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(54) **COMBINED PICKLING AND ROLLING PLANT FOR PICKLING AND ROLLING METAL STRIPS**

(57) A pickling and rolling plant for pickling and rolling a metal strip, comprising a continuous pickling line; storing means (20, 20') for storing the pickled strip having a capacity of 1000-3000 metres of strip length; a reversible rolling mill having at least two first stands (19) downstream of said storing means (20); a first reel (21), downstream of said at least two first stands, for winding the strip after an odd rolling step, for winding a coil weighing from 100 to 300 tons and with a diameter of up to 6 metres; a welder (2'), arranged between the pickling line and the first stands; at least one second reel (16), upstream of

the first stands and downstream of the welder (2'), for winding at least one portion of the strip after an even rolling step in the direction opposite to the odd step, said second reel being sized to wind strip portions with specific weight from 15 to 21 kg/mm; first cutting means (22, 23), arranged between said second reel and the first stands (19), which are adapted to cut the rolled strip each time a strip portion with specific weight from 15 to 21 kg/mm is wound onto the second reel; wherein said welder (2') is adapted to weld a head of the rolled strip cut by the first cutting means with a strip head still to be rolled.

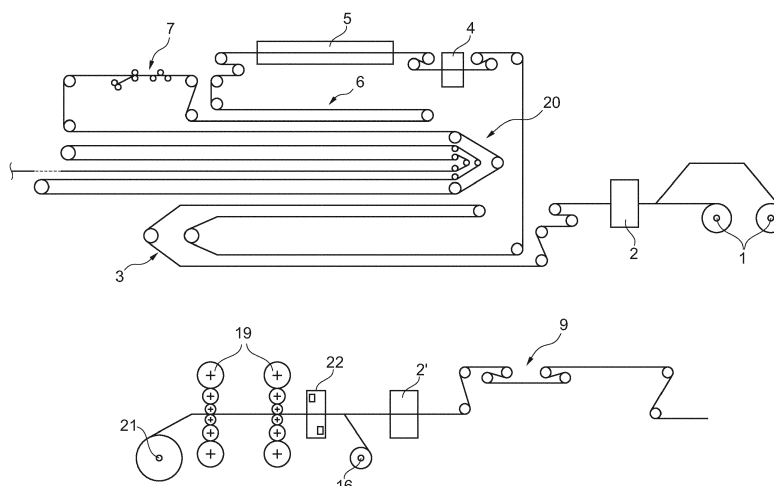


Fig. 1

Description

Field of the invention

[0001] The present invention relates to a combined pickling and rolling plant for pickling and rolling metal strips.

Background art

[0002] The first completely continuous rolling mills in the field of cold rolling were made in the 70's and 80's, followed by the first combined pickling and rolling plants.

[0003] The benefit of continuously rolling strips by rolling welding joints has significant benefits in terms of plant productivity, with 20% to 100% increases in hourly productivity or kilometres rolled, of surface quality, by reducing the risk of generating defects during the step of feeding the heads and of exiting the tails being rolled, and in terms of performance, by reducing the losses of head and tail material due to off-thickness.

[0004] Such a solution involves providing plants where the continuous pickling is connected directly to a tandem cold rolling mill with four or five rolling stands, with increased investment costs and with high production capacities, usually exceeding one million tons a year.

[0005] The drawback of such a solution is that based on the length of the product to be rolled each time, production is limited to the "bottleneck" of the plant which, according to the sizes and weight of the coil, can be the plant input, the pickling process, accumulations and the rolling mill in relation to the maximum speed expressible by the tandem rolling mill in relation to the speed obtainable from each stand and to the installed power.

[0006] The development of materials, especially of highly resistant steel, combined with the request for increasingly lower thicknesses, has led to the development of new continuous rolling mills coupled to pickling line. For example, a bent arrangement of the two plants has been made so that the unwinding reel of the pickling line is close to the winder of the rolling mill. Thereby, a reduction can be completed and the rolled coil can be fed at the input of the pickling line so as to achieve an increased number of reductions on the rolling mill. This configuration has the drawback associated with the significant reduction of production capacity because there is a need to provide several passes to finish a coil at the thickness wanted. An alternative applied by certain manufacturers has been the one of rolling so-called "jumbo coils", weighing in certain cases in excess of 60 tons and being close to 3 metres in diameter. This system, used on discontinuous tandem rolling mills, asymptotically brings productivity towards the value obtainable with a continuous mill, improves the performance thereof and partly the surface quality. The advantage of this solution is a reduced investment cost for the rolling plant, but it involves a significant cost for the coil handling structures, such as roadways and corresponding overhead cranes,

which must be sized upstream and downstream of the plants to continuously support these increased loads.

[0007] An alternative to tandem cold rolling mills is the one of reversible rolling mills, usually implemented for smaller production capacities, and precisely:

- for single-stand reversible rolling mills, from 100,000 to 400,000 tons a year;
- for double-stand reversible rolling mills, from 200,000 to 1,000,000 tons a year. Due to its nature, rolling on reversible rolling mills involves a worse performance of the material with respect to tandem rolling mills with several stands because the rolling heads and tails are not rolled or are partly rolled. Furthermore, the possibility is excluded in reversible rolling mills of controlling the surface finish of the exiting strip, as is obtained in tandem rolling mills. This is because it is not recommendable to replace the rolling stand before performing the last pass, with the purpose of transferring roughness to the strip surface, and it is very complex and costly to use a different emulsion system to reduce surface dirt.

[0008] To improve the performance of reversible rolling mills, various procedures and innovations have been tried, such as:

- developing equipment and corresponding automation to obtain the feed of the heads and the exit of the tails with stands closed;
- implementing spot welders for welding the head of the coil to a leading strip, that is to a stretch of strip not to be rolled, in order to allow the feeding and the closing of the stand on the material to be produced, as soon as possible.

[0009] These techniques have given partial results because the application thereof involves obvious stiffening of the rolling mill operating conditions and possible risks of damaging the rolling rollers.

[0010] An example of combined pickling and rolling plant for metal strips with reversible rolling mills is disclosed in US2012/0272703A1.

[0011] Therefore there is a need to provide a combined pickling and rolling plant, and a corresponding process, which allows to overcome the aforesaid drawbacks.

Summary of the invention

[0012] It is the main object of the present invention to provide a combined pickling and reversible cold rolling plant which allows quality, productivity and performance of the material to be obtained comparable with those of a four- or five-stand tandem rolling mill coupled to continuous pickling, but with a lower investment cost.

[0013] It is another object of the invention to provide a plant which allows coils of strip of specific weight from 15 to 21 kg/mm to be obtained, which are therefore com-

patible with usual coil handling structures.

[0014] It is another object of the invention to provide a plant in which the reversible rolling process is provided, so as to allow the surface finish to be controlled, which is required by the plates for the automotive and household appliance industries.

[0015] Therefore, the present invention suggests to achieve the above objects by providing a combined plant for pickling and cold rolling metal strip which, in accordance with claim 1, comprises

- a pickling line for continuously pickling the strip;
- storing means for storing the pickled strip which are arranged downstream of the pickling line;
- a reversible cold rolling mill having at least two first rolling stands, arranged downstream of said storing means;
- a first reel, which is arranged downstream of said at least two first rolling stands, for winding the strip after a first rolling step;
- at least one second reel, arranged upstream of said at least two first rolling stands, for winding at least one portion of the strip after a second rolling step in direction opposite to the first step, said at least one second reel being sized to wind strip portions up to a predetermined weight limit or diameter limit of coil;
- first cutting means, arranged between said at least one second reel and said at least two first rolling stands, which are adapted to cut the rolled strip each time a strip portion wound on the at least one second reel reaches said predetermined weight limit or diameter limit of coil;

characterized in that

said storing means have a capacity of 500-3000 metres of strip length,

said first reel is sized to wind a coil weighing from 100 to 300 tons and/or with a diameter of up to 6 metres,

- a welder is arranged between said storing means and said at least two first rolling stands,

said at least one second reel is arranged downstream of said welder,

and in that said welder is adapted to weld a head of the rolled strip exiting the second rolling step, obtained from a cut performed by the first cutting means, with a strip head coming from said storing means.

[0016] A second aspect of the present invention provides a pickling and cold rolling process for pickling and cold rolling a metal strip, performed by means of the aforesaid plant, which, according to claim 10, comprises the following steps:

- a) continuously pickling the strip by means of the pickling line;
- b) storing the continuously pickled strip by means of the storing means having a capacity of 500-3000 me-

tres of strip length;

c) performing a first rolling step of a predetermined quantity of strip in the at least two first rolling stands and a successive winding onto the first reel of a coil weighing from 100 to 300 tons and/or with a diameter of up to 6 metres;

d) performing a second rolling step, in direction opposite to the first step, of said predetermined quantity of strip in the at least two first rolling stands, defining a rolled strip, and performing a winding of a first portion of rolled strip onto at least one second reel up to a predetermined weight limit or diameter limit of coil, thus defining a first rolled coil;

e) cutting, by means of the first cutting means, the rolled strip after the formation of said first rolled coil;

f) winding further portions of rolled strip onto said at least one second reel up to a predetermined weight limit or diameter limit of coil, defining further rolled coils, performing a cut of the rolled strip, by means of the first cutting means, after the formation of each of said further rolled coils;

g) welding, by means of the welder, a head of the rolled strip exiting the second rolling step, obtained from the last cut performed by said first cutting means, with a strip head coming from said storing means;

h) repeating the steps from b) to g) while continuing to perform step a).

[0017] The invention provides to continuously roll a mega coil, in the first rolling step, or odd rolling step, thus obtaining two or three thickness reductions.

[0018] A mega coil is a coil of strip obtained, for example, from at least 4-15 weldings of smaller strips, weighing from 100 to 300 tons and with a diameter from 4 to 6 m.

[0019] In a first variant of the invention, when the first winding reel, downstream of the rolling mill, reaches the predetermined maximum weight or maximum diameter, the strip entering the rolling mill is cut, thus uncoupling the rolling mill from the pickling line. Preferably, the aforesaid mega coil is wound onto the first reel after the first rolling step.

[0020] The pickling line continues processing the strip while storing it in the increased capacity exit storing means (500-3000 m of strip length, preferably at least 2000 m, equivalent to about 2-3 traditional coils which sizes or weight are equal to about ¼ of the sizes or weight of the mega coil). In this first variant of the invention, such increased capacity storing means consist of a horizontal store comprising, at one end, at least a movable carriage containing at least three idler rollers and, at the opposite end, fixed idler rollers so as to define a serpentine path of the pickled continuous strip. By moving, the movable carriage can cause the stored strip to be increased. The pickled strip is supported by suitable support rollers and deviated by diverter rollers located at the end opposite to the movable carriage.

[0021] In the meantime, by inverting the rolling direc-

tion, the rolling mill performs the second rolling pass with two or three thickness reductions. When the second winding reel, upstream of the rolling mill, reaches the predetermined weight limit or diameter limit, the strip is cut and a first coil is unloaded. This operation is continued thus producing, for example, four or five coils with specific weight from 15 to 21 kg/mm (kg per mm of strip width). The sizes and/or weights of the final coils on the second reel are fixed at automation level by setting a weight limit and a diameter limit. The first of the two limits to be reached by the coil on a second reel triggers the cutting by means of the first cutting means.

[0022] At the end of this activity of preparing the final coils, the process starts again with the strip head cut previously, and a new rolling step or odd step is started.

[0023] A condition of continuous rolling is created in the first (odd) pass by inserting a welder at the input of the rolling mill and leaving a tail from the previous rolling, available to be welded with the aforesaid head.

[0024] For the second (even) pass, continuous rolling is also achieved for the second step by installing a double winding reel or a carousel of reels upstream of the rolling mill in cooperation with a flying shear.

[0025] At the end of the second step, the pickling line and reversible rolling mill are coupled again and continuous rolling is resumed from the first step.

[0026] A further advantage of the present invention lies in the fact that by providing said increased capacity storing means between pickling line and rolling mill and by separating the two plants before the second rolling pass, certain "bottlenecks" which limit the productivity of the traditional coupled plant are eliminated, thus allowing increased productivity to be obtained.

[0027] In a second variant of the invention, increased capacity storing means are instead provided between the pickling line and the reversible rolling mill, comprising at least one third reel sized to wind a coil weighing from 100 to 300 tons and with a diameter of up to 6 metres (mega coil). Advantageously, there can be provided two third reels integral to a rotating platform, adapted to rotate by 180° about a vertical axis after a predetermined time to wind a mega coil onto one of the two third reels, whereby alternatively a first third reel is used as winding reel for winding the strip coming from the pickling line, and a second third reel is used as unwinding reel for unwinding the strip to feed the rolling mill. In this variant, the welder arranged between the pickling line and the first rolling stands only performs pre-welding and welding operations but does not cut the strip to uncouple the rolling mill from the pickling line. Uncoupling in this case is achieved by means of second cutting means upstream of the rotating platform, and by means of the rotating platform itself. The dependent claims describe preferred embodiments of the invention.

Brief description of the drawings

[0028] Further features and advantages of the inven-

tion will become more apparent from the detailed description of preferred, but not exclusive, embodiments of a combined pickling and rolling plant, disclosed by way of a non-limiting example, with the aid of the accompanying drawings, in which:

Fig. 1 depicts a diagrammatic view of a first embodiment of the plant according to the invention;

Fig. 2 depicts an example of rolling sequence for the first (odd) step;

Fig. 3 depicts an example of rolling sequence for the second (even) step with static cutting shear;

Fig. 4 depicts an example of rolling sequence for the second (even) step with flying shear;

Fig. 5 depicts a variant of the rolling mill of the plant of the invention;

Figs. from 6a to 6d depict an example of using a welder installed upstream of the rolling mill;

Fig. 7 depicts a diagrammatic view of a second embodiment of the plant according to the invention;

Fig. 8 depicts a diagrammatic view of a dual winding and unwinding strip system for exiting the pickling line and entering the rolling mill;

Fig. 9 depicts a working sequence of the aforesaid dual winding and unwinding system.

[0029] The same numbers in the figures identify the same elements or components.

Detailed description of preferred embodiments of the invention

[0030] With reference to figures from 1 to 9, there are depicted preferred embodiments of a combined continuous pickling and reversible cold rolling plant.

[0031] The plant, object of the present invention, in all its embodiments comprises:

- a pickling line for continuously pickling the strip;
- increased capacity storing means 20, 20' for storing the pickled strip having a capacity of 500-3000 metres of strip length, which are arranged downstream of the pickling line;
- a reversible cold rolling mill having at least two first rolling stands 19, arranged downstream of said storing means 20, 20';
- a reel 21, which is arranged downstream of the first rolling stands 19, for winding the strip after a first rolling step, or odd rolling step, and advantageously sized to wind a coil weighing from 100 to 300 tons and with a diameter of up to 6 metres;
- a welder 2', arranged between the storing means 20, 20' and the first rolling stands 19;
- at least one reel 16, arranged upstream of the first rolling stands 19 and downstream of welder 2', for winding at least one portion of the strip after a second rolling step, or even rolling step, in direction opposite to the first step, said at least one reel 16 being ad-

vantageously sized to wind strip portions up to a predetermined weight limit or diameter limit of coil, for example a specific weight from 15 to 21 kg/mm or a diameter of about 2000-2100 mm;

- first cutting means, for example a shear 22, 23, arranged between said at least one second reel 16 and the first rolling stands 19, which are adapted to cut the rolled strip each time a strip portion wound on reel 16 reaches said predetermined weight limit or diameter limit of coil.

[0032] Advantageously, welder 2' is adapted to weld the head of the rolled strip exiting the second rolling step, obtained from a cut performed by the first cutting means, with a strip head coming from the storing means 20, 20'.

[0033] Reel 21 has increased capacity and is made with an increased thickness tube or with a metal round bar capable of supporting the weight of large sized coils weighing up to 300 t or with a diameter of up to 6 metres. Such a reel 21 is also sized to apply a pulling action of 350 to 500 kN, preferably 400 kN, during rolling, in order to facilitate increased thickness reductions at the rolling mill.

[0034] In a first embodiment of the invention, welder 2' is configured to cut the strip coming from the storing means 20 after a predetermined quantity of strip has undergone the first rolling step, thus uncoupling the rolling mill from the pickling line. With reference to figure 1 and figure 6d, the pickling line comprises, in sequence:

- an input section with at least two unwinding reels 1 and a welder 2, preferably a laser welder, capable of making rollable joints between the strips unwound by said reels 1, thus defining a continuous strip;
- input storing means 3 for storing said continuous strip and ensuring the continuous operation of the pickling process;
- a scale or oxide breaker 4 in which, through the combined action of pulling and alternating bending about rollers of a suitable diameter, the crushing is obtained of the layer of oxide covering the continuous strip, thus promoting the successive etching;
- pickling tanks 5, for example from two to four according to the productivity required, where the aforesaid etching occurs on the continuous strip; said tanks 5 being provided with auxiliary systems for recirculating and heating the acidic pickling solution.

[0035] Along the entire pickling line, there are provided strip guide systems, systems for controlling the pulling, and various auxiliary systems.

[0036] Optionally, downstream of the pickling tanks 5, there can be provided:

- intermediate storing means 6 where there is stored the pickled continuous strip exiting the pickling tanks 5, after being rinsed and dried;
- a machine 7 for trimming the edges of the pickled

continuous strip, said intermediate storing means 6 serving the function of avoiding stops in the pickling process in case the trimming machine 7 is stopped to change the strip width or the blades.

[0037] Advantageously, the plant in this first embodiment of the invention provides, directly downstream of the pickling tanks 5 or of the trimming machine 7, increased capacity storing means 20 acting as storing means at the exit of the pickling line, which are sized to receive from 500 to 3000 metres of pickled continuous strip, preferably at least 2000 metres.

[0038] Said increased capacity storing means 20 consist of a horizontal store comprising, at one end, at least a movable carriage containing at least three idler rollers and, at the opposite end, fixed idler rollers so as to define a serpentine path of the pickled continuous strip. By moving, the movable carriage can cause the stored strip to be increased. Downstream of said increased capacity storing means 20, there are provided, in sequence:

- equipment for controlling the pulling and centring 9 of the pickled continuous strip, sized to obtain a pulling action from 250 to 500 kN, preferably 400 kN;
- said welder 2', preferably a laser welder;
- said at least one reel 16 advantageously configured to wind strip portions with specific weight from 15 to 21 kg/mm or coils with a diameter of up to 2000 - 2100 mm;
- a cutting shear 22, 23;
- said at least two reversible first rolling stands 19, of the four-high or six-high type;
- reel 21, advantageously configured to wind a coil weighing from 100 to 300 tons and with a diameter of up to 6 metres.

[0039] In an advantageous variant, there are only two first rolling stands 19. Thereby, two rolling steps are performed with four thickness reductions in total.

[0040] There are provided along the rolling mill auxiliary systems for cooling and lubricating the strip, and further auxiliary systems for monitoring the rolling process.

[0041] The operation of this first embodiment of the invention (figures from 1 to 6d) is described below.

[0042] The unwinding reels 1 of the input section unwind respective strips which are welded to each other by means of welder 2, thus defining a continuous strip. To ensure the continuous operation of the pickling process, the continuous strip is stored in the input storing means 3. The continuous strip, still covered by a layer of oxide, exiting from the storing means 3 crosses the scale breaker 4 where, through the combined action of pulling and alternating bending about rollers of a suitable diameter, the crushing is obtained of the layer of oxide, thus promoting the successive etching in the pickling tanks 5. Then the continuous strip passes through the pickling tanks 5 and afterwards is rinsed and dried.

[0043] When provided, the pickled continuous strip enters the intermediate storing means 6 and then crosses the edge trimming machine 7.

[0044] The pickled continuous strip then enters the increased capacity storing means 20, thus being stored in the serpentine path with the idler rollers of the pickled continuous strip, such as for example the one illustrated diagrammatically in fig. 1. Then the pickled continuous strip passes through the equipment for controlling the pulling action and centring 9, defining the input system to the rolling mill, and crosses welder 2'.

[0045] If a leading strip 40 about 30 metres long is provided on the winding reel 21, it is advantageously possible to provide a joint 26 between said leading strip 40 and head 41 (fig. 6a) of the pickled continuous strip by means of welder 2', thus obtaining the possibility of feeding this joint 26 through the reversible two-stand rolling mill 19 with the strip being pulled due to the winding reel 21 (figures from 6a to 6d). The head 41 of the strip is prepared for welding by performing a precision cut using welder 2'. Before performing the welding, the end of the leading strip 40 is also prepared by performing a precision cut using welder 2'.

[0046] During the first (odd) rolling step, the first stands 19 continuously roll, for example, at least four strips, welded to each other, belonging to the aforesaid continuous strip (with four welded joints, considering also the one with the leading strip) up to realizing the so-called mega coil on reel 21, that is a coil weighing from 100 to 300 tons and with a diameter of up to 6 metres. At this point, welder 2' cuts the joint that joins the fourth strip with the fifth strip of the aforesaid continuous strip. As soon as the weight limit of 300 tons or the diameter limit of the coil of 6 metres is reached, specific sensors send a command signal to welder 2' which performs the aforesaid cut.

[0047] The number of welded starting strips required to make the aforesaid mega coil can vary based on the length of the starting strips.

[0048] During this first rolling step, the increased capacity storing means 20, which at the beginning of the rolling were almost at their maximum storing capacity, are emptied due to the difference in speed between the rolling mill and the pickling line.

[0049] The tail of the pickled continuous strip, cut by welder 2', is fed onto the winding reel 16 (fig. 3a) to start the reversible second (even) rolling step of the strip wound on reel 21.

[0050] When reel 16 winds a first rolled coil having a specific weight from 15 to 21 kg/mm or with a diameter of 2000 - 2100 mm, the rolling mill stops, specific sensors send a command signal to the static cutting shear 22 which cuts the strip being wound onto reel 16 and the first rolled coil is unloaded from reel 16. The strip head obtained from this static cut, exiting from the first stands 19, is fed onto reel 16 and the second rolling step is resumed up to obtaining a second rolled coil on reel 16 having a specific weight from 15 to 21 kg/mm or with a

diameter of 2000 - 2100 mm. The rolling mill stops again, the static cutting shear 22 cuts the strip being wound onto reel 16 and the second rolled coil is unloaded from reel 16. These operations are repeated up to the second rolling step of a last rolled coil, for example the fourth coil, when the leading strip, fixed to reel 21, is about to enter the first rolling stands 19. Rolling stops, the first stands 19 are opened, the static cutting shear 22 cuts the strip again and said last rolled coil having a specific weight from 15 to 21 kg/mm or with a diameter of 2000 - 2100 mm, is unloaded from reel 16, while the head of the leading strip reaches welder 2' to make a welding joint which can be rolled with the head of the pickled continuous strip, cut previously by welder 2'. Once this welding is completed, the cycle starts again with a first (odd) rolling step and the formation of a new mega coil on reel 21. By inserting welder 2' at the input of the rolling mill and leaving a strip tail from the previous rolling, available to be welded with the head of the pickled continuous strip, cut previously by welder 2', a condition of continuous rolling is created in the odd first rolling step.

[0051] During the rolling step, the increased capacity storing means 20 are filled by the pickled continuous strip exiting from the pickling line. Advantageously, the speed of the pickling line is adjusted so as to substantially make equal the time to completely fill the storing means 20 with the cycle time of the rolling mill to complete the formation of the aforesaid rolled coils on reel 16.

[0052] To obtain a condition of continuous rolling also in the second, or even, rolling step, a variant provides using a flying cutting shear 23 in place of the static cutting shear 22, and a double reel or a carousel 24 of reels 16, in place of the single reel 16 (figure 4). The flying cutting shear 23 is adapted to cut the rolled strip at a speed of 50 to 500 mpm. Carousel 24 generally has two reels 16, which are diametrically opposed to one another and are hinged on a rotating drum, which alternatively wind the rolled strip: when one of the reels is winding a final coil, the other reel is freed of the previously wound final coil.

[0053] In a second embodiment of the invention, illustrated in figures 7 to 9, the increased capacity storing means 20' instead comprise at least a further increased capacity reel 28 sized to wind a coil weighing from 100 to 300 tons and with a diameter of up to 6 metres (mega coil). Advantageously, there are provided two further increased capacity reels 28, 28' integral to ends or opposite sides of a rotating platform 27 (figure 8), adapted to rotate by 180° about a vertical axis after a predetermined time in which a mega coil is wound onto one of the two reels 28, 28', whereby alternatively a first reel 28 is used as reel for winding the pickled continuous strip coming from the pickling line, and a second reel 28' is used as reel for unwinding the pickled continuous strip feeding the rolling mill. There are provided second cutting means, for example a further shear (not illustrated), arranged upstream of the rotating platform 27 and configured to cut the pickled strip once the mega coil has been wound onto one of the two reels 28, 28'. In this case too, specific sensors

send a command signal to the second cutting means once the weight limit of 300 tons or the diameter limit of 6 metres of coil is reached. After this cut, the rotating platform 27 is rotated by 180°.

[0054] A serpentine path 8 (figure 7) can be provided upstream of said second cutting means, with idler rollers 8' of the pickled continuous strip, which object is the one of storing the strip processed by the pickling line each time the increased capacity winding reel 28 stops. The same components of the plant in fig. 1, that is all components indicated with numerals 1, 2, 3, 4, 5, 6 and 7, are provided upstream of said coil path 8.

[0055] The rotating platform 27, defining a dual system for winding/unwinding the strip, can be actuated by means of, for example, a rack system. The rotation thereof is controlled by electric or hydraulic motor 32 which allows a rotation of 180° to be achieved. On the opposite sides of said rotating platform 27, there is mounted a respective increased capacity reel 28, 28' adapted to wind/unwind mega coils weighing from 100 to 300 t and with a diameter of about 6 metres.

[0056] The rotation commands 31, 30 and 31', 30' of the respective reels 28, 28' are independent from each other so as to independently control the winding rotation of the strip coming from the pickling line and the unwinding rotation of the pickled strip towards the first rolling stands 19 of the reversible cold rolling mill.

[0057] During the 180° rotation of the rotating platform 27, the rotation commands 31, 30 and 31', 30' are uncoupled from the respective reels 28, 28' through a respective movable joint 29, 29' which is retracted.

[0058] The strip wound onto and unwound from the reels 28, 28' is kept aligned and centred by an axial movement of a respective mandrel 34, 34' controlled by a corresponding hydraulic cylinder 33, 33'.

[0059] Downstream of the reels 28, 28', and therefore of the rotating platform 27, there are provided in sequence (fig. 7):

- welder 2', preferably a laser welder;
- at least one reel 16 advantageously configured to wind strip portions with specific weight from 15 to 21 kg/mm or coils with a diameter of up to 2000 - 2100 mm;
- the cutting shear 22;
- said at least two reversible first rolling stands 19, of the four-high or six-high type;
- increased capacity reel 21, advantageously configured to wind a coil weighing from 100 to 300 tons and with a diameter of up to 6 metres.

[0060] In an advantageous variant, there are only two first rolling stands 19. Thereby, two rolling steps are performed with four thickness reductions in total.

[0061] There are provided along the rolling mill auxiliary systems for cooling and lubricating the strip, and further auxiliary systems for monitoring the rolling process.

[0062] The operation of this second embodiment of the

invention (figures from 7 to 9) is described below.

[0063] The unwinding reels 1 of the input section unwind respective strips which are welded to each other by means of welder 2, thus defining a continuous strip. To ensure the continuous operation of the pickling process, the continuous strip is stored in the input storing means 3. The continuous strip, still covered by a layer of oxide, exiting from the storing means 3 crosses the scale breaker 4 where, through the combined action of pulling and alternating bending about rollers of a suitable diameter, the crushing is obtained of the layer of oxide, thus promoting the successive etching in the pickling tanks 5. Then the continuous strip passes through the pickling tanks 5 and afterwards is rinsed and dried.

[0064] When provided, the pickled continuous strip enters the intermediate storing means 6 and then crosses the edge trimming machine 7.

[0065] The pickled continuous strip then enters the increased capacity storing means 20' by winding, for example, on the increased capacity reel 28' of the rotating platform 27 (figure 8).

[0066] Fig. 9 diagrammatically depicts the working sequence at speed of the rotating platform 27. In a first step (fig. 9a), the first reel 28 starts winding a mega coil of pickled strip, while the second reel 28' starts unwinding another mega coil, wound previously, towards the first rolling stands 19 so as to start the first rolling step.

[0067] In a second step (fig. 9b), while the reversible rolling mill performs the second rolling step and the second reel 28' is empty, the first reel 28 completes winding the mega coil of pickled strip, winding is interrupted, the pickled strip is cut upstream of the rotating platform 27 by means of the second cutting means, and the rotating platform 27 begins to rotate to bring said first reel 28 into position for unwinding the pickled strip towards the first rolling stands 19.

[0068] In a third step (fig. 9c), with the first reel 28 in the unwinding position, the strip is unwound from the first reel 28 and brought to the feed or welding position, close to welder 2', while the second reel 28' starts winding a new mega coil of pickled strip. The head of the strip, unwound from a new mega coil onto reel 28 or reel 28', is prepared by performing a precision cut with welder 2' so as to be ready for the successive welding.

[0069] Supposing to have left a leading strip about 30 metres long on the winding reel 21, it is advantageously possible, by means of welder 2', to make a joint between the leading strip and the head of the pickled strip coming from the first reel 28, thus obtaining the possibility of feeding this joint through the reversible rolling mill with two first stands 19 with the strip taught due to the exiting winding reel 21.

[0070] Before performing the welding, the end of the leading strip is also prepared by performing a precision cut using welder 2'.

[0071] During the first (odd) rolling step, the first stands 19 continuously roll the strip unwound from the first reel 28 up to obtaining the so-called mega coil again on the

increased capacity reel 21.

[0072] During this first rolling step, the mega coil on the increased capacity unwinding reel 28 is completely unwound, at the same time the other reel 28', in the position of winding the pickled strip, winds a new mega coil.

[0073] The tail of the pickled continuous strip, rolled and rewound onto reel 21 is fed onto the winding reel 16, thus starting the second reversible (even) rolling step (fig. 7). When reel 16 winds a first rolled coil having a specific weight from 15 to 21 kg/mm or with a diameter of 2000 - 2100 mm, the rolling mill stops, specific sensors send a command signal to the static cutting shear 22 which cuts the strip being wound onto reel 16 and the first rolled coil is unloaded from reel 16. The strip head obtained, exiting from the first rolling stands 19, is fed onto reel 16 and the second rolling step is resumed up to obtaining a second rolled coil on reel 16 having a specific weight from 15 to 21 kg/mm or with a diameter of 2000 - 2100 mm. The rolling mill stops again, the static cutting shear 22 cuts the strip being wound onto reel 16 and the second rolled coil is unloaded from reel 16. These operations are repeated up to the second rolling step of a last rolled coil, for example the fourth coil, when the leading strip is about to enter the first rolling stands 19. Rolling stops, the first rolling stands 19 are opened, the static cutting shear 22 cuts the strip again and said last rolled coil having a specific weight from 15 to 21 kg/mm or with a diameter of 2000 - 2100 mm is unloaded from reel 16.

[0074] In the meantime, as soon as the winding of a mega coil is completed on the increased capacity winding reel 28', winding is interrupted, the pickled strip is cut upstream of the rotating platform 27 by means of the second cutting means, and said rotating platform 27 rotates by 180° thus bringing reel 28' into the unwinding position towards the reversible rolling mill and reel 28 into the position for winding the strip coming from the pickling line.

[0075] The head of the strip, unwound from the new mega coil onto reel 28', is fed in known manner up to reaching welder 2' and is prepared by performing a precision cut with welder 2' so as to be ready for the successive welding. Before performing the welding, the end of the leading strip is also prepared by performing a precision cut using the same welder 2'.

[0076] Once this welding between the leading strip and the head of the strip of the new mega coil is completed, the cycle starts again with a first (odd) rolling step and the successive formation of the mega coil on reel 21. By inserting welder 2' at the input of the rolling mill and leaving a strip tail from the previous rolling, available to be welded with the head of the successive pickled continuous strip, a condition of continuous rolling is created in the first, or odd, rolling step.

[0077] To obtain a condition of continuous rolling also in the second, or even, rolling step, a variant provides using a flying cutting shear 23 in place of the static cutting shear 22, and a double reel or a carousel 24 of reels in place of the single reel 16 (in similar manner to the one

in figure 4). The flying cutting shear 23 is adapted to cut the rolled strip at a speed of 50 to 500 mpm. Carousel 24 generally has two reels 16, which are diametrically opposed to one another and are hinged on a rotating drum, which alternatively wind the rolled strip: when one of the reels is winding a final coil, the other reel is freed of the previously wound final coil.

[0078] In both embodiments described above, it is possible to provide a further rolling stand 25 arranged upstream of the at least two first rolling stands 19 and configured to be open in the odd rolling step and closed in the even rolling step. Thereby, two rolling steps are performed with five thickness reductions in total. Advantageously, the further rolling stand 25 is provided with working rolls having a surface roughness greater than the surface roughness of the working rolls of the two first rolling stands 19. This variant allows a rolling surface with controlled roughness to be obtained in the last rolling step. Preferably, the rolling stand 25 will be cooled in the second and last rolling step with a dedicated system in order to obtain better surface cleaning.

Claims

1. A combined pickling and rolling plant for pickling and rolling a metal strip, comprising

- a pickling line for continuously pickling the strip;
- storing means (20, 20') for storing the pickled strip which are arranged downstream of the pickling line;
- a reversible cold rolling mill having at least two first rolling stands (19), arranged downstream of said storing means (20, 20');
- a first reel (21), which is arranged downstream of said at least two first rolling stands (19), for winding the strip after a first rolling step;
- at least one second reel (16), arranged upstream of said at least two first rolling stands (19), for winding at least one portion of the strip after a second rolling step in direction opposite to the first step, said at least one second reel (16) being sized to wind strip portions up to a predetermined weight limit or diameter limit of coil;
- first cutting means, arranged between said at least one second reel (16) and said at least two first rolling stands (19), which are adapted to cut the rolled strip each time a strip portion wound on the at least one second reel (16) reaches said predetermined weight limit or diameter limit of coil;

characterized in that

said storing means (20, 20') for storing the pickled strip have a capacity of 500-3000 metres of strip length,
said first reel (21) is sized to wind a coil weighing

- from 100 to 300 tons and/or with a diameter of up to 6 metres,
 - a welder (2') is arranged between said storing means (20, 20') and said at least two first rolling stands (19),
 said at least one second reel (16) is arranged downstream of said welder (2),
 and **in that** said welder (2') is adapted to weld a head of the rolled strip exiting the second rolling step, obtained from a cut performed by the first cutting means, with a strip head coming from said storing means (20, 20').
2. A plant according to claim 1, wherein the welder (2') is configured to cut the strip coming from the storing means (20) after a predetermined quantity of strip has undergone the first rolling step, uncoupling the rolling mill from the pickling line.
 3. A plant according to claim 1, wherein said storing means (20') comprise at least one third reel (28) sized to wind a coil weighing from 100 to 300 tons and/or with a diameter of up to 6 metres.
 4. A plant according to claim 3, wherein there are provided two third reels (28, 28') integral to opposite ends of a rotating platform (27) adapted to rotate about a vertical axis, whereby alternatively a first third reel (28) is used as reel for winding the strip coming from the pickling line, and a second third reel (28') is used as reel for unwinding the strip feeding the rolling mill.
 5. A plant according to claim 4, wherein there are provided second cutting means arranged upstream of said rotating platform (27), configured to cut the pickled strip once the coil weighing from 100 to 300 tons and/or with a diameter of up to 6 metres has been wound onto one of the two third reels (28, 28').
 6. A plant according to any one of the preceding claims, wherein there is provided at least one further rolling stand (25) arranged upstream of the at least two first rolling stands (19) and configured to be open in the first rolling step and closed in the second rolling step, said further rolling stand (25) being equipped with working rolls having a surface roughness greater than the surface roughness of the working rolls of the two first rolling stands (19).
 7. A plant according to any one of the preceding claims, wherein there is provided a leading strip (40), fixed to said first reel (21), whereby the welder (2') is also adapted to weld, before the first rolling step, the leading strip (40) to a first strip head (41) coming from said storing means (20, 20').
 8. A plant according to any one of the preceding claims,
- wherein the first cutting means are a static cutting shear (22) or a flying cutting shear (23).
9. A plant according to claim 8, wherein, in the case of flying cutting shear, a double second reel (16) or a carousel (24) of second reels (16) is provided for performing an even step of continuous rolling.
 10. A pickling and rolling process for pickling and rolling a metal strip, by means of a plant according to claim 1, comprising the following steps:
 - a) continuously pickling the strip by means of the pickling line;
 - b) storing the pickled strip by means of the storing means (20, 20') having a capacity of 500-3000 metres of strip length;
 - c) performing a first rolling step of a predetermined quantity of strip in the at least two first rolling stands (19) and a successive winding onto the first reel (21) of a coil weighing from 100 to 300 tons and/or with a diameter of up to 6 metres;
 - d) performing a second rolling step, in direction opposite to the first step, of said predetermined quantity of strip in the at least two first rolling stands (19), defining a rolled strip, and performing a winding of a first portion of rolled strip onto at least one second reel (16) up to a predetermined weight limit or diameter limit of coil, thus defining a first rolled coil;
 - e) cutting, by means of the first cutting means, the rolled strip after the formation of said first rolled coil;
 - f) winding further portions of rolled strip onto said at least one second reel (16) up to a predetermined weight limit or diameter limit of coil, defining further rolled coils, performing a cut of the rolled strip, by means of the first cutting means, after the formation of each of said further rolled coils;
 - g) welding, by means of the welder (2'), a head of the rolled strip exiting the second rolling step, obtained from the last cut performed by said first cutting means, with a strip head coming from said storing means (20, 20');
 - h) repeating the steps from b) to g) while continuing to perform step a).
 11. A process according to claim 10, wherein between step c) and step d) there is provided a cut of the pickled strip by means of the welder (2'), for uncoupling the rolling mill from the pickling line.
 12. A process according to claim 11, wherein the speed of the pickling line is adjusted so as to make equal the time to completely occupy the storing means (20) and the cycle time of the rolling mill to complete the

formation of the rolled coils on said at least one second reel (16).

13. A process according to claim 10, wherein, once a coil weighing from 100 to 300 tons and/or with a diameter of up to 6 metres has been wound onto said storing means (20') comprising two third reels (28, 28') integral to opposite ends of a rotating platform (27), there is provided a cut of the strip upstream of said rotating platform (27). 5 10
14. A process according to claim 13, wherein, after a first coil weighing from 100 to 300 tons and/or with a diameter of up to 6 metres is wound onto a reel (28') of said two third reels (28, 28'), the rotating platform (27) rotates by 180°, whereby the other reel (28) of said two third reels (28, 28') is used as reel for winding the strip to make a second coil weighing from 100 to 300 tons and/or with diameter of up to 6 metres, while the reel (28') is used as reel for unwinding the first coil to supply the rolling mill, and so on. 15 20
15. A process according to any of the claims from 10 to 14, wherein there is provided a leading strip (40), fixed on the first reel (21) to produce, before the first step c), by means of the welder (2'), a welding joint between said leading strip (40) and a first head (41) of the pickled strip arriving to the rolling mill; and wherein, before the step g), when said leading strip is about to enter the rolling mill, the at least two rolling stands (19) are opened and the head of the rolled strip obtained from the last cut performed by the first cutting means is brought in proximity of the welder (2'). 25 30 35

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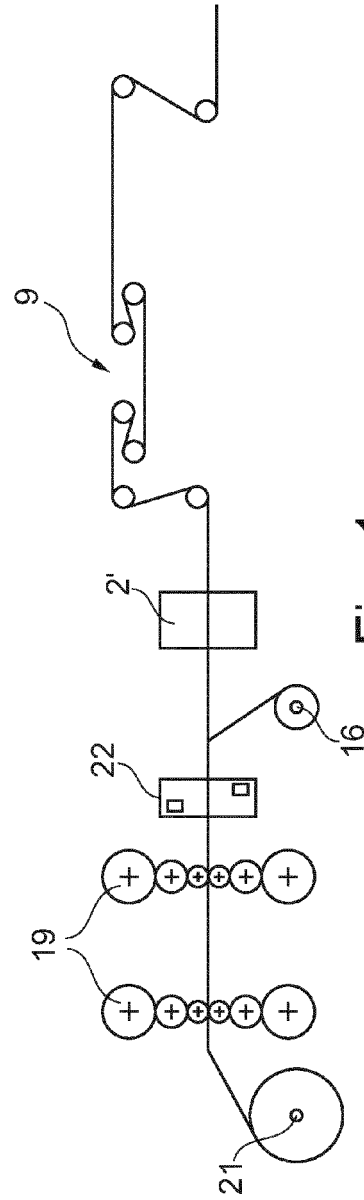
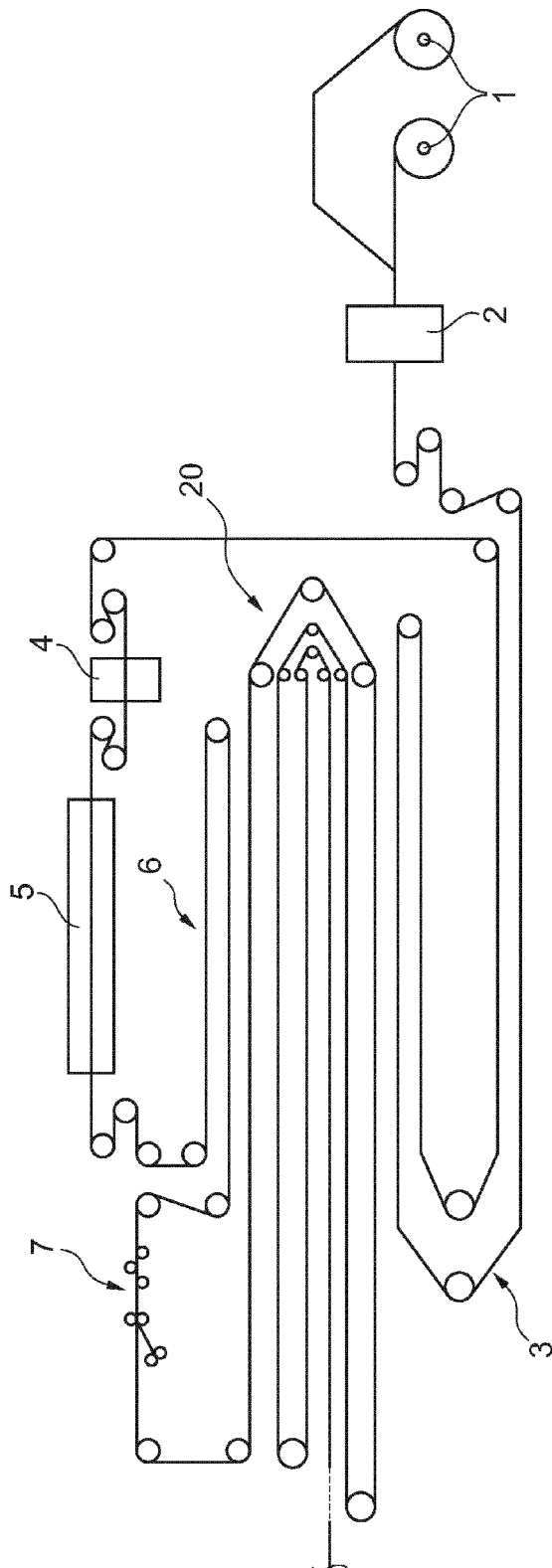


Fig. 1

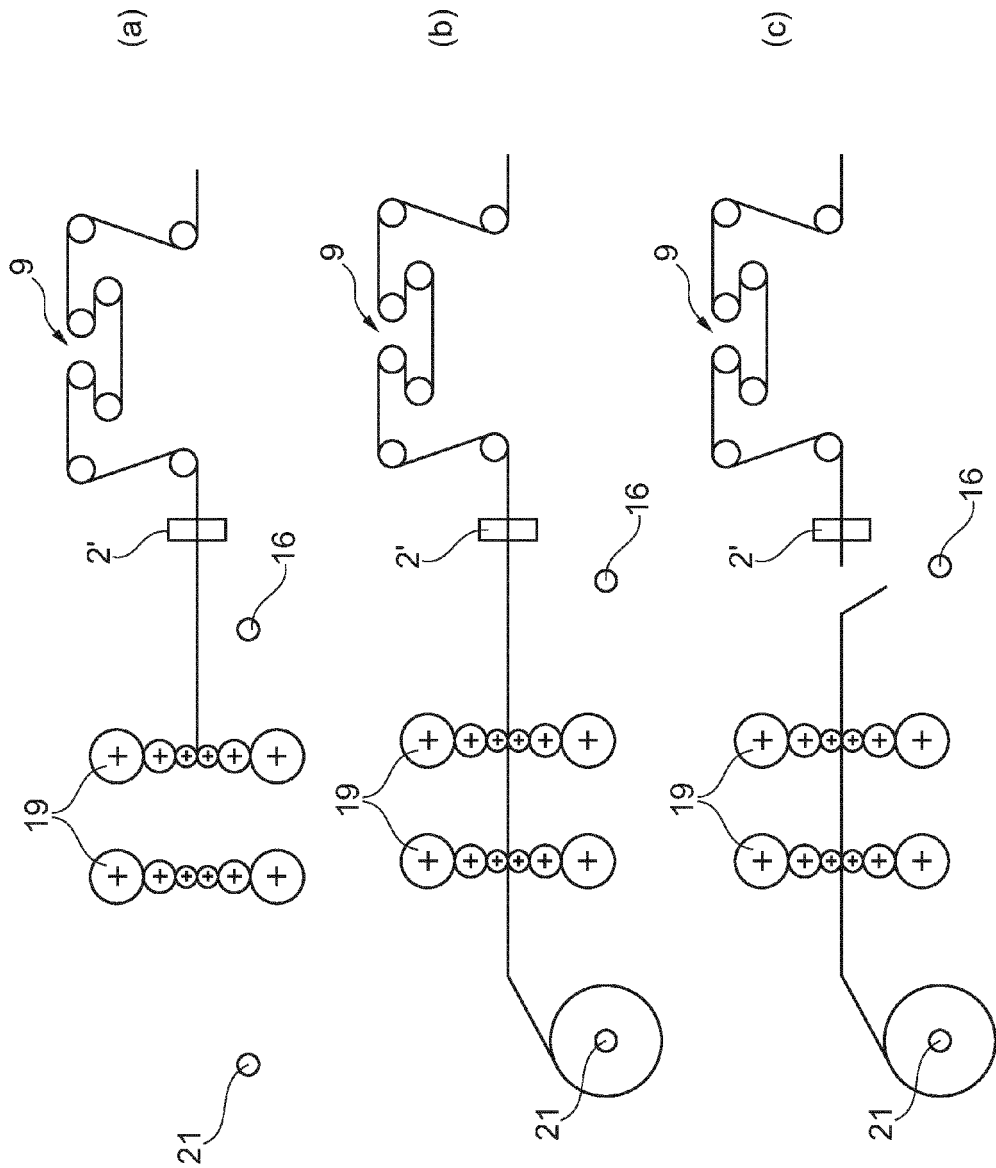


Fig. 2

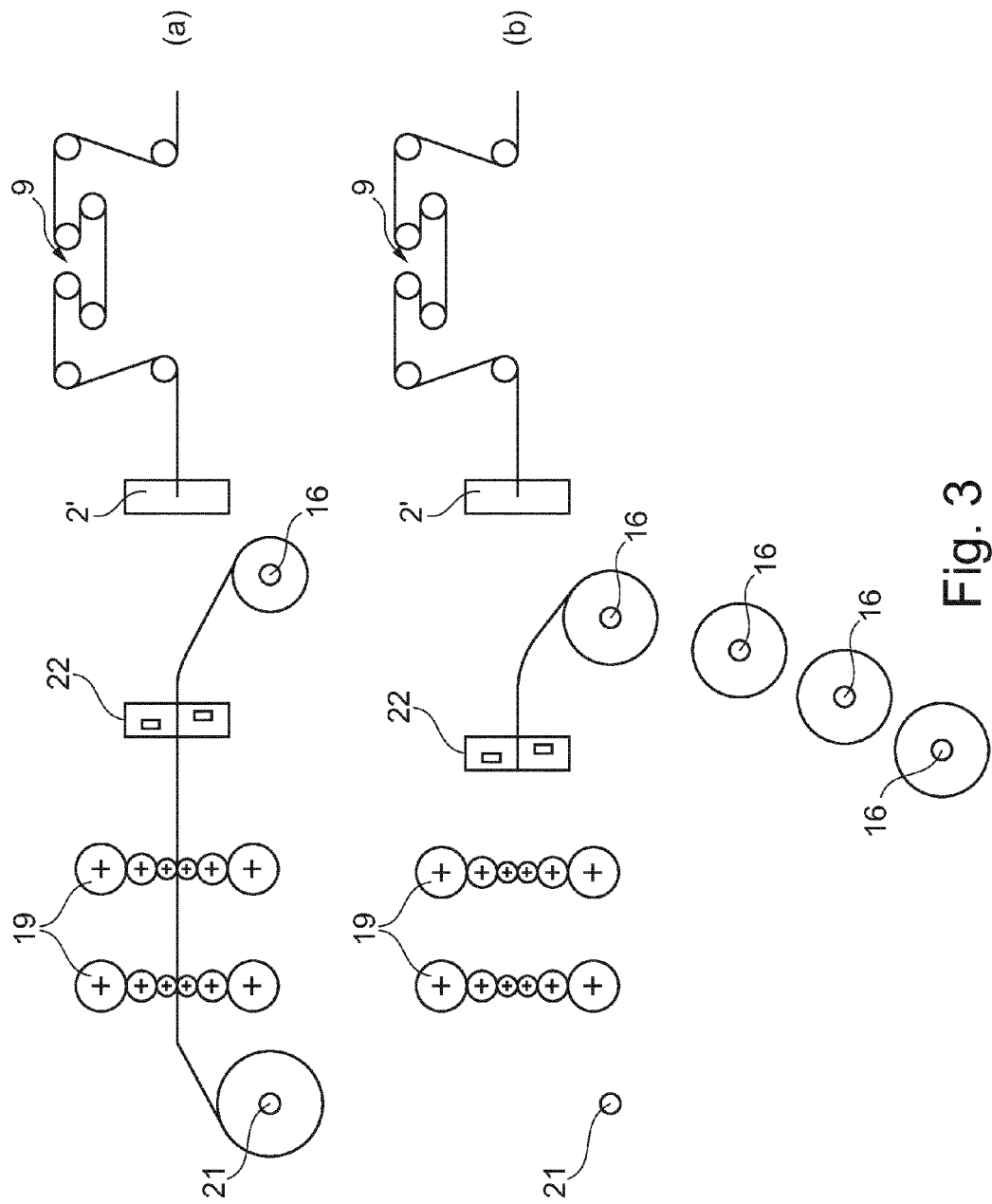


Fig. 3

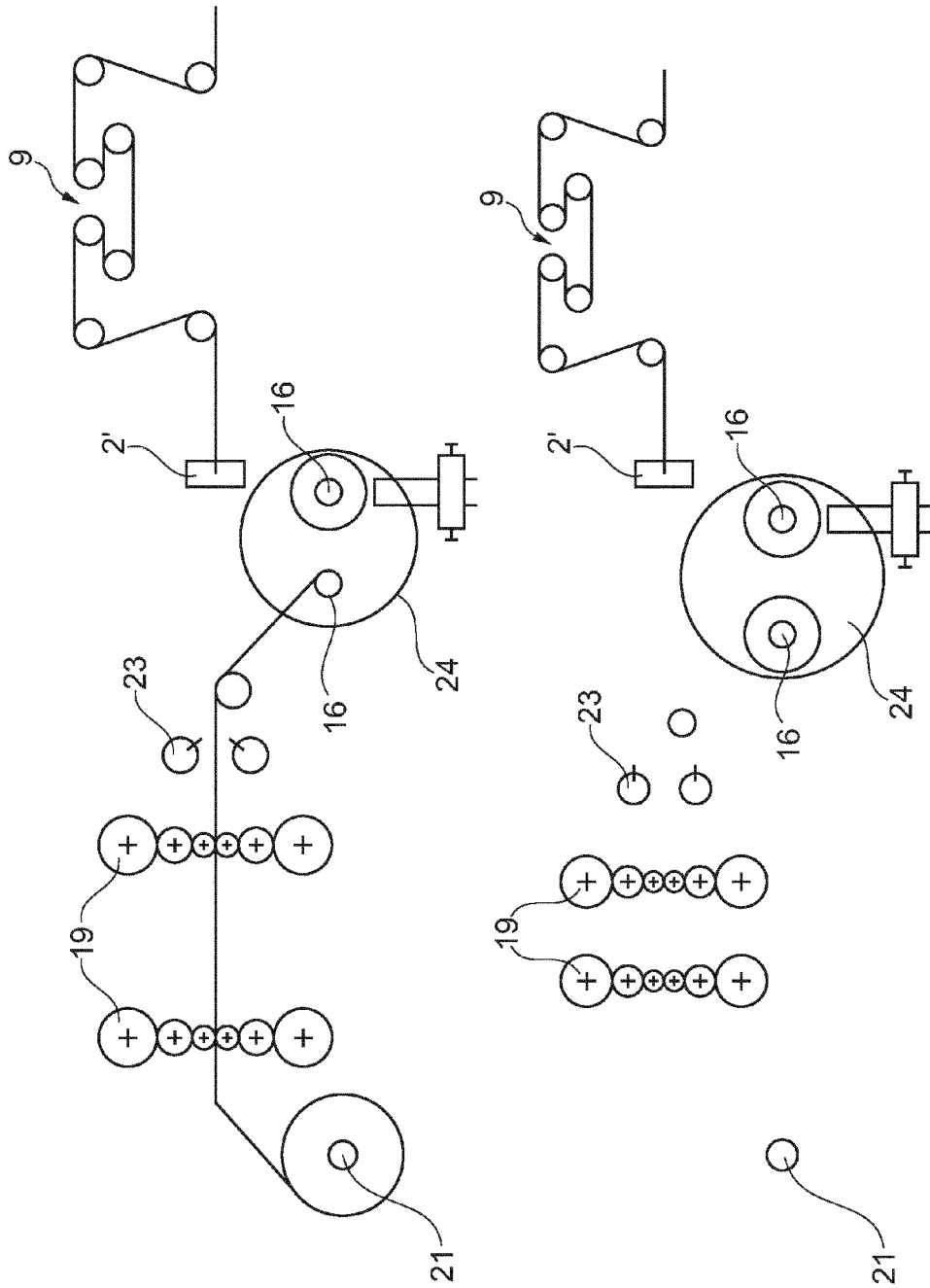


Fig. 4

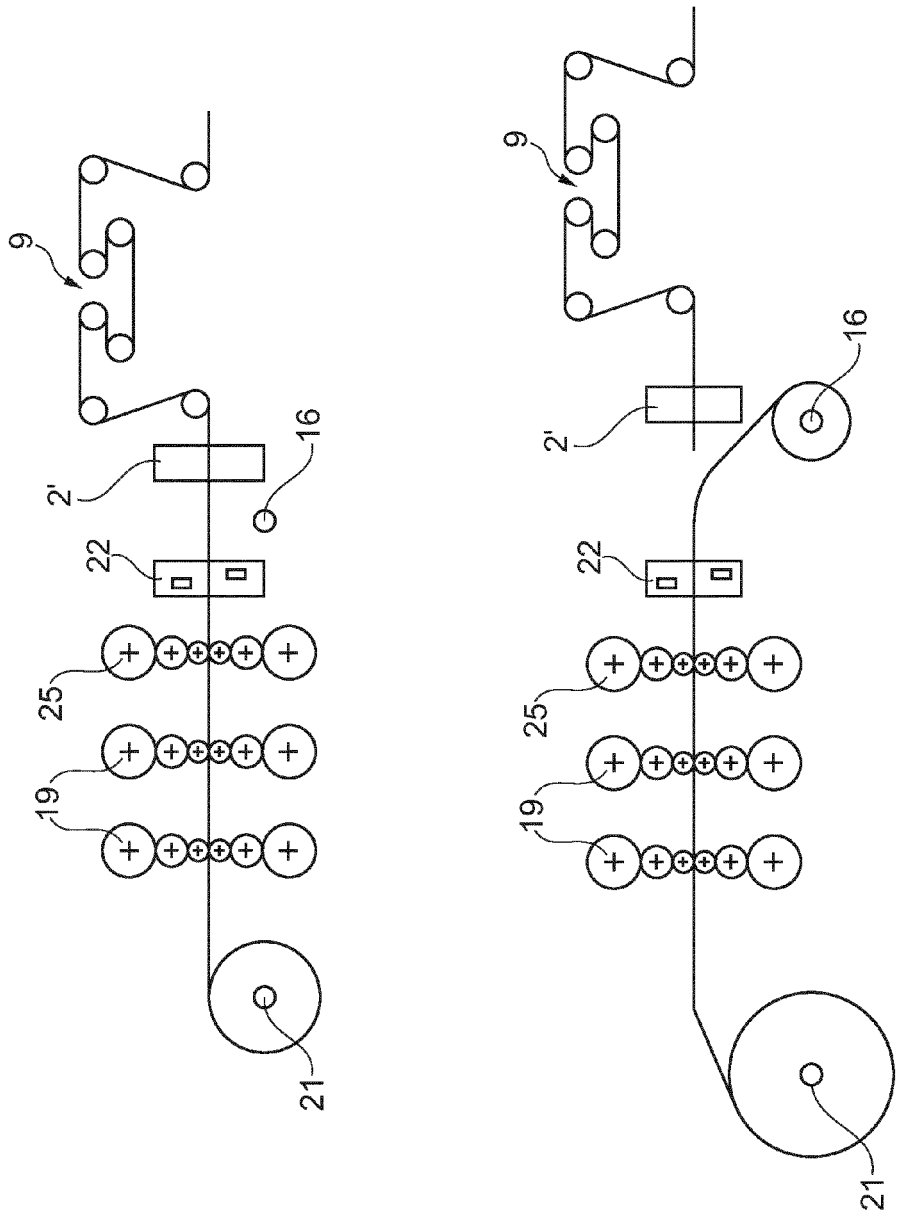
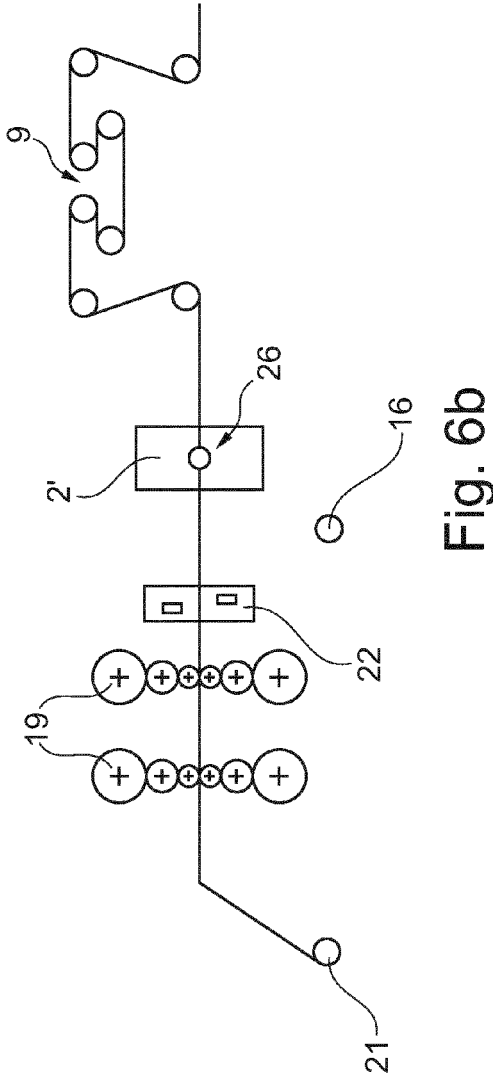
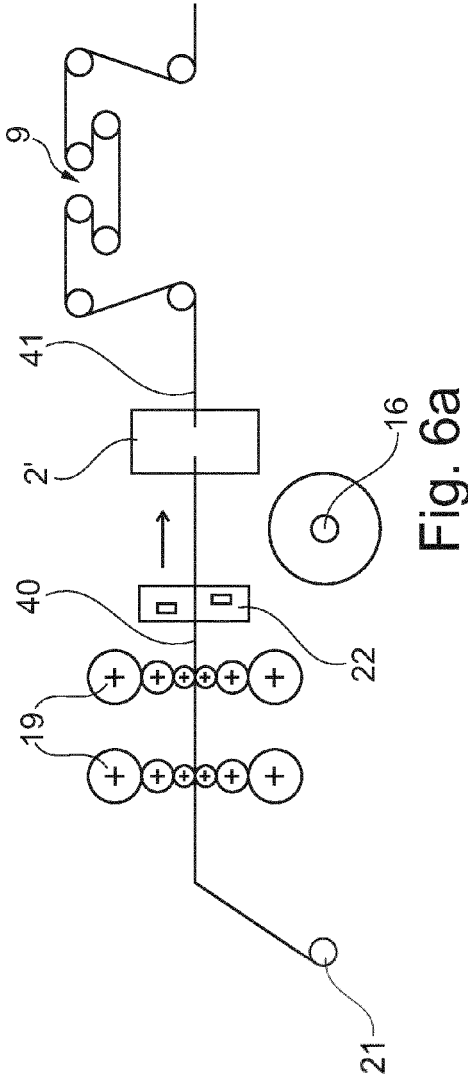


Fig. 5



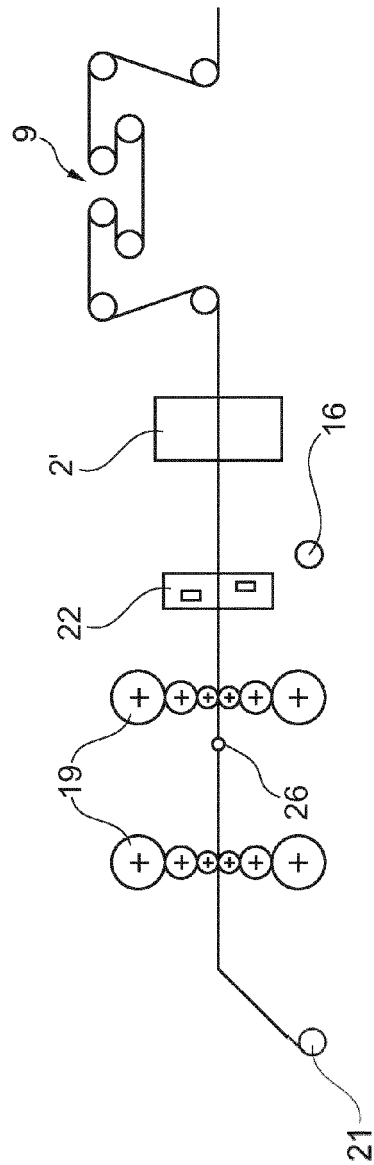


Fig. 6c

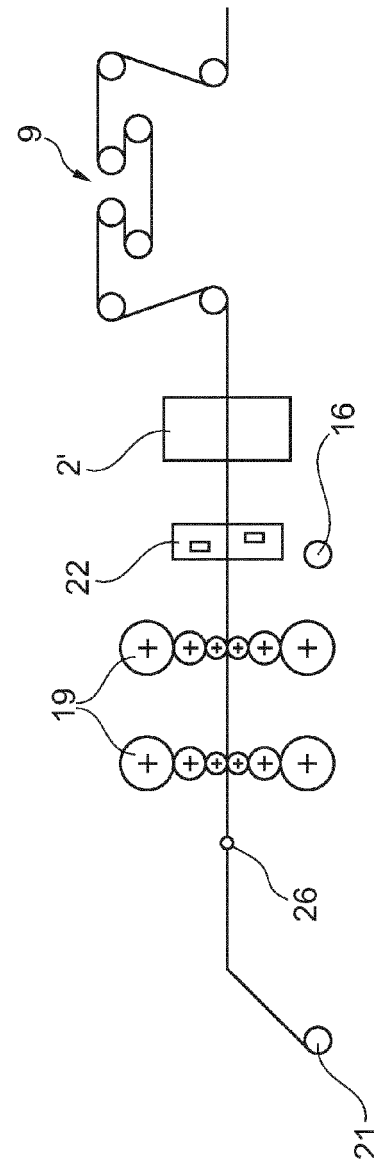


Fig. 6d

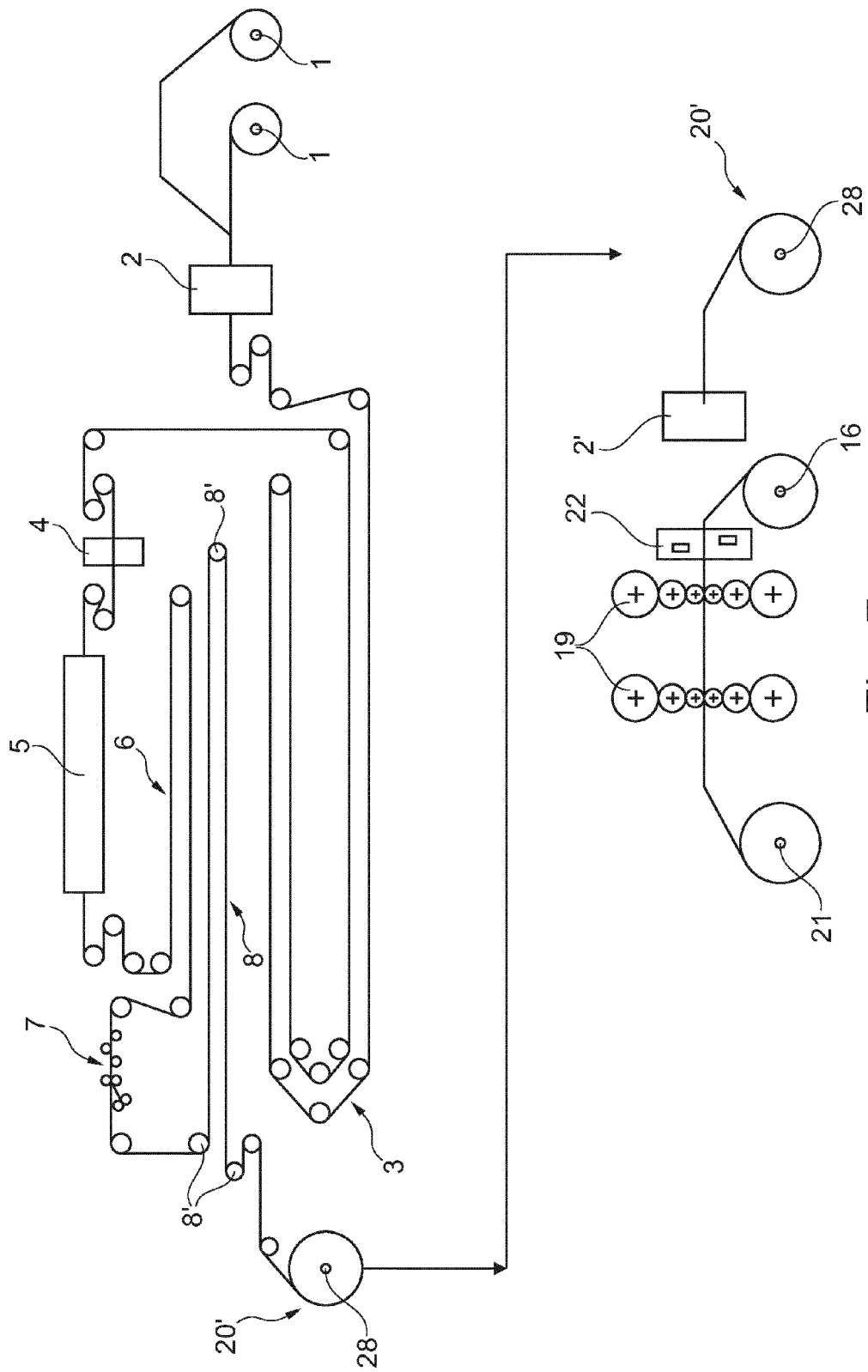


Fig. 7

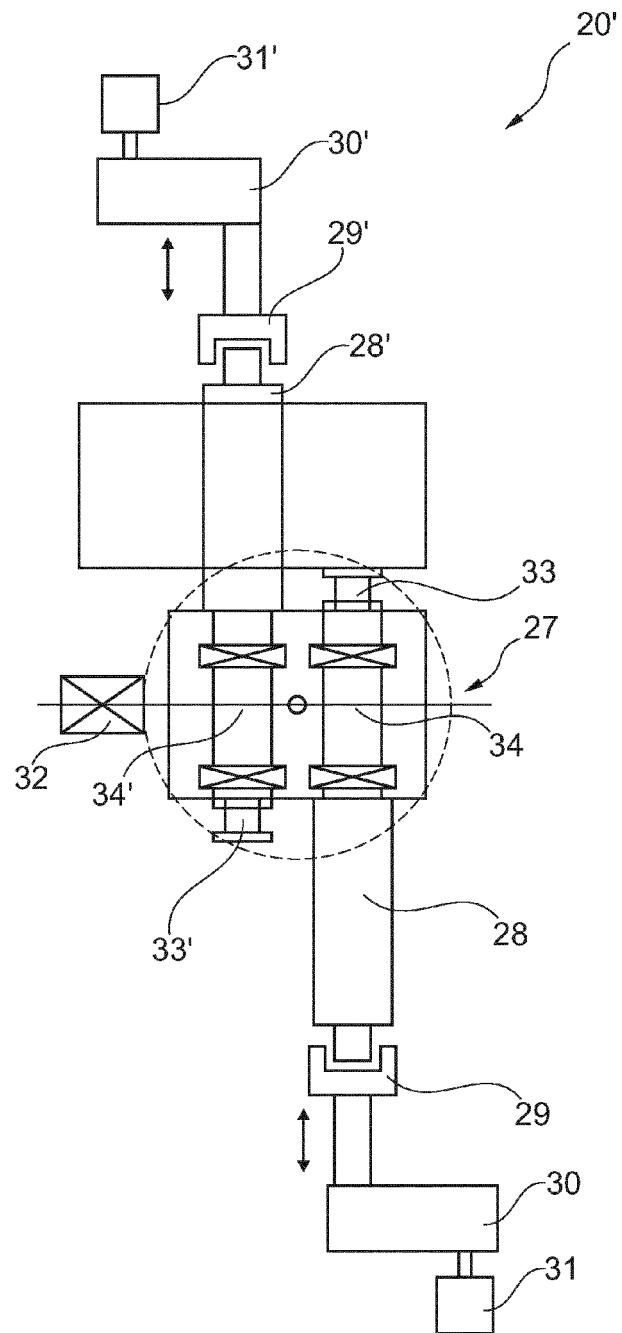


Fig. 8

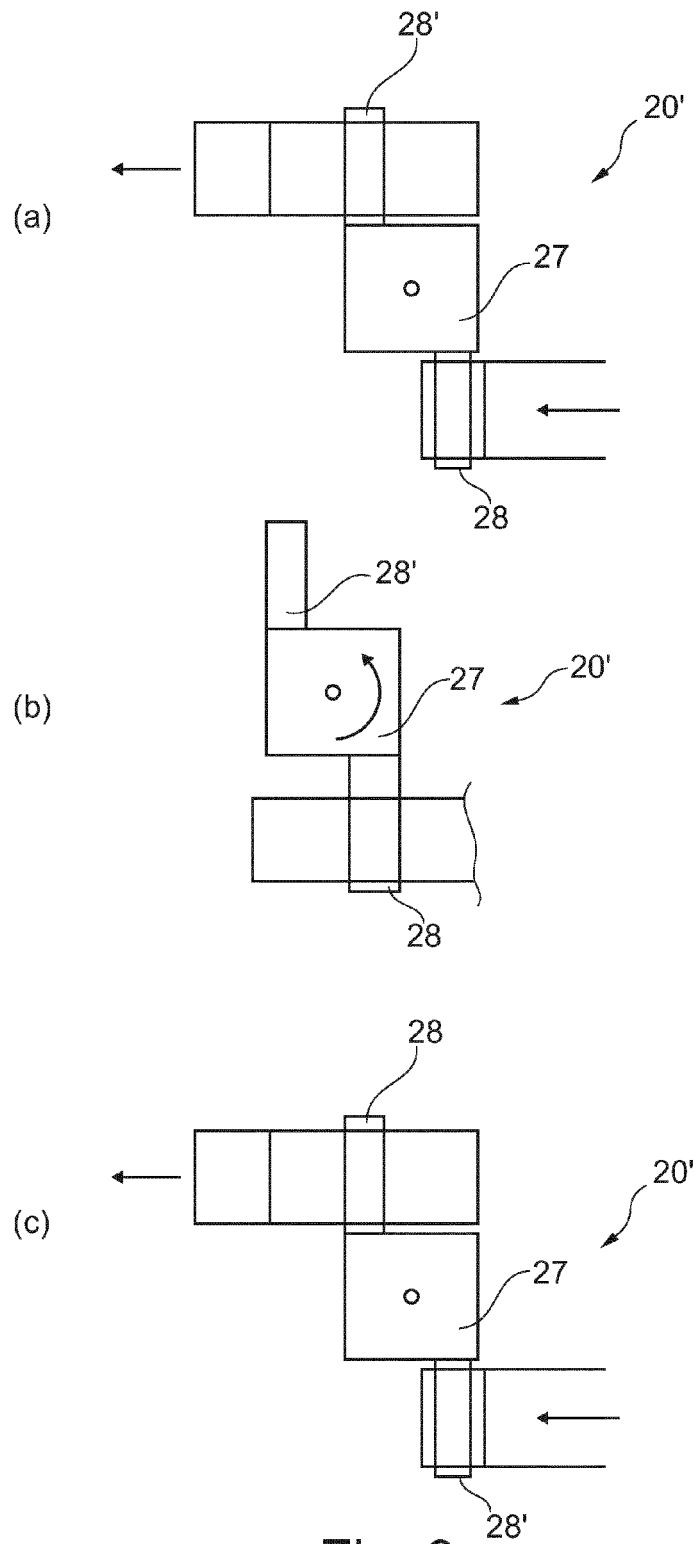


Fig. 9



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Application Number
EP 15 18 9093

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Place of search Munich		Date of completion of the search 17 December 2015	Examiner Forciniti, Marco
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