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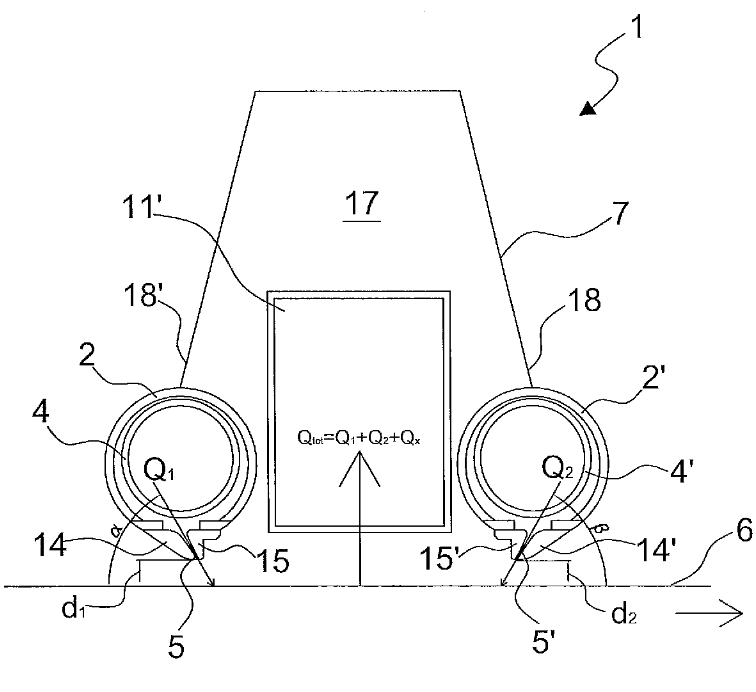

Fig. 7

(57) Abstract: A device for removing a liquid or solid particles from at least one flat surface of metal products, such as strips, sheets, blooms or billets, exiting from rolling mill stands which allows a perfect, uniform removal of the emulsion and the total drying of the product thus eliminating the problems of quality deriving from the permanence of the emulsion on the finished product. The device, object of the present invention, may advantageously be applied in any process in which continuously drying and removing a liquid previously deposited on a surface in translating motion is required.

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DEVICE FOR REMOVING A LIQUID OR SOLID PARTICLES FROM A FLAT SURFACE OF A METAL PRODUCT

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DESCRIPTION

Field of the invention

The present invention relates to a device for removing a liquid or solid particles from flat metal surfaces, particularly used for removing oil emulsion and/or pure oil and/or dust and/or scales and for drying and cleaning flat surfaces of metal products, such as strips, sheets, blooms, billets, in a rolling process, e.g. in reversible rolling mill stands for cold rolling said products.

State of the art

An oil emulsion or pure oil is commonly used in rolling plants to lubricate the working zone of the rollers and ensure the adequate cooling thereof. The emulsion introduction temperature is of 50-60°C; while crossing the contact surface of the working rollers (roll bite), the temperature exceeds the value of 100°C, even if the rolling process is cold, with a consequent atomization.

The high speeds at which a strip, for example, moves up to 1500 m/min and faster according to the thickness of the strip and, therefore, the high rotation speeds of the mill stand rollers, determine a dispersion of atomized emulsion, which very often passes beyond all the normally used drying devices and is disadvantageously deposited in the form of drops on the rolled product immediately prior to winding.

Once the strip has been wound, a chemical reaction is produced which generates a visible stain on the strip itself which compromises the quality thereof, so that the strip length concerned by the stain must be rejected before the subsequent machining processes.

The solution commonly used in the state of the art includes a series of rows of nozzles fed by high-pressure compressed air, 5 bars and more, possibly followed by an air blade fed by a dedicated fan to create a flat jet on the strip. The nozzles used may be of various types, with flat or cylindrical jet, single jet or multiple jet, injector effect nozzles, etc.

The first rows of nozzles serve the function of blocking the feeding of the most consistent part of the emulsion, while the last rows and the air blade serve the function of performing the final drying of the strip. However, the high dispersion and the turbulent atomization of the drop emulsion, operated by all the known devices, make this configuration not fully efficient, despite the use of globally high flow rates of compressed air. The dispersion of the emulsion inside and outside the mill stand, with a subsequent condensation and falling back onto the strip itself, causes the formation of stains which invalidate the quality of the finished product with at least a 4% rejection rate. The fume suction hood placed over the mill stand indeed is not able to aspirate the atomized emulsion.

It is thus felt the need to make a drying and cleaning device for flat surfaces of metal products which allows to overcome the aforesaid drawbacks.

Summary of the invention

It is the main object of the present invention to provide a device for removing a liquid or solid particles from flat surfaces of metal products, e.g. a strip, which allows a perfect and uniform removal of the oil emulsion and/or pure oil and/or dust and/or scales and the total drying and cleaning of the strip prior to winding, thus eliminating the quality problems upon the permanence of the liquid and solid particles on the finished product.

The present invention thus suggests to achieve the aforesaid object by providing a device for removing a liquid and solid particles from a flat surface of a metal product, said device and said flat surface being adapted to move in a relative motion along a longitudinal path, the device comprising, in accordance with claim 1:

- first and second feeding means for feeding gas jets along the width of the longitudinal path, arranged in a position proximal to said longitudinal path,
- a casing defining a collection chamber for collecting the liquid or the solid particles removed from the flat surface of the metal product by means of said gas jets,

wherein the first feeding means are configured so as to generate a first gas flow with a vectorial component in a sense opposite to the direction of said relative motion, and the second feeding means are configured so as to generate a second gas flow with a vectorial component in the same sense as the direction of said relative motion to contain the first flow within said collection chamber,

and wherein there are provided suction means arranged at the side of the longitudinal path substantially at said first and second feeding means or there are provided suction means arranged in a position distal from said longitudinal path.

According to a further aspect of the invention, there is provided a method for removing a liquid or solid particles from a flat surface of a metal product by means of the aforesaid device, said device and said flat surface reciprocally moving in a relative motion along a longitudinal path, the method comprising, in accordance with claim 16, the following steps:

- feeding a first gas flow, by means of first feeding means arranged in a position proximal to said longitudinal path, having a vectorial component in the sense opposite to the direction of said relative motion,
- feeding a second gas flow, by means of second feeding means arranged in a position proximal to said longitudinal path, having a vectorial component in the same sense as the direction of said relative motion, to contain the first flow within a volume between said first and second feeding means,
- sucking in a resulting flow of said vectorial components of first and second flows by means of suction means arranged at the side of the longitudinal path and substantially at said first and second feeding means or by means of suction means arranged in a position distal from said longitudinal path.

The device, object of the present invention, may be advantageously applied in any process in which the continuous removal of a liquid previously deposited on a translating surface is required, or in which the continuous removal of dust or scales previously deposited or formed on said surface is required.

The operation of the device includes two flat jets or blades of compressed air or other suitable gas, such as for example nitrogen in the case of special processes, generated by respective nozzles which, seen in vertical cross section, are appropriately angled with respect to the surface of the strip. In particular, a first nozzle is oriented in a sense opposite to that of the strip feed and a second nozzle is oriented in the same sense of the strip feed.

The jet of the first nozzle produces a concentrated viscous shear action on the strip, which represents the main mechanism for atomizing and removing the liquid film from the surface of the strip and the main mechanism for lifting and removing the solid particles.

The jet of the second nozzle, opposite to that of the first nozzle, in addition to contributing to the aforesaid mechanisms, allows to contain the totality of the atomized liquid and the raised solid particles inside the device.

The jet resulting from the meeting of said first and second jets is locally evacuated by an integrated suction system in order to ensure that the liquid atomized or the dust or scale raised by the delivery jets is removed from the zone of the product and cannot fall back thereon. The suction means, in a cross section view along a plane containing the median longitudinal line of the strip, are either arranged in a central position with respect to nozzles of the delivery jets or are placed at the side in a symmetric or asymmetric manner.

The whole air or gas introduced by the nozzles is aspirated by the integrated suction/evacuation system. No significant leakage of gas contaminated by the liquid or dust appears outside the system, which is therefore capable of working in safety.

In order to further increase the tightness of the device, an integrated suction system communicating with the inner volume of the casing may be made, including a central collection zone between the two feeding collectors and one or two lateral collection zones between each feeding collector and the ends of the casing proximal to the feed plane of the strip.

The device of the invention has the following considerable advantages:

- the opposing jets exert both a drying and cleaning action and a reciprocal containment action, so as to confine the atomized liquid or the raised solid particles, without dispersion into the external environment, inside a central volume from which a flow rate, nearly equal to the sum of the introduced flow rates, is removed by means of the suction means;

- the combination of the repulsion force of the strip, caused by the delivery jets, and the attraction force of the strip, caused by the suction, ensures the neutrality of the overall force exerted by the device on a free surface of the strip; the whole of geometric and operative parameters of jets or blades which allows to obtain a zero value of the force integral on the surface of the strip is named "neutral configuration". This "neutral configuration" allows to dry and clean a strip which has particularly low thickness and traction force values.

Another major advantage is found in reversible rolling processes where the strip has a thickness ranging from 3 mm to 0,1 mm, in which the same "neutral configuration" of the system may be applied and kept over the whole duration of the rolling process, during which the thickness of the strip is reduced, regardless of the strip thickness values and the traction force to which the strip is subjected.

A further advantage of the device of the invention is that its geometric symmetry makes it particularly applicable on a "reversible" strip, i.e. suitable for moving in both senses of feed, from left to right and from right to left. The symmetry condition is not however strictly binding for the purposes of reversibility; in other words the delivery jet nozzles do not need to have the same geometric configurations (blade opening, angle with respect to the feed plane of the strip, distance from the strip, etc.) and the same feeding conditions (flow rate and pressure).

In a variant of the process of removing liquids or solid particles from metal strips, carried out with the device of the invention, the impact between the delivery jets generates an overpressure which minimizes the vacuum to be created in the suction step, with a considerable reduction of the required suction power. A further advantage of this variant consists in that the repulsion force, caused by the delivery jets, prevails on the attraction force, caused by the suction, thus the device is able to provide a stabilizing action on the strip with respect to possible oscillations caused by the traction decrease.

The aforesaid device may be applied to only one part or either over or under the strip. The distance between the two devices, the lower one and the upper one, varies in the range from 5 to 200 mm.

A further advantage which may be provided by the device according to the invention fitted on both sides or surfaces of the strip is represented by the fact that the net resultant of the attractive forces is averagely balanced.

Rows of nozzles arranged close to the working rollers may possibly cooperate with the device of the invention.

The dependent claims describe preferred embodiments of the invention.

<u>Brief description of the drawings</u>

Further features and advantages of the present invention will be more apparent in the light of the detailed description of preferred but not exclusive embodiments of a device for removing a liquid or solid particles from metal strips, shown by the way of non-limitative example with the aid of the accompanying drawings, in which:

Fig. 1 is a perspective view of a first embodiment of the device according to the invention;

Fig. 2 is a cross section of the device in figure 1;

Fig. 3 is a cross section of a second embodiment of the device according to the invention;

Fig. 4 is a cross section of a third embodiment of the device according to the invention;

Fig. 5 is a cross section of a fourth embodiment of the device according to the invention;

Fig. 6 is a cross section of a fifth embodiment of the device according to the invention;

Fig. 7 is a cross section of a sixth embodiment of the device according to the invention;

Fig. 8 is a side view of the device in figure 7;

Fig. 9 shows a 2D pressure profile on the strip, with indication of the attraction zones and repulsion zones of the strip, obtained using the embodiment of the device in Fig. 1;

Fig. 10 is a diagram of the device in Fig. 1 with indication of the vectors of the forces acting in the various attraction and repulsion zones.

The same reference numbers in the figures identify the same elements or components.

Detailed description of preferred embodiments of the invention

The device for removing a liquid or solid particles from metal strips, object of the present invention, comprises:

- feeding means for feeding air jets or blades onto the strip during its feed so as to remove the oil emulsion or other liquid and/or solid particles previously deposited on the strip;
- air suction means;
- a casing being, for example, tubular bell-shaped, comprising said feeding means and communicating with said suction means so as to allow the suction of the air containing the removed atomized emulsion and/or raised solid particles.

Figures 1 and 2 show a first embodiment of the device, indicated by reference numeral 1 as a whole.

The feeding means comprise two feeding or delivery collectors 2, 2' provided with a delivery pipe 4, 4' placed on a side of the device, respectively.

At their part closest to the feed direction of strip 6, the feeding collectors 2, 2' are provided with two respective members 14, 15, 14', 15' appropriately machined and joined so as to define respective delivery nozzles or slots 5, 5' for delivering an air jet or blade.

An air flow enters the feeding collectors 2, 2' through the delivery pipes 4, 4', and the jets exit from the nozzles 5, 5'.

The jets are fed by the delivery pipes 4, 4' which are engaged onto the collectors 2, 2' of larger diameter, as shown in Fig. 2.

Alternatively, the delivery pipes 4, 4' may be inserted into the collectors 2, 2', along the longitudinal extension of the device, and communicate with the latter by means of delivery equalization holes (not shown), so as to ensure feeding uniformity along the longitudinal extension of the nozzles 5, 5'.

The jets may be fed from both sides of the device or from only one side. In Fig. 1, the delivery nozzles are fed from only one side.

The configuration of the collectors 2, 2' provided on the ends 18, 18' of the bell 7 close to the feed plane of the strip, and the configuration of the corresponding nozzles 5, 5' are such that the flat air jets emitted by said nozzles are appropriately angled with respect to the surface of the strip and oriented in a reciprocally opposite sense.

The jet of the first nozzle 5', named "removing jet", produces a concentrated viscous shearing action on the strip being fed, by atomizing and removing the liquid film from the surface of the strip and/or by lifting and removing the solid particles existing thereon. The jet of the second nozzle 5, or "holding jet", opposite to that of the first nozzle 5', in addition to contributing to the aforesaid drying and cleaning action, allows to contain the totality of the atomized liquid and the raised solid particles within the bell 7 of the device. The "holding jet" has a flow rate Q_1 lower than flow rate Q_2 of the "removing jet", therefore the higher shearing strength is the one produced by the jet properly named removing jet.

The resulting jet produced by the impact of the two delivery jets, i.e. the removing jet and the holding jet, is locally evacuated by the suction means in order to ensure that the atomized liquid and/or the raised particles are removed from the zone of the product being fed.

In this first embodiment (Fig. 2), the suction means comprise a suction hood 3 communicating with the tubular bell 7. The hood 3 creates a vacuum in the inner volume or collection chamber 17 of the tubular bell 7. Due to this vacuum, an air flow rate Q_x is advantageously drawn from the external environment through the free section existing between the device 1 and the strip 6, thus ensuring a further tightness of the flows Q_1 and Q_2 generated within the bell 7 by means of the delivery jets.

As a result, both the flows produced on the strip by the jets and those aspirated from the external environment are diverted within bell 7, thus generating a resulting flow $Q_{TOT} = Q_1+Q_2+Q_x$ towards the hood 3.

The distance "d" between the two nozzles 5, 5' is advantageously variable in the range from 5 to 2000 mm, preferably from 200 to 300 mm, according to some parameters such as air pressure and flow rate, impact angle of the jets on the strip surface, type of substance to be removed.

The distance d_1, d_2 between the nozzles 5, 5' and the strip feed plane varies from 5 to 100 mm. The shearing strength action of the jets on the strip may be modulated and up to three times higher than that of the jets emitted by the nozzles installed in the known devices, especially due to the close distance.

The geometric configuration of the air jets or blades includes a nozzle opening of 1-5 mm and an impact angle of the delivery jets, i.e. an inclination angle of the nozzles with respect to the feed plane of the strip, variable in the range from 30 to 85°.

In a preferred variant of the device of the invention, the delivery jets form a 60° angle with respect to the strip surface; the opening of the nozzles is of 1,5 mm and the distance d_1, d_2 of the nozzles 5, 5' from the feed plane of the strip is of 20 mm.

In other variants, the distance d_1 of the nozzle 5 may be different from the distance d_2 of the nozzle 5' from the feed plane of strip 6. The inclination angle α of nozzle 5 with respect to the strip feed plane may also be different from the inclination angle β of nozzle 5'. For example, the distance d_1 of the delivery nozzle 5 from the feed plane of strip 6 is of about 20-30 mm, with an angle α of 45°, while the distance d_2 of the delivery nozzle 5' from said feed plane is of about 10-20 mm, with an angle β of 60°.

Advantageously, there are no significant leakages of gas or air contaminated by the emulsion or by the dust outside the device.

The suggested dimensioning thus appears safe and the feeding and suction conditions described below, which reduce the flow rates and thus the powers involved, have been experimentally found.

Figures 9 and 10 show some results of the theoretical calculations which have preceded the experimental tests. In particular, these figures refer to the case with removing jet pressure of 100 mbar, holding jet pressure of 50 mbar and vacuum at the pipe of the hood of -20 mbar.

Fig. 9 shows a pressure profile 2D on the strip, with indication of the attraction zones 23, 24 and repulsion zones 20, 21, 22 of the strip. The repulsion is determined by impacting the jets on the strip 6 at the zones 20 and 21 and by stopping the holding and removing jets at the zone 22; the attraction is caused by the suction, which affects the zones 23 and 24 intermediate with respect to the repulsion zones. Balancing these zones advantageously ensures the neutrality of the forces acting on the strip, i.e. the repulsion forces balance the attraction forces.

The "reciprocal" extension of the attraction and repulsion areas depends on the geometric repulsion of the device and on the feeding and suction conditions.

Fig. 10 is a diagram of the device in Fig. 1 with indication of the vectors of forces acting in the various attraction and repulsion zones.

A second embodiment of the device of the invention is shown in Fig. 3.

Unlike the first embodiment in Fig. 2, in this case, the air suction means comprise suction collectors 10 provided at respective ends of suction pipes 11.

The tubular bell 7, symmetric with respect to the longitudinal plane Y, includes the feeding collectors 2, 2' at the end 18, 18' thereof, close to the feed plane of the strip. Further ends 16, 16' of the bell 7 are instead appropriately shaped so as to define a communication zone between the inner volume 17 of the bell 7 and the suction collectors 10. Such a communication zone has a convergent-divergent type configuration.

Through the suction pipes 11 at least one dedicated fan, arranged for suction, returns the flow from the suction collectors 10 creating a vacuum in the inner volume 17 of the tubular bell 7.

Due to this vacuum, an air flow rate Q_x is advantageously drawn from the external environment through the free section existing between device 1 and strip 6, thus ensuring a further tightness of the flows generated within the bell 7 by means of the delivery jets.

Upon this effect, both the flows produced on the strip by the jets and those aspirated from the external environment are diverted within bell 7, thus generating a resulting flow towards the suction collectors 10.

The whole suction system of the device of the invention has a uniform section along its whole longitudinal extension and displays an appropriate convergent-divergent configuration to generate a Venturi effect. The main function of converging portion is to ensure the suction uniformity across the width of the strip.

The passage section which is obtained from the converging portion to the suction collectors 10 is appropriately calibrated so as to ensure that the resulting flow is uniformly directed in a direction which is substantially orthogonal to the strip feed direction, in particular upwards in the case of the configuration in Fig. 3 and downwards in the case of a device symmetrically arranged to that of Fig. 3 with respect to the plane defined by the strip.

Thereby, the presence of recirculations or of zones not crossed by the flow, which could cause the fall back and the accumulation within the bell 7, and thus on strip 6, of the atomized liquid and/or the raised solid particles carried by the air, is avoided.

The upper portion of the tubular bell 7 is appropriately dimensioned so as to be inserted into the suction collectors 10.

The importance of this contrivance resides in that the flow of air aspirated from sections closer to the median longitudinal line of the strip is made to turn within collector 10 and forced to progressively occupy the zone closest to the respective axis, thus leaving free and not disrupting the air flow which is aspirated from outermost sections with respect to the median longitudinal line of the strip.

The result is that the suction system integrated in the device of the invention may aspirate air with high uniformity and over the whole width of the strip.

A third and a fourth embodiments of the device of the invention are shown in Fig.

4 and 5.

The main difference as compared to the device in Fig. 3 is in that, in these two embodiments there is provided a single suction collector 10 provided at the respective ends with suction pipes 11. The side arrangement of the suction collector 10 and the form of the tubular bell 7 make the device of the invention asymmetric.

In Fig. 4 the passage section which is obtained from the converging portion towards the suction collector 10 is appropriately calibrated so as to ensure the resulting flow being uniformly directed in a direction which is substantially orthogonal to the direction of the strip feed.

In Fig. 5 the passage section which is obtained from the converging portion towards the suction collector 10 is instead appropriately calibrated so as to ensure the resulting flow being uniformly directed in a direction which is substantially parallel to the direction of the strip feed.

In both cases, the resulting flow is uniformly directed in a direction which is substantially tangential within the suction collector 10, thus avoiding the presence of recirculations or zones not crossed by the flow which could cause the falling back or accumulation within the bell, and thus on the strip, of the atomized liquid and/or the raised solid particles carried by the air.

These two embodiments ensure the same performance as the embodiments described above and simplify the layout in the cases in which the flow rate to be aspirated is such to require a single suction collector.

A fifth embodiment of the device of the invention is shown in Fig. 6.

The main difference as compared to the device in Fig. 3 is in that the tubular bell 7 comprises the feeding collectors 2, 2' therein, i.e. in the inner volume 17 defined therein.

The arrangement of the feeding collectors 2, 2' advantageously divides the inner volume 17 of the bell 7 into three zones:

- a central collection zone 30 for the air or gas, provided between the two feeding collectors 2, 2';
- and two side collection zones 40, 50 for the air or gas, provided between each feeding collector and the ends 19, 19' of the bell 7 in proximity of the feed plane of strip 6.

The ends 19, 19' of the bell 7 are arranged at a predetermined distance d_3 from the strip surface, the further ends 16, 16' of the bell 7 are instead appropriately shaped so as to define the communication zone between the inner volume 17 and the suction collectors 10, i.e. the zone where the three flows aspirated from the central zone 30 and side zones 40, 50 converge.

Such a communication zone has a convergent-divergent type configuration. Each of the three collection zones 30, 40, 50 also has a converging-diverging portion.

At least one dedicated fan, arranged for suction, returns the flow from the suction collectors 10 through the suction pipes 11 thus creating a vacuum in the inner volume 17 of the tubular bell 7.

Due to this vacuum, an air flow rate Q_x is advantageously returned from the external environment through the free section existing between the device and the strip 6, thus ensuring a further tightness of the flows generated within the bell 7 by means of the delivery jets. Each delivery jet indeed impacts on the strip 6 so as to produce flows in both directions thereon. As shown in Fig. 6, the flows directed towards the central zone of the bell reciprocally impact thus creating a first resulting upward flow, which crosses the central collection zone 30. The flows directed towards the side zones of the device, instead, impact on the air flows from the external environment, thus creating second resulting upward flows which pass through the side collection zones 40, 50. The air flows coming from the outside are sufficiently concentrated to prevent the flows directed towards the side zones of the device from exiting from the bell 7. The external surface of the feeding collectors 2, 2' advantageously serves the important function of supporting the rotation of the second resulting upward flows.

All three resulting flows then meet at the aforesaid communication zone between the inner volume 17 and the suction collectors 10, thus generating a total resulting flow towards said collectors 10.

The ends 19, 19' of the bell 7 may also be asymmetric with respect to the longitudinal plane Y. For example, the end 19 which meets the strip first during its feed may have a different shape from the end 19', so as to define a respective side zone, within the bell, which is greater than that defined by the end 19'. Furthermore, the distance d_3 from the surface of the strip may be different for the two ends 19, 19'.

A sixth embodiment of the device of the invention is shown in Figures 7 and 8. This sixth embodiment comprises all components and variants thereof described for the first embodiment of the device of the invention with a main difference, as compared to the device in Fig. 1, represented by the fact that the suction means do not include the suction hood 3 in a distal position from the strip feed plane or path, said hood communicating with the tubular bell 7 which is arranged in a position proximal to said feed plane. Furthermore, as compared to the other embodiments of the device shown in Figures from 3 to 6, the suction means do not include the suction collectors 10 in a distal position from the strip feed path, said collectors communicating with the tubular bell 7 arranged in a proximal position to said feed path.

Instead, in this sixth embodiment, the suction means comprise two suction pipes 11', each arranged at a side end 60 of the device 1, i.e. arranged at the sides of the longitudinal feed path of the strip 6, and substantially at the feeding collectors 2, 2'. In particular, as shown in Figures 7 and 8, the suction collectors 11' laterally communicate with the inner volume 17 of the tubular bell 7, in a substantially central position with respect to the feeding collectors 2, 2', and thus also to the delivery pipes 4, 4', and can be provided on only one side or both sides of device 1. Through the suction pipes 11' at least one dedicated fan, arranged for suction, returns flow from the tubular bell 7 forming a vacuum inside the inner volume 17 thereof. Due to this vacuum, an air flow rate Q_x is advantageously returned from the external environment through the free section existing between device 1 and strip 6, thus ensuring a further tightness of the flows Q_1 and Q_2 generated within the bell 7 by means of the delivery jets. Upon this effect, both the flows produced on the strip by the jets and those aspirated from the external environment are diverted within bell 7, thus generating a resulting flow $Q_{TOT} = Q_1+Q_2+Q_x$ moving away from the surface of the strip 6. This resulting flow Q_{TOT} is advantageously laterally aspirated by the two suction pipes 11', each of the two pipes 11' aspirating an air flow rate of about $Q_{TOT}/2$.

The main advantage of this sixth embodiment of the invention is that the lateral configuration of the suction pipes 11', engaged in the collection chamber 17 substantially at the height of the feeding collectors 2, 2', prevents any attraction force from being exerted on the surface of the strip because the suction flow is split into two currents of equal flow rate, in a parallel direction with respect to the strip surface and in an opposite sense, whereby their effect is neutralized.

The drying and cleaning device of the invention may be nearly entirely formed by pipes made of stainless steel, for example DIN 2462. However, it may also be made by using different methods and shapes without therefore departing from the scope of the invention.

The feeding collectors 2, 2' and the suction collectors 10 are preferably but not necessarily circular tubes.

The delivery collectors 4, 4' and the suction collectors 11 are preferably but not necessarily circular tubes.

The suction pipes 11' are preferably but not necessary square-section tubes, e.g. rectangular tubes (Fig. 7).

The nozzles or slots 5, 5' may have a longitudinal extension equal to that of the feeding collectors 2, 2' or a plurality of nozzles of smaller extension along a same feeding collector may be provided.

Seen in section along a plane parallel to the strip feed plane, the nozzles 5, 5' may be either parallel to one another or arranged along reciprocally incident lines. In the latter case, in the sixth embodiment of the invention, a single side suction pipe 11' may be provided, applied to the side end 60 of the device 1 to which a greater volume of tubular bell corresponds.

In other variants, at least one nozzle 5, in section along a plane parallel to the strip feed plane, has a broken-line shape comprising three parts: a central part of the broken line is parallel to the other rectilinear nozzle 5', while the two side parts of the broken line are either converging or diverging with respect to the other rectilinear nozzle 5'.

The pneumatic dimensioning of the device includes using fans and feeding air at ambient temperature.

With regards to the feeding conditions adopted to reduce the flow rates and thus the powers involved, the pressures for feeding air to the nozzles 5, 5' are advantageously in the range from 50 to 400 mbar.

A small- or medium-sized delivery fan is able to ensure this lift.

The suction vacuums or overpressures which determine the suction flow rate, equal to the sum of the introduced flow rates plus a variable quantity, may vary from 0 to 600 mbar, preferably between 250 and 500 mbar, and between 0 and 100 mbar, respectively.

The suction pressure in the pipes 11, 11' is produced by means of a medium-sized extraction fan.

During the suction step, the extraction fan is connected to both sides, and thus to all pipes 11, 11', while during the step of feeding, the delivery fan is connected at only one side to the pipe 4, 4'.

The rectilinear-shaped drying device defines a longitudinal axis and may be installed with said longitudinal axis preferably but not necessarily orthogonal to the feed direction of the strip 6.

The device may advantageously be connected both for delivery and for suction to higher efficiency aeraulic machines, such as compressors, without any restriction. In these cases, the delivery pressures may be in the range from 0,4 to 2 bars and more, the suction vacuums may reach 0,8 bar. The opening of nozzle 5 may also be larger, up to a value of 10 mm.

The device may be mounted so as to be fixed with respect to the strip feed path or may be provided with degrees of freedom. In this second case, it may be spaced from said path to allow specific steps of the process, such as for example the insertion of the first length of the strip, or may be continuously adjusted, for example to manage the distance of the device from the strip or to track the exact positioning of the strip by means of transversal movements.

The device, being either fixed or provided with degrees of freedom, may be advantageously used also for drying and cleaning static flat surfaces of metal products, such as strips, sheets, blooms and billets, the device being motorized and being possible to establish a relative motion with respect to said flat surfaces.

Both feeding and suction may be connected at both ends of the device or at one end only. Specifically, in the case of suction, it is preferable to connect the extraction fan at both sides, then to all the pipes 11, 11', but if this configuration is not feasible due to layout constraints, the device is able to ensure high performance even with the connection at only one side. In all variants, a heater may advantageously be included between the delivery fan and the drying and cleaning device serving the function of increasing the air temperature, e.g. up to temperatures from 100 to 400°C. In this case, the hot air allows to engage a mechanism for evaporating the emulsion which is added to the atomization induced by the viscous shearing. Using a heater of power proportioned to the enthalpy of the air to be fed is needed in the delivery branch.

Moreover, in the system design, particularly relevant components and accessories may be included, such as for example a filter for the delivery air in order to avoid impurities from being carried through the jet onto the strip.

A further filter may be also included on the suction system of the device, which filter removes the emulsion or dust from the aspirated air flow rate and thus prevents the introduction thereof into the environment.

In addition to the management of the rotation rate of the delivery and extraction or suction fans, from the point of view of adjustment, the suction system may be split in two parts, with respect to the two ends of the device, by means of an appropriate set of valves controlled by the corresponding pressure transducers.

Adjusting the device may globally allow to control and minimize the involved powers and flow rates depending on the real conditions of the strip, considering the degree of contamination by emulsion, the speed, etc.

The device of the invention may be installed either at only one side of the strip, for example on the upper side, or on both sides.

In this second case, the two devices may either be placed symmetrically with respect to the strip, or staggered or arranged at different distances from the strip.

If the drying process occurs on different strip widths, the width of the device may advantageously be adjusted according to the width of the strip.

A first variant of the device of the invention may be provided as split along the rectilinear extension into compartments on the feeding section and/or on that of suction, with the possibility of progressively activating external sections in parallel and proportionally to the width of the strip.

A second variant provides, instead, for the device being adapted for the lateral insertion of movable plates capable of simulating the presence of a wider strip.

These two solutions advantageously allow to keep optimal fluid-dynamic conditions regardless of the width of the strip to be dried. Specifically, by operating on considerably narrower strips, the portions of the device which remain outside the strip may become significant and the suction may tend to preferably occur in these portions to the detriment of the suction effect in the central zone of the strip.

CLAIMS

1. A device (1) for removing a liquid or solid particles from a flat surface of a metal product, said device and said flat surface being adapted to move in a relative motion along a longitudinal path, the device comprising:

- first and second feeding means (2', 2) for feeding gas jets along the width of the longitudinal path, arranged in a position proximal to said longitudinal path,

- a casing (7) defining a collection chamber (17) for collecting the liquid or the solid particles removed from the flat surface of the metal product by means of said gas jets,

wherein the first feeding means (2') are configured so as to generate a first gas flow with a vectorial component in a sense opposite to the direction of said relative motion, and the second feeding means (2) are configured so as to generate a second gas flow with a vectorial component in the same sense as the direction of said relative motion to contain the first flow within said collection chamber (17), and wherein there are provided suction means (11') arranged at the side of the longitudinal path and substantially at said first and second feeding means (2', 2) or there are provided suction means (3, 10, 11) arranged in a position distal from said longitudinal path.

2. A device according to claim 1, wherein said collection chamber (17) communicates at at least one side end (60) of the device (1) with said suction means (11') or communicates at first ends (16, 16') thereof with said suction means (3, 10, 11).

3. A device according to claim 2, wherein said first and second feeding means (2', 2) are provided at second ends (18, 18') of said casing (7).

4. A device according to claim 3, wherein said suction means comprise two suction pipes (11'), each arranged at a side end (60) of the device (1), laterally communicating with the collection chamber (17) in a central position with respect to the feeding means (2, 2').

5. A device according to claim 2, wherein said first and second feeding means (2', 2) are provided within the casing (7), close to said longitudinal path, arranged so as to divide said collection chamber (17) into three zones: a central zone (30) provided between first (2') and second (2) feeding means and two side zones (40, 50) provided between each of said feeding means (2, 2') and second ends (19,

19') of said casing (7).

6. A device according to claim 3 or 5, wherein said first and second gas jet feeding means respectively comprise a first tubular collector (2', 2) provided with a corresponding injection nozzle (5', 5) of the jet along its longitudinal extension, each nozzle (5', 5) being spaced by a predetermined first distance (d_2, d_1) ranging from 5 mm to 100 mm from said path.

7. A device according to claim 6, wherein two plates (14, 15, 14', 15'), appropriately machined and jointed so as to define the corresponding nozzle (5, 5') inclined by a respective angle (α, β) between 30 and 85° with respect to said path, are provided on each said first tubular collector (2, 2').

8. A device according to claim 7, wherein the distance (d) between the nozzles (5, 5') is variable in the range from 5 to 2000 mm and the opening thereof is variable from 1 to 10 mm.

9. A device according to claim 8, wherein the opening of the nozzles (5, 5') is of 1,5 mm and the angle (α, β) is of 60°.

10. A device according to claim 7, wherein the inclination angle (β) of a first nozzle (5') is either equal to or different from the inclination angle (α) of a second nozzle (5).

11. A device according to any one of the claims from 6 to 10, wherein each first tubular collector (2, 2') is provided with a delivery pipe (4, 4'), placed at least on one side of the device, either engaged in the first collector (2, 2') having a diameter larger than said delivery pipe or inserted within the first collector (2, 2'), along the longitudinal extension of the device, and communicating with the latter by means of flow rate equalization holes.

12. A device according to claim 3, wherein the suction means comprise a suction hood (3) centrally arranged in said distal position from the longitudinal path.

13. A device according to claim 3 or 5, wherein the suction means comprise at least a second tubular collector (10), laterally arranged in said position distal from the longitudinal path, provided at the respective ends with suction pipes (11).

14. A device according to claim 13, wherein there are provided two second tubular collectors(10), laterally and symmetrically arranged.

15. A device according to any one of the claims from 6 to 14, wherein the casing (7) is tubular bell-shaped with the second ends (18, 18', 19, 19') either symmetric

Therefore, the removal of the emulsion from the central region of the strip may be insufficient. The contrivances described above eliminate this drawback.

An advantageous installation variant, in particular for the first five embodiments of the device of the invention, includes the positioning of the device(s) of the invention close to a means constraining the mobility of the strip, e.g. a roller about which the strip is slightly wound.

This advantageous configuration allows possible vibrations triggered by the control of the strip traction and winding and/or by the instability of the air flows in each drying device, due for example to the even minimal operation instabilities of the delivery and suction fans, to have a minimum amplitude, limited by the closeness of the mechanical constraint. This optimal installation minimizes the possibility of the strip to start vibrating under the effect of the attractive force of the suction system, due to the high vacuum which is established within the external tubular bell 7. A high vacuum could indeed determine an attraction of the strip of intensity up to 100 kgf and over. For small thicknesses of the strip and/or low pulling forces applied to the strip, the strip could come in contact with the device, especially if the latter is very close.

By virtue of the introduction of constraint means, such as for example rollers, which prevent the strip from excessively approaching the device, such a drawback is simply avoided.

Similarly, this problem may be considerably limited if the device of the invention is arranged only on one side of the strip, as the cleaning action mainly concerns the upper part of the strip. By positioning an appropriate roller on the opposite side of the device, a zone of slight winding of the strip is created thereabout. In this case, the pulling force applied to the strip produces a component opposite to the attraction force of the device which may be capable of contrasting it thus avoiding the strip approaching.

This detailed description relates, by way of example, to the removal of liquid or solid particles from the surface of a strip. The device of the invention may however be used, as previously mentioned, for removing a liquid or solid particles from at least one flat surface of different metal products, such as sheets, blooms or billets.

or asymmetric with respect to a longitudinal plane (Y) of the device, and wherein the first ends (16, 16') of the bell (7) are appropriately shaped so as to define a communication zone between the collection chamber (17) and the suction means (10) having a convergent-divergent type configuration.

16. A method for removing a liquid or solid particles from a flat surface of a metal product by means of a device according to claim 1, said device and said flat surface reciprocally moving in a relative motion along a longitudinal path, the method comprising the following steps:

- feeding a first gas flow, by means of first feeding means (2') placed in a position proximal to said longitudinal path, having a vectorial component in the sense opposite to the direction of said relative motion,
- feeding a second gas flow, by means of second feeding means (2) placed in a position proximal to said longitudinal path, having a vectorial component in the same sense as the direction of said relative motion, to contain the first flow within a volume (17) between said first and second feeding means (2', 2),
- sucking in a resulting flow of said vectorial components of first and second flows by means of suction means (11') arranged at the side of the longitudinal path and substantially at said first and second feeding means (2', 2) or by means of suction means (3, 10, 11) arranged in a position distal from said longitudinal path.

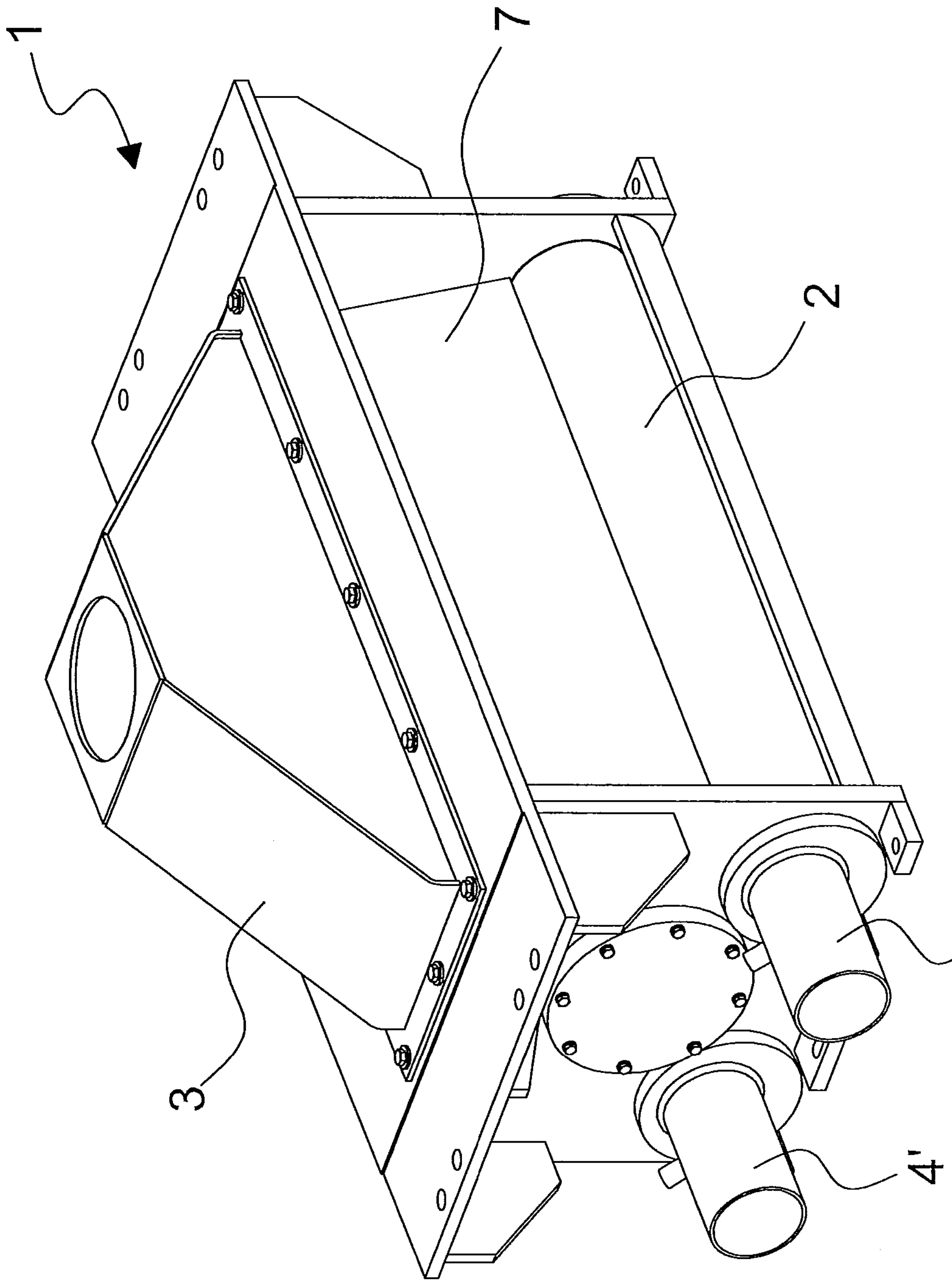

Fig. 1

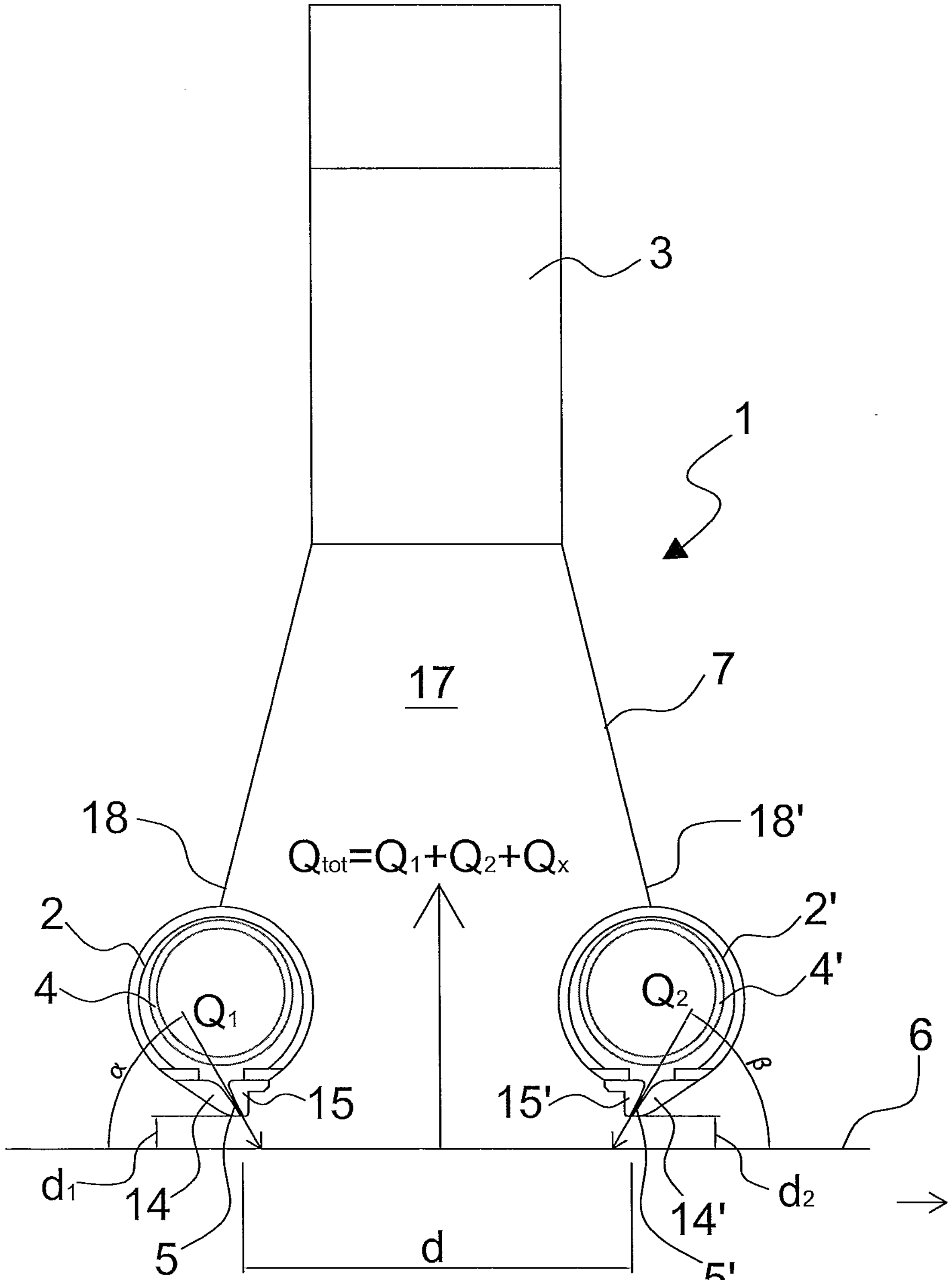

Fig. 2

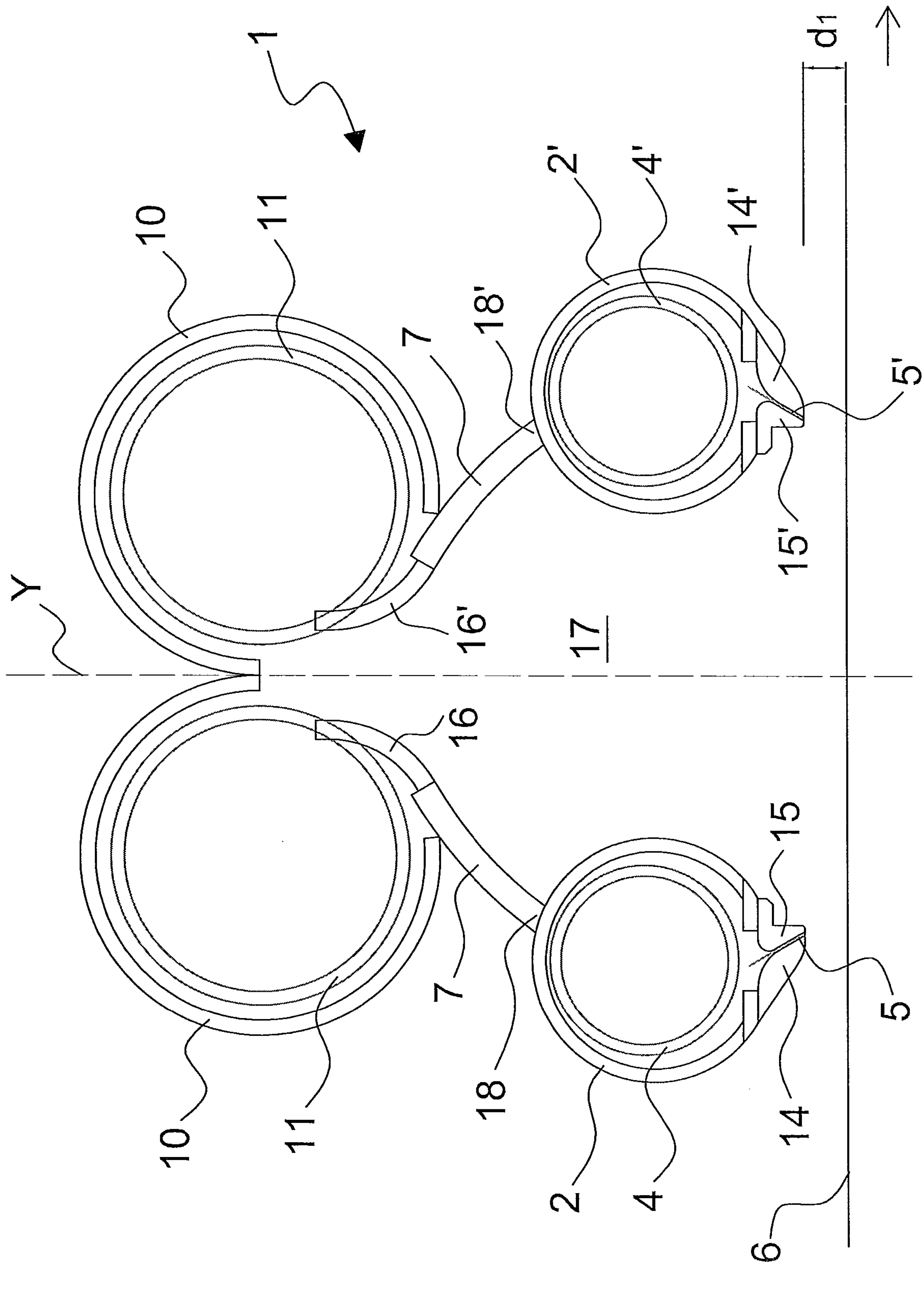

Fig. 3

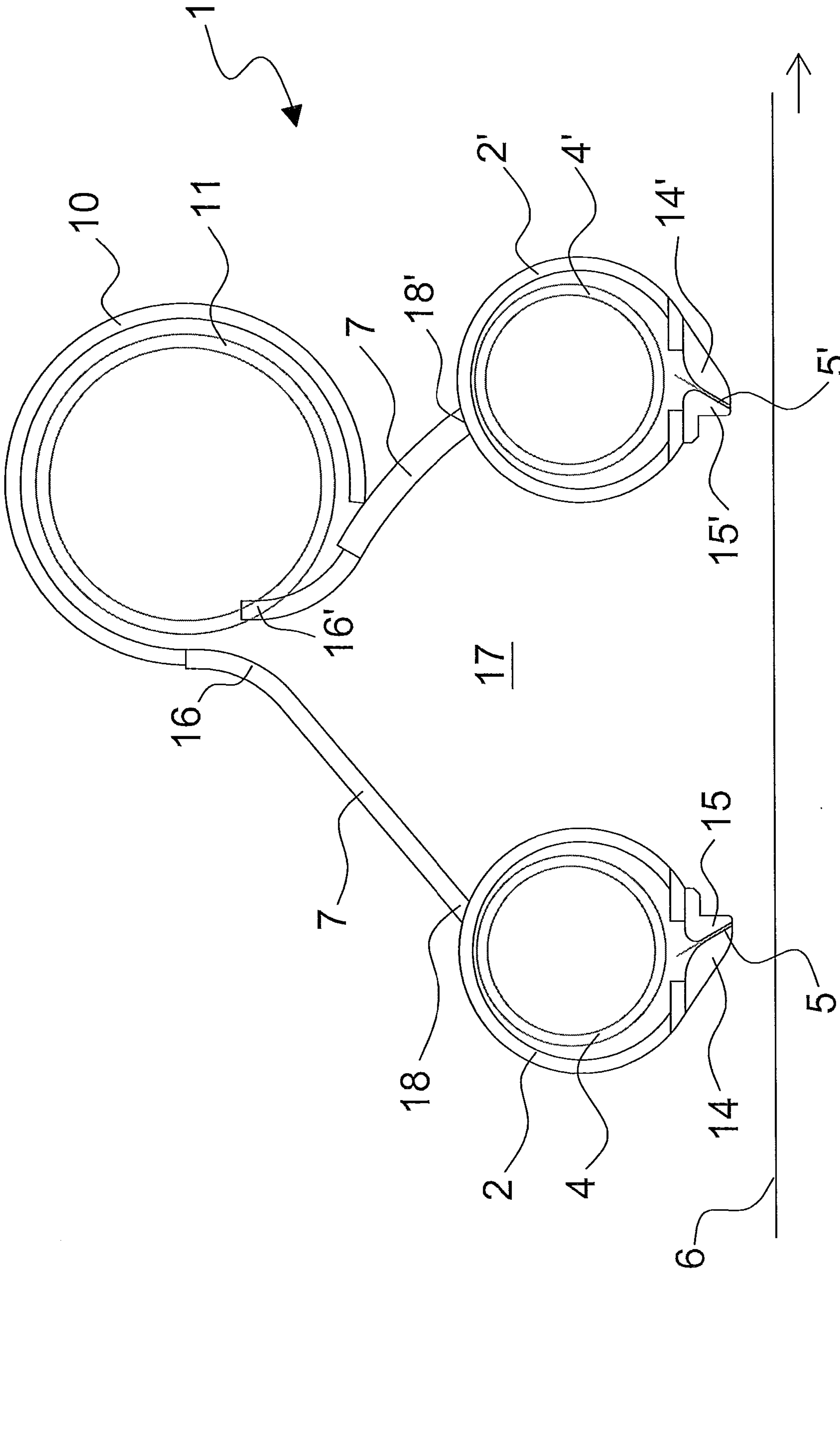

Fig. 4

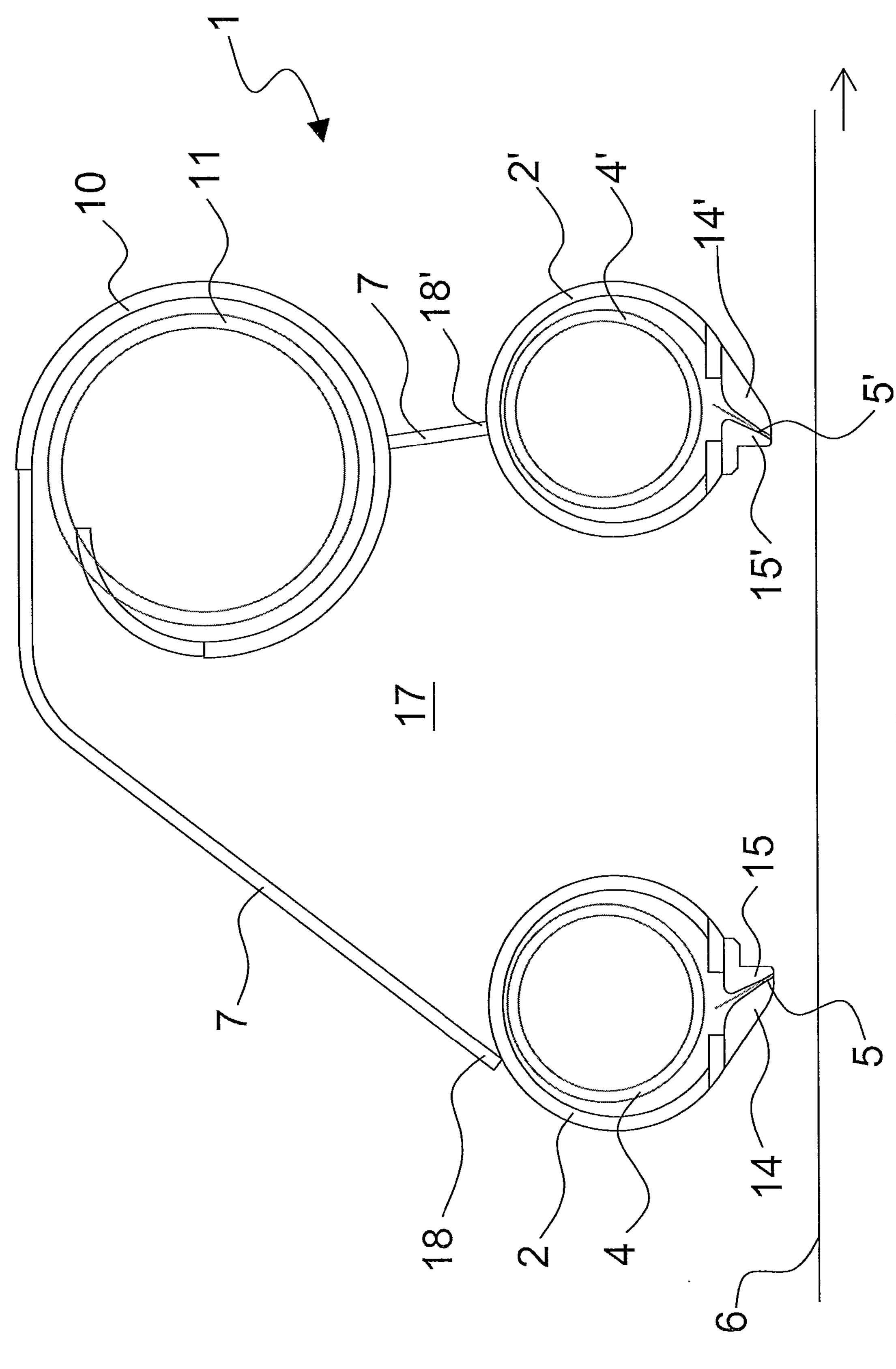

Fig. 5

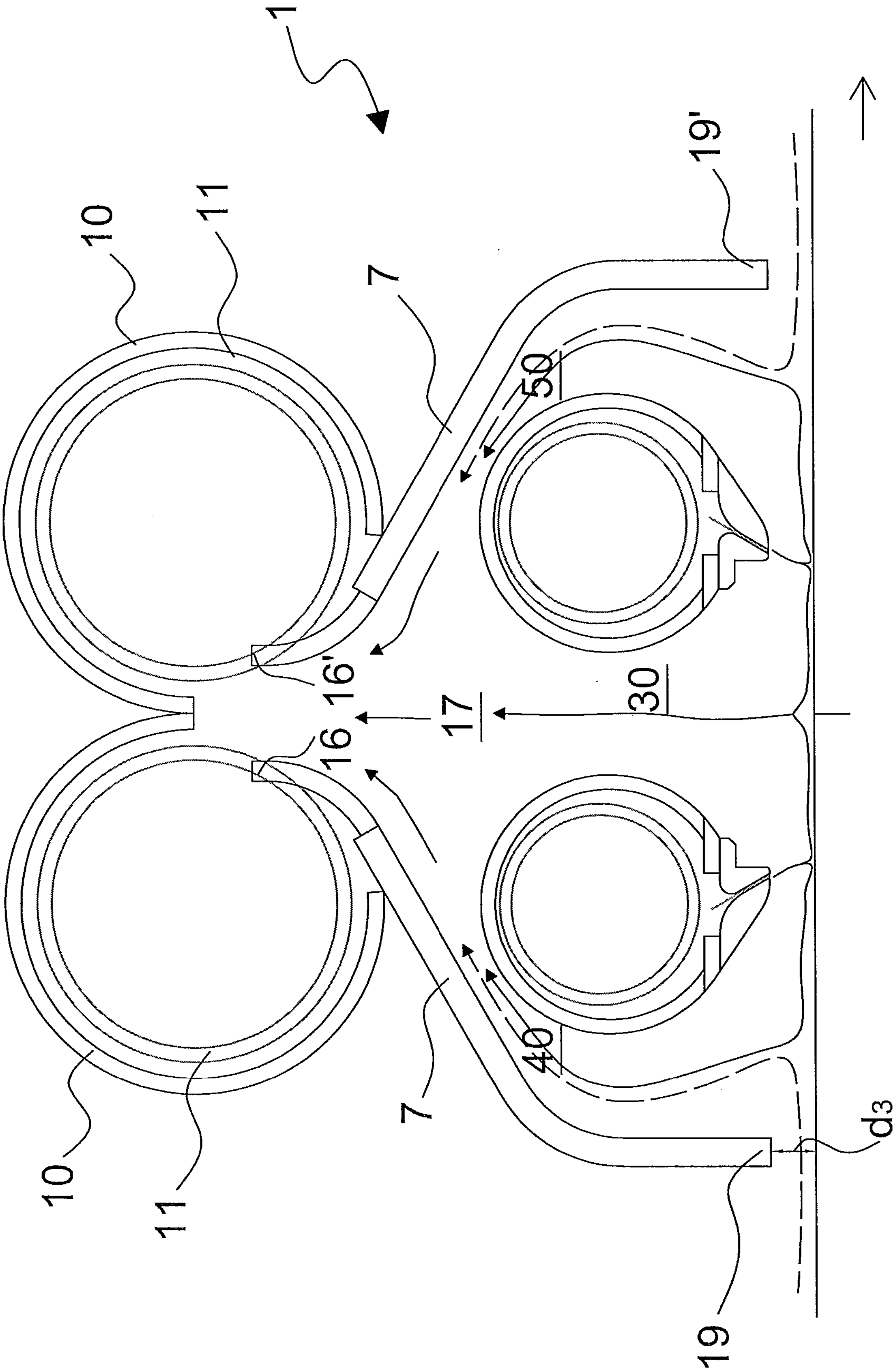

Fig. 6

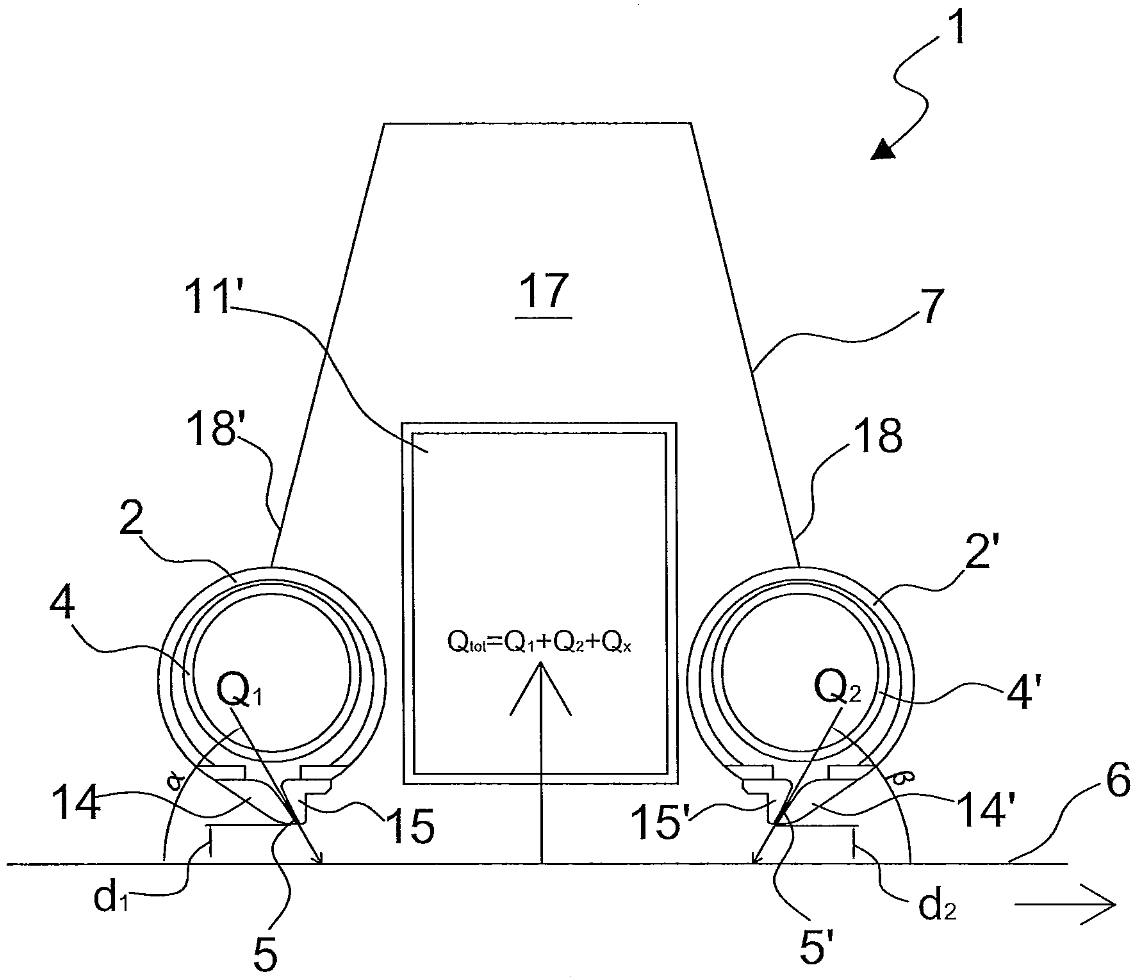

Fig. 7

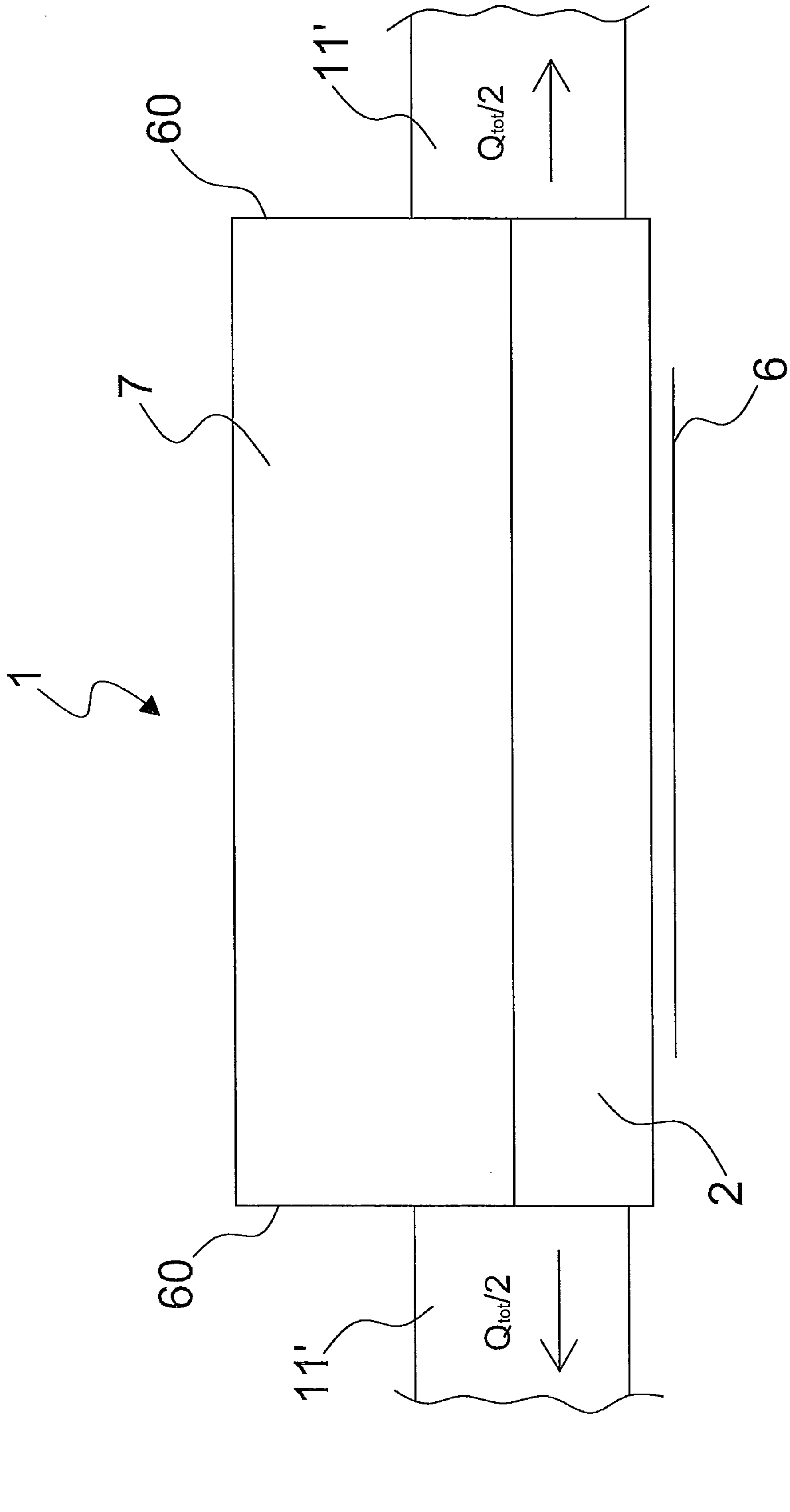

Fig. 8

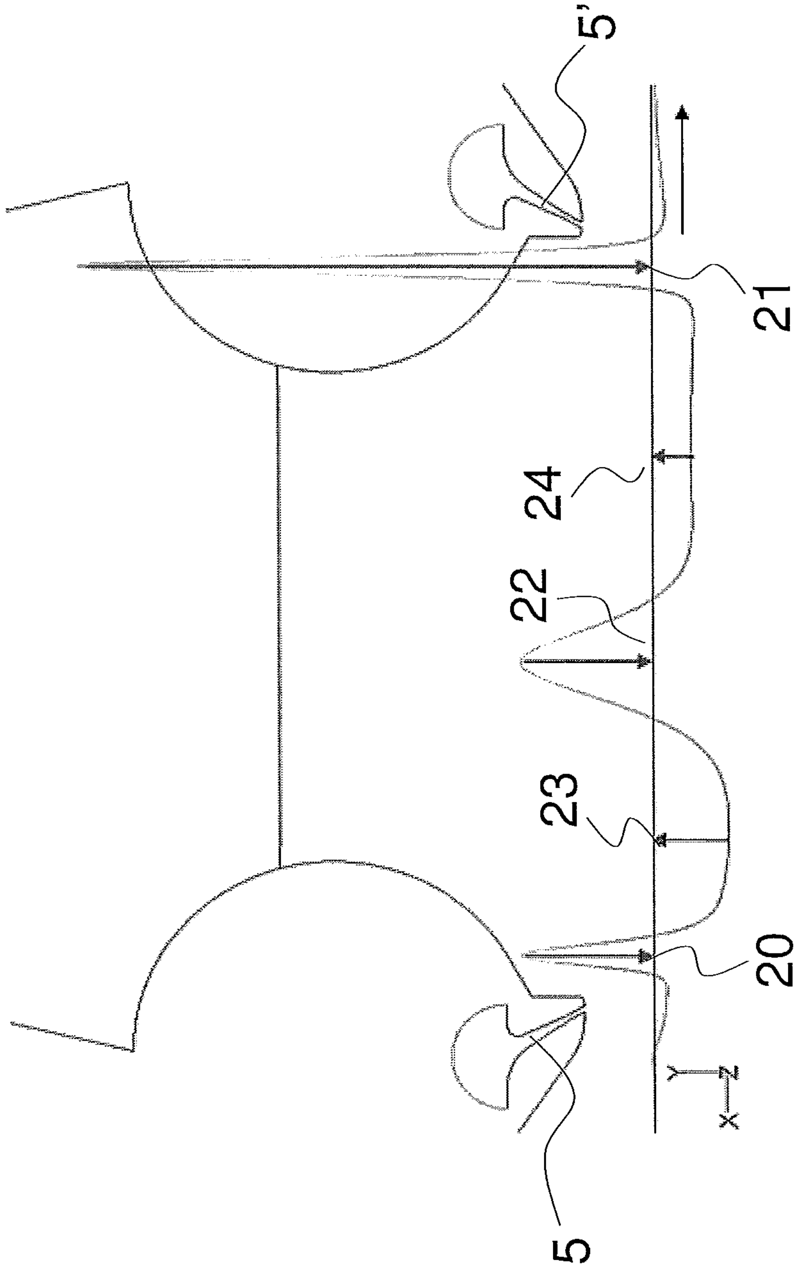

Fig. 9

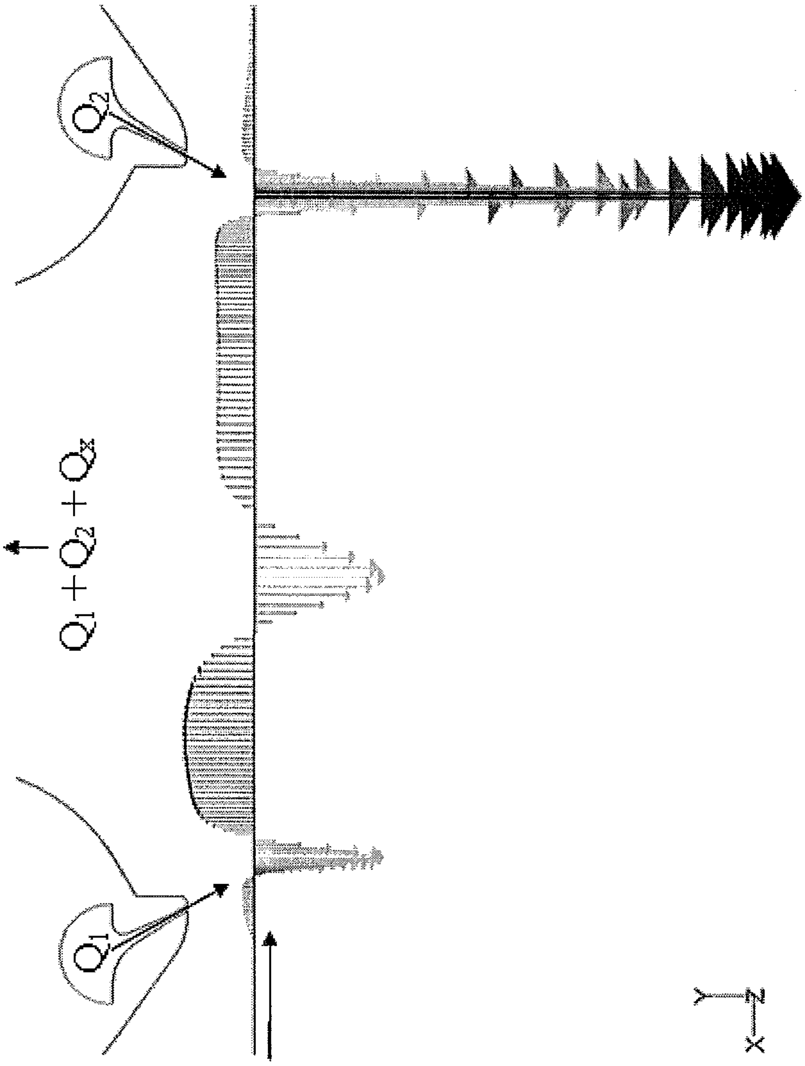

Fig. 10