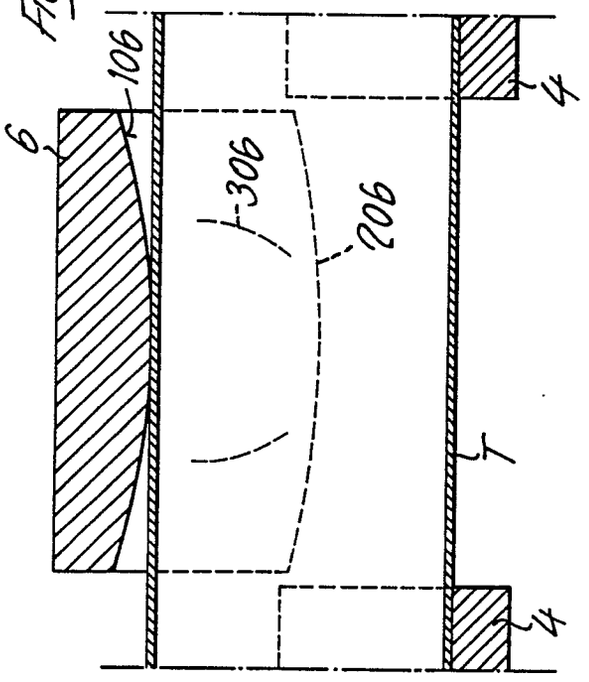


Fig.5

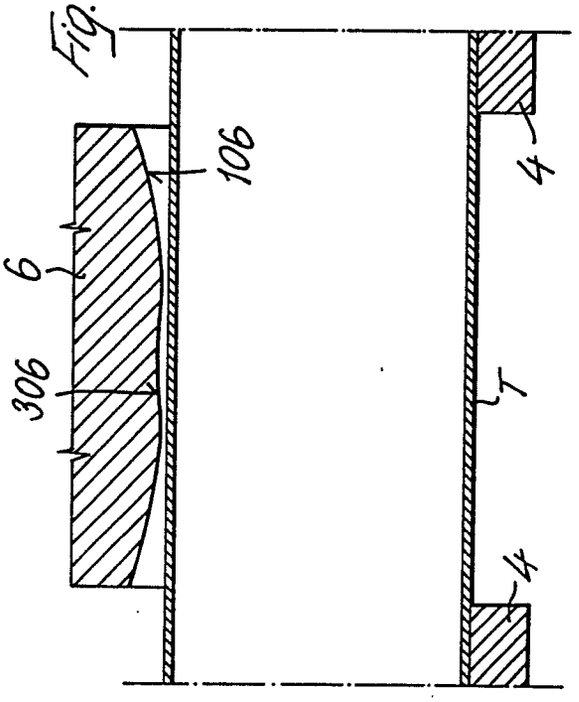


Fig.12

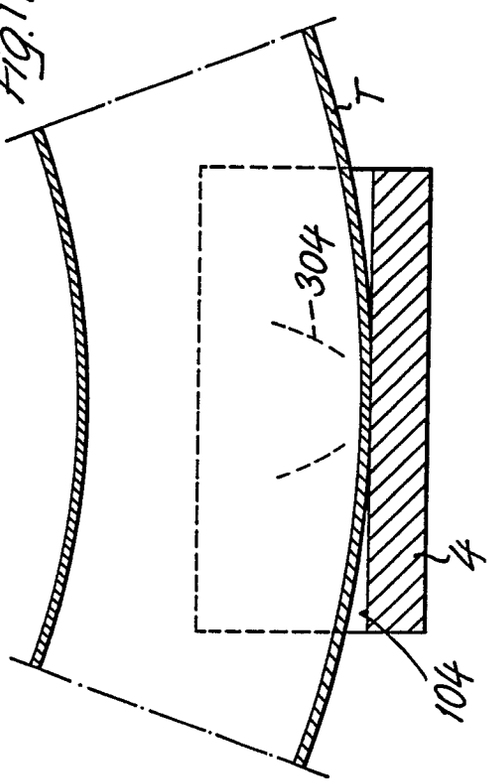


Fig.13

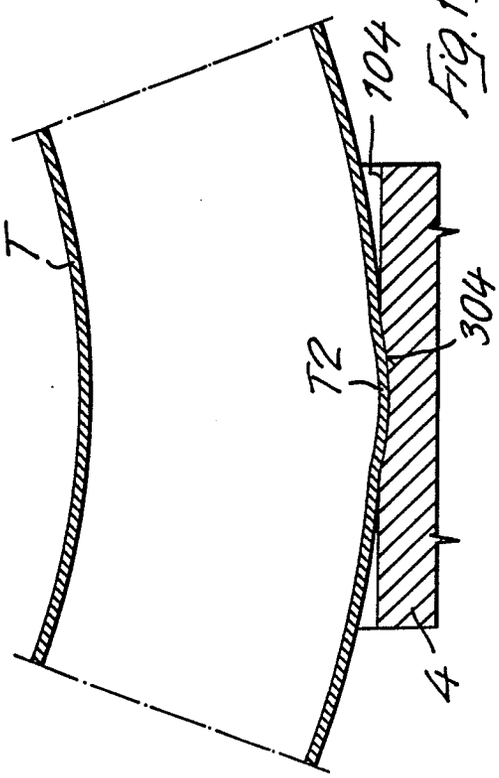


Fig.10

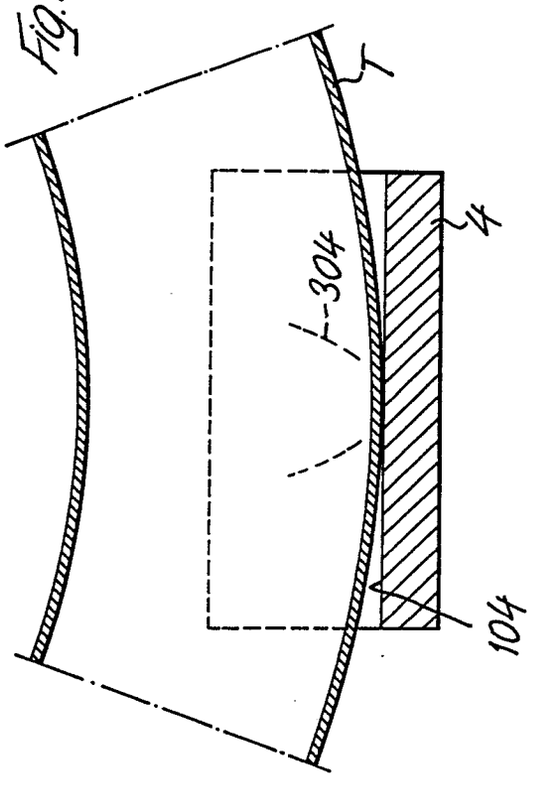
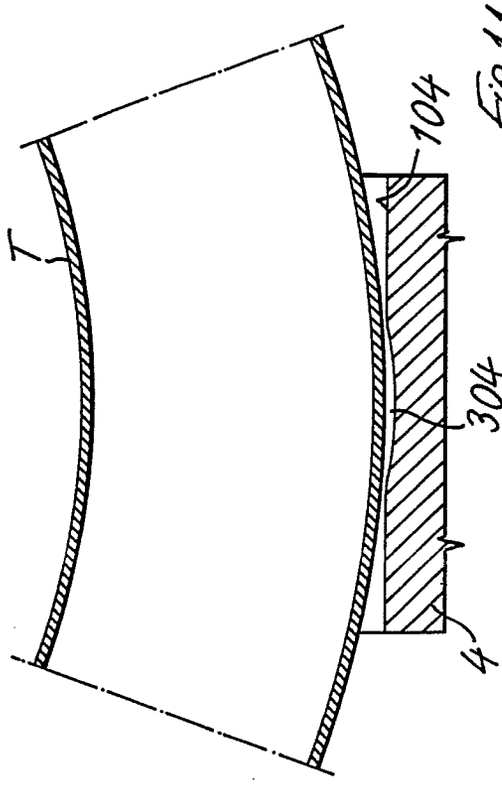


Fig.11



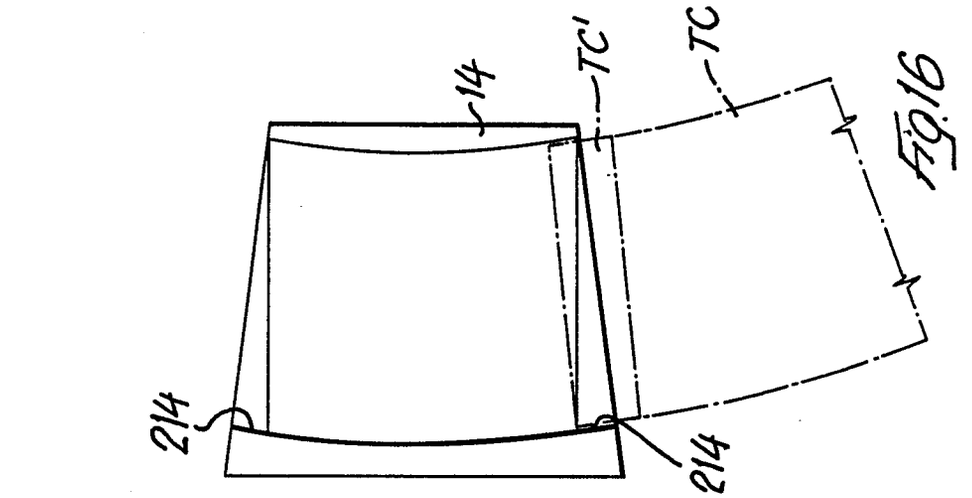


Fig.16

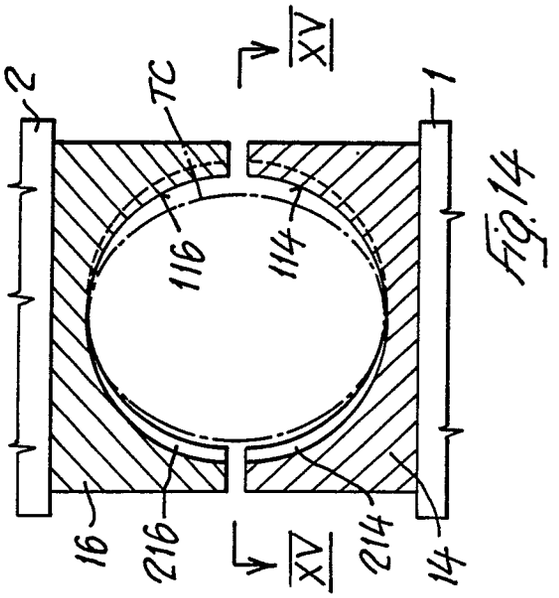


Fig.14

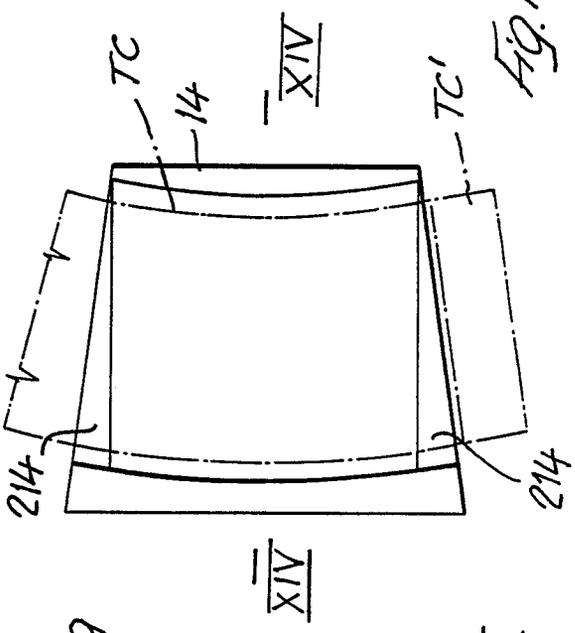


Fig.15

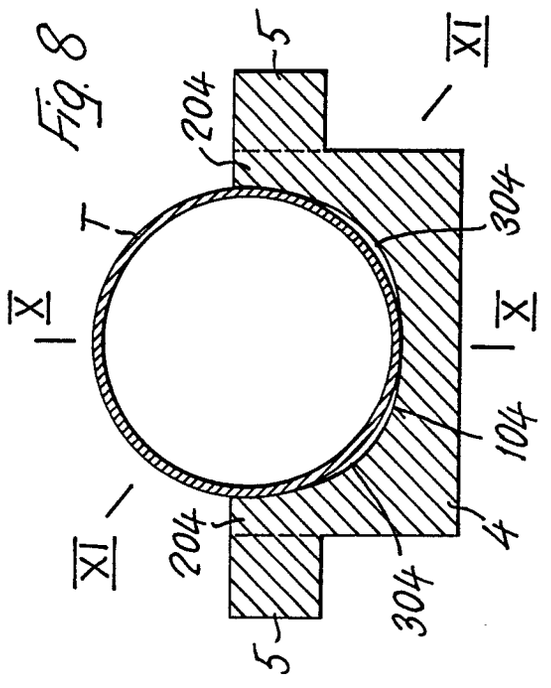


Fig. 8

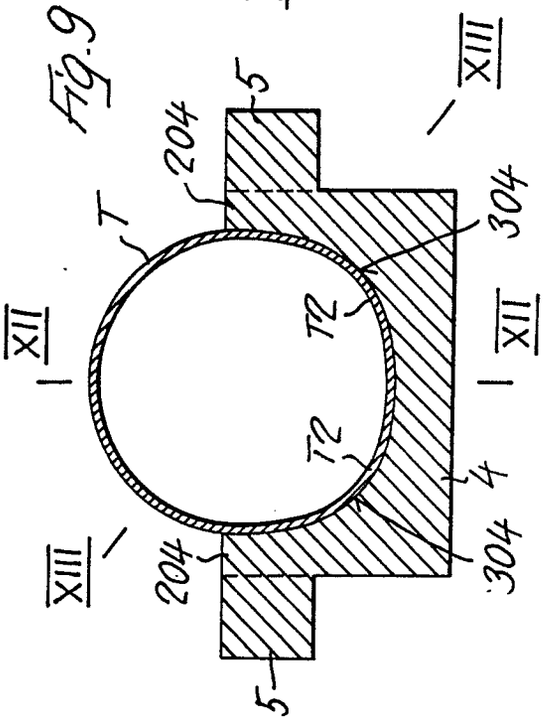


Fig. 9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 87 11 6269

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-1 948 474 (MEYER)	1	B 21 D 7/06
A	GB-A- 690 007 (WELLINGTON TUBE WORKS)	1	
A	FR-A-1 034 267 (HUET)	1	
A	FR-A- 716 470 (JENSEN)	1	
A	FR-A- 889 424 (WESER FLUGZEUGBAU)	1	
A	DE-A-3 218 662 (LEYBOLD-HERAEUS)	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 21 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	04-02-1988	PEETERS L.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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