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METHOD AND DEVICE FOR FORMING A FLANGE
OR A RIM ON AN END OF A STEEL PIPE

20/5 verification

The invention concerns a process according to the precharacterizing portion of Claim 1.

The invention is more specifically concerned with relatively thin-walled pipes, and in particular those with a diameter in the range of approximately 100 to 3000 mm and a wall thicknesses of 1.5 to 6.0 mm. Such pipes are primarily employed for air lines or conduits, ventilation ducts, device housings and the like in ventilation, air conditioning and vacuum engineering, but are however also employed in process engineering.

There are various types of connections for tightly and securely connecting individual pipe segments with each other. These connections have different influences upon the economics and technical characteristics of the pipe system. Until now angled, flat or other profiled flanges have been employed which are manufactured separately and seated upon the pipe end, although advantages of flanges formed directly, that is, unitarily, as one piece on the pipe ends is readily apparent and thus a need for such formed-on flanges and rims exist. The reason that there is a need is due to the lack of an economically justifiable process for forming desirable flange shapes on the ends of, above all, mass-produced pipes. Until now only radially projecting ring rims with relatively low stability or radially projecting flanges, which are provided with holes for screwing, are formed onto the pipes. The latter is employed primarily for ventilator housings. The simple ring can be produced with two rollers using a beading and rim machine. The latter flat flanges with holes are produced in a press process. For this, the pipe body is



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caused to rotate with high rotational speed, which is possible only with very short pipe bodies such as axial ventilator housings. The pipe ends are inserted into a die or negative pattern of the flat flange to be formed. With a pressure lever, on the end of which a roller revolves, pressure is applied against the rapidly rotating pipe end until the material is caused to flow and lie against the negative pattern. The "pressure" process is somewhat similar to the deforming of clay using a potter's wheel. It is also used for the forming of ring flanges on short pipe rings, which are then subsequently seated upon a pipe end and secured thereto. This latter process is described, for example, in DE 196 32857 A1.

This known process is poorly suited to the formation of flanges directly onto pipe ends, since it is almost impossible and besides this dangerous to spin larger pipes with the necessary speed of rotation. Further, the energy required for many types of forming in the case of a wide variety of different pipes is much too high for an economical process. Above all, however, the manufacture of complex flange shapes, such as for example conical flanges or the like, is not possible due to the occurrence therein of cutbacks or inclusions, since in this case the mold or pattern cannot be removed again from the finished flange.

For the manufacture of boxes, frames, profiles, or channels with straight edges the so-called beveling process or pivot bend process is known. For this, a planar sheet metal plate is clamped or tensioned between a fixed lower member and a moveable upper member, and bent using a pivotable bending member. The great advantage therein is that during pivot bending an entire sheet metal segment can be raised, or as the

case may, be curved, without any stretching. The sheet metal materials need flow only in the area of the edge being formed. All the remaining material remains completely unchanged. Thus, the edge profile without stretching and without any particular effort is precisely straight and free of tension. In contrast thereto, in the case of the above-discussed "pressing" the entire material is bent through and thereby unavoidable tensions are introduced. Accordingly, the energy required for pivot bending is substantially less.

The present invention is concerned with providing a process and a device for carrying out this process, in which the one-piece forming of even complicated flanges and rims not only on short pipes, but rather in particular also on long pipe segments, is economically possible.

This task is inventively solved with respect to the process by the characterizing features of Claim 1 and with respect to the device by the characteristics of Claim 5.

The dependent claims are directed primarily to advantageous embodiments of the invention.

It is the basis of the inventive process to employ the advantages of the linear pivot process also in the case of bending at pipe ends. It is thus referred to herein as the circular-pivot-bending process.

The linear pivot bending process can obviously not be applied to round pipes without modification, since herein the edges to be produced are not straight or linear, but rather curved, and these curved edges are to be produced with various radii with as few change-outs in work tools as possible. The invention

accomplishes this by circumferential clamping of the pipe ends from inside, for example by means of a clamping disk. This clamping disk in has a slightly smaller diameter than the pipe inner diameter prior to clamping. Following insertion into the pipe it is widened, that is, the diameter is increased, until it lies with its outer circumference tightly against the inner surface of the pipe wall. The clamping disk or other device used for clamping can be connected with a strong drive axle for imparting the rotational movement. The tight clamping of the pipe end is thus also simultaneously used for the rotation of the pipe, wherein naturally only substantially lower rotational speeds are necessary than in the case of the pressure process. It is necessary that sufficient friction is created between the inner surface of the pipe and the clamping device, for example clamping disk, such that the pipe can be rotated against the resistance of the bending tools.

It is on the other hand basically also possible to allow the pipe and the therewith rigidly connected parts of the device to remain stationary and to rotate the bending tools and the therewith rigidly connected parts about the pipe axis.

The subsequent bending out of a part of the projecting pipe piece to form a rim or flange about the circumference of the pipe piece being modified occurs continuously during the rotation of the pipe. For this, a pivotable bending jaw is preferably employed, which in its rest position lies against the inner side of the pipe end. Its axial breadth should be at least somewhat larger than the segment of the pipe end to be bent. Thereby it is ensured that the segment to be bent is raised as a whole, and not changed in its straight shape. Preferably the contact surface of the bending jaw on the pipe end should have the same radius as the inside of the pipe,

such that the segment of the pipe end to be bent has a large surface area contact surface. In principle however a circular shape of the contact surface of the bending jaw, with a somewhat smaller radius than the inside of the pipe, is also possible. Since the pivotable bending jaws can bend respectively only one partial segment of the pipe circumference, the pipe must be caused to rotate in an even, slow rotation. When the pipe rotates, the bending jaws are slowly pivoted unto the position of the desired bending angle. This inventive process can thus be properly referred to as a circular-pivot-bending process.

In a preferred embodiment of the invention it is possible to additionally apply pressure upon the bending point of the pipe from the outer side of the pipe, preferably using a shaping roller or the like, wherein a tip of the shaping roller cross-section terminates at that location, where the pipe end is to be bent over. Thereby the shape of the bent edge (sharp or round) can be predetermined quite precisely. The remainder of the cross-sectional shape of the shaping roller is determined by the maximal angle of bending of the tip-stretch profile. Since substantial forces are applied upon the shaping roller during the bending process, a precondition for obtaining a clean bent-edge is thus a rigid mounting and positioning of the shaping roller. Preferably, the shaping roller and its mounting are connected to a fixed unit with the likewise fixed and non-rotating bending jaws and the drive means therefore, whereby the stability of the device is substantially increased.

In the case that high precision in the form of the shaped flange or rim is not required, it is possible in the case of relatively small pipe thicknesses, to bend these without using

a shaping roller. In this case the curvature of the pipe wall there suffices to provides sufficient resistance to bending. Sharp bent edges are therein however not possible, and with the increase in the wall thickness the radius of the bent edge continuously increases.

The sequence of steps of the inventive process, as well as preferred embodiments of the inventive device, will now be described in greater detail with reference to the figures. There is shown

Figs. 1-12 the process steps of the inventive process on the basis inventive process, showing the steps for forming a conical flange on the end of a pipe, wherein the device parts shown schematically in side view serve only as an example of the results to be achieved by the process and wherein other or differently shaped designs can be achieved,

Fig. 13 a schematic side view of a first embodiment of the device for carrying out the inventive process in a first processing position,

Fig. 14 a side view of the device according to Fig. 13 in a second processing position,

Fig. 15 a side view of the device according to Fig. 13 in a third processing position,

Fig. 16 a schematic partial section along the line XVI-XVI in Fig. 13,

- Fig. 17 a schematic frontal view of the clamping disk employed in accordance with the process shown in Figs. 13 through 18,
- Fig. 18 a schematic side view of the parts shown in Fig. 17,
- Fig. 19 a schematic side view of a clamping disk, pipe and the parts of the drive device of the inventive device,
- Fig. 20 a sectional side view, shown in reduced scale compared to Fig. 19, of a part of the components shown in Fig. 19,
- Figs. 21 and 22 an axial section or, as the case may be, schematic side view of a different embodiment of the clamping disk,
- Figs. 23 and 24 schematic side views of pipe, clamping disk, bending jaws and shaping rollers with different locations or positions of the bending jaws,
- Figs. 22 through 29 a schematic partial view of a clamping disk and a bending jaw in different bending positions with shaping rollers having differing cross-sections or, as the case may be, without shaping rollers,
- Figs. 30

and 31 partial broken away schematic oblique views of parts of an inventive device with pipe, clamping disk, shaping rollers and bending jaws in the resting or, as the case may be, bending position of the bending jaws,

Fig. 32 a partial oblique view corresponding to Fig. 30 but without pipe and shaping roller,

Figs. 33

through 35 a partial representation according to Fig. 32 with respectively three differing embodiments of the bending jaws, and

Fig. 36 a schematic partial view of an embodiment with two inventive devices working simultaneously on both ends of a pipe.

Figs. 1 through 12 show respectively in schematic partial representation the process steps of the inventive process on one pipe end. Fig. 1 shows, for simplification, a largely broken away partial sectional view through an unprocessed pipe 12 with circular cross-section and with end 10 facing towards the right in Fig. 1. Fig. 2 shows the condition of the pipe end 10 following the first processing step. The pipe end 10 has become a pipe piece to be further bent, which presently is bent outwards approximately 150° about a rounded-off bending edge 14 relative to the axial direction 16 of the pipe 12. Fig. 3 shows the condition of the pipe 12 following a second circular pivot bending process, wherein the second pipe piece 18 bordering the first pipe piece 10 is bent outwards about a sharp angle or edge 20 about a right angle against the axial direction 16. Thereby a conical flange is produced from the

combination of the adjacent lying pipe pieces 10 and 12, which are formed as a single piece on the pipe 12.

The subsequent Figs. 4 through 12 illustrate schematically the manner of operation of a device for carrying out the inventive process. In all figures for comparison purposes the same parts are indicated with the same reference numbers.

Fig. 4 shows a not-yet-clamped pipe 12 close to a clamping disk 22 in its not yet expanded resting state, which clamping disk 22 is rigidly connected to a drive shaft 24 which can be caused to rotate upon application of force. A first bending jaw 26 for bending the first pipe piece 10 about 150° into a position shown in Fig. 2 is represented in Fig. 4 in the starting position prior to the bending process, in partially broken away view. Therein it is to be noted that Figs. 1 through 3, in comparison to Figs. 4 through 12, are mirror images rotated 180° perpendicular to the pipe axis 28. A second bending jaw 30 is rotated by 180° about the pipe axis 28 relative to the first bending jaw 26 shown likewise in its resting position prior to the bending process and shown partially broken away. The second bending jaw 30 serves for bending or introducing the angle into the second pipe piece 18 90° relative to the axial direction 16 of the position shown in Fig. 3. In Fig. 4 there are further shown a first shaping roller 32 and a second bending roller 34 likewise shown in their resting positions distanced from the pipe 12. The first bending roller has a cross-section with rounded off tip 36, of which the flanks 40 encompass an angle of 30°. Rotated by 180° about the pipe axis 28 is the second bend roller 34 provided removed from the pipe 12 into its resting position, of which the cross-section has a sharp angle 38 and of which the flanks

42 define a right angle. The shown condition of the device corresponds to the starting position of the process.

Fig. 5 shows a subsequent process stage, in which the clamping disk 22 is introduced into the pipe 12 and is extended to its spread position according to arrows 44 against the inner surface of the pipe 12 from the inside. Together with the clamping disk 22, the bending jaws 26 and 30 are introduced into the pipe end, but are however both still in the rest position with respect to their pivoting for bending open the pipe end. Likewise, both shaping rollers 32 and 34 are still located in their rest position just as in Fig. 4. At the same time the drive shaft 24 is brought to rotate in the direction of arrow 46, so that the clamping disk 22 rotates together with the pipe 12, while the bending jaws 26 and 30 as well as shaping rollers 32 and 34 do not rotate about pipe axis 28. The friction resistance between the cylindrical outer surface 48 of the clamping disk and the inner surface of the pipe 12 is so large, due to the clamping of the clamping disk 22 in its working position according to Fig. 5, that the pipe 12 rotates along with the clamping disk even overcoming large resistance.

The next process step of the shaping process is shown in Fig. 6, wherein the first shaping roller 32 is moved to its work position lying solidly against the outer side of the pipe 12, having been moved along the displacement axis 52 according to arrow 50.

According to Fig. 7, next the first bending jaw 26 is bent about an angle of 150° out of its resting position (Fig. 6) into its work position (Fig. 7), said pivoting about an axis perpendicular to the plane of the drawing, whereby the first

pipe piece 10 projecting beyond the clamping disk 22 is bent outwards about 150° about the first shaping roller 32. Since drive shaft 24 and clamping disk 22 rotate simultaneously together with the clamped pipe 12 about the rotation axis 28, after only a few rotations of these parts about the pipe axis 28 the pipe piece 10 is bent outwards about 150° from the pipe 12 about the rounded off edge 14. By the rotatable mounting of the shaping roller 32 the frictional resistance of the pipe piece 10 occurring at the location of bending is substantially reduced.

Subsequently, according to Fig. 8, the first shaping roller 32 is withdrawn along the displacement axis 52, according to arrow 56, out of the work position and back into its rest position away from the pipe 12, and at the same time the first bending jaw 26 is pivoted back out of its work position according to arrow 58, back into its rest position.

In the next processing step according to Fig. 9 the second shaping roller is moved out of its resting position along the displacement axis 60 according to arrow 62 into the working position in solid contact against the outer side of the pipe 12. All of these process steps occur while the drive shaft 24, the clamping disk 22 and the pipe 12 rotate about the rotation axis 28 and the first bending jaw 26, second bending jaw 30 as well as the two shaping rollers 32 and 34 remain at rest. Preferably the rotating parts and the non-rotating parts are assembled respectively to stable work units. Within the non-rotating work tool unit, naturally the moveability of the individual parts to and from the rest position and the drive positions must be made possible. On the other hand, it is naturally also possible to allow the drive shaft 24,

clamping disk 22 and pipe 12 comprising work unit to remain at rest and the other work unit comprised of the bending jaws and the shaping rollers to rotate about the pipe axis 28.

In the subsequent processing step according to Fig. 10 the second bending jaw 30 is pivoted according to arrow 64 out of its resting position into the working position, whereby the second pipe piece 18 projecting beyond the clamping disk 22 is bent outwards with a sharp bent angle 20 of 90° corresponding to the cross-section of the second shaping roller 34. The complete bending of the second pipe piece 18 away from the pipe 12 towards outwards is accomplished after the rotating parts 24, 22 and 12 have carried out a few rotations about the pipe axis 28.

In the next processing step according to Fig. 11 the second shaping roller 34 is retracted from the pipe 12 along the displacement axis 60 according to arrow 66 and the second bending jaw 30 is pivoted back to its resting position along arrow 68.

Therewith the path is cleared for the return movement of all parts back to the starting position as shown in Fig. 4. Thus, at the end of the process, all parts in accordance with Fig. 12 are again located in the starting position according to Fig. 4, and the result of the inventive work process is the one-piece or unitary forming onto the end of the pipe 12 a flange comprising the pipe segments 10 and 18.

In Figs. 13 through 16 a preferred embodiment of the device for carrying out the inventive process is shown schematically with the parts necessary for carrying out the invention. For improved overview, individual parts of the pieces are omitted,

for example from the pipe 12, the clamping disk 22, the drive shaft 24 and the bending jaws 26. It is further to be noted that in the illustrated device only one bending jaw 26 and shaping roller 32 is shown, which is suitable for a single bending process of a projecting pipe piece 10. Obviously additional bending jaws and shaping rollers can be provided about the rotation axis 28 outside of the plane of the drawing. Their detailed description can however be omitted, since they function in the same manner as the parts shown in Figs. 13 through 16. If an individual work unit comprised of bending jaw and shaping rollers is employed for each bent edge, then this has the advantage, that for the individual processing steps no work tools need be changed. It is necessary particularly in mass production that the processing units can come into engagement sequentially without interference.

Each of the work units including one bending jaw 26 and one shaping roller 32 is respectively mounted on a mobile sled 70, wherein multiple sleds can be mounted radially on a base plate 72. In this manner the individual processing units can be easily adapted to the respective diameters of the pipe 12 to be processed. Each sled 70 can be moved along two parallel sled guides 71 according to the double arrow 74 via a threaded spindle 78 rotated by a rotational drive 76.

Two parallel side plates 80 (Fig. 16) are provided parallel and spaced apart from each other on the sled 70, which are connected rigidly with each other in the manner of a frame by intermediate plates 82. Between the two side plates 80 lying slidably on the inner sides of the side plates 80 is a broad, somewhat circular or cylindrically shaped sector plate 84, on which by means of screws 86 the bending jaws 26 are secured.

The sector plate 84 forms, parallel to the side plates 80, as can be seen in the cross-section of Fig. 13, an incomplete sector of a circle, of which the middle segment lying opposite the circular arc 88 is missing, since the center of the arc sector must remain free for the bending process of the pipe piece 10. The angles 90 and 92 connecting to the outside of the circular arc 88 intersect outside the center point of the arc 88. The bending jaws 26 are secured to the flat surface 92 of the sector plate 84 by screws 86.

It is to be noted that in Fig. 16, in comparison to Figs. 13 through 15, only those parts necessary for the pivoting of the bending jaws 26 is shown.

The guidance of the sector plate 84 during the necessary pivoting together with the bending jaws 26 occurs by guide rollers 94, which run in arc-shaped guide grooves 96 in the side plates 80. The guide rollers 94 project on both sides beyond the sides of the sector plate 84 and are respectively guided in a guide groove 96. In the cylindrical circumference surface of the sector plate 84 corresponding to the arc 88 of the cross-section of the sector plate 84 there is provided gear teeth 98, which are in engagement with a drive pinion 102 driven by rotational drive 100. The sector plate 84 can therewith be pivoted out of the rest position of the bending jaws 26 according to Figs. 13 and 14 into the work position of the bending jaws 26 corresponding to the position shown in Fig. 15. The pivot angle of the sector plate 84 can therein be freely widely selected and corresponds in the present case to the angle between the two flanks of the cross-section of the shaping roller 32.

From Figs. 13 through 15 it can further be seen, that the shaping roller 32 is mounted rotatable about its central axis 105 in a fork shaped mounting block 104, which for its part is moveable along double arrow 50, 56 out of its resting position according to Fig. 13 into the working position according to Fig. 14. For moving the mounting block 104 a threaded spindle 106 is provided driven by a drive motor 108. It is important that the mounting block with shaping roller is secured in work position rigidly and capable of accepting high loads, according to Fig. 14 and 15, with the working unit comprised of bending jaws, shaping rollers and associated parts.

In the work condition according Figs. 13 through 15 the clamping disk 22 is introduced into the pipe end by movement of the pipe 12, while it is still in its resting state as described above. Subsequently, the clamping disk 22 is, as described in greater detail below, spread to its work position and now cylindrically clamps pipe 12 from the inside. From this there results a pipe piece 10 projecting beyond the cylindrical outer surface of the clamping disk 22, which is to be subsequently further bent in accordance with the following bending process. Prior to the sliding on of the pipe 12 upon the clamping disk 22 the working unit comprised of bending jaws, shaping roller and associated parts and drive mechanism is so adjusted by means of movement of the sled 70 along the double arrow 78 with respect to the fixed base plate 72, that it is adapted to the respective diameter of the pipe 12. In Figs. 13 through 15 such a working unit is shown. Additional work units can be mounted on the base plate 72 with mostly doubled sled guides 71 radiating outward from pipe axis 28, so that they can be sequentially brought to bear upon the pipe 12, in order to respectively deform one pipe piece to a part of a complicated flange. For each sled 70 there is therein

provided one rotation drive 76 with threaded spindle 78, a threaded follower 110 running upon the threaded spindle 78 and a mounting means 112 connecting this with the sled 70, wherein the mount 112 can be displaced in a slit 114 of the base plate 72 running radially to the pipe axis 28.

In the following the design and manner of operation of a first embodiment of the clamping disk 22 is described in greater detail on the basis of Figs. 17 through 20. Since the task of the clamping disk 22 is comprised therein, to prevent the deformation or change in form of the pipe inner side, it is important that a substantially complete contacting of the inner cylindrical circumference 116 of the pipe wall occurs. The shown preferred embodiment of the clamping disk is thus subdivided into multiple, in the illustrated embodiment six, sectors 118, which in a subsequently in greater detail described manner can be spread from their inner rest position shown in the left half of Figs. 17 and 18 into an outward work position in tensioned manner on the inside of the pipe 12 shown in the right half of Figs. 17 and 18 via an axial drive, for example, a hydraulic cylinder 124 driven pull rod 122. The number of the sectors is as large as desired. Therein a larger number of sectors has the advantage, that the gap 126 between the sectors 118, which result following spreading of the clamping disk 22, becomes smaller, and it covers the wall of the pipe 12, even when the pipe is very thin walled, without changing the shape of the pipe. The sectors 118 are arc sectors and end, a distance from the pipe axis 28, in a cylindrical-sectional inner surface 128. The radial breadth of the sectors 118 can be freely selected, in order to conform the diameter of the clamp 22 to the respective diameters of the pipe 12. The adaptation or conforming can occur by the simple exchange of sectors 118. The inner surfaces 128 of

sectors 118 lie on the cylindrical outer surfaces 130 of cylindrical shaped clamp jaws 132. The sectors 118 are secured by radial screws 142 to the clamp jaws 132. The clamp jaws 132 have a slanted inner face surface 134 with respect to the pipe axis 28, which respectively lie against a face 136 of the widening end 120 of the pull rod 122. In the illustrated embodiment the widening end 120 has a hexagonal cross-section, so that one side surface is provided for each of the six clamp jaws 132.

The main drive shaft 24 for rotating the clamping disk and the pipe 12 is centrally axially bored through, and the pull rod 122 extends through this bore. By actuation of the hydraulic cylinder 124 the pull rod 122 can be moved from the rest position 138 shown in the lower half of Fig. 19 to the wider or working position 140 shown in the upper half of Fig. 19. Thereby the sectors 118 are moved out of the rest position shown in the left half of Figs. 17 and 18 with close spacing from the inner surface of the pipe 12 into the working position shown in the right half of Figs. 17 and 18 lying with tension against the inner surface of the pipe 12. This movement is caused by the appropriate displacement of the clamp jaws 132.

The drive shaft 24 extends through a cutout 144 of the base plate 72 of the overall device and is mounted rotatably in a manner known to those of ordinary skill and is caused to rotate by a drive motor 146 with hollow shaft drive 148. The opposite end of the drive shaft 24 exhibits a mushroom shaped widening 150 with a planar end face 152, upon which the planar slide surfaces 154 of the clamping jaws 132 lie radially slideable. The slide surfaces 156 of the clamp jaws lying opposite to the slide surface 154 lie slidingly against the

inner surface of a counter slide 158, which is secured by screws 160 to the mushroom shaped widening 150. The screws 160 pass through the mentioned holes 169 in the clamp jaws 132, which allow the necessary slight radial displacement of the clamp jaws 132.

The screws 160 are surrounded by distance casing 162, which together with the holes 169 of the clamp jaws 132 allows a linear radial guidance of the clamp jaws 132.

The hydraulic cylinder 124 for operating the pull rod 122 is supported axially on the drive means 148 for the hollow drive shaft. The already sufficiently large force of the hydraulic cylinder 124 is again amplified as desired by the slanting of the widening end 120 of the pull rod 122 relative to the pipe axis 28. In this manner the necessary amount of clamping force is produced, which produces a sufficient frictional connection of the clamping disk 22 to the pipe wall, in order to rotate the pipe against the resistance of the bending tools (bending jaws 26 and shaping roller 32). Of course, the slanting of the widening end 120 can be reversed, that is, be reduced towards the right in Fig. 19, in the case that an oppositely operated pressure rod is employed.

The return of the clamp jaws 132 during de-tensioning of the clamping disk 122 back into its rest position can occur in simple manner by not shown springs, which are incorporated in the individual clamp jaws, or by an endless pull-spring running about the outer circumference of the clamp jaws, likewise not shown, which would be incorporated in a likewise not shown groove.

Alternatively, the drive shaft 24 can, in the embodiment shown in Fig. 20, be mounted via a ball rotation ring 164, of which the outer side (or even the inner side) is provided with gear teeth 166. The drive motor 146 in this case is seated beside the ball rotation ring 164. The pinion 168 of its drive shaft 170 engages in the teeth of the ball rotation ring 164 and brings about a driving of the drive shaft 24. Naturally, other mounting types well known to those of ordinary skill can be considered.

An alternative advantageous embodiment of the clamping disk referred to in general with 22 and the drive therefore is shown in Figs. 21 and 22. In this embodiment the clamping disk 22 exhibits clamp ring 174 with cylindrical circumference surface 116 and conical inner surface 176, which clamp ring 174 is divided by a circumferentially running slanted slit 172. Against the conical inner surface 176 lies the outer surface 178 of the clamp plate 180 having the same conical shape, which by means of bolts 182 and nuts 184 is secured to the widened end 186 of the pull rod 122. By displacement of the pull rod 122 in the sense of the double arrow 188 between the detensioned resting position shown in the upper half of Figs. 21 and 22 and the tensioned work position shown in the lower halves of Figs. 21 and 22 the clamp ring 174 allows itself to be tensioned or as the case may be detensioned with development any desired amount of force. A slit of the clamping ring 174 running in the axial direction parallel to the pipe axis 128 would also be possible. The slanted arrangement of the slit 172 however prevents, that the gap opening during clamping causes a gap in the widening of the pipe wall causing a deformation or wrinkle in this location. The return of the clamp 174 during detensioning occurs in this case by the spring effect of the clamp ring itself. As

necessary the spring effect can be amplified by a not shown circumscribing endless pull spring in a groove of the clamp ring 174.

It is apparent that the sheet metal thickness of the pipe 12, the desired flange shape, or a material change of the clamping disk 22 has no influence on the desired flange shape. The pipe end 10, 18 is respectively slid so far over the clamping disk 22, until sufficient material becomes available for the forming of the designed flange.

In the subsequent Figs. 23 through 35 advantageous embodiments of bending jaws 26 and shaping rollers 32 are shown together with a segment of the pipe 12 to be deformed as well as a part of the spread clamping disk 22. Figs. 23 and 24 show a first embodiment of these parts, wherein in the above described manner the shaping rollers 32 are moved into a working position pressed against the outer side of the pipe 12. The bending jaw 26 pivotable in the above described manner lies in its rest position against the inner side of the pipe piece 10 to be bent and extending beyond the clamping disk 22, whereupon the pipe wall is clamped and held between the clamping disk 22 and shaping roller 32. The tip 36 of the cross-section of the shaping roller 32 ends at the point, where the projecting pipe piece 10 is to be bent. By the shape of the shaping roller 32 the shape of the bending edge on the pipe end can be determined.

The pivotable bending jaw 26 lies on its resting position according to Fig. 23 against the inner side of the pipe piece 10. Its axial breadth is at least somewhat larger than the axial length of the pipe piece 10 to be bent. Thereby it is ensured that the pipe piece to be bent is lifted as a whole

and thus is not changed in its linear shape. Likewise the cylindrical contact surface 190 of the bending jaw 26 should have the same radius at the pipe end as the pipe inner side, so that the pipe piece 10 to be bent has a large surface area contact surface.

Since the pivotable bending jaw 26 can only bend a partial area of the pipe circumference, the pipe 12 must be caused to rotate in an even, slow rotation. If the pipe 12 rotates, then the bending jaw 26 is pivoted slowly to the desired bending angle (Fig. 24). The bending jaw 26 remains in this work position until the end of its last complete rotation of the pipe 12 about the pipe axis 28, whereupon the bending out of the pipe piece 10 is ended.

So that the pipe 12 following the forming of the flange or rim can be removed from the clamping disk 22, the shaping roller 32 with its mounting lock 104 must be withdrawn to a rest position sufficiently far from the pipe. For a further circular bending process now a further processing unit, which is adjusted to a further bending angle, is brought to action in the above-described manner.

For the easier introduction of the clamping disk 22 into the pipe end 10 the introduction side of its cylindrical outer surface 48 can exhibit a conical narrowing 192.

In Figs. 25 through 28 various embodiments of the shaping roller 32 or, as the case may be, 34 are shown with narrow tip 36 or, as the case may be, right-angled tip 38. The tip 36 serves for bending of the pipe piece 10 about 150°, while the tip 38 serves for bending the pipe piece 10 about 90°.

In Fig. 29 there is schematically shown how, absent precise demands on the forming precision of the formed flange or rim, one can entirely bend without shaping rollers and only with clamping disk 22 and bending jaws 26.

Figs. 30 and 31 show an embodiment of the bending jaw 26 with almost half cylindrical contact surface 190 in resting position (Fig. 30) and work position (Fig. 31).

Fig. 32 shows in somewhat enlarged scale a partial representation of a somewhat differently shaped bending jaw 26 with flatter cylindrical contact surface 190, which is secured by screws 86 to a only partially shown, pivotable sector plate 84. The contact surface 190 lies with all its frictional force against the inner wall of the not shown pipe. In the following figures the individual advantageous embodiments of a similar bending jaw 26 as in Fig. 32, however with less friction between contact surface 190 and pipe inner wall is shown. It is actually ideal, when the working radius of the contact surface 190 of the bending jaw 26 corresponds to the pipe inner diameter. Without serious disadvantage the radius of the contact surface 190 can however be smaller than the pipe inner radius. Thereby it is possible, with the same bending jaws to change through multiple pipe diameters. In the main friction location in the center of the contact surface 190 there can, for a substantial reduction of friction and drive, in the body of the bending jaw 26 a roller mounted support roller 194 be introduced, of which the rotation axis 196 runs parallel to the contact surface 190 and of which the circumference surface 198 projects slightly beyond the contact surface 190. The pipe piece 10 to be bent then lies in this

area free of friction on the circumference surface 198 of the support roller 194.

The bending jaws 26 can be further improved by introduction of a whole series or chain of support rollers 194 in the contact surface 190 in the same manner as the support roller 194 according to Fig. 34. In the shown embodiment according to Fig. 34 five such support rollers 194 are provided in a chain. The remaining part of the contact surface 190 between the support rollers 194 prevents a drooping of the wall of the pipe 12 between the support rollers 194 which would result in wave formation and stretching or distortion.

A minimal friction between bending jaws 26 and the inner wall of the pipe 12 is achieved when the bending jaws 26 according to Fig. 35 are fully cylindrical with cylindrical contact surfaces 190, wherein the entire cylindrical bending jaws 26 are mounted rotatable about a drive shaft 200 on the sector plate 84. Although in this manner the least amount of friction is produced, since however in most cases insufficient space is available for a large diameter of the cylindrical shaped bending jaws 26, one must accept the disadvantages in the deformation formation as well as stretching of the pipe wall. These disadvantages are lesser in the case of greater pipe wall thicknesses so that in the case of bending thicknesses above 1.5 mm such a "bending roller" can be employed in the place of bending jaw 26.

The total inventive device for carrying out of the inventive circular pivot bending process can selectively be carried out both in the horizontal as well as in the vertical pipe axis 28, wherein there is preferred on the one hand straight pipes and on the other hand shorter pipe-shaped pieces to be shaped.

For a rational preparation of straight pipes with flanges 10, 18 formed on both ends using the inventive circular bending process, devices 204 of the described type are seated upon a common rail system designated overall with 202 mounted to be slidable according to the double arrow 206, so that the clamping disk 22 and bending jaws 26 indicated schematically lie on opposite ends. Each device 204 can be moved using an independent driven threaded spindle 208 in the rail system 202.

For introduction of the pipe 12 the devices 204 are moved apart from each other, until the pipe length of the pipe 12 fits between the clamping disk 22. After that both devices 204 are moved towards each other, the clamping disks 22 are introduced into the pipe ends until reaching an abutment, which is set to the processing length of the pipe. Both clamping disks 22 are clamped in the processing position, and processing occurs subsequently simultaneously on both sides. For removal of the pipe 12 the devices 204 must again be moved apart from each other.

Reference Number List

10	first projecting pipe piece
12	pipe
14	bending edge
16	axial direction of the pipe
18	second projecting pipe piece
20	sharp bending edge
22	clamping disk
24	drive shaft
26	first bending jaw
28	pipe axis
30	second bending jaw
32	first shaping roller
34	second shaping roller
36	tip of first shaping roller
38	tip of second shaping roller
40	flanks, first shaping roller
42	flanks, second shaping roller
44	arrow showing spreading direction
46	arrow, drive shaft
48	outer surface
50	arrow
52	displacement axis
54	arrow
56	arrow
58	arrow
60	displacement axis
62	arrow
64	arrow
66	arrow
68	arrow
70	sled

71 sled guide
72 base plate
74 double arrow
76 rotation drive
78 threaded spindle
80 side plate
82 intermediate plates
84 sector plate
86 screws
88 arc
90 straight
92 straight
94 guide rollers
96 guide rollers
98 gears
100 rotation drive
102 drive pinion
104 mounting block
105 central axis
106 threaded spindle
108 drive motor
110 spindle follower
112 holder
114 slit
116 circumference
118 sector
120 widening end
122 pull rod
124 hydraulic cylinder
126 gap
128 inner surface
130 outer surface
132 clamp jaws

134 end face
136 end face
138 rest position
140 work position
142 screw
144 segment
146 drive motor
148 hollow shaft internal gear
150 widening
152 end face
154 slide surface
156 slide surface
158 counter disk
160 screws
162 distance housing
164 ball rotation mount
166 gear
168 pinion
169 holds
170 drive shaft
172 slit
174 clamping ring
176 inner surface
178 outer surface
180 clamping plate
182 bolt
184 nut
186 connecting end
188 double arrow
190 contact surface
192 slanting
194 support roller
196 rotation axis

198 circumference
200 drive shaft
202 rail system
204 circular rivet bending device
206 double arrow
208 threaded spindle

Patent Claims:

1. Process for the unitary forming in of a flange or rim on an end of a pipe of sheet metal, thereby characterized, that the pipe (12) is subject to annular clamping tension along its internal surface near one of it's ends, wherein a segment of the pipe projects beyond the annularly clamped and tensioned internal surface, wherein at least one axial partial segment of the projecting pipe piece is bent outwards by the exercise of pressure against a segment of the circumference of it's inner surface, until achieving a desired angle of bend outwards away from the pipe axis, and that by the rotation of the pipe relative to said circumference of it's inner surface, in which the bending takes place, the desired angle of bend is imparted to the entire pipe piece or partial segment thereof.
2. Process according to claim 1, thereby characterized, that a bending out of the pipe outer side at a location within the segment of the circumference in which the bending is taking place is prevented by exercising force from outside upon the pipe at the location of bending.
3. Process according to claim 2, thereby characterized, that the exercise of pressure upon the location of bending occurs with reduced friction on the pipe rotating relative the location of bending.
4. Process according to one of the preceding claims, thereby characterized, that for forming a multiple-bent

flange, the process is repeated multiple times sequentially.

5. Device for carrying out a process according to one of the preceding claims, characterized by a clamping disk (22) with cylindrical circumference surface (48) introducible into the inside of the pipe (12), which is adjustable between a resting setting spaced closely to the inner surface of the pipe (12) and a spread setting with frictional engagement against the inner circumference of the pipe, a drive shaft (24) mounted fixed against rotation relative to the clamping disk (22), a drive motor (146) for rotating the drive shaft (24) against great resistance, and a bending jaw (26, 30) pivotable between a rest position lying against the inner side of the pipe to be bent (10, 18) and a work position representing the finished bent pipe piece (10, 18) with an at least partially cylindrical contact surface (190) for contact with the pipe piece (10, 18), wherein the cylindrical diameter of the contact surface (190) is smaller than or equal to the diameter of the pipe piece to be bent (10, 18) and the cylinder height of the contact surface (190) is greater than the length of the pipe piece.
6. Device according to claim 5, characterized by a shaping roller (32, 34) moveable between a rest position spaced from the pipe (12) and a working position lying against the outer surface of the pipe (12) at the bending edge (16, 20) of the pipe piece (10, 18) to be bent, which shaping roller (32, 34) is mounted rotatably on a mounting block (104), which with the mounting block

(104) is held fixed against rotation relative to the pipe axis (28).

7. Device according to claim 5 or 6, thereby characterized, that the clamping disk (22) is comprised of multiple sectors (118), which can be adjusted between a resting setting and a spread setting of the clamping disk (22) by a spreading device (120, 122, 124).
8. Device according to claim 7, thereby characterized, that the spreading device is comprised of a widening end (120) of a pull rod (122), which with slanted side surfaces (136) widening relative to the pipe axis (28) cooperate with the inner ends of the sectors (118) of the clamping jaws (132), wherein the pull rod (122) is connected to a pull means (124).
9. Device according to claim 8, characterized by a spring biased reset device for returning the sectors (118) from the work setting to the rest setting.
10. Device according to claim 5 or 6, thereby characterized, that the clamp disk (22) is comprised of an externally cylindrical and inner conical slitted clamping ring (174) and a clamping plate (180) with conical outer surface lying against the inner conical inner surface (176) of the clamping ring (174), which is associated with a pull rod (122) with pull drive means (124).
11. Device according to claim 10, thereby characterized, that the slit (172) of the clamping ring (174) is

slanted relative to the longitudinal axis (28) of the clamping ring.

12. Device according to one of claims 5 to 11, thereby characterized, that at one or more locations of the support surface (190) one or more support rollers (194) is introduced in a recess of the contact surface (190) of the bending jaw (26), which projects slightly beyond the contact surface (190) and is mounted rotatable about a shaft (196) parallel to the cylinder axis of the contact surface (190).
13. Device according to claim 12, thereby characterized, that multiple parallel support rollers (194) are seated in recesses in the contact surface (190) of the bending jaw (26) spaced apart from each other.
14. Device according to one of claims 5 to 11, thereby characterized, that the bending jaws (26) is a fully cylindrical bending roller, which is mounted rotatably about a rotation shaft (200) extending in the cylinder axis, wherein it's rotation mount is pivotable between work and rest positions together with the bending rollers.
15. Device according to one of claims 6 to 14, thereby characterized, that the shaping rollers (32, 34) exhibit on their outer circumference a tip (36, 38) which in cross-section is rounded or sharp edged, which tip transitions to flanks (40, 42), which define the desired bending angle (14, 20) of the flange (10, 18) or the angle of the rim.

16. Device according to one of claims 5 through 15, thereby characterized, that the pivotable bending jaws (26) and the shaping rollers (32) with their associated mounting and drive elements and assembled into an integrated stable work unit, which is rotatable about the pipe axis (28) relative to a work unit comprised of pipe (12) and clamp disk (22) including mounting and drive elements.
17. Device according to claim 16, thereby characterized, that multiple work units (26, 32) are distributed about the circumference of the pipe (12), which are respectively adapted for carrying out one of the bending processes for the formation of a flange (10, 18) with multiple bends.
18. Device according to claim 17, thereby characterized, that the work units (26, 32) are respectively provided on moveable sleds (70) for adaptation to the various diameters of the pipe (12).
19. Device according to one of claims 1 to 18, thereby characterized, that the work unit (26, 32) includes two side plats (80), which are rigidly connected with each other on opposite ends via intermediate plates (82), that between the side plates (80) a broad sector plate (84) extends, on the two sides of which facing the side plates (80) respectively multiple guide rollers (94) are rotatably mounted, which run along arc shaped guide grooves (96) on the inner side of each side plate (80), and that the sector plate (84) carries the bending jaws (26) of the work unit.

20. Device according to claim 19, thereby characterized, that the sector plate (84), in cross section taken parallel to the sector plate (80), forms an incomplete arc, of which the middle section opposite the circular arc (88) is missing, wherein the straight lines (90, 92) connecting to the arc (88) intersect outside the center point of the arc (88), and that the surface of the sector plate (84) defined by line (92) is connected to the bending jaw (26).
21. Device according to claim 20, thereby characterized, that gear teeth are provided on the cylindrical surface of the sector plate (84) corresponding to the arc (88), which are in engagement with a drive pinion (102) driven by a drive means (100).
22. Device according to one of claim 5 to 21, thereby characterized, that two such devices (204) are provided mounted on a rail system moveable in the direction of the pipe axis (28) for processing the two ends of a pipe, and that a drive (208) is provided for moving the associated devices (204) towards and away from the oppositely lying ends of the pipe (12).