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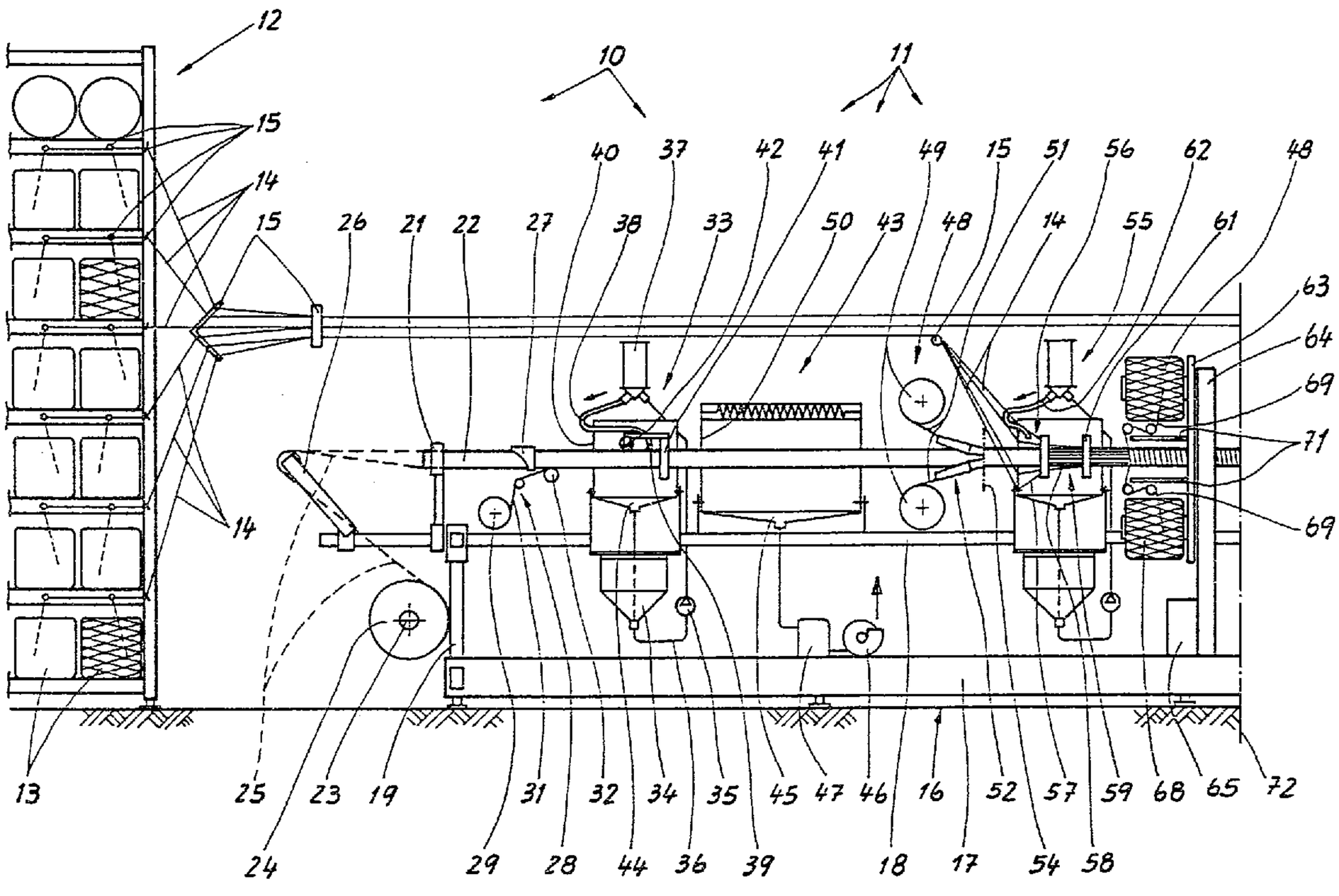
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(54) **METHODE POUR FABRIQUER EN CONTINU DES TUYAUX EN PLASTIQUE RENFORCE DE FIBRES, ET DISPOSITIF POUR METTRE EN OEUVRE LADITE METHODE**

(54) **PROCEDURE FOR CONTINUOUS PRODUCTION OF FIBRE-REINFORCED PLASTIC PIPES AND DEVICE FOR IMPLEMENTATION OF THE PROCEDURE**



(57) By means of the procedure a plastic pipe is built up progressively, the tube having a series of layers which, from the interior outwards, consist of an internal parting film, an inner skin, an intermediate resinous layer in which a fibre fleece is embedded, a number of alternately axial and tangential reinforcing layers of fibre strands embedded in synthetic resin, an outer coat and an outer parting film. The device for the implementation of the procedure includes the necessary work stations, which are positioned on a common frame. To this frame an extended shaft is firmly attached by means of a holding device. Positioned along the shaft are a feeding and shaping device for the tube-shaped

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parting film, a feeding device for the synthetic resin of the inner skin, a heating device for hardening the inner skin, a feeding device for a fibre fleece for the intermediate layer, a number of feeding devices for the individual synthetic resin layers as well as feeding devices placed alternately between them for axially and tangentially disposed fibre strands used to form the corresponding reinforcing layers, and also between them circular doctor blades for stripping off excess synthetic resin, a feeding device for the synthetic resin of the outer coat, a feeding device and shaping device for feeding in the outer parting film, a heating station for initiating the process of hardening the various synthetic resin layers with attached hardening section, a drawgear with chain conveyors for advancing the plastic pipe, a mobile cutting assembly for sectioning the endless plastic pipe into commercially acceptable lengths and finally a tube support.

Abstract:

Procedure for continuous production of fibre-reinforced plastic pipes and device for implementation of the procedure:

By means of the procedure a plastic pipe is built up progressively, the tube having a series of layers which, from the interior outwards, consist of an internal parting film, an inner skin, an intermediate resinous layer in which a fibre fleece is embedded, a number of alternately axial and tangential reinforcing layers of fibre strands embedded in synthetic resin, an outer coat and an outer parting film. The device for the implementation of the procedure includes the necessary work stations, which are positioned on a common frame. To this frame an extended shaft is firmly attached by means of a holding device. Positioned along the shaft are a feeding and shaping device for the tube-shaped parting film, a feeding device for the synthetic resin of the inner skin, a heating device for hardening the inner skin, a feeding device for a fibre fleece for the intermediate layer, a number of feeding devices for the individual synthetic resin layers as well as feeding devices placed alternately between them for axially and tangentially disposed fibre strands used to form the corresponding reinforcing layers, and also between them circular doctor blades for stripping off excess synthetic resin, a feeding device for the synthetic resin of the outer coat, a feeding device and shaping device for feeding in the outer parting film, a heating station for initiating the process of hardening the various synthetic resin layers with attached hardening section, a drawgear with chain conveyors for advancing the plastic pipe, a mobile cutting assembly for sectioning the endless plastic pipe into commercially acceptable lengths and finally a tube support.

Procedure for the continuous production of fibre-reinforced plastic pipes and device for implementing the procedure

In practice, a number of procedures exist for the production of fibre-reinforced plastic pipes. One of these procedures involves the application of a parting compound to a rotating shaft. A supporting layer is then applied, a highly resinous coating often being specified. In addition, a layer containing no bonding agent, i.e. that is not resin impregnated, is sometimes wound on from a random laid non-woven fabric and subsequently impregnated with a synthetic resin. More often, a layer bonded with a bonding agent is applied, specifically either a resin bonded fleece or a matting web of short fibre fibreglass, which is bonded together with a bonding agent, or a sprayed coating from a mixture of short fibre fibreglass and a bonding resin. The sprayed supporting layer is usually mechanically compressed and thus any air is expelled.

The dried fleece, the bonded fleece and the matting web can also be previously passed through an impregnating bath and thus impregnated with an impregnating resin before being wound onto the parting compound on the rotating winding shaft. Sometimes the impregnating resin is also applied directly to the parting tube before the fleece or the matting web is wound on and then immediately embedded in the impregnating resin.

One or more reinforcing layers are then applied to a supporting layer produced in this manner. For its part, such a reinforcing layer consists of a belt-shaped or strand-shaped layer and an impregnating resin. The layer can take various forms, specifically a fibreglass web or a so-called unidirectionally oriented web, in which a number of filaments or fibres lying parallel to each other are mechanically held together as a band at fixed large intervals with weft filaments or supporting filaments, or a fibre

web, a so-called roving, in which the fibres lie against each other in a band. The impregnating resin is applied to the reinforcing layer either by the web or the fibre strand being passed through the impregnating resin and thus impregnated, or by the impregnating resin being applied previously to the supporting layer, at least partially, and the web or the fibre strand being subsequently embedded into it. During the formation of the reinforcing layer, the web or the fibre strand can be applied in single layers or in multiple layers. If it is applied in multiple layers, the web or the fibre strand is applied to the liner in one or more repeated lengthwise movements of a support, a pin wheel sometimes being arranged at each end of the pipe, and the web or the strand being wound around the pins, producing a sort of diagonal web.

A covering layer is sometimes applied to this reinforcing layer, which can contain a fleece and this covering layer always consists of a layer of resin, which forms a smooth exterior for the fibre-reinforced plastic pipe.

The impregnating resins are hardened by chemical reactions, which are mainly initiated by thermal application, thus fastening the tube-shaped layered structure to the pipe. Only after this fastening process can the pipe be removed from the shaft. The end segments are then usually detached at both ends if the web or the fibre strand ends irregularly or, in the case of a multiple layer covering layer, if the web or the fibre strand is inverted in places. These detached end segments represent waste which cannot be used.

One of the disadvantages of this procedure is that it operates in a discontinuous manner. Because of the discontinuous operation, production is very time-consuming. In addition, in the case of a multiple layer reinforcing layer, the support must be stopped and

then accelerated again in the reverse direction of movement. This represents an additional time expenditure. An even greater disadvantage is that the winding speed and thus the feeding speed of the fibre web or the fibre strand are subject to deviations that adversely affect the layer itself, particularly the resin impregnation.

The pipe section which develops on the winding shaft sits very securely on the winding shaft, and must be removed from it with difficulty, and a great deal of force.

For such a pipe, if the air in the supporting layer in particular has not been expelled properly and occlusions remain in the supporting layer, the pipe tends to "sweat". Any medium under pressure in the interior of the pipe seeps in more or less large quantities through the pipe wall to the exterior, where it appears as beads of sweat.

Pipes wound in this manner have a more or less buckled, i.e. irregular exterior, particularly along their circumference. Such a pipe is not calibrated externally. It has more or less large deviations in its wall thickness, and correspondingly, even larger deviations in its exterior diameter.

With such a pipe, the layer or the liner of the web or the fibre strand is aligned at a large lead angle compared with a normal plane along the longitudinal axis of the pipe. Thus, the resistance of the liner as such does not completely correspond entirely to the resistance of the pipe wall. Therefore, such pipes must be produced with relatively thick walls, in order actually to obtain a certain pressure resistance. The relatively thick walls result in a correspondingly high weight per metre of the pipe.

Another result of this "crossover layer" of the liner is that, with changes in temperature, the relatively large thermal expansion resident in the resin of the liner cannot be sufficiently absorbed. Such pipes thus have relatively large thermal expansion themselves, which is very damaging, particularly in the longitudinal direction. Therefore, such pipes are generally unsuitable for lines in which temperature deviations or even sudden temperature changes occur within the medium.

With the procedures described above, the webs or fibre strands are generally applied with the same lead angle in both winding directions, in the case of multiple layer application. Moreover, there is also another winding procedure, in which different winding angles are used (dual angle winding). A parting film is applied to a stationary shaft, in a spiral shape with a very large lead angle. The edges of the spiral sheet overlap each other. A belt-shaped resin impregnated fleece is wound spirally onto the parting film with a large lead angle. This fleece is applied to the parting film with a certain tension. This resin impregnated fleece forms the supporting layer for the plastic pipe. A resin impregnated web of a specific width, which is smaller than the exterior circumference of the supporting layer, is wrapped onto the supporting layer. The web is thus wrapped onto the supporting layer with a very large lead angle, so that because of the approximate axial alignment of the warp threads of the web a "quasi-axial" reinforcing layer is formed. This first reinforcing layer is compressed with rollers.

A resin impregnated web of a width considerably smaller than the width of the first web is wrapped onto the first reinforcing layer. It is wrapped on with a lead which is clearly smaller than that of the first reinforcing layer, in which the spirals of the band butted up against each other. The lead of the warp threads of the web of the second reinforcing layer is generally

between 45° and 30°, so that this reinforcing layer can be called "quasi-tangential". The lead of the warp threads of the web of the second reinforcing layer is aligned in the same direction as the lead of the warp threads of the first reinforcing layer. A third resin impregnated web is wound on top, once again with a smaller lead and with a lead angle between 45° and 30°, so that a second "quasi-tangential" reinforcing layer is formed. Its lead is in the same direction as that of the second reinforcing layer. This third reinforcing layer is also compressed with rollers.

The parting film, the fleece for the supporting layer and the resin impregnated webs for all three reinforcing layers are applied by rotors which rotate around the axis of the pipe. The respective bands are rolled onto delivery spools on the rotors. In this way, this wrapping procedure operates continuously.

There are still a number of disadvantages attached to fibre reinforced plastic pipes produced with this procedure. The spirals of the bands of the three reinforcing layers lie loosely against each other, and only touch each other at the edges. They do not overlap each other, because they are too thick. If they overlapped, spiral-shaped bulges would form. Because the spirals of the bands only lie against each other, the resistance of each reinforcing layer across from its lead is very small, because they are bonded to each other at best by their impregnating resin.

Because of the formation of the web, webs applied with this wrapping procedure have a total thickness which is approximately equal to the sum of the thickness of their warp threads and their weft threads. As a result of this situation, the webs have relatively large hollow spaces inside the imaginary planes which cover them, which are filled up with impregnating resin. Therefore, pipes produced in this manner have a relatively high resin content. They are thus also relatively thick walled and heavy.

Webs used with this procedure are relatively expensive to produce. They are also of only limited length. The webs must therefore be changed more often in continuous pipe production, in that the beginning of the new web is applied as closely as possible to the end of the previous web. This is a constant source of difficulty.

With this procedure also, the resistance resident in the resin impregnated webs can only be partially utilized in the pipe, because the warp threads of the first reinforcing layer are only aligned quasi-axially, and in reality still have a noticeable lead angle, and because the warp threads of the second and third reinforcing layer, for their part, are only aligned quasi-tangentially, and there is still a relatively large difference between their lead and the zero lead of a pure tangential alignment.

Because of the alignment of the warp threads of the first reinforcing layer being only quasi-axial, and that of the warp threads of the second and third reinforcing layers being only quasi-tangential, and the increasingly larger deviations in their shape compared with an ideal alignment, these pipes have a relatively large thermal expansion coefficient, even if it is smaller than that of pipes made entirely of resin.

The exterior of these pipes is not smooth. Their wall thickness and their exterior diameter have relatively large deviations. For these reasons, these pipes cannot be connected together using purely metallic fitting procedures, or be connected to armatures. Fitting procedures that use O-rings as a flexible sealing element cannot be used either, because of the irregularity of the exterior of these pipes. They do not provide sufficient density. These pipes can thus only be connected together using adhesive couplings, and here again, because of the uneven exterior and the large deviations in diameter, the inserting end must be sharpened conically into a so-called pointed end and smoothed at the

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same time. This requirement presents a great disadvantage, particularly on construction sites.

The basic objective of the invention is to specify a procedure for the continuous production of fibre-reinforced plastic pipes which have better resistance properties than do pipes produced by traditional procedures, which have thinner walls and a correspondingly lower weight per metre with the same compression resistance and which have a smoother and more regular exterior. The invention also has the basic objective of specifying a device with which this procedure can be implemented.

To this end, in accordance with the present invention, an inner skin is first constructed on the parting tube and then gelled, so that it has a certain compression resistance, and the supporting layer with the fleece liner is then applied, the future plastic pipe being given an internal layer which is free of web or fibre liners, thus eliminating the problem of occlusions. The pipe's permeability to a medium which is to be passed through it in the future is thereby reduced to a very great extent, if not completely eliminated. The fact that the synthetic resin layer for the inner skin was gelled before being applied to the supporting layer prevents the supporting layer, particularly its fleece liner, from being pushed into the inner skin when the reinforcing layers are applied in later stages of the procedure, thus reducing its impermeability. This is further supported by the utilization of a random laid non-woven fabric for the supporting layer. Because the fibres for the first reinforcing layer are first guided into the guiding device in the form of a number of individual fibre strands, and from there guided to the circular doctor blade around the shaft in the form

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of a closed fibre jacket in the shape of a truncated cone, and from there embedded into the previously poured synthetic resin coating, a precisely axially aligned run of fibres is obtained in the first reinforcing layer. Because these fibres are embedded into the previously applied synthetic resin coating from the outside, and not wound onto a synthetic resin impregnated web, there is practically no risk of air pockets forming and of a corresponding porosity in the reinforcing layer. Because a narrow fibre strand is wound onto the shaft from the spool support for the second reinforcing layer, rather than a considerably wider web, the alignment of the fibres in the second reinforcing layer comes very close to the ideal of a purely tangential alignment. This is further supported by the fact that, to avoid an imbalance in the spool support, at least two spools are used in practice, thus reducing the number of fibres in each of the two fibre strands by half. Moreover, these fibre strands can be wound on in such a way that they at least partially overlap each other and thus come closer to the ideal. Because the fibres of the second reinforcing layer are embedded into the previously applied synthetic resin coating from the outside, the risk of air bubbles being embedded in the layer is practically eliminated. Moreover, the friction already occuring at the guide elements for the fibre strand ensures that the fibre strand is wound on with a certain basic tension, whereby it compresses the axially aligned fibres of the axial reinforcing layer beneath it down onto the shaft. This displaces the excess synthetic resin of the first reinforcing layer outwards, so that the resin content of the axial reinforcing layer, and also of the tangential reinforcing layer, is reduced to a minimum. This reduces the wall thickness of these two reinforcing layers and thus that portion of the weight per metre of the completed plastic pipe attributable to them. This compression of the two reinforcing layers and the squeezing out of excess synthetic resin also displaces the few, if any, remaining air bubbles out of the reinforcing layers that might have

been embedded into the synthetic resin coating when the fibres were embedded. Because another axial reinforcing layer follows the tangential reinforcing layer, the axially running fibres of which have been embedded into the previously applied synthetic resin coating by the circular doctor blade or into the excess synthetic resin remaining from the compression of the reinforcing layers underneath, and have thus also been compressed, the tangential reinforcing layer underneath is also additionally compressed, particularly in the area of its external fibres. This is also true for the second axial reinforcing layer, if a tangential reinforcing layer is subsequently applied to it. Because the fibres are wound on in the opposite winding direction to that in the first tangential reinforcing layer, because of the opposite direction of rotation of the respective spool support, the unavoidable but very small deviation in the alignment of the fibres from the purely tangential alignment is compensated for, especially since the two tangential reinforcing layers lie very close on top of each other because of the consecutive compressing operations. Because application of a further axial reinforcing layer and a further tangential reinforcing layer in the same manner is possible if necessary, and can even be repeated again, the future plastic pipe can be constructed to any dimension desired in order to meet ever greater demands as regards its mechanical properties. Because an outer coat is applied to the outermost reinforcing layer, which is optimally a tangential reinforcing layer, the future pipe can also be connected or attached to metal fitting systems which act to improve the tightness of the connections with joints, nuts, washers, etc. on the exterior of the plastic pipe, without running the risk that the fibres of the exterior reinforcing layers will be damaged or destroyed by these fitting components. Moreover, an even smoother surface of the plastic pipe is obtained with this outer coat than is already obtained with the knot-free outermost reinforcing layer alone made of parallel fibres. Because a belt-shaped parting film is ap-

plied to the outer coat and shaped into a parting tube which covers the outer coat, it is possible to pass the plastic pipe through a calibration device, whereby a further calibration is possible in addition to the calibrating effect of the circular doctor blade for the outer coat, before the layer structure of the plastic pipe is hardened in the hardening device and the finished plastic pipe is produced. Because the shaft ends within the hardening device and the plastic pipe is then moved freely without it from that point on, the frictional force between the shaft and the hardening and thus setting plastic pipe does not become so great that the pipe can only be advanced further along the shaft with great difficulty. Because the continuously produced plastic pipe is divided into individual lengths of a set dimension by the cutting device, the plastic pipe is easier to handle both when it is being transported and when a line is being produced.

The belt-shaped fleece used in producing the supporting layer may also be processed in different widths, only the rotational speed of the spool support and the speed of movement of the plastic pipe being coordinated with each other regarding the width of the band. The belt-shaped fleece may be fed to the shaft in an axial alignment, without a winding force being produced, so that the risk of the fleece penetrating into the gelled inner skin underneath is further reduced. Fluctuations in the gelling speed of the synthetic resin for the inner skin can thus be better detected. Furthermore, it is possible for the synthetic resin for the supporting layer only to be poured at the rear of the shaft when and where the two fleece bands are already near to the shaft from the side. The guiding and shaping device for the two fleece bands can also be used in forming the synthetic resin layer from the poured synthetic resin and thus contributing to an even distribution of the synthetic resin.

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A variation of the procedure allows the number of feeding devices for the synthetic resin to be reduced from three to at least two and even one, thus simplifying and shortening the procedure.

The present invention allows for a plastic pipe with the properties described above to be produced also from a plastic inner tube. This allows for fibre-reinforced plastic pipes to be produced of which the inner walls have physical and/or chemical properties which could perhaps not be achieved with a plastic pipe with an inner skin made of a gellable liquid synthetic resin. This also applies to the production of plastic pipes from a plastic inner tube, having previously been provided with an adhesive layer which is already applied either in the course of the production of this plastic inner tube or subsequently thereto.

In an embodiment of the three procedures for producing fibre-reinforced plastic pipes, a portion of the feeding devices for the synthetic resin in the production of the reinforcing layers can also be reduced, starting with the third reinforcing layer, thus simplifying and speeding up the procedure.

The present invention also relates to a device which allows for the procedure of the invention to be carried out particularly advantageously and with particularly good results.

One embodiment of the device allows for the circular doctor blade for forming the inner skin to be always exactly centred around the shaft and to follow all lateral movement of the shaft made by the latter because of its flexibility under the influence of lateral forces which might be exerted upon it when the fibre strands for the tangential reinforcing layer are being wound on. A very high regularity in the wall thickness of the inner skin and a correspondingly very exact centering of the exterior

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of the inner wall in relation to exterior of the shaft is thus achieved, which also brings with it a very high regularity in the wall thickness of the subsequent layers of the plastic pipe.

Another embodiment of the invention provides a device which allows for the procedures of the invention to be implemented very advantageously with a plastic inner tube. The plastic inner tube thus replaces the plastic pipe's inner skin made from a synthetic resin. With this device, an adhesive buffer layer is applied to the plastic inner tube instead of a supporting layer, which is not needed because of the plastic inner tube, because the plastic inner tube is produced from a thermoplastic material. The subsequent reinforcing layers would thus frequently not adhere or not adhere sufficiently to it. Good adhesion is achieved by the adhesive resin layer, however, which can be fully coordinated with the properties of the plastic inner tube so that a good bonding between the plastic inner tube and the fleece of the adhesive buffer layer is achieved, with which the subsequent reinforcing layers will bond well in turn.

This device is quite advantageous, in that the feeding device for the synthetic resin and the unwinding device for the fleece of the adhesive buffer layer remain inoperative, and are moved aside if necessary.

The following data apply to both devices described above.

One embodiment of the device allows for the synthetic resin to be continuously rotated within a feeding device, insofar as it does not remain in one or more of the layers of the plastic pipe as an impregnating resin. The constant rotation of the synthetic resin prevents it from partially settling, in the storage container for example, thus preventing possible chemical reactions from taking place within that portion of the synthetic resin, for example, which

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could cause a hardening or even a setting process within that portion of the synthetic resin, that could also spread into the remaining portion of the synthetic resin. Moreover, the constant rotation of the synthetic resin facilitates the mixing of additional amounts of the synthetic resin, which are added either continuously or at fixed intervals, with the rotating base amount, thus increasing the regularity of the consistency of the synthetic resin.

In another embodiment of the device, the fleece used to form the supporting layer is fed onto the shaft (or the plastic inner tube) from each side in two partial lines, and shaped into two halves of a circular cylinder by the guiding and shaping device running in an axial direction. Rotary lateral forces are thus avoided, which would occur if the fleece were wound on using a spool support. In a further development of the design, the presence of two partial lines of the fleece fed from the side is used so that the synthetic resin for the supporting layer is only poured on or in to the inner skin and between the latter and the plastic fleece at a relatively late stage in the process.

Another embodiment of the device allows for the fibre strands for an axial reinforcing layer to be shaped very regularly, first into a jacket of fibre strands in the shape of a truncated cone around the shaft, and from the guide ring into a fibre jacket with an equally regular truncated cone shape, allowing for a very regular construction of the axial reinforcing layer.

In yet another embodiment of the device, the interval is decreased between the feeding point of the synthetic resin and the point at which the fibres of the fibre jacket are embedded into the synthetic resin layer made from the synthetic resin. This prevents the synthetic resin from

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flowing down prematurely from the previous layer of the plastic pipe, even for resins with lower viscosity, and thus causing a possible shortage of synthetic resin at the upper side of the plastic pipe.

Each one of two further embodiments of the device provides for a very compact construction of its respective portion of the device, because only one additional feeding device for the synthetic resin is required for the formation of the supporting layer and the two subsequent reinforcing layers or for the axial reinforcing layer and tangential reinforcing layer each formed in sections, enabling the number of collecting tanks and of the various connecting lines to be correspondingly reduced, or enabling these parts to be designed correspondingly smaller. Moreover, the production time of the plastic pipe is thus reduced.

In yet another embodiment of the device, the increase in the number of spools on the spool supports and the corresponding increase in the number of fibre strands for a tangential reinforcing layer permits the number of fibres per fibre strand to be reduced in inverse proportion to the number of fibre strands, which in turn permits the lead angle to be reduced when the fibre strands are being wound on and thus permits the ideal tangential alignment to be more closely approximated. The brake on each spool permits the fibre strands for the tangential reinforcing layer to be wound on with a greater initial tension than is possible with only the basic stress resulting from the friction of the fibre strands already existing at the guiding devices. With the increased initial tension of the tangential fibre strands, the axial fibres of the reinforcing layer below are additionally compressed to a considerable extent, and the tangential fibre strands are thus also compressed down more strongly. In both reinforcing layers, the reduction of the intervals between the fibres squeezes the resulting

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excess synthetic resin out of the reinforcing layer, thus reducing the resin content of the reinforcing layers. Moreover, an additional expelling of any air in the two reinforcing layers is thus effected, if it is required at all.

An embodiment of the device provides for a mutual linking of the rotation of the spool supports along the entire main shaft and, at the same time, because of the infinitely adjustable gears, enables the rotation speed of each of the spool supports to be adapted to the winding diameter that exists at its point of use.

In another embodiment of the device, the fibre strands for the axial reinforcing layers receive an additional initial tension, which exceeds the basic stress that already exists as a result of the friction of the fibre strands at the guiding devices. This prevents the direction of rotation of the axial fibres already embedded in their synthetic resin layer from being shifted as a result of the tangential fibre strands being wound on, and particularly as a result of the compression of the axial fibres caused by these tangential fibres.

A further embodiment of the device prevents the small amount of synthetic resin which might be seeping out of the elongated slot of the outer parting tube between the parting tube and the wall of the guide tube from being pushed inwards, causing the outer parting tube to become stuck to the guide tube, or at least increasing to a great extent the friction between the parting tube and the guide tube.

A feature of the device makes it possible to achieve an even hardening of the plastic pipe, without using special measures. This also applies to a somewhat longer section, in which a perforated metal pipe is used instead of a considerably more expensive glass pipe permeable to infrared light.

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In another aspect of the device, an effective but gentle tensile motion is exerted on the plastic pipe by the chain conveyors, which are equipped with drive supports made of an elastomer, ensuring a reliable movement of the plastic pipe through all workstations.

In yet another aspect of the device, the cutting device is driven by the plastic pipe itself during a cutting operation, the pipe sections on both sides of the cutting point being held simultaneously at a constant distance from each other, even during a gradual cut, so that the pipes are neither compressed together nor pulled apart at the cutting point. The cutting device may be automatically returned, in a simple manner, after the clamping device has been released, because the pneumatic piston drive can be adjusted in such a way that it is able to push the brake back into its initial position, as a result of the constant pressure of the pneumatic pressurizing medium when the clamping devices are released, and because it is conversely sufficiently flexible when the clamping devices are closed to permit the cutting device to move along with the plastic pipe.

The exterior diameter of the shaft may be adapted in stages to the contraction of the plastic pipe, or more exactly, of the blank of the plastic pipe, which occurs in the area of the winding on points of the fibre threads for the tangential reinforcing layers and in the area of the hardening device. The friction of the plastic pipe on the shaft is thus considerably reduced. The traction required to draw the plastic pipe through the entire device is thus also reduced. Moreover, the cohesion for the shaft and its tensile load is also reduced in this manner. Reducing the friction between the plastic pipe and the shaft also eliminates the risk of intermittent slipping motion (so-called "stick-slip" friction) of the plastic pipe on the shaft.

In a further embodiment of the device, the production of

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the shaft is simplified and facilitated. Moreover, replacing individual lengths, if necessary, that wear out more quickly than the other lengths or that have to be replaced for other reasons, is facilitated. Dividing the shaft into individual pieces also makes it easier to produce the range of diameters, because in general the individual pieces can have the same diameter over their entire length.

The feeding of a pressure gas into the interior of the shaft and its subsequent exit through the through holes distributed over the length of the shaft creates a series of pneumatic lubrication layers. These also reduce the friction of the plastic pipe on the shaft.

In a further aspect of the device, the excess pressure of the pressure gas in this length of the shaft can be adjusted independently of the excess pressure in the previous

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lengths. The excess pressure in this length can thus be better adjusted to the requirements prevailing there, which arise especially because the contraction of the plastic pipe is greatest in the area of the hardening device, and can vary depending on the synthetic resins used and progress of the hardening operation.

In yet another embodiment of the device, the amounts of excess synthetic resin can be more easily removed, and a flawless construction of the outer coat can thus be more securely obtained. Moreover, the exterior diameter of the plastic pipe can thus be more exactly regulated, or in other words, a smaller deviation in the diameter of the plastic pipe can be obtained. Moreover, the remaining clearance at both the guiding and shaping device and the connecting circular doctor blade eliminates the risk that the synthetic resin, when it is peeled off, might spread over the exterior of the parting film and remain stuck there, and subsequently bond in the hardening device with the parting film.

The invention is subsequently explained in greater detail using a sample construction presented in the drawings, and then using a modification thereof. The drawings show:

Figures 1 through 5: cross sections of an extensive schematic side view of the device for the continuous production of fibre-reinforced plastic pipes;

Figure 6: the first section of a side view of a partially modified sample construction of the device;

Figure 7: an extracted top view of a circular doctor blade of the device as shown in Figure 1;

Figure 8: an extracted top view of a combined work-station of the device as shown in Figure 1;

Figure 9: a side view and a longitudinal section of a guiding and shaping device and a circular doctor blade of the device as shown in Figure 1;

Figure 10: a bottom view of the guiding and shaping device and the circular doctor blade as shown in Figure 9;

Figure 11: a front view of the guiding and shaping device and the circular doctor blade as shown in Figures 9 and 10.

The device 10 has a machine part 11 with a number of workstations and devices and a shelf frame 12, which is positioned at the front of the machine part and at a considerable distance from it.

A large number of spools 13 with fibre strands 14 are stored in the shelf frame 12, the fibre strands being formed of a more or less large number of glass fibres, carbon fibres and textile fibres. The spools 13 are postioned with vertically aligned spool cores, so that fibre strands 14 can be drawn off from the inside. To this end, numerous guiding devices 15 are arranged in the shelf frame 12, through which the fibre strands are drawn off from the spools 13 and guided to the machine part 11. Such guiding devices are also positioned between the shelf frame 12 and the machine part 11, which for reasons of clarity are only partially shown or indicated.

The machine part 11 has a frame 16 which extends along the entire length of the machine part 11 and accomodates all of the devices belonging to the machine part 11 within the space properly alloted on each side. For reasons of clarity, only a few parts of the frame 16 are shown, including a base frame 17, a crossbeam 18 positioned at a certain distance above the base frame 17 and a number of posts 19.

At the front of the frame 16 there is a holding device 21, which is secured to the frame 16. The holding device 21 secures the front of a shaft 22, which is aligned horizontally and is in an overhung position to the holding device 21 and extends along a whole series of workstations and devices. The shaft is designed as a circular cylinder shaped hollow body.

An unwinding device 23 is positioned at the front of the frame 16, which accomodates a belt-shaped rolled parting film 25 with a spool 24, the axis of which is aligned horizontally and at a right angle to the length of the frame. The parting film 25 is guided to a shaping device 27 by a guiding device 26, and shaped into a parting tube encircling the shaft 22 by a stretched parting film 26 suspended above the shaft 22 in the axial direction. A bonding device 28 is located in the area of the shaping device 27, which has an unwinding device 29, from which an adhesive band 31 is drawn off and pressed by a pressing roller 32 onto the edges of the parting tube which butt against each other or overlap each other slightly, thus bonding the edges of the parting film together such that they are impermeable to synthetic resin.

The bonding device 28 can also be modified, such that instead of the pressing roller 32, a welding shoe of an ultrasonic welding device is pressed against the overlapping edges of the parting film, thus welding the edges of the parting film 25 together and forming the parting tube.

A feeding device 33 for a synthetic resin has a storage container 34 for the synthetic resin, a circulating pump 35 and various lines 36. A feeding pipe 38 feeds the synthetic resin to the shaft 22 from an upper intermediate container 37. The mouth 39 of the feeding pipe 38 is aligned at the top of the shaft 22 in the vertical meridian plane of the latter, the resin being poured

onto the parting tube from the mouth 39 and then dispersing evenly to both sides and forming a closed synthetic resin layer. Some of the parts of the feeding device 33 are enclosed by a box-shaped covering 40, the front walls of which have a pass-through opening for the shaft 22 along the alignment of the shaft 22. A part of the covering 40 is hinged, so that the interior is accessible.

In the direction of the future plastic pipe, a ring-shaped blade is positioned, connected with the mouth 39, which will be subsequently referred to as a circular doctor blade 41 for short, as will the ring-shaped blades to be described later. This circular doctor blade 41 is positioned at a feeding device 42, which will be explained later in greater detail using Figure 7. The circular doctor blade 41 is fed by this feeding device 42 in the longitudinal direction of the shaft in a fixed manner and in the normal plane of the shaft, always axially, to the shaft 22. The synthetic resin poured onto the parting tube by the feeding device 33 is shaped by the circular doctor blade 41 into a circular synthetic resin layer of regular thickness. This synthetic resin layer is heated in a subsequent heating device 43 and thus activated such that this synthetic resin layer gels into an inner skin of the future plastic pipe.

Underneath the mouth 39 of the feeding pipe 38 and underneath the circular doctor blade 41, a common collecting tank is positioned that collects the synthetic resin which has dripped off the parting tube or been stripped off by the circular doctor blade 41 and brings it back to the storage container 34. There is also a collecting tank in the heating device 43, which collects the reagents coming out of the inner skin during its gelation. From there these reagents, including their fumes which have formed because of the heating, are subsequently extracted by a fan 46 and collected in a filter 47, preferably in the form of an activated

charcoal filter. The purified air which carried the fumes is blown out freely. The extraction of the fumes is supported by a box-shaped covering 50, which has a design similar to that of the covering 40.

An unwinding device 48, which holds two spools 49 of a belt-shaped fleece 51, is located behind the heating device 43. The unwinding device 48 is connected to a guiding and shaping device 52, by which the two fleece bands 51 are guided to the shaft 22, where they are shaped into two semicylindrical halves of a layer 53 which is open at two diametrically opposite points, as explained later using Figure 8.

Regarding the unwinding device 48 and the guiding and shaping device 52, it should be noted that these are shown in Figure 1 rotated 90° around the longitudinal axis of the shaft 22, but are in reality aligned in the horizontal plane that passes through the longitudinal axis of the shaft. The tube 53 (Figure 8) formed by the guiding and shaping device 52 is thus delimited in Figure 1 by the dotted line 54. Because of the tilted presentation, the unwinding device 48 and the guiding and shaping device 52 connected to it are shown restored in the axial direction in relation to the following devices. Their true alignment in the axial direction is shown in Figure 8.

In reality, another feeding device 55 for the synthetic resin is positioned in close proximity to the guiding and shaping device 52, the design of which is almost identical to that of the feeding device 33, and for this reason the description of the feeding device 33 should be consulted for details of the feeding device 55.

A guiding and shaping device 56 is positioned close to the feeding device 55, which is also explained in greater detail using Figure 8. This guiding and shaping device 56, which surrounds

the exterior of the shaft 22, guides a portion of the fibre strands 14 drawn off the shelf frame 12 to the shaft, and aligns them as fibre strands 57 along the surface of a truncated cone, and subsequently guides the fibres 58 of these fibre strands 57 as a closed fibre jacket 59 in the shape of a truncated cone to a circular doctor blade 61. The circular doctor blade 61 embeds the fibres 58 of the fibre jacket 59 into the layer of synthetic resin formed from the synthetic resin which was previously poured onto the inner skin of the plastic pipe through the feeding pipe 52 of the feeding device 55. This synthetic resin layer and the fibres 58 embedded in it in an axial alignment together form a first reinforcing layer for the plastic pipe, which is referred to as an axial reinforcing layer because of the axial alignment of its fibres.

The synthetic resin poured onto the inner skin through the feeding pipe 62 was poured in an amount which exceeds the volume which the fleece bands 51 can absorb, the excess amount being so great that there is not only sufficient synthetic resin for the first axial reinforcing layer, but also some left over for the next reinforcing layer. This next reinforcing layer is formed in such a way that it is connected directly to the first axial reinforcing layer. For this reason there is a ring-shaped spool support 63 near the feeding device 55 for the synthetic resin, which surrounds the exterior of the shaft 22 and which is fixed with ring bearings to a bearing support 64, such that it can be rotated. The spool support 63 is driven by an infinitely adjustable or controllable gear 65 of a common drive shaft 66, which is outlined in Figure 4 and which extends out from the driving motor 67 positioned there along the frame 16 to all driven devices, including the gear 65 of the spool support 63.

The spool support 63 has an even number of spools 68 which each have one fibre strand 69, which are fixed to the spool support 63 such that they can be rotated. In Figure 1 only two spools 68 are shown, for reasons of clarity. In reality, there are optimally at least four or even six spools.

Guiding devices 71 are positioned on the spool support 63, by which the fibre strand 69 of each of the spools 68 is guided to the shaft 22. When the spool support 63 rotates around the shaft 22, the fibre strands 69 wrap onto the axial reinforcing layer below, becoming embedded in the excess synthetic resin which was not absorbed by either the supporting layer or the first axial reinforcing layer and which seeped out of the fleece tube formed by the fleece bands 51 and out of the fibre jacket of the first reinforcing layer.

At the cut-off point 72, which is necessary purely because of the format of the drawing, and which is represented by a dotted line, the other devices are connected, which are shown in Figure 2. This is also true for the cut-off points 73 through 74 in Figures 2 through 5.

Another feeding device 76 for a liquid synthetic resin is located subsequent to the spool support 63, which has the same design as the that of the feeding device 55. A guiding and shaping device 77 is positioned near this feeding device 76, which has the same design as that of the feeding device 59. There is also a circular doctor blade 78, which has the same design as that of the circular doctor blade 61, the inside diameter of the circular doctor blade 78 being somewhat larger than that of the circular doctor blade 61, however. A synthetic resin layer is poured through the feeding device 76, to which the fibre strands 14 brought from the shelf frame 12 are guided as a fibre jacket in

the shape of a truncated cone, and embedded in the synthetic resin layer by the circular doctor blade 78. In this manner, a second axial reinforcing layer is produced.

Another spool support 81 with a number of spools 82 is positioned near the feeding device 76, which has the same design as that of the spool support 63. The fibre strands 83 drawn off from the spools 82 are wound onto the second axial reinforcing layer below when the spool support 81 rotates and are embedded in the synthetic resin layer, which was poured previously through the feeding device 76, with a corresponding excess amount of resin. The spool support 81 rotates in the opposite direction of rotation to the spool support 63. A second tangential reinforcing layer is formed by the feeding device 76 and the spool support 81.

Following these devices, there is another feeding device 84 for a synthetic resin, which also has the same design as that of the feeding device 76, through which a synthetic resin layer with a certain amount of excess resin is poured onto the second tangential reinforcing layer. Fibre strands 14 are guided by a guiding and shaping device 85 as a fibre jacket 86 in the shape of a truncated cone, and embedded in the synthetic resin layer by a circular doctor blade 87. A third spool support 88 which follows these devices, with a number of spools 89, winds its fibre strands 91 onto the third axial reinforcing layer, which was formed by the circular doctor blade 87, and embeds them in the synthetic resin layer, thus creating a third tangential reinforcing layer.

If desired or required, another axial and tangential reinforcing layer can be formed using one or more other groups of a feeding device for a liquid synthetic resin, a guiding and shaping device for an axially aligned fibre jacket in the shape of a truncated

cone, a circular doctor blade for embedding this fibre jacket into the synthetic resin layer and a spool support for wrapping on a number of fibre strands tangentially.

A circular doctor blade 92 is connected to the last spool support 88, under which a collecting tank 93 is positioned. In this manner, any remaining excess synthetic resin is stripped from the outermost tangential reinforcing layer which was formed with the spool support.

Another feeding device 94 is connected to the circular doctor blade 92, which has a design that is, to the greatest extent possible, the same as that of the first feeding device 33. A synthetic resin for an outer coat is poured through the feeding device 94 onto the outermost tangential reinforcing layer. This synthetic resin is formed into the outer coat of the plastic pipe with a circular doctor blade 95. This circular doctor blade 95 is guided in the same manner as the circular doctor blade 41 with a guiding device, which is explained in greater detail in Figure 7, in connection with the circular doctor blade 41.

Above the shaft 22, an unwinding device for a belt-shaped parting film 98 wound onto a spool 97 is positioned, connected to the circular doctor blade 95. The parting film 98 is guided by a saddle-shaped guiding and shaping device 29 down onto the plastic pipe 100, which is now completed except for hardening, and thus shaped into a layer surrounding the exterior of the outer coat of the plastic pipe 100. This layer, which forms an outer parting tube for the plastic pipe 100, is open along its length at the bottom, the edges of the parting film butting against each other. The width of the parting film 98 must therefore be coordinated with the outer circumference of the outer coat of the plastic pipe 100.

Following the guiding and shaping device 99 is another circular doctor blade 101, which has a collecting tank 102 positioned beneath it. This circular doctor blade 101 strips off any synthetic resin that might pass outwards through the longitudinal separation of the outer parting tube when the outer parting tube is being shaped and applied. For this reason, the circular doctor blade 101 is positioned directly beside the guiding and shaping device 99, and is only shown at a certain distance from the latter in Figure 2 for reasons of clarity.

A hardening device 103 connects with the guiding and shaping device 99 and the circular doctor blade 101. The hardening device has heat sources and/or radiation sources 104, which are optimally designed as infrared radiators. These radiation sources 104 surround the plastic pipe 100, the lower portion of the radiation sources 104 having been left out in Figure 2 to avoid misunderstanding.

The hardening device 103 is equipped with a box-shaped covering 105, which at the same time acts as a thermal insulator, preventing the heat energy of the radiation sources 104 from radiating or escaping, where possible.

A receptacle or collecting tank 106 is positioned at the bottom of the hardening device 103, in which any reagents or fumes which escape during the hardening of the plastic pipe are received or collected, and extracted with a fan 107 and guided into a filter 103, where they are filtered out of the air carrying them, which is exhausted in a purified state.

The hardening device 103 has another guiding tube 109, which is shown as a dotted line in Figure 2, because it is equipped with a large number of slits, which are staggered next to each other along the length and circumference of the tube. These slits make

the guiding tube 109 permeable to heat and to the infrared radiation of the radiation sources, which can thus advance to the plastic pipe 100 and penetrate it. The hardening process of the various plastic layers of the plastic pipe is thus initiated.

The guiding tube 109 has an inner diameter which is at least approximately equal to the sum of the nominal diameter of the finished plastic pipe 100 and twice the wall thickness of the parting tube, which was formed from the parting film 98. The guiding tube 109 is equipped with longitudinal slits at its bottom, so that the reagents leaving the plastic pipe 100 during the hardening process pass through the slit and can drop into the collecting tank 106, and are not forced into the space between the outer parting tube and the guiding tube 109.

The guiding tube 109 extends along the section of the hardening device which contains the radiation sources 104, and which is contained by the covering 105. The guiding tube 109 extends in the direction of the plastic pipe 100 at least to the point at which the outer coat of the plastic pipe 100 has sufficient dimensional stability to permit the plastic pipe 100 to be supported on rollers 111, which transmit the plastic pipe from that point on (Figure 3).

The shaft 22, on which the pipe was carried from the first workstation, ends in the extension of the hardening device 103. From that point on, the pipe moves forward freely and is supported by the rollers 111. These rollers can be adjusted to the vertical position of the plastic pipe 100, so that pipes of a different diameter can also be carried and forwarded by them.

A hardening section 112 connects with the hardening device 103, which has thermal insulation devices in the form of thermal insulation hoods 113. These thermal insulation hoods 113 have a U-

shaped or C-shaped design, that is designed so that the longitudinal opening is situated on the bottom of the thermal insulation hoods 113. It is sufficiently wide to permit the supports of the rollers 111 to extend into it. The thermal insulation hoods are movable lengthwise along the pipe 100 by a longitudinal guide 115. The longitudinal guide 115 is formed of guide rails 116 and rollers 117. The guide rails 116 are secured to the posts 19 of the frame 16. The rollers are mounted on to the thermal insulating hoods 113, such that they can be rotated.

The guide rails 116 are of a length that is longer than the sum of the length of the individual covering hoods 113 by at least the length of one of the covering hoods. The covering hoods 113 can thus be moved individually on the guide rails 116 sufficiently far enough that each point of the guiding tube 109 is accessible.

The thermal insulation hoods 113 are shown in a retracted position in Figure 2. When the machine part 11 is operated for the production of the plastic pipe 100, the covering hoods 113 are moved forward to the hardening device 103, so that they already enclose the length of the guiding tube protruding from the hardening device 103 and prevent the section of the plastic pipe 100 within it from losing heat, this being necessary for the hardening of the plastic pipe.

A drawgear 118 is positioned at the end of the guide rails 116 of the longitudinal guide 115. It has at least two chain conveyors 119, which are positioned along the diameter of the plastic pipe 100. For the protection of the plastic pipe 100, at least four chain conveyors 119 are used, optimally.

The chain conveyors each have one roller chain 121, which is driven by a track 122 when the roller adjacent to the plastic pipe 100 is drawn. The roller chains are equipped with angle brackets to which drive supports 123 made of an elastomer are secured.

The drawgear 118 is driven by the electric motor 67 via an infinitely adjustable gear 124 with which the continuous drive shaft for the driven devices is also connected.

A cutting device 125 is connected to the drawgear 118, with which the plastic pipe 100 is divided into individual lengths 126 (Figure 5) of a set dimension. The cutting device 125 is designed to be moved lengthwise by a longitudinal guide 127 along the plastic pipe 100. The cutting device 125 is equipped with a clamping device 128. This has two pairs of clamping jaws 129, one of which is positioned before and one after the cutting tool 132 of the cutting device 125 in the direction of the plastic pipe 100. Each clamping jaw of these two pairs of clamping jaws is connected with a double-acting pneumatic piston drive 131, with which it can be positioned with a certain clamping force on the plastic pipe 100, as shown by a dotted line at right in Figure 4, or retracted from the plastic pipe 100, as shown at left in Figure 4.

The cutting device 125 is connected to a reset device with a pneumatic piston drive, which is not shown. This is operated with a control device, which is also used in the operation of the clamping devices 128. Optimally, there is a fixed stop in the initial position of the cutting device outlined in Figure 4, against which the cutting device is pushed by the reset device.

A pipe take-off device 133 is positioned at a certain distance from the cutting device 125 (Figure 5), which removes the length 126 (Figure 5) separated from the continuously produced plastic pipe 100 from the alignment of the plastic pipe and transports it to a pipe storage area.

In Figure 6, the first section of the device 10' can be seen, in which a portion of the devices has been modified in comparison with the sample construction shown with the device 10 in Figure 1.

The device 10' is designed for the production of a fibre-reinforced plastic pipe similar to the plastic pipe 100 from a plastic inner tube, which in general consists of a thermoplastic. This plastic inner tube 140 is guided continuously through the alignment of subsequent workstations and devices by a feeding device 141. At the machine part 11' of the device 10', a feeding device 142 for an adhesive resin is positioned in a first work-station, which is very similar to the feeding device 33, which is positioned at approximately the same location of the machine part 11. The adhesive resin poured onto the plastic inner tube by the feeding device 142 is formed into a circular layer of adhesive resin of regular thickness by a circular doctor blade 143. This circular doctor blade 143 is, like the circular doctor blade 41, also connected to a guiding device, as is explained in greater detail using Figure 7.

An unwinding device 144 is positioned next to the feeding device 142, which has two spools 145 with a belt-shaped fleece in the form of a random laid non-woven fabric wound on them. Beside this is a guiding and shaping device 147, with which the two fleece bands drawn off the unwinding device 144 are guided to the plastic inner tube 140 and shaped into the two semicylindrically shaped halves of a tube which is open lengthwise at two points.

A circular doctor blade 148 is positioned connected to the guiding and shaping device 147, with which the two-part fleece tube is embedded in the adhesive resin layer formed by the feeding device 142 and the circular doctor blade 143, whereupon an adhesive buffer layer is formed on the exterior of the plastic inner tube 140. The excess adhesive resin stripped from this layer is collected in a collecting tank 149 and guided back to the storage container of the feeding device 142.

Three axial reinforcing layers with three alternating axial reinforcing layers are applied in succession to the adhesive buffer layer, using devices for the production of the plastic pipe 100 described in greater detail for the device 10. The only difference with this device is that the unwinding device 48 and the guiding and shaping device 52 for the tube-shaped fleece liner of the supporting layer are not present at the feed end of the feeding device 55. With the device 10', only an amount of synthetic resin sufficient for the first axial reinforcing layer and the first tangential reinforcing layer is applied to the adhesive buffer layer on the plastic inner tube 140.

Figure 7 shows the circular doctor blade 41 and the guiding device 42 connected to it in greater detail.

The guiding device 42 has two guide arms 151, which are connected to each other by a yoke 152. The circular doctor blade 41 is secured to the yoke 152, such that it can be replaced if necessary. The two guide arms 151 are fixed on both sides by universal joints 153, such that they can rotate, and are thus fixed such that they cannot be moved in the direction of movement of the future plastic pipe 100 indicated by the arrow 154. The two guide arms 151 extend past the universal joints 153 to the other end, where a counter-weight 155 is clamped to each of them. The

two counter-weights are laid in such a way that they are able to counterbalance the momentum of the guide arm 151 opposite them, including the yoke 152 and the circular doctor blade 41, as well as two guide rollers 156 and their supporting arms 157, to a certain residual weight force. This residual weight force positions the guide rollers on the shaft 22, the inner parting tube for the future plastic pipe 100, which is not shown, still being located between them.

In order to achieve good control of the circular doctor blade 41, in both the vertical and horizontal direction, the guide rollers 156, which are secured on the supporting arms 157 such that they can rotate, are aligned such that their planes of motion at least approximately pass through the longitudinal axis of the shaft 22 and that the two planes of motion form an angle between 60° and 120°, the optimal angle amounting to 90°.

To allow the planes of motion of the guide rollers 156 to be aligned with the longitudinal axis of the shaft 22 or the plastic inner tube 140 even if the diameter of the shaft 22 or the plastic inner tube 140 is changed, it is advantageous to connect the supporting arms 157 to their longitudinal axis with the yoke 152, such that they can rotate.

A more detailed description of the guiding and shaping device 52 for the fleece bands 51 and the guiding and shaping device 56 for the fibre strands 14 is given below, using Figure 8.

The guiding and shaping device 52 has a guide vane 161 for each of the fleece bands 51, the interior of which, which faces the shaft 22, is bent in a concave shape at least at its end, so that the initially flat fleece band 51 is shaped into approximately semicircular cylindrical surfaces and can be guided to the shaft

22 as fleece tube halves 163, which are formed into the fleece tube 53 when joined, which is open lengthwise at the top and bottom of the shaft 22.

The guiding and shaping device 56 for the fibre strands 14 has a guide blade 164 and a guide ring 165. A number of passages 166 corresponding to the number of fibre strands 14 are located in the guide blade 164, one of the fibre strands 14 being drawn through each of them. The through-holes are distributed either along a single circular ring or along several circular rings lying axially against each other. The number of these circular rings depends on the number and thickness of the fibre strands 14. The guide ring 165 has a circular closed inner surface 167, which, as shown in Figure 8, can take the form of, for example, a wire ring 168 inserted in the guide ring 165. This wire ring is made of spring steel and, like a snap ring for boreholes, is expanded past its nominal width, and inserted into the interior of the guide ring 165 in a flexible, compressed state. In this manner, the wire ring 168 can be easily replaced when it wears out.

The nominal inner surface 167 of the guide ring 165 has a smaller inside diameter than the smallest circular ring in the sample arrangement of the passages 166 in the guide blade 164. In this manner, the fibre strands 14 are fed from the guide blade 164 as a fibre jacket 169 in the shape of a truncated cone to the guide ring 165. In the more narrow guide ring 165, the fibre strands 14 lie so close together that their fibres already form a closed fibre jacket in the form of a truncated cone inside the guide ring 165, which is guided out of the guide ring 165 to the circular doctor blade 61, the fibres of the fibre jacket 170 being pushed together ever more closely in a circumferential direction and thus coming so close to the amount of excess synthetic resin present on the exterior of the supporting layer that they are already immersed in this artificial resin layer in the section be-

tween the guide ring and the circular doctor blade 61, and fully embedded in it by the circular doctor blade 61, from which point they form the first axial reinforcing layer of the future plastic pipe 100.

As shown in Figure 8, the joining of the two fleece tube halves 163 into the fleece tube 53 takes places near the guide blade 164 of the guiding and shaping device 56. The pouring of the synthetic resin, both for the supporting layer and for the two subsequent reinforcing layers, takes places above the feeding tube 38 of the feeding device 33, between the edges of the fleece tube halves, which are coming together, the mouth 39 of the feeding tube 38 being placed as far as possible into the slot, which is closing.

The fibre strands 14, which are formed into a fibre jacket in the shape of a truncated cone in the various guiding and shaping devices and then embedded in the respective synthetic resin layer to form an axial reinforcing layer, are optimally additionally tensioned individually beyond the basic tension existing already as a result of the friction at the guiding devices 15 before entering the guide blade of the guiding and feeding device, by a tensioning device not shown in the drawings. In doing so, care should be taken to ensure that the fibre strands have a uniform total tension amongst themselves. The fibre strings drawn off the spool supports which are wound onto the axial reinforcing layer below and are embedded in the synthetic resin layer present to form a tangential reinforcing layer are also additionally prestressed. For this reason, the spools on the spool support are each stopped with a brake, the braking force of which is controlled by a control device as a function of the respective exterior diameter of the spool, which is measured by a caliper for this purpose in the control device.

It has so far been assumed, for reasons of simplicity, that the shaft 22 is an elongated, continuous cylindrical hollow body with a uniform exterior diameter. In reality, the shaft 22 is composed of a number of longitudinal sections, that are all cylindrical, but of which the exterior diameter decreases in stages, from the holding device 21 to end of the shaft, near the hardening device 103. For practical reasons, the shaft is constructed of a number of independent individual sections, which are connected with each other by threaded couplings at each of their ends. Optimally, the length of these independent individual sections is selected such that the connecting points of the individual pieces coincide with the transition points from one size of diameter to the next. The individual sections of the shaft 22 can thus be produced with a constant exterior diameter along their entire length. Connecting these individual sections in the proper sequence thus results in a gradation of the exterior diameter of the entire shaft 22.

The transition points from one diameter size to the next are positioned on the shaft 22 at those points where there is a tendency for the diameter of the plastic pipe 100, which is still flexible because it has not yet fully hardened, to diminish as a result of external influences. In particular, they are positioned at those points where the fibre strands for a tangential reinforcing layer are wound onto the blank of the plastic pipe 100 present there. This winding on of the fibre strands causes the previous axial reinforcing layer to be tightened, causing its fibre strands to be embedded in the plastic layer and causing this layer and the tangential reinforcing layer itself to be compressed. This compression of the pipe wall causes the blank to contract very slightly each time. It is thus optimal to position the transition point from one diameter size to the next along the plastic pipe 100 directly next to the winding on point of the fibre strands for a tangential reinforcing layer, where the con-

traction of the pipe wall is most noticeable. The pipe wall then remains generally unchanged from that point to the next winding on point of a fibre strand for the next tangential reinforcing layer.

A contraction of the plastic pipe 100 occurs near the hardening device, for other reasons. At this point, the intensive hardening process that has been initiated of the plastic contained in the pipe wall causes a contraction of the plastic pipe 100. It is thus optimal to position another transition point from one diameter size to another near the hardening device 103.

Depending on the type of synthetic resin used and its change in volume during the hardening process in the hardening station 103, it may be optimal, because of the reduction in the exterior diameter of the shaft 22, no longer to construct the shaft in an exactly cylindrical shape along this length of the shaft, but rather, in a slightly conical shape which follows the decreasing exterior diameter along the plastic pipe 100.

The relatively tight positioning of the plastic pipe 100 gradually being formed on the shaft 22 can also necessitate a type of pneumatic lubrication. For this purpose, a pressure gas is brought into the interior of the shaft 22 through a feed line, which is not shown in Figure 1 for reasons of clarity. In the simplest case, compressed air is used as a pneumatic lubricant.

In order to prevent the arbitrary escape of the pressure gas from the axial opening of the shaft 22, a partition is positioned at a location near the beginning of the shaft at which no other devices interchangeable from the outside need to be inserted, which prevents the pressure gas from escaping to the other sections of the shaft. Such a partition is most easily positioned at a connecting point of two individual sections of the shaft 22.

It is also easiest to connect the pressure gas line at this point. To implement pneumatic lubrication, radial passages are positioned at a number of points along the extension of the shaft 22, which pass from the interior of the shaft to its exterior. It is optimal to position these passages at the transition points from one diameter size to the next, because the pneumatic lubricating film is most easily obtained at the beginning of a longitudinal section which has a reduced diameter, and can spread out from there in an axial direction under the influence of the excess pressure of the pneumatic lubricant in its wake, on the one hand, and through the movement of the plastic pipe 100 along the shaft, on the other hand. In the simplest case, the passages are formed by radial recesses in the front of the individual sections of the shaft 22. In general, this makes it unnecessary to drill separate boreholes in the individual sections.

Because the contraction of the plastic pipe 100 near the hardening device 103 can vary depending on the type of plastic used and the type and intensity of the application of heat or radiation for initiating and continuing the hardening process, it is optimal to seal off the interior of the shaft 22 in this section from the interior of the previous section with an additional partition, and connect the sealed off interior with an isolated compressed air line through this partition, which is positioned through the hollow shaft 22 and connected with a compressed air source, the excess pressure of which is or can be greater than the excess pressure in the previous section of the shaft 22. In this way it is possible, when necessary, to increase the lubricating effect of the pneumatic lubricant by raising the pressure in this section of the shaft 22.

To prevent the pressure gas used as a pneumatic lubricant from escaping arbitrarily at the end of the shaft 22, thus making it impossible to build up the desired pressure, the shaft 22 is sealed off at its end by a partition.

The guiding and shaping device 99 and the adjacent circular ring 101 are described in greater detail below using Figures 9 through 11.

The guiding and shaping device 99 for the parting film 98 works somewhat differently than the shaping device 27 for the inner parting film 25. The circular doctor blade 101 also works somewhat differently than the circular doctor blades 61, 78, 87, and 95 used ahead of it. This is evidenced by the fact that the latter circular doctor blades strip off any remaining excess synthetic resin from the exterior of the pipe blank directly. In the case of the guiding and shaping device 99, the parting film 98 is wrapped around the last or outermost synthetic resin layer of the plastic pipe 100, thus enveloping the plastic pipe 100. The saddle-shaped guiding and shaping device 99 has a body 171, which is derived from a thick-walled circular cylinder, along which a diagonal and at the same time somewhat curved cutting line is made. The edges 172 of the side walls 173 of the foundation 171 run lengthwise around the plastic pipe 100 from an inlet shoulder 174 for the parting film 98 positioned above the plastic pipe 100, constantly one over the other. They get closer to each other in the vertical meridian plane until they reach a very small residual opening, gap or slot 175. The width of this gap is in the order of magnitude of a few tenths of a millimetre. It depends partially on the hydraulic properties of the synthetic resin to be stripped off, such as viscosity and surface tension.

As shown in Figure 11, the side faces 176 and 177 in the area of the residual gap or slot 175 run from their inside edge 178 to the leading edge 179 at a certain angle to each other, which generally amounts to 90°.

The outer sections 181 of the inlet shoulder 174 can be produced in one piece with the body. They can also be produced as separate parts, however, and subsequently connected with the body 171 with, for example, screws.

The circular doctor blade 101 positioned in the proximity of the guiding and shaping device 99 is, like the shaping device 99, also not completely closed as a ring. On the contrary, it has a reisdual opening or gap 182 in the vertical meridian plane below, the design of which is similar to that of the residual gap or slot 175 of the shaping device 99, and which is aligned with the residual gap 175.

As with the shaping device 99, the side faces 183 and 184 of the circular doctor blade 101 run from the inside edge to the leading edge at an angle to each other, which is generally the same as the angle between the side faces 176 and 177 on either side of the residual gap 175. To an extent, then, Figure 11 also represents an axial view of the circular doctor blade 101.

The collecting tank 102, which is shown only underneath the circular doctor blade 101 in Figure 2, also extends in reality underneath the shaping device 99. This collecting tank extends crosswise only a short distance past the leading edge 179, and can thus also be called a collecting trough, because of its relatively narrow width.

A stripper 185 is positioned at the end of the collecting tank 102 on the other side of the circular doctor blade 101 in the direction of the plastic pipe 100, the stripping edge 186 of which is aligned with the exterior contour of the plastic pipe 100.

The stripper 185 strips any remaining synthetic resin from the plastic pipe 100 that may have remained stuck to the bottom of the plastic pipe after the circular doctor blade 101 left the area of its residual gap 182.

Claims

1. A method for the continuous production of fibre-reinforced plastic pipe comprising the steps of:

- providing a horizontally disposed shaft which is held at one end;

- continuously drawing a belt-shaped parting film longitudinally onto said shaft and simultaneously wrapping said film around said shaft to form a parting tube, said film having edges that are impermeably bonded together;

- moving said parting tube continuously in the same direction as the plastic pipe through all successive work stations;

- pouring a liquid synthetic resin onto said parting tube and using a first circular doctor blade to shape said resin into a ring-shaped layer of uniform thickness;

- applying heat to said synthetic resin to gel said resin and form an inner skin of the plastic pipe;

- pouring additional synthetic resin onto said inner skin and embedding a belt-shaped fleece continuously into said additional resin as it forms so as to form a supporting layer;

- pouring additional synthetic resin onto said supporting layer to form a second layer of synthetic resin;

- drawing a large number of fibres in the form of a plurality of fibre strands from a rack, feeding said strands into a first guiding device arranged radially spaced about the shaft, feeding said strands from said guiding device in the form of a closed fibre sheath having the shape of a truncated cone to a second circular doctor blade surrounding said shaft, and embedding said strands in said second layer of synthetic resin to form an axial reinforcing layer;

- pouring additional synthetic resin onto said reinforcing layer to form a third layer of synthetic resin;

- revolving a circular spool support around said shaft in a given direction, said spool support mounting at least one spool carrying a plurality of fibres in the form of a fibre strand, drawing said fibre strand from said at least one spool, winding said fibre strand onto said reinforcing layer tangentially with the smallest possible lead angle and simultaneously embedding said fibre strand in the last-mentioned additional synthetic resin to form a tangential reinforcing layer while compressing the fibres of said axial reinforcing layer towards said shaft;

- pouring additional synthetic resin onto said tangential reinforcing layer to form a fourth

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layer of synthetic resin;

- drawing a second large number of additional fibres in the form of a plurality of fibre strands from said rack, feeding said strands into a second guiding device arranged radially spaced about the shaft, feeding said last-mentioned strands from said second guiding device in the form of a closed fibre sheath having the shape of a truncated cone to a third circular doctor blade surrounding said shaft, and embedding said last-mentioned strands in said fourth layer of synthetic resin to form a second axial reinforcing layer;

- pouring additional synthetic resin onto said second reinforcing layer to form a fifth layer of synthetic resin;

- revolving a second circular spool support around said shaft in a direction opposite to said given direction, said second spool support mounting at least one second spool carrying a plurality of fibres in the form of a fibre strand, drawing said last-mentioned fibre strand from said at least one second spool, winding said last-mentioned fibre strand onto said second axial reinforcing layer tangentially with the smallest possible lead angle and simultaneously embedding said last-mentioned fibre strand in the fifth layer of synthetic resin to form a second tangential reinforcing layer while compressing the fibres of said second axial reinforcing layer towards said shaft;

- when required, forming yet another axial reinforcing layer and yet another tangential reinforcing layer on said second tangential reinforcing layer, the direction of rotation of the spool support used therewith being opposite to the direction of rotation of the second spool support;

- stripping any excess synthetic resin from the last-formed tangential reinforcing layer by means of a fourth circular doctor blade;

- pouring additional liquid synthetic resin onto the last-formed tangential reinforcing layer and shaping said last-mentioned resin into an outer skin of uniform thickness for the plastic pipe;

- guiding a belt-shaped parting film on said outer skin continuously along the length of said shaft and simultaneously shaping said last-mentioned parting film into a parting tube enveloping said outer skin;

- guiding the formed plastic pipe through a hardening device in which, by means of heat and/or light, the hardening of said layers of synthetic resin is initiated and at least partially completed;

- removing said plastic pipe from said shaft within said hardening device; and

- cutting said plastic pipe into sections of desired length after said plastic pipe has exited

said hardening device.

2. The method of claim 1 including the steps of drawing said fleece in the form of two or more bands from an equal number of spools positioned on an equal number of spool carriers surrounding said shaft, and feeding said bands of fleece onto said inner skin without gaps and overlapping while simultaneously embedding said bands of fleece in the synthetic resin formed on said inner skin.

3. The method of claim 1 including the steps of drawing said fleece in the form of a band, the width of which is at least approximately equal to the circumference of said supporting layer, from a spool positioned above said shaft, and guiding said band of fleece onto said shaft on all sides while simultaneously embedding said band of fleece in the synthetic resin formed on said inner skin.

4. The method of claim 1 including the steps of drawing said fleece in the form of two bands, the total width of which is at least approximately equal to the circumference of said supporting layer, from each of two spools positioned on opposite sides of said shaft in alignment with the diameter thereof, and guiding said bands of fleece onto said shaft on all sides while simultaneously embedding said bands of fleece in the synthetic resin formed on said inner skin.

5. The method of claim 1 in conjunction with any one of claims 2 to 4 wherein:

- the synthetic resin for said supporting layer is poured onto the inner skin as an excess of resin exceeding the minimum quantity for the supporting layer, the amount thereof being sufficient to form the synthetic resin layer for at least said first axial reinforcing layer and possibly also for said first tangential layer;

- said fleece for the supporting layer is embedded in the synthetic resin layer such that any synthetic resin in excess of the absorptive capacity of said fleece is squeezed outwards;

- the fibre strands for the first axial reinforcing layer are embedded by said first circular doctor blade in the synthetic resin layer formed by the excess quantity of resin so as to form said first axial reinforcing layer; and

- in the event that the excess quantity of resin is sufficient to form the second reinforcing layer, the fibre strands drawn from the first spool support for the first tangential reinforcing layer are

wound onto said first axial reinforcing layer and at the same time are embedded in said excess resin.

6. A method for continuous production of fibre-reinforced plastic pipe having a plastic inner tube comprising the steps of:

- guiding and feeding said plastic inner tube concentrically in a horizontal direction to succeeding work stations and continuously along a line of travel of the tube;

- pouring a liquid adhesive resin onto the plastic inner tube to form an adhesive buffer layer and shaping said buffer layer by means of a first circular doctor blade to have a uniform thickness;

- continuously embedding a belt-shaped non-woven fabric fleece in the adhesive resin without gaps to complete said adhesive buffer layer;

- pouring a liquid synthetic resin on said adhesive buffer layer to form a first synthetic resin layer;

- drawing a large number of fibres in the form of a plurality of fibre strands from a rack, feeding said strands into a first guiding device arranged radially spaced about the tube, feeding said strands from said guiding device in the form of a closed fibre sheath having the shape of a truncated cone to a second circular doctor blade surrounding said tube, and embedding said strands in said layer of synthetic resin to form an axial reinforcing layer;

- pouring additional synthetic resin onto said axial reinforcing layer to form a second layer of synthetic resin;

- revolving a circular spool support around said tube in a given direction, said spool support mounting at least one spool carrying a plurality of fibres in the form of a fibre strand, drawing said fibre strand from said at least one spool, winding said fibre strand onto said axial reinforcing layer tangentially with the smallest possible lead angle and simultaneously embedding said fibre strand in the second layer of synthetic resin to form a tangential reinforcing layer while compressing the fibres of said axial reinforcing layer towards said tube;

- pouring additional synthetic resin onto said tangential reinforcing layer to form a third layer of synthetic resin;

- drawing a second large number of additional fibres in the form of a plurality of fibre strands from said rack, feeding said strands into a second guiding device arranged radially spaced about the tube, feeding said last-mentioned strands from said second guiding device in the form of a closed fibre sheath having the shape of a truncated cone to a third circular doctor blade surrounding

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said tube, and embedding said last-mentioned strands in said third layer of synthetic resin to form a second axial reinforcing layer;

- pouring additional synthetic resin onto said second axial reinforcing layer to form a fourth layer of synthetic resin;

- revolving a second circular spool support around said tube in a direction opposite to said given direction, said second spool support mounting at least one second spool carrying a plurality of fibres in the form of a fibre strand, drawing said last-mentioned fibre strand from said at least one second spool, winding said last-mentioned fibre strand onto said second axial reinforcing layer tangentially with the smallest possible lead angle and simultaneously embedding said last-mentioned fibre strand in the fourth layer of synthetic resin to form a second tangential reinforcing layer while compressing the fibres of said second axial reinforcing layer towards said tube;

- when required, forming yet another axial reinforcing layer and yet another tangential reinforcing layer on said second tangential reinforcing layer, the direction of rotation of the spool support used therewith being opposite to the direction of rotation of the second spool support;

- stripping any excess synthetic resin from the last-formed tangential reinforcing layer by means of a fourth circular doctor blade;

- pouring additional liquid synthetic resin onto the last-formed tangential reinforcing layer and shaping said last-mentioned resin into an outer skin of uniform thickness for the plastic pipe;

- guiding a belt-shaped parting film on said outer skin continuously along the length of said tube and simultaneously shaping said last-mentioned parting film into a parting tube enveloping said outer skin;

- guiding the formed plastic pipe through a hardening device in which, by means of heat and/or light, the hardening of said layers of synthetic resin is initiated and at least partially completed; and

- cutting said plastic pipe into sections of desired length after said plastic pipe has exited said hardening device.

7. A method for the continuous production of fibre-reinforced plastic pipe having a plastic inner tube provided with an adhesive layer formed by a band of webbing embedded in the plastic inner tube, comprising the steps of:

- feeding a plastic inner tube in a horizontal direction to succeeding work stations by means

of a feeding device, said inner tube being fed continuously along the line of travel thereof;

- pouring a liquid synthetic resin onto the adhesive layer to form a first layer of synthetic resin;

- drawing a large number of fibres in the form of a plurality of fibre strands from a rack, feeding said strands into a first guiding device arranged radially spaced about the tube, feeding said strands from said guiding device in the form of a closed fibre sheath having the shape of a truncated cone to a second circular doctor blade surrounding said tube, and embedding said strands in said layer of synthetic resin to form an axial reinforcing layer;

- pouring additional synthetic resin onto said axial reinforcing layer to form a second layer of synthetic resin;

- revolving a circular spool support around said tube in a given direction, said spool support mounting at least one spool carrying a plurality of fibres in the form of a fibre strand, drawing said fibre strand from said at least one spool, winding said fibre strand onto said axial reinforcing layer tangentially with the smallest possible lead angle and simultaneously embedding said fibre strand in the second layer of synthetic resin to form a tangential reinforcing layer while compressing the fibres of said axial reinforcing layer towards said tube;

- pouring additional synthetic resin onto said tangential reinforcing layer to form a third layer of synthetic resin;

- drawing a second large number of additional fibres in the form of a plurality of fibre strands from said rack, feeding said strands into a second guiding device arranged radially spaced about the tube, feeding said last-mentioned strands from said second guiding device in the form of a closed fibre sheath having the shape of a truncated cone to a third circular doctor blade surrounding said tube, and embedding said last-mentioned strands in said third layer of synthetic resin to form a second axial reinforcing layer;

- pouring additional synthetic resin onto said second axial reinforcing layer to form a fourth layer of synthetic resin;

- revolving a second circular spool support around said tube in a direction opposite to said given direction, said second spool support mounting at least one second spool carrying a plurality of fibres in the form of a fibre strand, drawing said last-mentioned fibre strand from said at least one second spool, winding said last-mentioned fibre strand onto said second axial reinforcing layer tangentially with the smallest possible lead angle and simultaneously embedding said last-mentioned

fibre strand in the fourth layer of synthetic resin to form a second tangential reinforcing layer while compressing the fibres of said second axial reinforcing layer towards said tube;

- when required, forming yet another axial reinforcing layer and yet another tangential reinforcing layer on said second tangential reinforcing layer, the direction of rotation of the spool support used therewith being opposite to the direction of rotation of the second spool support;

- stripping any excess synthetic resin from the last-formed tangential reinforcing layer by means of a fourth circular doctor blade;

- pouring additional liquid synthetic resin onto the last-formed tangential reinforcing layer and shaping said last-mentioned resin into an outer skin of uniform thickness for the plastic pipe;

- guiding a belt-shaped parting film on said outer skin continuously along the length of said tube and simultaneously shaping said last-mentioned parting film into a parting tube enveloping said outer skin;

- guiding the formed plastic pipe through a hardening device in which, by means of heat and/or light, the hardening of said layers of synthetic resin is initiated and at least partially completed; and

- cutting said plastic pipe into sections of desired length after said plastic pipe has exited said hardening device.

8. The method of any one of claims 1 to 7 wherein:

- for an axial reinforcing layer that is not immediately preceded by any supporting layer, the synthetic resin is poured in a quantity greater than the minimum quantity required for the axial reinforcing layer, thereby forming at the same time the synthetic resin layer for the immediately following tangential reinforcing layer;

- the fibre strands guided by said second guiding device are embedded in the previously formed synthetic resin layer such that the quantity of resin that exceeds the absorptive capacity of such fibre strands is squeezed outwardly through the fibres; and

- the fibre strands drawn from the second spool support are wound tangentially onto said second reinforcing layer and are embedded in the excess resin.

9. Apparatus for the continuous production of fibre-reinforced plastic pipe comprising:

- a rack (12) carrying a plurality of spools (13) loaded with strands (14) of glass, carbon, or

textile fibres;

- said rack (12) being provided with guiding devices (15) for drawing the fibre strands (14) from said spools (13) and for advancing the fibre strands (14);

- a frame (16) including a plurality of work stations;

- a holding device (21) for a shaft (22), in the form of an extended hollow cylinder, positioned adjacent the front of said frame (16) and securely connected to said frame;

- an unwinding device (23) for a belt-shaped parting film wound onto spools;

- a guiding device (26) for guiding said parting film along the axis of said shaft (22) as the parting film is drawn from said unwinding device (23);

- a shaping device located near the front of said shaft (22) for shaping said parting film into a parting tube around said shaft (22);

- a bonding device (28) for impermeably bonding the edges of said parting film together after said film has been shaped into said parting tube;

- first means (33) for pouring a synthetic resin from a storage container (34) onto said parting tube near the rear of said shaft (22);

- a first circular doctor blade (41) surrounding the exterior of said shaft;

- a collecting tank (44) located below said first doctor blade to collect synthetic resin stripped by said first doctor blade;

- heating means downstream of said first doctor blade and surrounding the exterior of said shaft for gelling the layer of synthetic resin on the parting tube into an inner skin for the plastic pipe;

- an unwinding device (48) for drawing a fleece (51) in the form of a random laid non-woven fabric from spools (49) on which said fleece is wound;

- a first guiding and shaping device (52) for guiding said fleece towards said shaft and for shaping said fleece into a layer which is open along its length and surrounds the exterior of said shaft;

- second means (55) for pouring additional synthetic resin from a container onto said inner skin;

- a second circular doctor blade (61) for shaping the poured synthetic resin into a synthetic resin layer of uniform thickness and for simultaneously embedding the fleece in the synthetic resin layer to form a supporting layer;

- a second guiding and shaping device (56) surrounding the exterior of said shaft for guiding

the fibres from a plurality of said fibre strands (14) to form a closed fibre sheath (59) in the form of a truncated cone;

- said second circular doctor blade (61) also serving to embed said fibre sheath (59) in the synthetic resin layer to form an axial reinforcing layer;

- a first circular spool support (63) centered on said shaft and resting on a bearing support (64);

- at least one spool (68) mounted on said spool support (63), carrying a fibre strand (69), and coupled to an adjustable drive (65,66,67);

- guiding devices (71) mounted to said spool support (63) for guiding a fibre strand (69) from each spool (68) towards said shaft and embedding the fibre strand in the synthetic resin layer to form a first tangential reinforcing layer;

- third means (76) for pouring additional synthetic resin from a container near the rear of said shaft;

- a third guiding and shaping device (77) surrounding the exterior of said shaft for guiding the fibres from a plurality of said fibre strands (14) to form a closed fibre sheath (79) in the form of a truncated cone;

- a third circular doctor blade (78) for shaping the poured synthetic resin into another synthetic resin layer of uniform thickness while embedding the fibre sheath (79) in the synthetic resin layer to form a second axial reinforcing layer;

- a second circular spool support (81) centered on the shaft and rotatable around a bearing;

- at least one spool (82) for a fibre strand (83) mounted on said spool support (81) for rotation thereon;

- said second spool support (81) being coupled to adjustable drive means, the direction of rotation being opposite to that of said first spool support;

- guiding devices mounted on the second spool support (81) for guiding the fibre strand from each spool (82) mounted thereon towards said shaft and embedding the fibre strand in the synthetic resin layer to form a second tangential reinforcing layer;

- a fourth circular doctor blade (92) for shaping a tangential reinforcing layer and which permits the stripping of any excess resin;

- fourth means (94) for pouring additional synthetic resin from a container to form an outer coat for the plastic pipe;

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- a fifth doctor blade (95) for shaping the poured synthetic resin of said outer coat into a uniformly thick layer of resin;

- an unwinding device (96) for a belt-shaped parting film (98);

- a fourth guiding and shaping device (99) for guiding said parting film (98) towards said shaft and for shaping said parting film (98) into a layer that is open along its length and surrounds the outer coat, the edges of said parting film (98) being butted together beneath said shaft;

- a hardening device (103) attached to said fourth guiding and shaping device (99) and surrounding the exterior of the plastic pipe;

- said hardening device including heating or radiation means (104) positioned around the plastic pipe;

- a guiding tube (109) included in said hardening device, having an interior diameter at least approximately equal to the sum of the nominal diameter of the plastic pipe and twice the thickness of the parting film, the wall of said guiding tube being permeable to the heat or radiation emitted from said heat or radiation means (104) and extending over the length of said hardening device, the longitudinal extent of said guiding tube being such that it surrounds the plastic pipe at least up to the point on its line of travel at which the outer coat of the plastic pipe is sufficiently firm to support the plastic pipe on bearing rollers (111);

- said shaft (22) terminating at least approximately at the rear end of the hardening device;

- a curing section (112) attached to said hardening device and provided with thermal insulation hood means (113) surrounding the plastic pipe;

- a drawing device (118) attached to the curing section (112) for frictionally moving the plastic pipe in the direction of travel;

- a plurality of said bearing rollers (111) being located between the rear end of said guiding tube (109) and said drawing device (118), said rollers being height adjustable and adapted for conveying the plastic pipe to the drawing device (118);

- a cutting device (125) following the drawing device (118), movable by means of a longitudinal guide (127) in the direction of travel of the plastic pipe, for cutting the plastic pipe into separate sections (126) of a given length;

- said cutting device having a clamping device (128) for clamping the cutting device to the plastic pipe during a cutting operation; and

- said cutting device (125) having a reversing device for moving said cutting device back to

its point of departure after termination of a cutting operation.

10. The apparatus of claim 9 comprising:

- fifth means (84) for pouring additional liquid synthetic resin;

- a fifth guiding and shaping device (85) for guiding the fibres from a plurality of said fibre strands (14) to form a closed fibre sheath (86) in the form of a truncated cone;

- a sixth circular doctor blade (87) for shaping the synthetic resin layer and embedding the fibre sheath (86) in the synthetic resin layer to form an additional axial reinforcing layer; and

- a third spool support (88) for shaping an additional tangential reinforcing layer, the direction of rotation of said third spool support being opposite that of said second spool support.

11. The apparatus of claim 9 wherein:

- said bonding device (28) includes an unwinding device for an adhesive band (31); and

- a spring-loaded pressure roller (32) is positioned around the circumference of the edges of the parting film (25), said roller (32) being adapted to press the adhesive band (31) onto the edges of the parting film (25).

12. The apparatus of claim 11 wherein said bonding device is an ultrasonic bonding device and is used to bond the overlapping edges of said parting film (25) together.

13. The apparatus of any one of claims 9 to 12 wherein:

- said first circular doctor blade (41) is positioned on a guiding device (42) which guides said first doctor blade undeviatingly along the length of said shaft d(22) and retains it while in motion in a plane normal to the longitudinal axis of said shaft;

- said guiding device (42) includes at least one guiding roller which rests on the shaft (22) over the parting tube and rotates in a plane which intersects the longitudinal axis of the shaft, forming an angle with said axis which ranges from 60° to 120°; and

- a plurality of guide rollers (156) are positioned in front of the mouth of the feeding means (33) for the synthetic resin of the inner skin.

14. Apparatus for the continuous production of fibre-reinforced plastic pipe comprising:

- a rack (12) carrying a plurality of spools (13) loaded with strands (14) of glass, carbon, or textile fibres;

- said rack (12) being provided with guiding devices (15) for drawing the fibre strands (14) from said spools (13) and for advancing the fibre strands (14);

- a frame (16) including a plurality of work stations;

- a feeding device (141) for a plastic inner tube (140), said device guiding the plastic inner tube in alignment with openings through the successive work stations;

- first means (142) for pouring an adhesive resin from a storage container onto said plastic inner tube (140);

- a first circular doctor blade (143) surrounding the exterior of said tube for shaping said adhesive resin into a ring-shaped layer of uniform thickness;

- a collecting tank located below said first doctor blade to collect adhesive resin stripped by said first doctor blade;

- an unwinding device (144) for drawing a fleece (146) in the form of a random laid non-woven fabric from spools (145) on which said fleece is wound;

- a first guiding and shaping device (147) for guiding said fleece towards said inner tube and for shaping said fleece into a layer which is open along its length and surrounds the exterior of said inner tube;

- a second doctor blade (148) for embedding the layer of fleece in the adhesive resin layer and for simultaneously stripping off excess adhesive resin;

- second means (55) for pouring synthetic resin from a container onto said inner tube;

- a second guiding and shaping device (56) surrounding the exterior of said inner tube for guiding the fibres from a plurality of said fibre strands (14) to form a closed fibre sheath (59) in the form of a truncated cone;

- a third circular doctor blade (61) for shaping the poured synthetic resin into a synthetic resin layer of uniform thickness also serving to embed said fibre sheath (59) in the synthetic resin layer to form an axial reinforcing layer;

- a first circular spool support (63) centered on said plastic inner tube (140) and resting on a bearing support (64) so that it can rotate thereon;

- at least one spool (68) mounted on said spool support (63), carrying a fibre strand (69), and coupled to an adjustable drive (65,66,67);

- guiding devices (71) mounted to said spool support (63) for guiding a fibre strand (69) from each spool (68) towards said inner tube and embedding the fibre strand in the synthetic resin layer to form a first tangential reinforcing layer;

- third means (76) for pouring additional synthetic resin from a container near the rear of said inner tube;

- a third guiding and shaping device (77) surrounding the exterior of said inner tube for guiding the fibres from a plurality of said fibre strands (14) to form a closed fibre sheath (79) in the form of a truncated cone;

- a fourth circular doctor blade (78) for shaping the poured synthetic resin into another synthetic resin layer of uniform thickness while embedding the fibre sheath (79) in the synthetic resin layer to form a second axial reinforcing layer;

- a second circular spool support (81) centered on the inner tube and rotatable on a bearing support;

- at least one spool (82) for a fibre strand (83) mounted on said spool support (81) for rotation thereon;

- said second spool support (81) being coupled to adjustable drive means, the direction of rotation being opposite to that of said first spool support;

- guiding devices mounted on the second spool support (81) for guiding the fibre strand from each spool (82) mounted thereon towards said inner tube and embedding the fibre strand in the synthetic resin layer to form a second tangential reinforcing layer;

- a fifth circular doctor blade (92) for shaping a tangential reinforcing layer and which permits the stripping of any excess resin;

- fourth means (94) for pouring additional synthetic resin from a container to form an outer coat for the plastic pipe;

- a sixth doctor blade (95) for shaping the poured synthetic resin of said outer coat into a uniformly thick layer of resin;

- an unwinding device (96) for a belt-shaped parting film (98);

- a fourth guiding and shaping device (99) for guiding said parting film (98) towards said inner tube and for shaping said parting film (98) into a layer that is open along its length and surrounds the outer coat, the edges of said parting film (98) being butted together beneath said inner tube;

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- a hardening device (103) attached to said fourth guiding and shaping device (99) and surrounding the exterior of the plastic pipe;

- said hardening device including heating or radiation means (104) positioned around the plastic pipe;

- a guiding tube (109) included in said hardening device, having an interior diameter at least approximately equal to the sum of the nominal diameter of the plastic pipe and twice the thickness of the parting film, the wall of said guiding tube being permeable to the heat or radiation emitted from said heat or radiation means (104) and extending over the length of said hardening device, the longitudinal extent of said guiding tube being such that it surrounds the plastic pipe at least up to the point on its line of travel at which the outer coat of the plastic pipe is sufficiently firm to support the plastic pipe on bearing rollers (111);

- a curing section (112) attached to said hardening device and provided with thermal insulation hood means (113) surrounding the plastic pipe;

- a drawing device (118) attached to the curing section (112) for frictionally moving the plastic pipe in the direction of travel;

- a plurality of said bearing rollers (111) being located between the rear end of said guiding tube (109) and said drawing device (118), said rollers being height adjustable and adapted for conveying the plastic pipe to the drawing device (118);

- a cutting device (125) following the drawing device (118), movable by means of a longitudinal guide (127) in the direction of travel of the plastic pipe, for cutting the plastic pipe into separate sections (126) of a given length;

- said cutting device having a clamping device (128) for clamping the cutting device to the plastic pipe during a cutting operation; and

- said cutting device (125) having a reversing device for moving said cutting device back to its point of departure after termination of a cutting operation.

15. The apparatus of claim 14 comprising:

- fifth means (84) for pouring additional liquid synthetic resin;

- a fifth guiding and shaping device (85) for guiding the fibres from a plurality of said fibre strands (14) to form a closed fibre sheath (86) in the form of a truncated cone;

- a seventh circular doctor blade (87) for shaping the synthetic resin layer and embedding

the fibre sheath (86) in the synthetic resin layer to form an additional axial reinforcing layer; and

- a third spool support (88) for shaping an additional tangential reinforcing layer, the direction of rotation of said third spool support being opposite that of said second spool support.

16. The apparatus of any one of claims 9 to 14 wherein the collecting tank (44) located below each of said doctor blades is connected with the storage container (34) of the pouring means via a return line (36).

17. The apparatus of any one of claims 9 to 16 wherein;

- said unwinding device (48) for the belt-shaped fleece (51) includes a pair of spool supports on each of which a spool (49) carrying fleece is positioned, the width of such fleece being equal to at least approximately half the outer circumference of the inner skin; and

- wherein said spools (49) are positioned at such a height that the centre of the fleece bands (51) is at least approximately in the same horizontal plane as the longitudinal axis of said plastic pipe.

18. The apparatus of claim 17 wherein said first guiding and shaping device (52) has a guide vane (161) on each side of said plastic pipe, the interior (162) of said vane being directed towards the plastic pipe, said vane terminating at a concave curve for forming said fleece band into approximately the shape of the covering surface of a semi-circular cylinder.

19. The apparatus of claim 18 wherein the mouth of said pouring means (55) for the synthetic resin for said supporting layer is, in the vicinity of said guide vanes, aligned along the plastic pipe at a point at which the approaching edges of the two fleece bands (51) are still sufficiently far apart.

20. The apparatus of any one of claims 9 to 19 wherein:

- said second guiding and shaping device (56) includes a guide blade (164) and a guide ring (165);

- said guide blade (164) has a plurality of passages (166) matching the number of fibre strands to be guided, said passages being circumferentially spaced about said guide blade, each such passage having a fibre strand drawn therethrough; and

- said guide ring (165) has a circular inner surface (167), the diameter of which is less than the diameter defined by the plurality of passages (166) in the guide blade (164) and is only slightly greater than the exterior diameter of the plastic pipe at the location of the guide ring.

21. The apparatus of claim 20 wherein the mouth of the pouring means (55, 72) for the synthetic resin for each axial reinforcing layer is positioned between said guide blade (164) and said guide ring (165), said resin being poured within the innermost surface of said sheath while said sheath is held in a state of tension by the fibre strands running from the guide blade to the guide ring.

22. The apparatus of any one of claims 9 to 21 wherein said second pouring means (55) of the synthetic resin for said supporting layer is sized to handle a flow of resin that is greater than the flow required solely for the supporting layer and that is at least sufficient for the next axial reinforcing layer and possibly for the first tangential reinforcing layer as well, whereby the pouring means for the next reinforcing layer and possibly for the next tangential reinforcing layer is not required.

23. The apparatus of any one of claims 9 to 22 wherein said third pouring means (76) is sized to handle a flow of synthetic resin that is greater than the flow required for the second axial reinforcing layer and is at least sufficient for the following tangential reinforcing layer, whereby a pouring means specifically intended for the resin for the following tangential reinforcing layer is not required.

24. The apparatus of any one of claims 9 to 23 wherein:

- a plurality of spools (68) are positioned at regular intervals on said spool support (63);
- each such spool having a braking device, the braking power of which can be adjusted by means of a measuring device for measuring the exterior diameter of the spool.

25. The apparatus of any one of claims 9 to 24 wherein each spool support (63) is coupled by means of a direct drive to a common drive shaft (66) located in said frame and which extends from a drive motor (67) to all powered devices (63,81,88).

26. The apparatus of claim 20 or claim 21 wherein a tension device is provided close to the guide blade (164) of the second guiding and shaping device (56) for each of the fibre strands (14)

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for an axial reinforcing layer, each such tension device being adjustable for adjusting the tension in such fibre strand.

27. The apparatus of any one of claims 9 to 26 wherein said guiding tube (109) has a narrow longitudinally extending slot in its underside.

28. The apparatus of any one of claims 9 to 27 wherein said guiding tube (109) in the hardening device (103) is in the form of a glass tube that is permeable to infra-red radiation.

29. The apparatus of any one of claims 9 to 27 wherein said guiding tube (109) in the hardening device (103) is in the form of a non-corroding, abrasion-resistant steel tube and is provided with a plurality of passages which are staggered along the length and around the circumference thereof.

30. The apparatus of any one of claims 9 to 29 wherein:

- said thermal insulation hood means includes a plurality of individual thermal insulation hoods (113) which define at least approximately a hollow cylinder and include heat retaining surrounding wall means;

- said thermal insulation hoods (113) are guided by a longitudinal guide (115) positioned along the length of the plastic pipe; and

- the length of said longitudinal guide exceeds the sum of the lengths of all said thermal insulation hoods by at least the length of one hood.

31. The apparatus of any one of claims 9 to 30 wherein:

- said drawing device (118) comprises at least a pair of chain conveyors (119) aligned with the diameter of the plastic pipe;

- each of the chain conveyors includes roller chains (121) which are guided at least at a pulling drum therefor by guide rails (122); and

- said roller chains are provided with angle brackets to which are attached elastomer drive supports (123).

32. The apparatus of any one of claims 9 to 31 wherein said clamping device (128) comprises

two pairs of clamping jaws (129), one pair being positioned in front of a cutting tool (132) of said cutting device (125) and the other being positioned behind said cutting tool, said cutting jaws being powered by pneumatic piston drive means.

33. The apparatus of any one of claims 9 to 32 wherein said reversing device of said cutting device is powered by a pneumatic piston drive means.

34. The apparatus of any one of claims 9 to 12 wherein:

- said shaft (22) comprises a plurality of cylindrical longitudinal sections of decreasing exterior diameter starting from said holding device (21);

- each point of transition in diameter is located immediately adjacent the point at which the fibre strands (69,83,92) forming the tangential reinforcing layer are wound onto the plastic pipe; and

- an additional point of transition in diameter of the shaft is located in the vicinity of said hardening device (103).

35. The apparatus of claim 34 wherein:

- said shaft comprises a plurality of separate pieces connected together by way of a threaded coupling; and

- said separate pieces are connected together at said points of transition in diameter.

36. The apparatus of claim 34 or claim 35 wherein:

- a connection for a pressurized gas is provided at the start of said shaft for introducing such gas into the interior of said shaft;

- said shaft is provided with a plurality of radial passages along the length thereof leading from the interior to the exterior thereof;

- some of said radial passages are located at or adjacent said points of transition in shaft diameter; and

- at each connection point and at least in the vicinity of the last passage partition means for closing off the interior of the shaft from the outside are provided.

37. The apparatus of claim 36 wherein said radial passages are formed by radial recesses at the

front of said separate shaft pieces.

38. The apparatus of claim 36 or claim 37 wherein:

- the interior of the longitudinal section of the shaft which is located in the vicinity of said hardening device (103) is separated from the interior of the preceding longitudinal section by a partition; and

- said longitudinal section located in the vicinity of said hardening device has a connection for a pressurized gas line located inside the shaft, in which the pressure is greater than the pressure in the preceding sections of the shaft.

39. The apparatus of any one of claims 9 to 38 wherein:

- the edges (172) of the side walls (173) of said fourth guiding and shaping device (99) extend from an inlet shoulder (174) for the parting film which is located above the plastic pipe along the length thereof continuously around the parting tube and over each other, said edges (172) approaching each other in the perpendicular meridian plane to a small residual gap;

- the side faces (176, 177) of said edges (172) diverge at least in the vicinity of said residual gap (175) from the inside edge (178) to the leading edge (179) thereof at a given angle;

- in the vicinity of said fourth guiding and shaping device (99) a circular doctor blade (101) is positioned, such doctor blade having a residual gap (182) therebelow in the perpendicular meridian plane; and

- the lateral surfaces of said residual gap (182) in such doctor blade (101) diverge from said inside edge (178) to the outer edge thereof at a given angle.

40. The apparatus of claim 39 wherein:

- a stripper (185) is positioned behind said doctor blade (101) in the line of travel of the plastic pipe, said stripper having a stripping edge (186) adjacent said plastic pipe; and

- a collecting tank (102) extends below said doctor blade (101) to the vicinity of said stripper (185) on one side and to the vicinity of said fourth guiding and shaping device (99) on the other side.

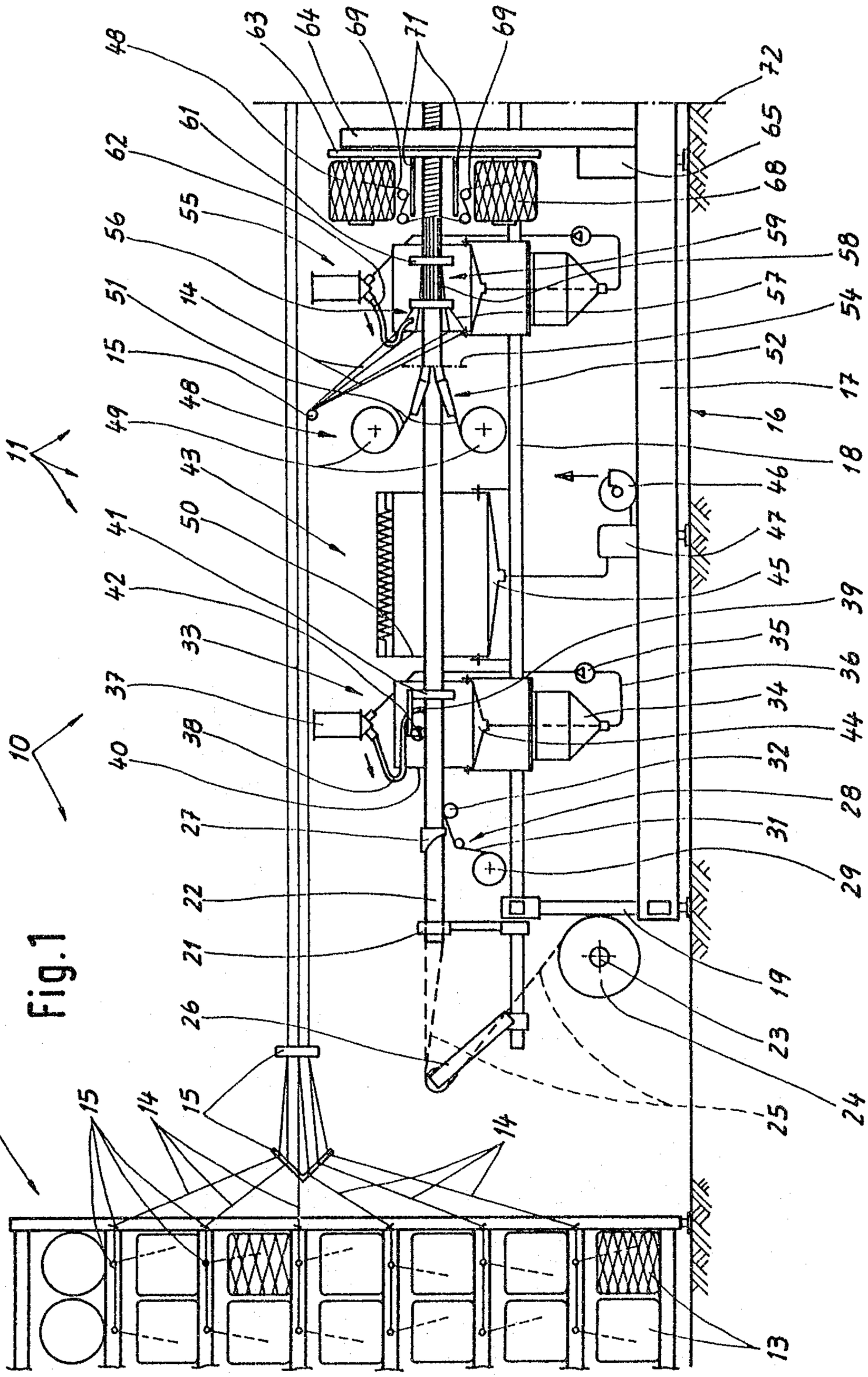
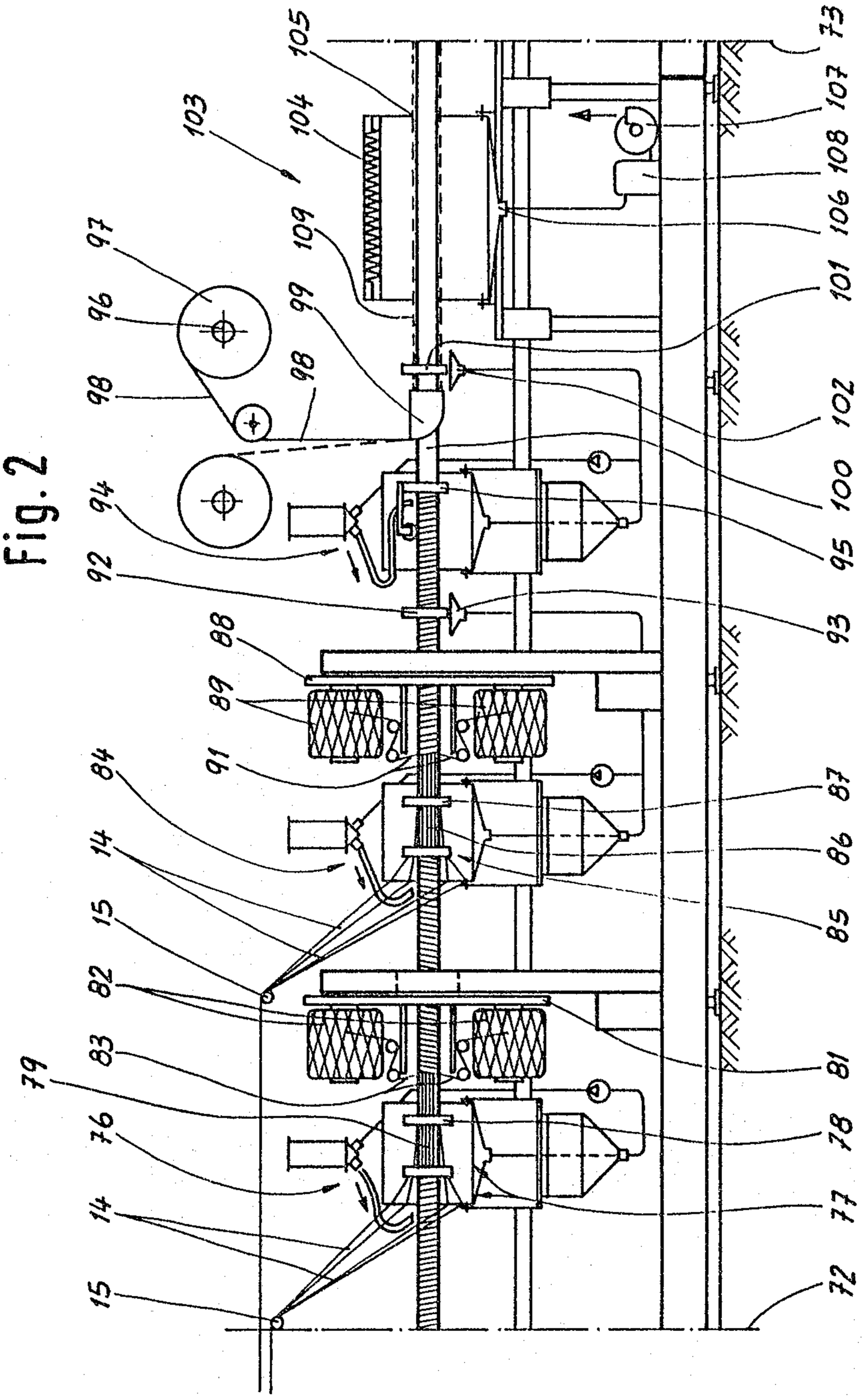


Fig.1

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Fig. 2



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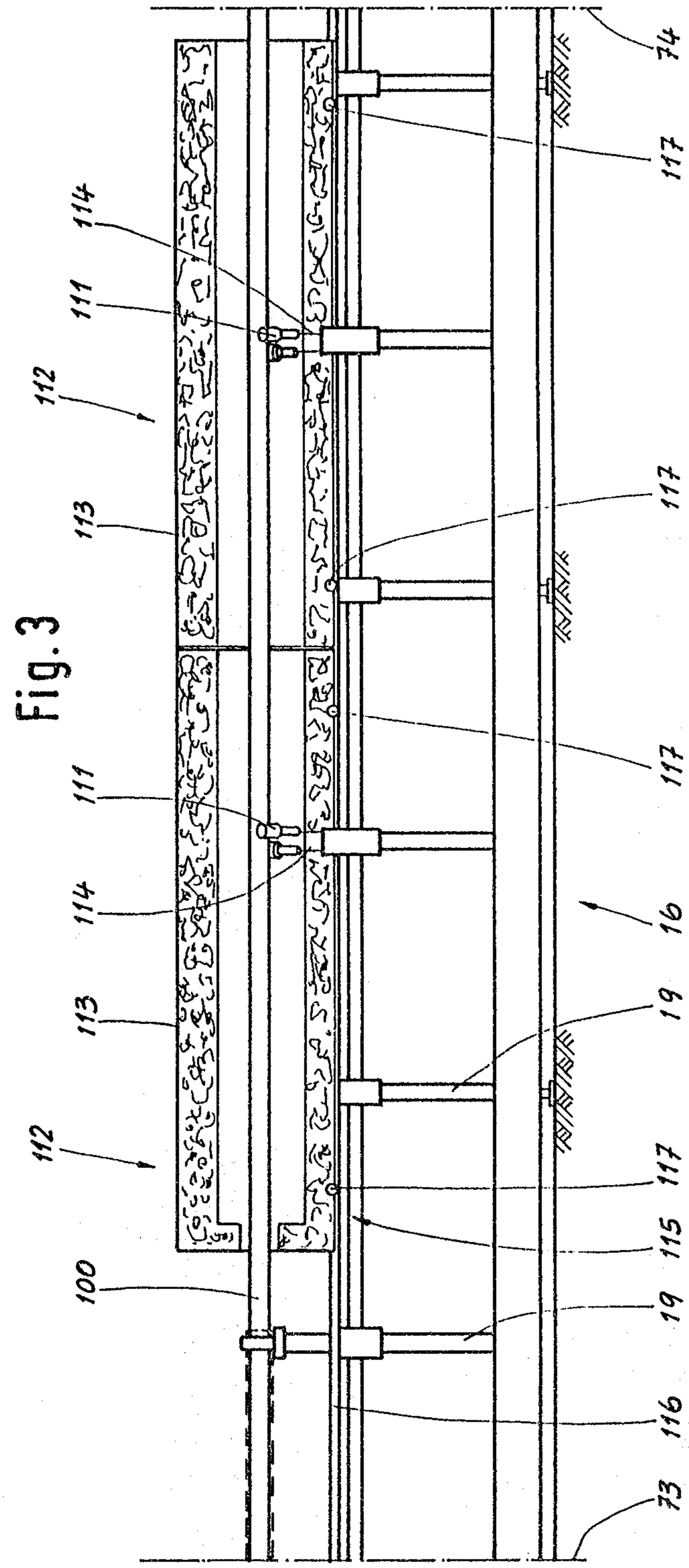


Fig. 3

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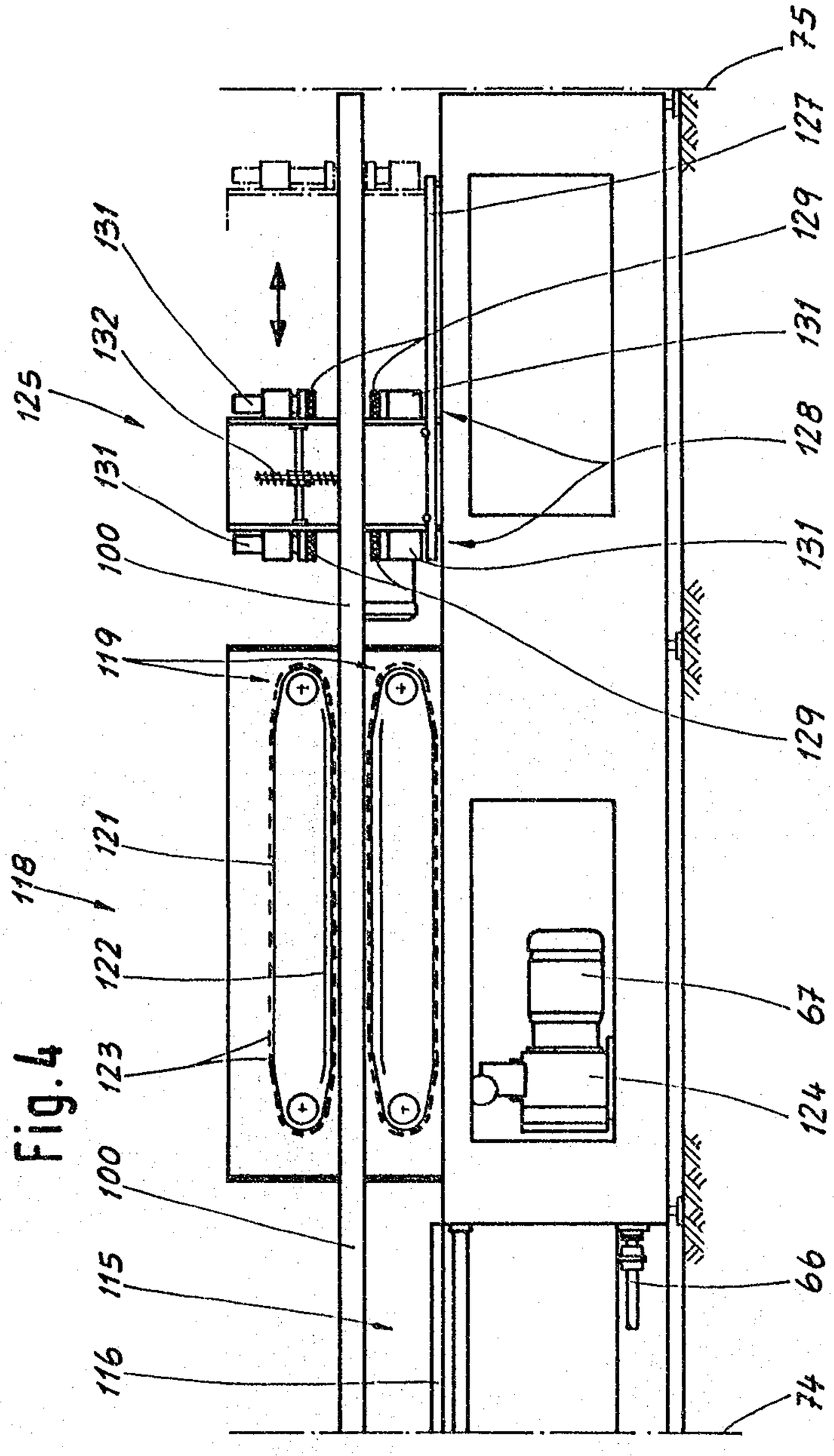


Fig. 4

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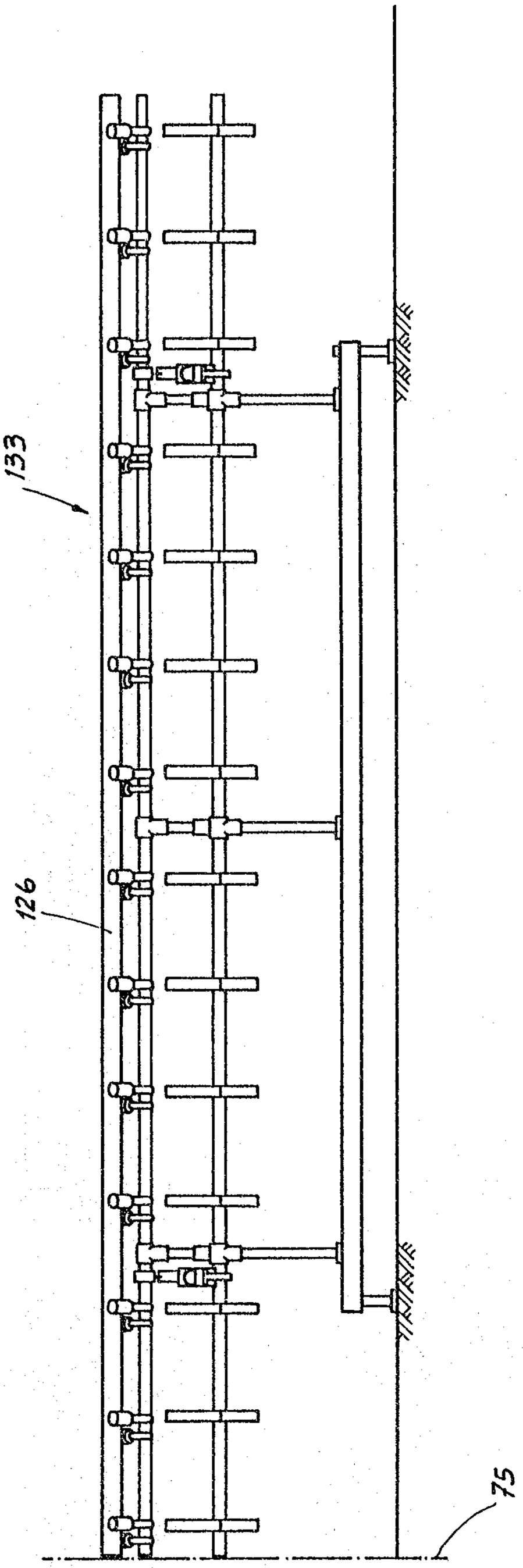


Fig. 5

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Fig.6

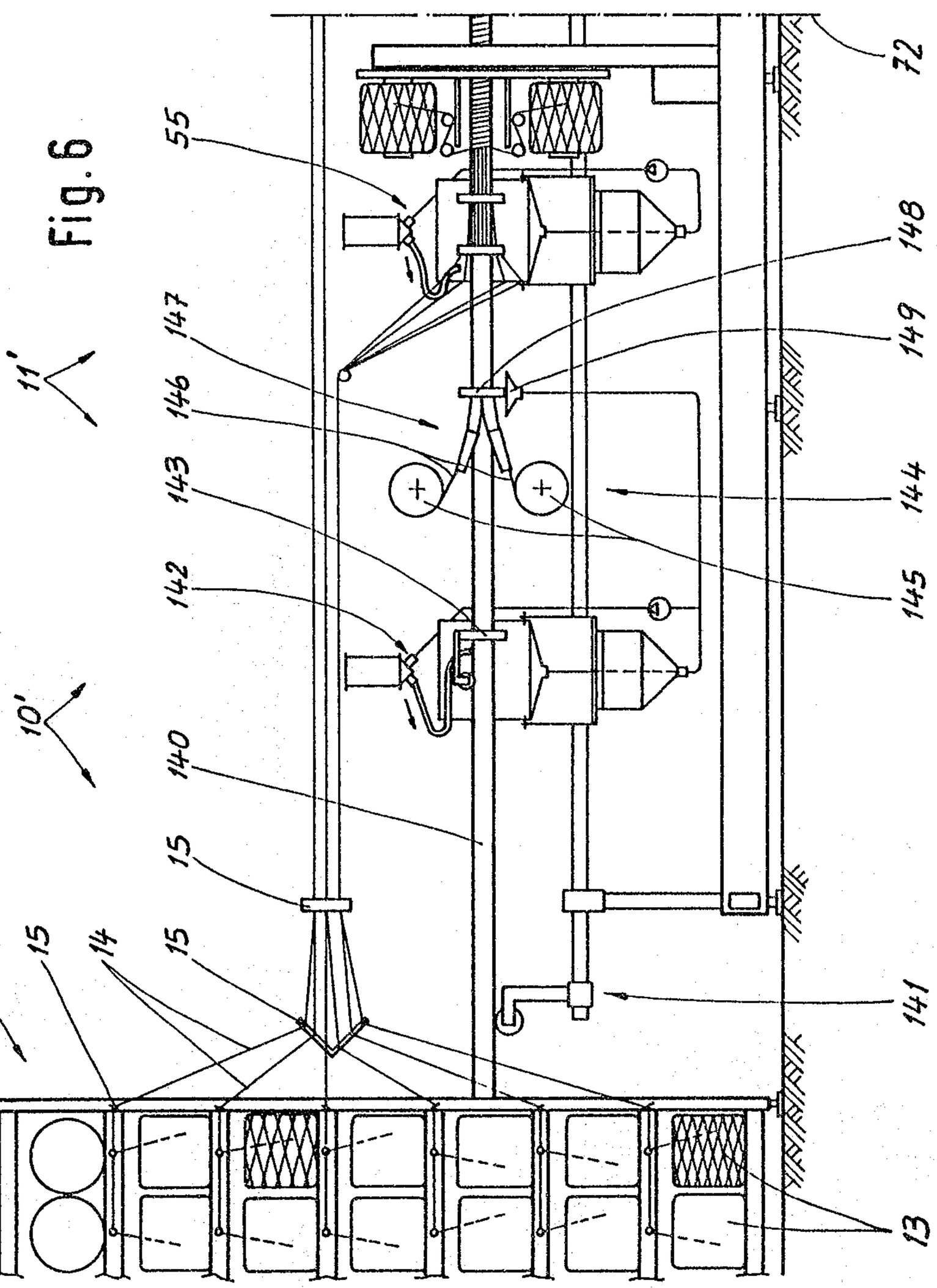
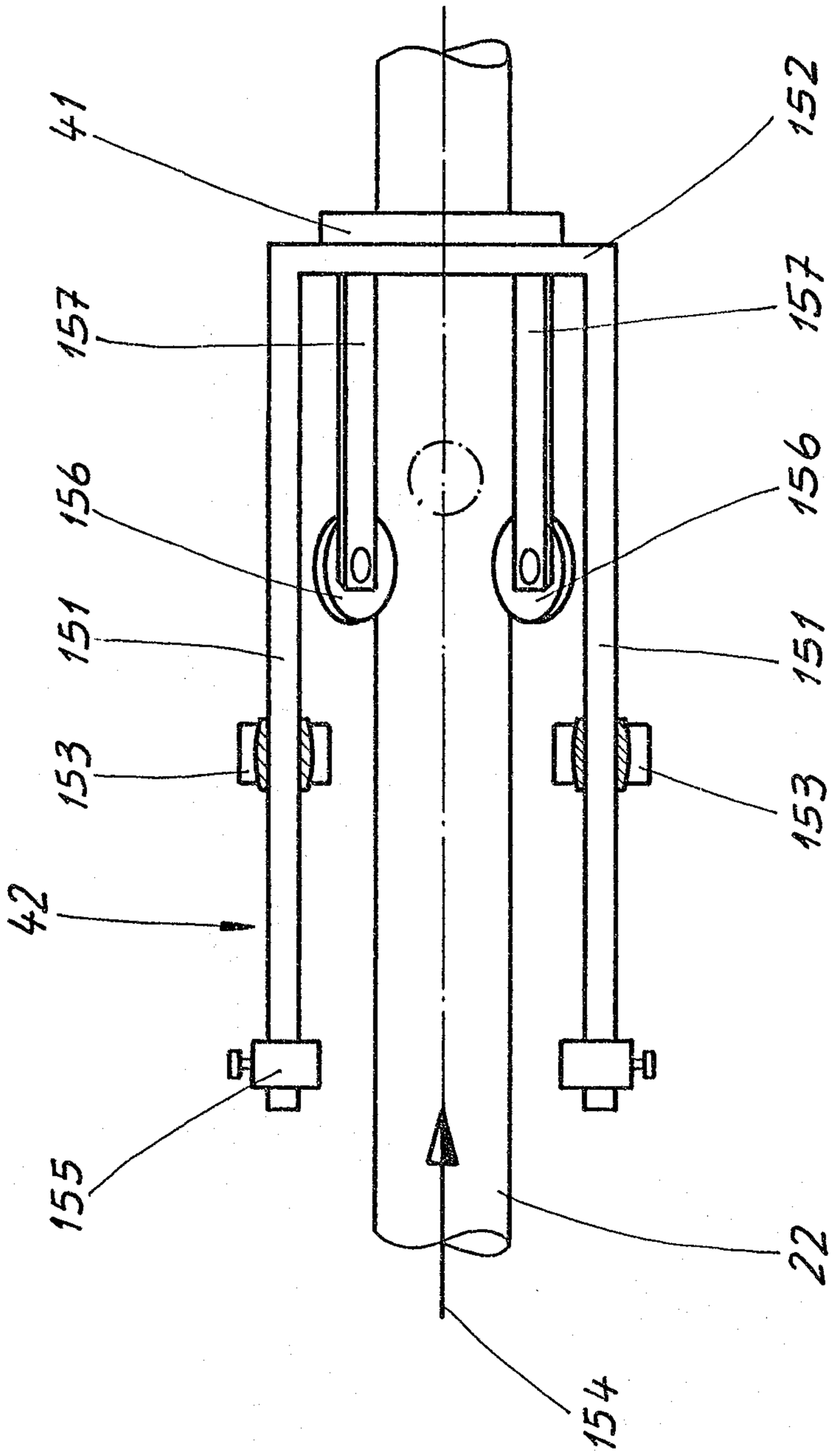


Fig.7



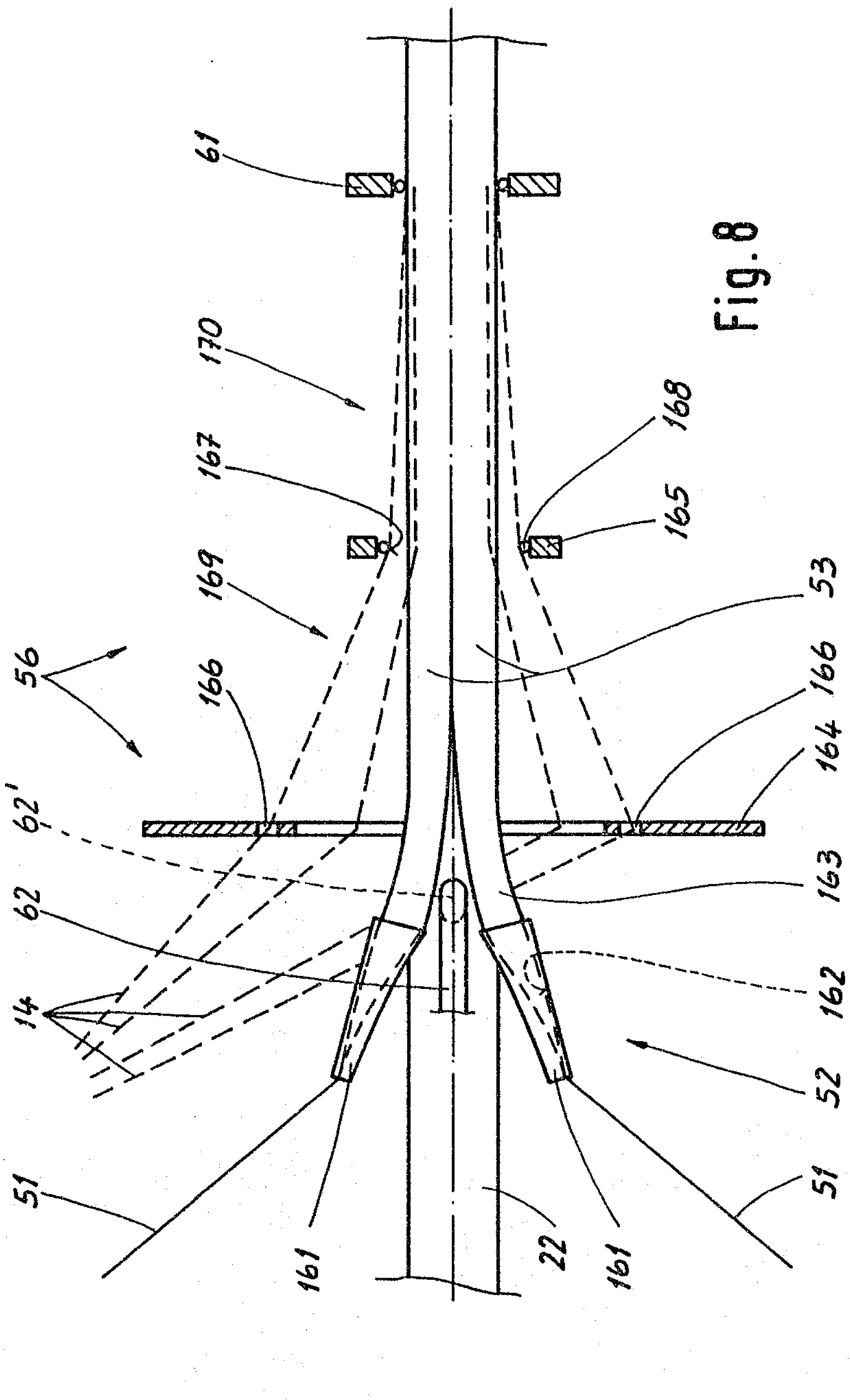

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Fig.8

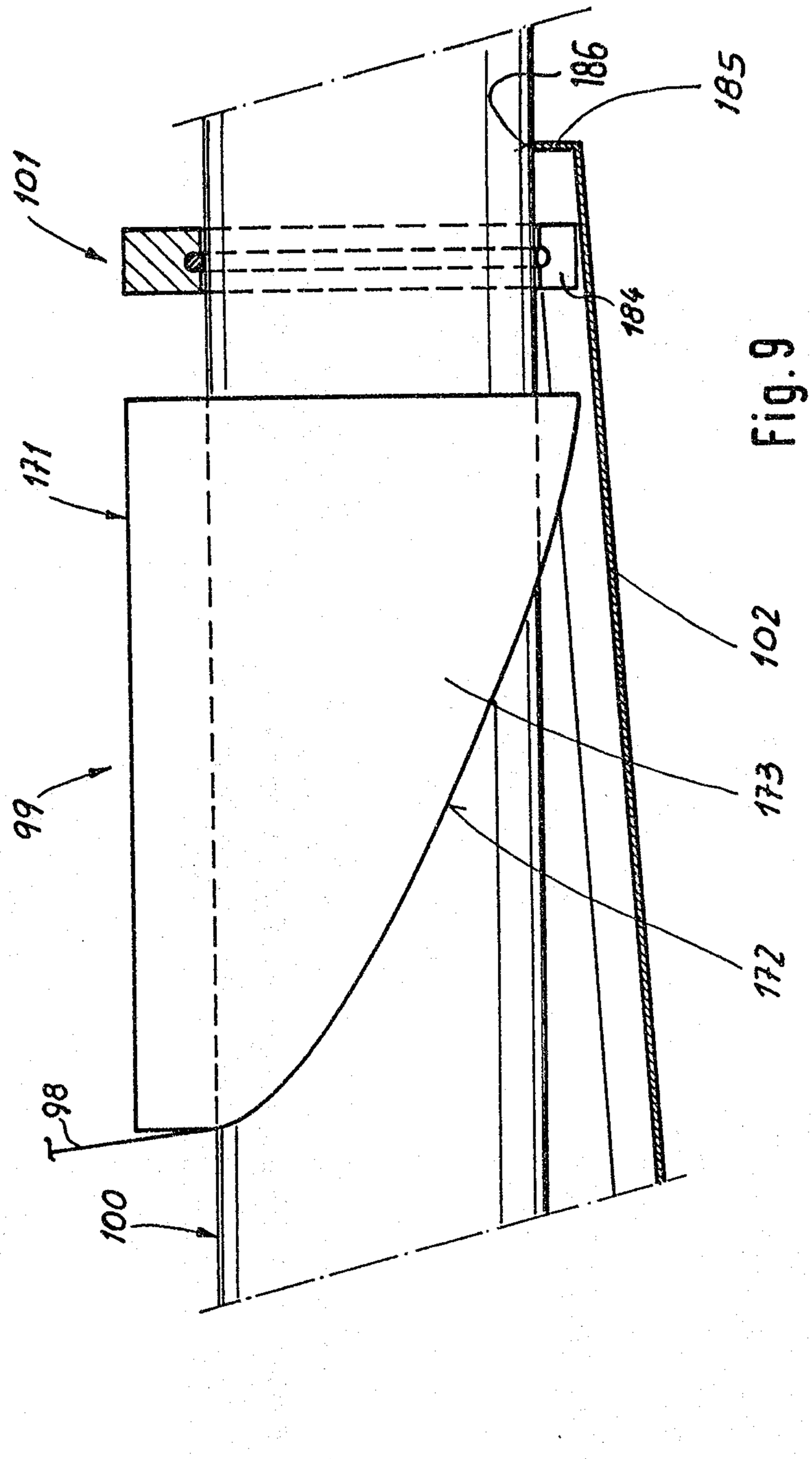


Fig.9

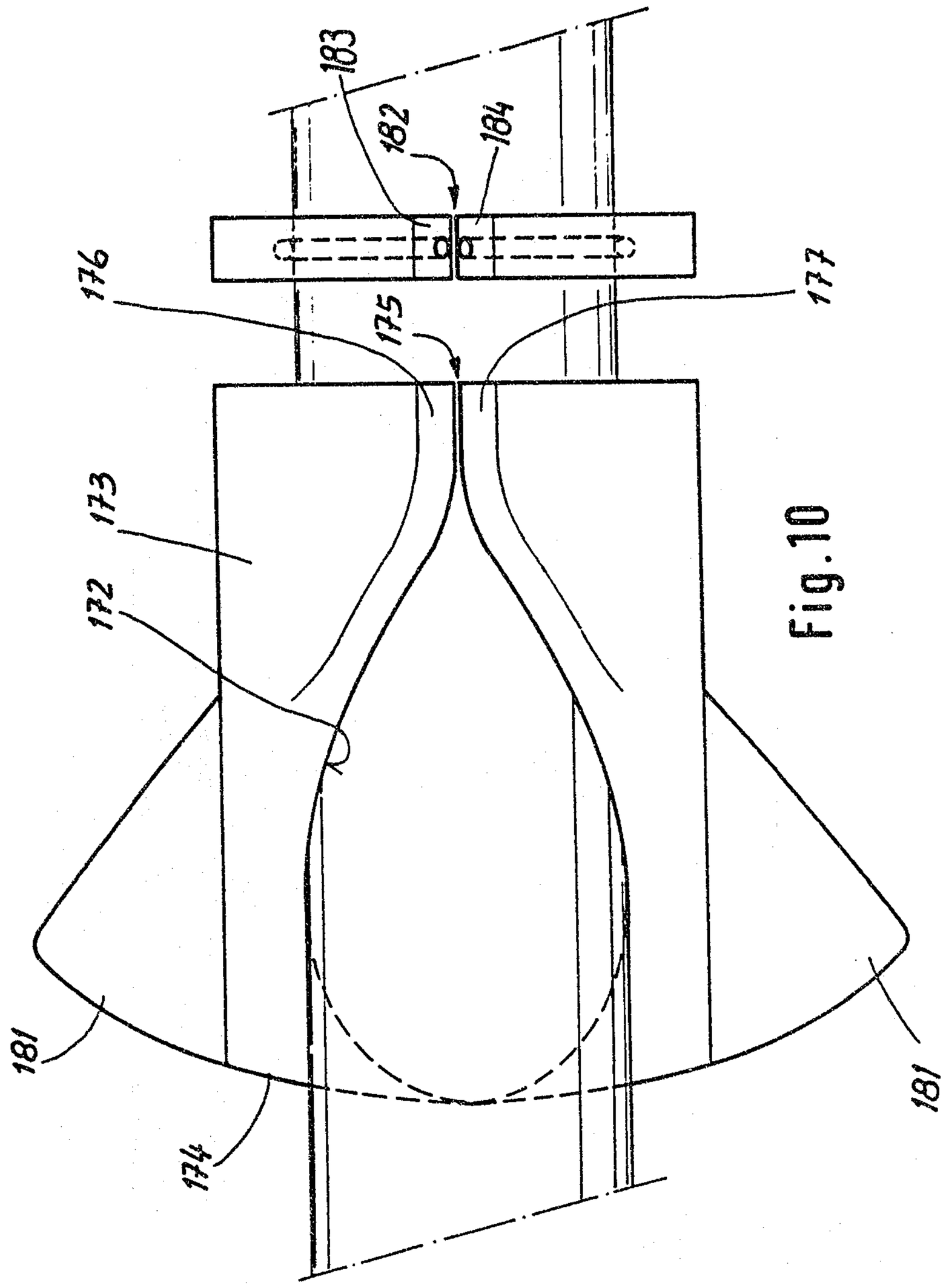


Fig.10

Fig. 11

