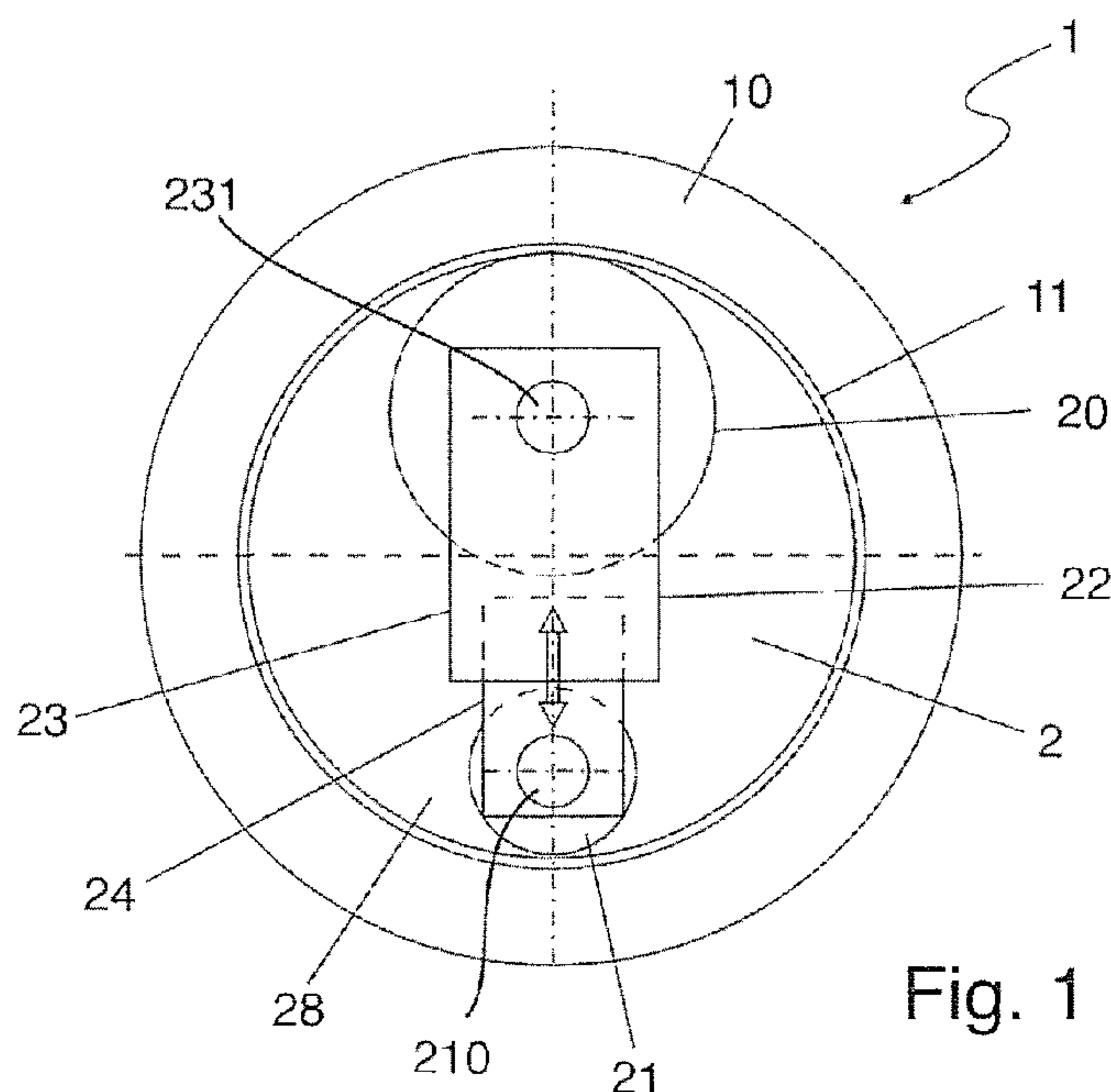




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(54) Titre : PROCEDE ET DISPOSITIF DE REVETEMENT POUR APPLIQUER UNE COUCHE DE RECOUVREMENT
LORS DE LA FABRICATION D'UN TUBE DE GRAND DIAMETRE MULTICOUCHE
(54) Title: METHOD AND COATING DEVICE FOR APPLYING A CLADDING LAYER DURING THE PRODUCTION OF A
MULTILAYER HEAVY-DUTY PIPE



(57) **Abrégé/Abstract:**

The invention relates to a method and a coating device for applying a cladding layer on the inside of a carrier layer during the production of a multilayer heavy-duty pipe, said device comprising a pressure-exerting unit (22) having a force-application unit. A stable application of the cladding layer is achieved in that the coating device comprises a roll-on tool (2) having the pressure-exerting unit (22) and the force-application unit and in that the pressure-exerting unit (22) is provided with at least one pressure roller (20) that has a smaller diameter than the inside diameter of the heavy-duty pipe to be produced and is provided with at least one support element that diametrically counteracts the pressure roller during operation by means of a supporting force.

Abstract

The invention relates to a method and a coating device for applying a cladding layer onto the inner side of a carrier layer during the production of a multilayer heavy-duty pipe, with a pressure-exerting unit (22) having a force application unit. A stable application of the cladding layer is achieved by having the coating device comprise a rolling tool (2) with the pressure-exerting unit (22) and the force application unit, and by providing the pressure-exerting unit (22) with at least one pressure roller (20) having a diameter that is smaller than the inside diameter of the heavy-duty pipe to be produced, and with at least one support element acting diametrically counter thereto with a supporting force in the operating state.

Method and coating device for applying a cladding layer during the production of a multilayer heavy-duty pipe

5 The invention relates to a method for producing a multilayer heavy-duty pipe with a pipe unit that is composed of an outer pipe forming a carrier layer and at least one inner pipe forming a cladding layer, as well as to a coating device for applying the cladding layer to the interior of the carrier layer with a pressure-exerting unit having a force application unit.

10

DE 10 2005 029 679 A1 describes a device and a method for joining pipe profiles with an inner pipe profile in an outer pipe profile through expansion by means of a rolling element, which is arranged in an expander head and, for the purpose of applying the rolling forces, is supported by means of a rotating support shaft. The rolling element moves epicyclically around the rotary axis of the support shaft, which runs eccentrically around the center axis of the pipe profiles. In order to shift the rolling element in the radial direction, the support shaft has a conical portion and can, in turn, be displaced in the axial direction. A support element that is embodied as a support roller, for example, is arranged on the expander head and supports the rolling forces against the inner surface of the inner pipe profile occurring on the rolling element. The expander head can be displaced along the pipe axis in order to create joining connections at various locations on the pipe profiles through expansion. This known device is also designed particularly for the joining of pipe profiles having smaller diameters.

25

In heavy-duty pipes, however, certain conditions are already present as a result of the large inside diameter as well as metallurgic limitations, such as an outer pipe that it is generally (practically) impossible to expand elastically, that make the necessary stable rolling-in of an inner cladding layer difficult. Heavy-duty pipes often have

unroundnesses and ovalities, so that, due to the inhomogeneous pressing forces that occur in the presence of unroundness, it is difficult to achieve a uniformly stable connection of the cladding layer by means of a rotating support roller and an epicyclic rolling element driven by same – that is, with a position-controlled pressing procedure.

Another coating device is described in WO 2004/103603 A1. This known coating device is designed to provide an outer pipe, which forms a carrier layer and is also referred to as a carrier pipe, with a cladding layer on the interior thereof. For this purpose, an inner pipe, also called a liner pipe or simply a liner, is pushed into the outer pipe and then expanded radially using an expander tool until it binds with the outer pipe, with the inner pipe being expanded plastically and the outer pipe being expanded in order to create a multilayer heavy-duty pipe. This process is repeated incrementally until the entire length of the heavy-duty pipe has been expanded. The expander tool is operated hydraulically but dry, thus excluding the possibility of the inner pipe coming into contact with the hydraulic fluid. The frictional mechanical bond between the two pipes is achieved by having the elastic resilience of the outer pipe be greater than the resilience of the inner pipe. This type of manufacture also influences the structure of the stable carrier pipe, and the combination of the materials of the inner pipe and of the carrier pipe must be selected such that the yield point of the inner pipe is lower than the yield point of the outer pipe, with corresponding limitations and drawbacks being associated with this.

During the manufacture of such multilayer heavy-duty pipes, the use of a coating device is also known which comprises a so-called hydroforming press (e.g., methods of the Butting Company). The inner pipe and the outer pipe are both slightly expanded by means of water pressure, with pressures being used that cause the

outer pipe to flow, so that an outer casting is necessary in order protect the heavy-duty pipe from uncontrolled expansion and rupturing.

Another method for producing a multilayer heavy-duty pipe from an outer pipe and an
5 inner pipe in the form of a largely frictionally connected cladding layer is described in
DE 10 2013 103 811 B3. During manufacture, a carrier plate that already has a
preformed initial bend is used, onto which a support plate is placed which is
connected along its two longitudinal edges to the carrier plate, after which the
interconnection to the multilayer heavy-duty pipe is formed and provided with a
10 longitudinal weld seam.

DE 10 2009 060 059 A1 also describes a method for producing a multilayer heavy-duty pipe. In that document, the wall of the heavy-duty pipe is formed from at least
two metallic sheets that are integrally connected to one another by means of a solder
15 introduced between the sheets. This type of connection requires special
combinations of materials and a special production method that is adapted to them,
which means that limitations exist from the outset.

Moreover, multilayer heavy-duty pipes are known which are plated with a cladding
20 layer by metallurgic means as so-called "clad pipes" and thus already formed in
special production steps during the manufacture of the plate. When employing this
procedure, however, narrow limits are set for the selection of material for many
applications.

25 It is the object of the present invention to provide a method for producing a multilayer
heavy-duty pipe and a coating device of the type mentioned at the outset by means
of which a wider variety of possibilities are offered for the application of a cladding
layer.

This object is achieved with the features of claim 1 and claim 10.

According to claim 1, the method has the following succession of method steps:

- 5 - Introduction of the inner pipe into the outer pipe;
- Introduction of the pressure-exerting unit with at least one pressure roller that has a smaller diameter than the inside diameter of the inner pipe and is rotatably mounted with its rotary axis at a distance from the longitudinal axis of the inner pipe;
- 10 - Application of pressing force aligned radially outward against the inner surface of the inner pipe to the pressure roller;
- Rotation of the pressure-exerting unit relative to the pipe unit while rolling the pressure roller on the inner surface of the inner pipe and pressing of the outer surface of the inner pipe against the inner surface of the outer pipe under local plastic deformation of the inner pipe wall, with the pressure-exerting unit being
- 15 simultaneously advanced axially during the rolling of the pressure roller relative to the pipe unit.

Through the rolling-in and pressing-on (rolling-on) of the inner cladding layer

20 continuously in the direction of rotation under plastic deformation and the simultaneous axial displacement of the pressure-exerting unit relative to the pipe unit, the cladding layer is applied and held frictionally in a uniformly stable and durable manner onto the inner surface of the carrier layer without the need to expand the outer pipe. The structure of the carrier layer, which forms a thick-walled, stable

25 jacket, is therefore practically not impacted, so that combinations of materials having very different metallurgic and/or geometric characteristics (thicknesses) can be used to produce the heavy-duty pipe. A slight expanding of the carrier layer within its elastic limit is also possible, if desired. The design of the original outer pipe and of

the (at least one) original inner pipe can be freely selected for the most part, it only being necessary for the inside diameter of the outer pipe and the outside diameter of the adjacent inner pipe to be coordinated with one another such that the inner pipe can be easily inserted into the outer pipe and frictionally connected by means of the rolling process under expansion over the yield point or plastification along the inner surface of the outer pipe. A practically smooth inner surface of the finished heavy-duty pipe is achieved if the feed rate of the pressure-exerting unit during the rolling of the pressure roller is coordinated with its rotational speed on the inner surface of the pipe unit such that the plastically deformed, helically revolving strips overlap (e.g., one or even multiple times).

In the coating device, a provision is made that it comprises a rolling tool with the pressure-exerting unit and the force application unit, and that the pressure-exerting unit is provided with at least one pressure roller having a smaller diameter than the inside diameter of the heavy-duty pipe to be produced as well as with at least one support element acting diametrically counter thereto with a supporting force in the operating state and the pressure-exerting unit has a pressure bearing part on which the pressure roller is rotatably mounted and has a support bearing part on which the support element is supported. The force application unit is arranged at least partially between the pressure bearing part and the support bearing part, i.e., within the pressure-exerting unit. The pressure bearing part and the support bearing part can be displaced radially toward one another by means of the force application unit in relation to a rotary axis of the pressure roller and thus also the central axis of the pipe unit.

This construction of the coating device makes it possible to continuously apply the cladding layer, particularly a cladding layer of an inner pipe inserted into an outer pipe as a stable carrier layer through rolling. As a result of the rolling process, the

inner pipe is continuously expanded under plastic deformation and thus pressed in a stable and durable manner against the interior of the outer pipe without the need to expand the outer pipe, so that the material structure thereof can remain unaffected. As a result, practically any combination of metallic materials can be selected for the inner pipe and outer pipe. Through the specified construction of the coating device, a plastic deformation of the inner pipe is brought about in order to form the cladding layer with a high level of pressing force applied using the pressure roller. Here, too, during the rolling of the pressure roller, the pressure-exerting unit, which is connected to a central (physical) axle, is passed axially over same in a continuous (uninterrupted) manner, thus resulting in the helically revolving strips during the rolling process.

In this regard, it is advantageous if, during the rolling of the pressure roller, the pressing force is selected such that the outer pipe is not expanded or is expanded only slightly, below its yield point.

The advantageous continuous procedure employed during the application of the cladding layer is thus maintained by having the pressure-exerting unit be fed axially forward relative to the pipe unit. The feed rate of the pressure-exerting unit is coordinated with the rotational speed of the pressure roller along the inner surface of the inner pipe such that a (practically) smooth contact surface or inner surface of the pressed inner pipe regions results. The selected physical parameters can also be established as a function of the material of the inner pipe and of the geometry of the (at least one) pressure roller. For example, the outer surface of the pressure roller can be embodied in its cross section so as to be straight and parallel to the longitudinal extension of the inner surface of the inner pipe or be conical or convexly arched toward the outside, for example, in order to achieve different pressing characteristics. In this way, the contact surface can be varied accordingly, and a

rolling-on effect with local deformation of material (similar to a walking process) achieved more or less in the direction of rotation or more or less in the feed direction.

One advantageous variant of the method is characterized in that, for example, the
5 pressure-exerting unit is advanced axially relative to the pipe unit by a distance between 1 mm and 10 mm per cycle of the pressure roller over the inner circumference of the inner pipe.

Another advantageous variant of the method is characterized in that, for example, the
10 relative rotational speed between pressure-exerting unit and pipe unit is between 5 and 100 revolutions per minute.

High pressing forces can be created by having the pressure-exerting unit be supported by a support unit on the inner surface of the inner pipe while the pressure
15 roller is rolling. The support unit can be supported on the inner surface of the inner pipe in a sliding manner or with one or more support rollers arranged at the base angles of an isosceles (acute-angled) triangle. In the latter case, the pressure roller is preferably arranged in extension of the bisector of the central angle of the isosceles triangle.

20

One embodiment that is advantageous for the execution of the method is also characterized in that the pressure-exerting unit is rotated relative to the pipe unit by means of an axle inserted coaxially into the pipe unit, with the axle being rotated by means of a drive arranged outside or inside of the pipe unit and/or the pipe unit is
25 rotated by means of a rotary drive.

Moreover, for the function and optimization of the production process, measures to the effect that the rotation of the pressure-exerting unit relative to the pipe unit and/or

the pressing force is carried out or applied in a controlled or regulated manner are advantageous.

5 Other advantageous measures are characterized in that the control or regulation is performed as a function of geometric and/or metallurgic material characteristics of the cladding layer.

10 Moreover, measures that are characterized in that the at least one support element is embodied as at least one support roller contribute to the good functioning of the coating device with an advantageous design.

15 Other measures that are advantageous for the functioning and construction are characterized in that the pressure bearing part and the support bearing part can be displaced radially outward toward one another by means of the force application unit in relation to a rotary axis of the pressure roller or the central axis of the pipe unit, so that, for the purpose of rolling on the cladding layer, the pressure roller can be pushed counter to the supporting force with the required pressing force against the interior of the cladding layer or of the inner pipe in the operating state.

20 Various design variants for applying the radially aligned pressing forces that are transmitted via the pressure roller to the inner pipe in order to deform the cladding layer are characterized in that the force application unit has an adjusting mechanism that is operated hydraulically or by means of solid, mechanically cooperating spreading parts.

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Another measure that is advantageous for the construction and function is characterized in that the pressure roller is supported in the pressure bearing part by means of a rotary axle in the pressure bearing part.

Furthermore, a provision is advantageously made that the the support roller is rotatably mounted in the support bearing part by means of a bearing shaft.

- 5 The deformation of the inner pipe in order to form the cladding layer can be influenced in various ways by having the pressure roller have a flat, inclined, or outwardly conical or convex contact surface in cross section. For example, depending on the material of the cladding layer, it can be ensured in this way that, during the continuous pressing with a (simultaneous) slight feed, the pressure
10 regions lining up (continuously) one after another in the manner of a helix are more or less wide and/or overlap to a greater or lesser extent in order to obtain a maximally homogeneous, smooth interior surface of the pressed cladding layer.

- What is more, as for the connection to a central leading axle or central drive shaft,
15 measures are advantageous that are characterized in that the pressure-exerting unit is provided with a connecting section with a coupling part for connecting the central drive shaft. By means of the central drive shaft, the pressure-exerting unit can be rotated relative to the inner surface of the multilayer heavy-duty pipe, with the pressure-exerting unit being rotatable when the heavy-duty pipe is at rest, or the
20 heavy-duty pipe being rotatable when the pressure-exerting unit is not rotating, or the heavy-duty pipe and the pressure-exerting unit being rotatable at different rotational speeds, and with the pressure roller rolling against the inner surface. At the same time, the relative feed between heavy-duty pipe and pressure-exerting unit can be performed in order to produce the axial feed during the helical pressing movement.

25

Moreover, a provision is advantageously made here that the connecting section is connected in a radially displaceable manner to the coupling part by means of an adapter, so that the pressure-exerting unit is supported so as to float in the radial

direction in relation to the drive shaft. This measure contributes to the achieving of uniform pressure and to a stable coating with the cladding layer.

Additional advantages for the construction and the function can be achieved by providing the pressure-exerting unit with a housing-like construction with two housing parts, with the support bearing part being embodied in a housing base and the pressure bearing part being embodied in a housing attachment, and by having the housing base and the housing attachment be coupled by means of the force application unit such that they can be displaced radially relative to one another.

10

Additional measures that are advantageous for the construction and function are characterized in that a housing cover part is mounted on the housing attachment and that a pivot bearing is embodied in the housing attachment for the rotary axle of the pressure roller.

15

The invention is explained in greater detail below on the basis of exemplary embodiments with reference to the drawings.

Fig. 1 shows a front-side schematic representation of a pipe unit consisting of outer pipe and inner pipe with a pressure-exerting unit inserted;

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Fig. 2 shows a perspective view of a pressure-exerting unit;

Fig. 3 shows a perspective view of a partially opened pressure-exerting unit;

25

Fig. 4 shows another perspective view of a pressure-exerting unit that is partially opened even further; and

Figs. 5A, 5B and 5C show a transparent representation of the pressure-exerting unit in a side view, rear view, and top view.

Fig. 1 shows a pipe unit 1 consisting of an outer pipe 10, which forms a stable, outside metallic carrier layer 10, and an inner pipe 11, which forms an inside metallic cladding layer 11 that is thinner in comparison to the carrier layer, as well as a pressure-exerting unit 22 (shown schematically) that is inserted into the interior of the pipe unit 1 in order to press the inner pipe 11 in a frictional and enduringly stable manner against the inner surface of the outer pipe 10 in a rolling-in process and obtain a multilayer heavy-duty pipe with coated interior. The term "heavy-duty pipe" is to be understood as referring to pipes having diameters of at least 150 mm and a total wall thickness of at least 5 mm, with the thickness of the carrier layer being a multiple of the thickness of the cladding layer. The material characteristics of the cladding layer are selected such that they resist, as well and as permanently as possible, the mechanical, physical, and/or chemical effects of a material to be conveyed. To this end, it provides a substantial advantage if the selection of material is limited as little as possible by the production method, which is achieved through the rolling-in and rolling-on process.

The pressure-exerting unit 22 introduced into the interior of the pipe is part of a rolling tool 2 and has a pressure roller 20 with a diameter that is substantially smaller than the inside diameter of the inner pipe 11. In the operating state, the pressure roller 20 is mounted in a pressure bearing part 23 so as to be rotatable about a rotary axis 231 that is parallel to the pipe axis. As a support element, a support roller 21 is arranged so as to be diametrically opposed to the pressure roller 20 in relation to the pipe axis during the rolling-on process, which support roller 21 is supported on the inner surface of the inner pipe 11 during the rolling-in process in order to offer sufficient supporting force to press the pressure roller 20 during the rolling-in process. The

support roller 21 is mounted so as to be rotatable about a bearing axle 210 that is parallel to the longitudinal axis of the pipe unit 1 and received in a support bearing part 24 of the pressure-exerting unit 22, particularly in a support unit 28. The pressure bearing part 23 and the support bearing part 24 are supported in the pressure-exerting unit 22 so as to be displaceable diametrically (in the radial direction) toward one another in relation to the pipe axis, for example hydraulically or by means of a mechanical adjustment mechanism, as shown by the double arrow in Fig. 1. Instead of only one support roller, it is also possible for several support rollers 21 to be present, preferably support rollers 21 that are arranged with the same angular separation from the diagonal of the inner pipe through the rotary axis 231 of the pressure roller 20 and/or several support rollers 21 spaced apart from one another in the direction of the pipe axis. Instead of only one pressure roller 20, several can also be present.

15 In the exemplary embodiment of a rolling-on tool 2 with a pressure-exerting unit 22 shown in a perspective view in Fig. 2, for example, the support bearing part 24 has two support rollers 21 which, when in the inserted state of the pressure-exerting unit 22, are arranged so as to be offset in relation to the diagonal of the inner pipe 11 through the rotary axis 231 of the pressure roller 20 in equal angular intervals (symmetrically), although only one of the two support rollers 21 is visible in Fig. 2. In order to drive the pressure-exerting unit 22 so as to rotate about a rotary axis that is concentric to the pipe axis, it is connected via a connecting section 25 to an adapter 27 and a coupling part 26 to a stable axle or drive shaft (not shown) and driven in a rotating manner by means of a drive unit 1 (also not shown) arranged outside or
25 inside of the pipe unit 1 in order to cause the pressure roller 20 to roll in the direction of rotation over the inner surface of the inner pipe 11 and thus carry out the rolling-in process for applying the cladding layer. The coupling part 26 and the adapter 27 of the connecting section 25 can be displaced toward one another in the radial direction

in order to floatingly mount and, optionally, to center the pressure-exerting unit 22 in the interior of the pipe, and the coupling part 26 has a flange-like design in order to create a stable connection to the front side or a mating flange of the axis or drive shaft.

5

As is shown in Fig. 2, the pressure-exerting unit 22 is embodied in the manner of a housing with two housing parts, namely a housing base 221, in which the support bearing part is embodied, and a housing attachment 223, in which the pressure bearing part 23 is embodied. The housing base 221 with the support bearing part 24
10 and the housing attachment 223 with the pressure bearing part 23 are displaceably coupled with one another via a force application unit such that they can be pressed outwardly apart radially to the rotary axle 231 or to the bearing axle 210 and thus also to the axle or drive shaft or to the axis of the heavy-duty pipe and displaced inwardly toward one another. For this purpose, an adjusting unit is arranged between
15 the two housing parts that provides for stable guidance in the radial direction. The force application unit is embodied as a hydraulically operated piston/cylinder unit, for example, by means of which the compressive force required to press the pressure roller 20 can be applied in a well-controlled and regulated manner. The housing attachment 223 is covered toward the outside with a housing cover part 222 in which
20 a slot-like opening extending transverse to the rotary axle 231 is disposed through which a portion of the pressure roller 220 protrudes outward in order to roll on the interior of the cladding layer during the creation thereof. The outer contour of the housing cover part 222, as well as the other parts of the housing 220, are dimensioned and shaped such that rotation can occur without hindrance within the
25 inner pipe during the rolling-on process, with the support rollers 21 also being supported on the interior of the inner pipe.

Figs. 3 and 4 show the housing 220 in a partially open state, with the housing cover part 222 being lifted off in Fig. 3 and with a side wall of the housing base 221 being additionally removed in Fig. 4. The housing cover part 222 is clamped stably to lateral wall portions of the housing attachment 223 by means of screws. A pivot bearing 230 with the rotary axle 231 is embodied in the housing attachment 223, with the rotary axle 231 being held stable by means of roller or antifriction bearings on the interior of the housing attachment 223 in order to ensure a reliable rolling process and well-defined guidance even under high pressing forces. As can be seen from Figs. 5A and 5C, the pivot bearing 230 has a centering construction with an oblique arrangement of the rolls or rollers, so that the roll-off line of the pressure roller 20 is maintained with precision and the pressure roller 20 is prevented from tipping over. The inner surfaces of the housing attachment 223 are provided with receptacles that are adapted to the bearing elements of the pivot bearing 230. As can be seen from Fig. 4, the housing attachment 223 is guided outside of the force application unit formed by the piston/cylinder unit between a front housing wall facing toward the connecting section 25 and a rear housing wall at a distance from same, with guide structures for being embodied in the front and rear housing walls for counter-guide structures in the side walls of the housing attachment 223 that are adapted thereto. The bearing axles 210 of the support rollers 21 are supported in the lower region of the front and rear housing walls as well as in a bottom-side housing wall of the housing base 221, with the support rollers 21 protruding with their outer contour in the lower edge region of the housing 221 and on the underside and the respective outer side of the housing walls in order to ensure unimpeded rolling. The protruding support rollers 21 and the oppositely situated pressure roller 20 that protrudes over the housing cover part 222 are particularly also visible in Fig. 5B.

In order to introduce the pressure-exerting unit 22 or pressure-exerting head of the rolling tool 2 into the pipe unit 1, the pressure bearing part 23 and the support

bearing part 24 can be moved diametrically together far enough in order to subsequently move them apart in the desired axial position and apply the required compressive force to the pressure roller 20 hydraulically or by means of an adjustment mechanism while supported against the support roller(s) 21 in order to
5 roll-in the inner pipe 11 and form the cladding layer. During the rolling-in process, the pressing force on the pressure roller 20 is increased to the extent that, during rolling-off in the circumferential direction on the inner surface of the inner pipe 11, the inner pipe 11 is pressed against the inner surface of the outer pipe 10 and deformed plastically locally to the point that the cladding layer formed remains stably and
10 frictionally on the inner surface of the outer pipe.

Simultaneously, during the rotation of the pressure-exerting unit 22 and thus the rolling of the pressure roller 20 in the circumferential direction over the inner surface of the inner pipe 11, the pressure-exerting unit 22 is pushed forward with the drive
15 shaft. The feed rate is selected such that the plastically deformed strip running helically around with a slight pitch is overlapped by at least the next plastically deformed strip that also runs helically around, and so on, until the cladding layer has been rolled on over desired length in the outer pipe 10. As a result of the at least single overlapping of the continuous plastically deformed strips, a practically very
20 smooth structure is obtained on the inner surface of the cladding layer, as investigations conducted by the inventors have shown.

During the rolling-in process, the rotational speed or revolutions per minute and the feed rate can be optimally coordinated with the respective material of the inner pipe
25 11 as a function of geometric and metallurgic characteristics. The cross-sectional contour (e.g., flat, conical, or outwardly convex) and/or the diameter of the preferably hardened pressure roller 20 as well as the material thereof can also be selected appropriately.

The pressing force of the pressure roller 20 is preferably selected such that the outer pipe 10 is at least substantially not deformed. As a result, the microstructure of the carrier layer is not negatively impacted by the coating process. If desired, however, a
5 slight expansion of the outer pipe 10 within the yield point of the carrier layer can be permitted.

All weldable, corrosion-resistant steels, nickel, nickel alloys, and titanium, *inter alia*, can be used as material for the inner pipe 11 (protective pipe, liner pipe, inliner,
10 liner). Carbon steel is preferably considered for the thick-walled outer pipe (carrier pipe).

Instead of or in addition to the rotating of the pressure-exerting unit 22 during the rolling-in process, the pipe unit 1 can be rotated relative to the pressure-exerting unit
15 22 in order to bring about the rolling-in process.

The described method can also be used for the locally limited production or restoration of a mechanical bond of a pipe-in-pipe system of the abovementioned type. It is also possible to use several coordinated inner pipes in an outer pipe 10
20 (simultaneously or successively) and roll them into a multilayer cladding layer in the described manner.

The rolling-in process with the pressure-exerting unit 22 allows for a wide control or regulating range for the rolling force and thus of the local degree of deformation of
25 the cladding layer (inliner). The maximum possible frictional connection of the outer pipe 10 and inner pipe 11 (pipe partners) depends on the thickness of the inner pipe 10, the mechanical characteristics, the local degree of deformation during rolling-in, and the frictional properties.

The described method makes it possible to use materials for the inner pipe 11 or cladding layer that have a higher yield point in comparison to the material of the outer pipe 10 during the production of multilayer heavy-duty pipes. Besides the advantageous manufacturing method, this offers an additional advantage over multilayer pipes that have been provided in a known manner with a coating, such as hydroforming, for example, in which the material of the cladding layer must have a lower yield point in order for a frictional connection to be created after the expansion of the inner and outer pipes and the subsequent common shrinkage of the two pipes.

Claims

1. A method for producing a multilayer heavy-duty pipe, with a pipe unit (1) that is
5 composed of an outer pipe (10) forming a carrier layer and at least one inner
pipe (11) forming a cladding layer, having the following succession of method
steps:
- Introduction of the inner pipe (11) into the outer pipe (10);
 - Introduction of the pressure-exerting unit (22) with at least one pressure
10 roller (20) that has a smaller diameter than the inside diameter of the
inner pipe (11) and is rotatably mounted with its rotary axis at a distance
from the longitudinal axis of the inner pipe (11);
 - Application of pressing force aligned radially outward against the inner
surface of the inner pipe (11) to the pressure roller (20);
 - 15 - Rotation of the pressure-exerting unit (22) relative to the pipe unit (1)
while rolling the pressure roller (20) on the inner surface of the inner
pipe (11) and pressing of the outer surface of the inner pipe (11) against
the inner surface of the outer pipe (10) under local plastic deformation
of the inner pipe wall, with the pressure-exerting unit (22) being
20 simultaneously advanced axially during the rolling of the pressure roller
(20) relative to the pipe unit (1).
2. The method as set forth in claim 1,
characterized in that
25 during the rolling of the pressure roller (20), the pressing force is selected such
that the outer pipe (10) is not expanded or is expanded only slightly, below its
yield point.

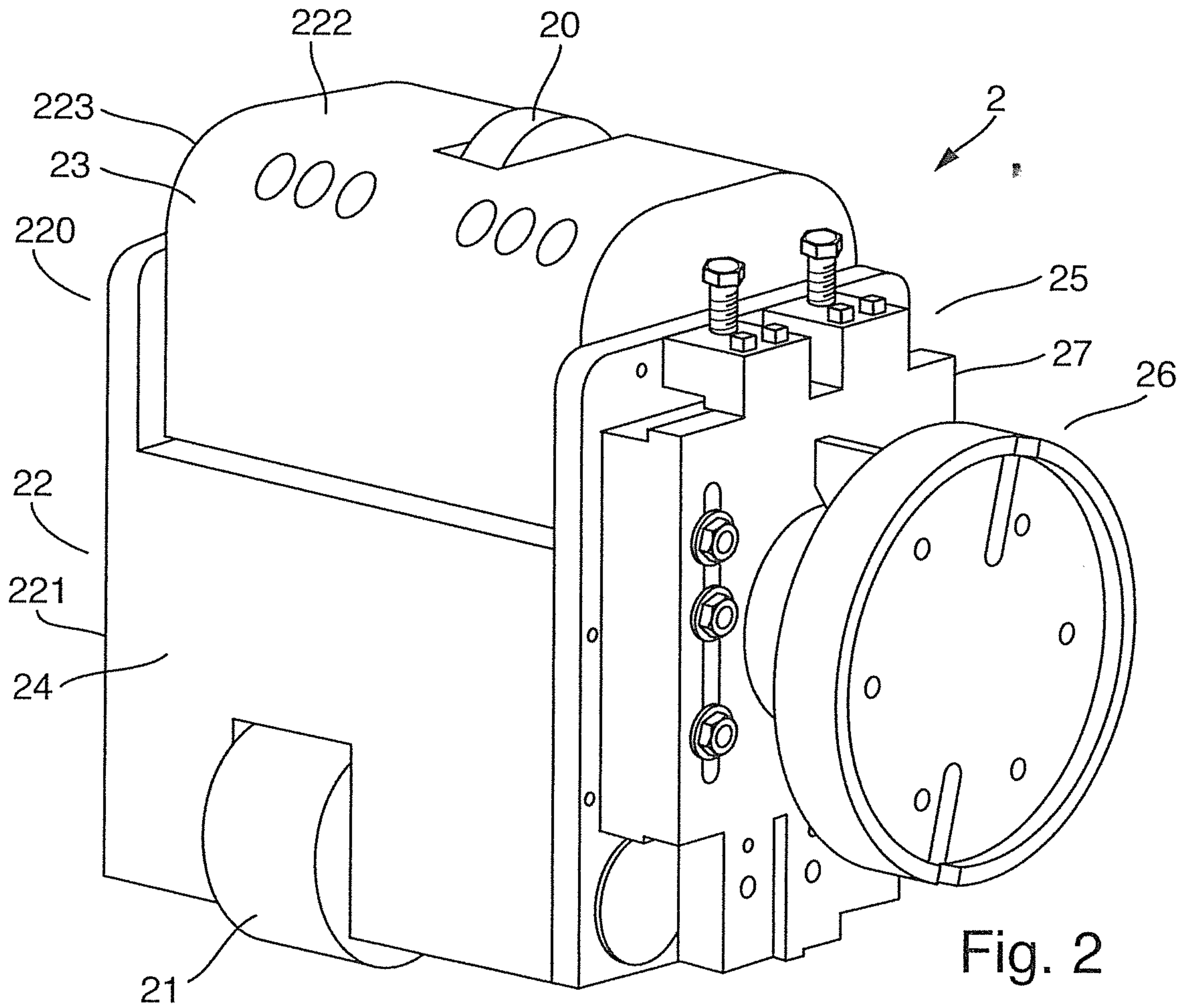
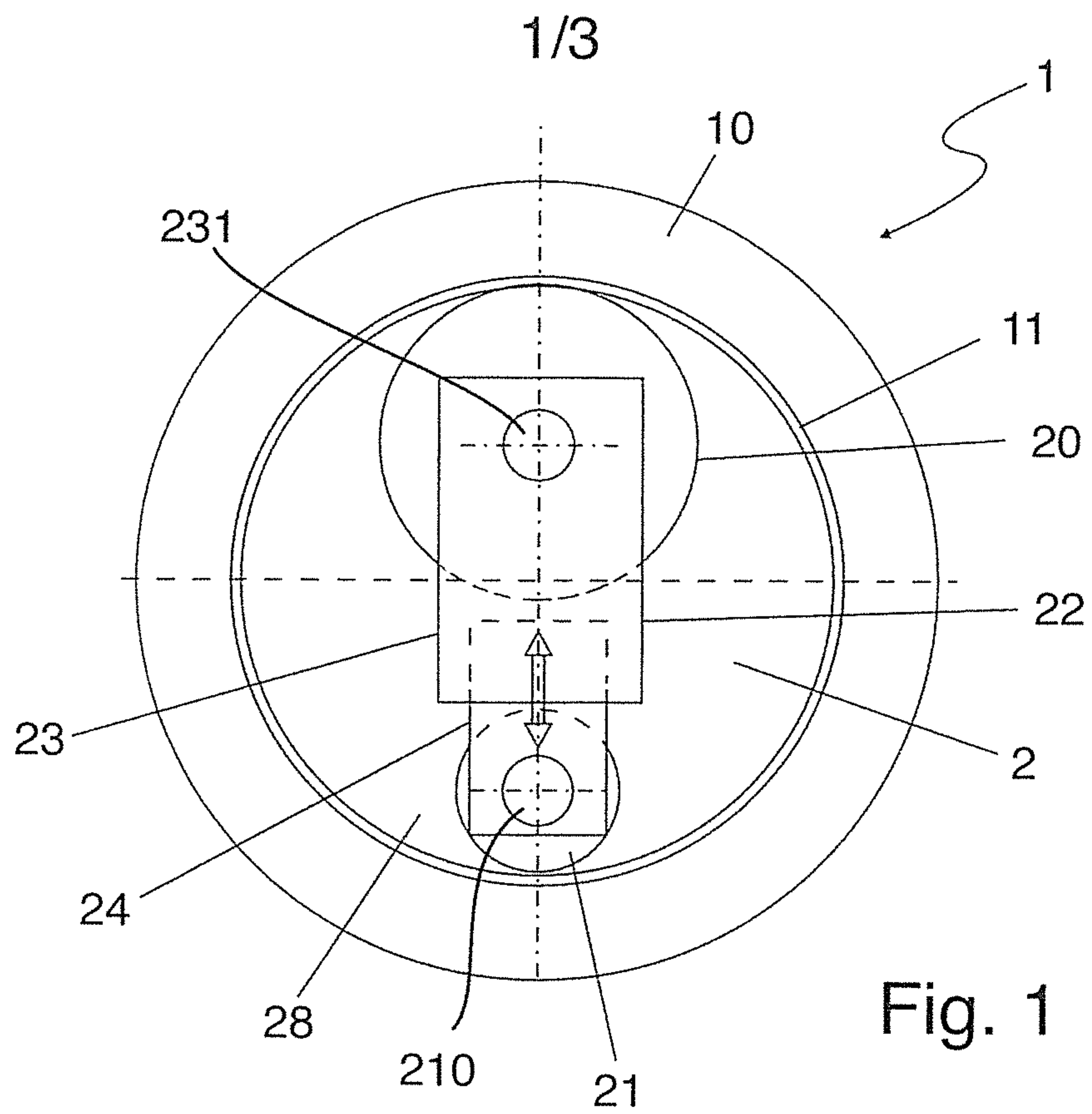
3. The method as set forth in claim 1 or 2,
characterized in that
the pressure-exerting unit (22) is advanced axially relative to the pipe unit (1)
during the rolling.
- 5
4. The method as set forth in claim 3,
characterized in that
the pressure-exerting unit (22) is advanced axially relative to the pipe unit (1) by
a distance between 1 mm and 10 mm per cycle of the pressure roller (20) over
10 the inner circumference of the inner pipe (11).
5. The method as set forth in any one of the preceding claims,
characterized in that
the relative rotational speed between pressure-exerting unit (22) and pipe unit
15 (1) is between 5 and 100 revolutions per minute.
6. The method as set forth in any one of the preceding claims,
characterized in that,
while the pressure roller (20) is rolling, the pressure-exerting unit (22) is
20 supported by a support unit (28) on the inner surface of the inner pipe (11).
7. The method as set forth in any one of the preceding claims,
characterized in that
the pressure-exerting unit (22) is rotated relative to the pipe unit (1) by means of
25 an axle inserted coaxially into the pipe unit (1), with the axle being rotated by
means of a drive arranged outside or inside of the pipe unit and/or the pipe unit
(1) is rotated by means of a rotary drive.

8. The method as set forth in any one of the preceding claims,
characterized in that,
the rotation of the pressure-exerting unit (22) relative to the pipe unit (1) and/or
the pressing force is carried out or applied in a controlled or regulated manner.
- 5
9. The method as set forth in any one of the preceding claims,
characterized in that
the control or regulation is performed as a function of geometric and/or
metallurgic material characteristics of the cladding layer.
- 10
10. A coating device for applying a cladding layer onto the inner side of a carrier
layer during the production of a multilayer heavy-duty pipe, with a pressure-
exerting unit (22) having a force application unit,
characterized in that
- 15
- the coating device comprises a rolling tool (2) with the pressure-exerting unit
(22) and the force application unit,
that the pressure-exerting unit (22) is provided with at least one pressure roller
(20) having a diameter that is smaller than the inside diameter of the heavy-duty
pipe to be produced, and with at least one support element acting diametrically
- 20
- counter thereto with a supporting force in the operating state,
that the pressure-exerting unit (22) has a pressure bearing part (23) on which
the pressure roller (20) is rotatably mounted, as well as a support bearing part
(24) on which the support element is supported, and
that the force application unit is arranged at least partially between the pressure
- 25
- bearing part (23) and the support bearing part (24).
11. The coating device as set forth in claim 10,
characterized in that
the at least one support element is embodied as at least one support roller (21).

12. The coating device as set forth in claim 10 or 11,
characterized in that
the pressure bearing part (23) and the support bearing part (24) can be
5 displaced radially outward toward one another by means of the force application
unit in relation to a rotary axle (231) of the pressure roller (20).
13. The coating device as set forth in any one of claims 10 to 12,
characterized in that
10 the force application unit has an adjusting unit that operates hydraulically or by
means of mechanical spreading parts.
14. The coating device as set forth in any one of claims 10 to 13,
characterized in that
15 the pressure roller (20) is supported by means of a rotary axle (231) in the
pressure bearing part (23).
15. The coating device as set forth in any one of claims 11 to 14,
characterized in that
20 the support roller (21) is rotatably mounted by means of a bearing axle (210) in
the support bearing part (23).
16. The coating device as set forth in any one of claims 10 to 15,
characterized in that
the pressure roller (20) has a flat, inclined, or outwardly conical or convex
25 contact surface in cross section.
17. The coating device as set forth in any one of claims 10 to 16,
characterized in that

the pressure-exerting unit (22) is provided with a connecting section (25) with a coupling part (26) for connecting a central drive shaft.

18. The coating device as set forth in claim 17,
5 characterized in that
the connecting section (25) is connected in a radially displaceable manner to the coupling part (26) by means of an adapter (27), so that the pressure-exerting unit (22) is supported so as to float in relation to the drive shaft.
- 10 19. The coating device as set forth in any one of claims 10 to 18, characterized in that
the pressure-exerting unit (22) has a housing-like construction with two housing parts, with the support bearing part (24) being embodied in a housing base (221) and the pressure bearing part (23) being embodied in a housing
15 attachment (223),
and that the housing base (221) and the housing attachment (223) are coupled by means of the force application unit so as to be radially displaceable relative to one another.
- 20 20. The coating device as set forth in claim 19, characterized in that
a housing cover part (222) is mounted on the housing cover part (223), and
that a pivot bearing (230) for the rotary axle (231) of the pressure roller (20) is embodied in the housing attachment (223).



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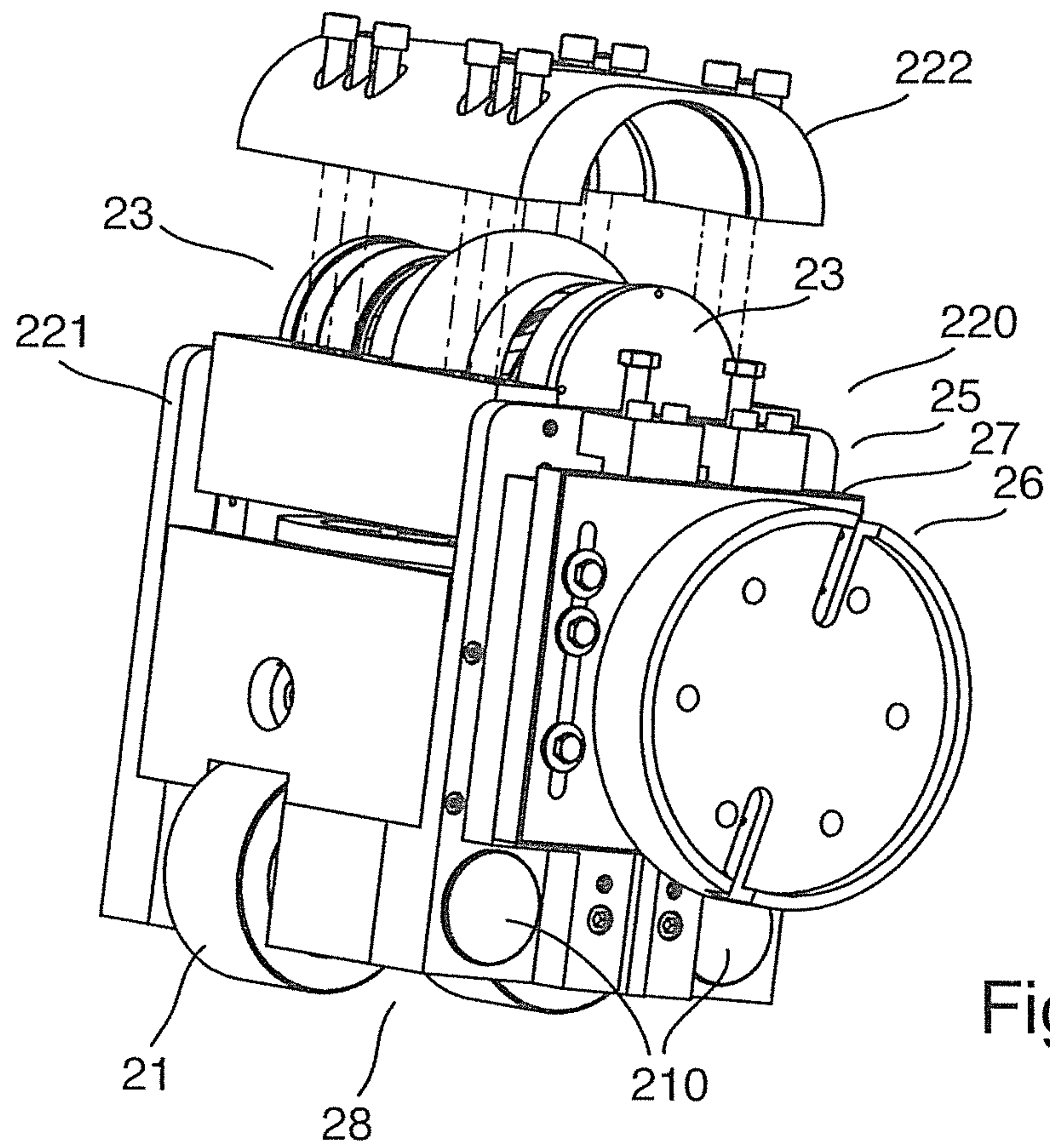


Fig. 3

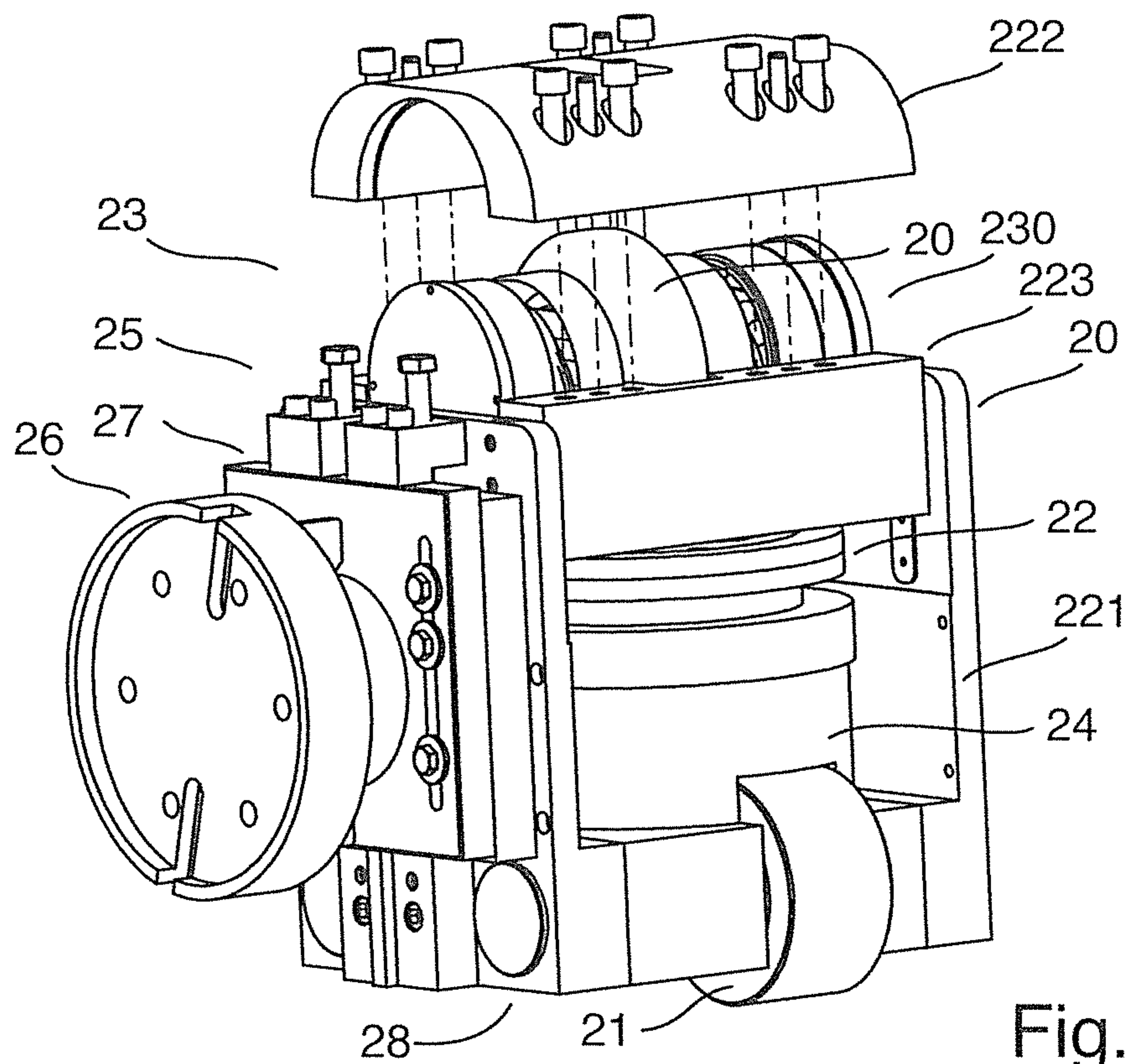


Fig. 4

