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(54) **APPARATUS FOR THE SURFACE ELECTROLYTIC TREATMENT IN CONTINUOUS OF METAL SEMI-FINISHED PRODUCTS, IN PARTICULAR FLAT METAL SEMI-FINISHED PRODUCTS**

VORRICHTUNG ZUR KONTINUIERLICHEN ELEKTROLYTISCHEN
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APPAREIL DE TRAITEMENT ÉLECTROLYTIQUE DE SURFACE EN CONTINU DE PRODUITS
SEMI-FINIS MÉTALLIQUES, EN PARTICULIER DE PRODUITS SEMI-FINIS MÉTALLIQUES PLATS

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Description

[0001] The present invention refers to an apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat semi-finished products.

[0002] By surface electrolytic treatment it is meant to indicate any electrolytic treatment for cleaning, preparing, finishing and coating the surfaces of metal semi-finished products, like, for example, pickling, degreasing, passivation, metal coating, galvanization and yet more.

[0003] By metal semi-finished products it is meant, in particular, flat metal semi-finished products, i.e. "two-dimensional" semi-finished products in the form, for example, of sheets, strips and plates having a pair of opposite flat faces and obtained, in particular, by hot or cold rolling of metal material, in particular steel. By metal semi-finished products it is also meant wires, rods, wire rods and similar.

[0004] It is known, for example, to subject metal strips, in particular steel strips, obtained by cold rolling, to electrolytic degreasing treatments aimed at eliminating rolling greases and oils from them.

[0005] Generally, electrolytic degreasing can take place by immersion in an electrolytic solution or by spray washing with an electrolytic solution or by washing using brushes and with high-pressure water.

[0006] In the case in which the electrolytic degreasing takes place by immersion, the metal strip is immersed in a tank containing an electrolytic solution and a pair of electrodes that is arranged at the opposite faces of the strip, as for example described in JP8174042-A, in US6, 216, 304B1, in US4,035,256 or in US6, 547, 886B1.

[0007] In the case in which the electrolytic degreasing takes place by spraying, the electrolytic solution is sprayed onto the opposite faces of the metal strip through nozzles which are arranged at the opposite faces of the strip itself and on which the electrodes are mounted, as described for example in JP10237700 or in US6, 547, 996B1.

[0008] The present invention refers to an apparatus for the surface electrolytic treatment in continuous "by immersion" of metal semi-finished products, in particular flat metal semi-finished products, i.e. wherein the semi-finished products are made to advance continuously through a containment tank containing an electrolytic solution in which they are immersed and wherein at least one pair of electrodes is immersed in such a same solution with the electrodes arranged facing each other and between which the semi-finished product is made to advance.

[0009] One of the problems encountered in carrying out electrolytic surface treatments "by immersion" is that of taking away and removing the waste products, generally in the form of metal powders, scales or sludges, the reaction products, generally in the form of gas (typically hydrogen or oxygen), and possibly the heat which are produced and generated during such treatments.

[0010] The waste products, the residues and the reaction products (even gaseous), as well as the heat, indeed, tend to build up on the metal semi-finished product and/or on the electrodes preventing both the continuous and homogeneous contact between the metal semi-finished product and the electrolytic solution, and the correct passage of current between the electrodes, the electrolytic solution and the metal semi-finished product also with risks of electrical discharges or of electrodes breakage.

[0011] Such a problem has a negative impact on the energy consumption of electrolytic surface treatments and on their yield and efficiency.

[0012] WO2011/039596 describes an apparatus for the surface electrolytic treatment of metal strips that in part solves this problem thanks to a particular configuration of the containment tank containing the electrolytic solution and the pairs of electrodes immersed in the latter.

[0013] At each pair of electrodes, indeed, the tank has a hopper configuration equipped with discharge means for discharging the waste materials.

[0014] The electrodes of each pair of electrodes, moreover, have a "discontinuous" structure and consist of a plurality of rods or plates arranged parallel to each other and spaced from each other so as to define openings that allow the evacuation of the waste and of the reaction products that are generated during the surface electrolytic treatment.

[0015] The electrolytic solution is kept under agitation through an inletting system for inletting new electrolytic solution possibly consisting of regenerated solution. Such a system comprises a plurality of inletting mouths for inletting the electrolytic solution that are fed by a pump and that are arranged on the walls of the tank preferably at each pair of electrodes so as to be immersed in the electrolytic solution at the level of the metal strip or under it. The electrolytic solution introduced into the tank through such inletting mouths keeps the electrolytic solution agitated in particular at the metal strip and the pairs of electrodes so as to promote the removal and taking away of the waste and the reaction products.

[0016] The purpose of the present invention is to propose an apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, which makes it possible to avoid the drawbacks of the prior art and in particular that makes it possible to improve the removal of waste products, of residues, of reaction products and of the possible heat that are generated during such treatments from the treatment zone without additional energy costs.

[0017] Yet another purpose of the present invention is to propose an apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, which makes it possible to improve the homogenisation and the circulation of the electrolytic solution and, consequently, to increase the treatment efficiency, i.e. to reduce energy wastage.

[0018] A further purpose of the present invention is to propose an apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, that is particularly simple and functional with low costs.

[0019] These purposes according to the present invention are accomplished by making an apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, as outlined in claim 1.

[0020] Further characteristics are provided in the dependent claims.

[0021] The characteristics and advantages of an apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, according to the present invention will become clearer from the following description, given as an example and not for limiting purposes, referring to the attached schematic drawings, in which:

figure 1 schematically represents a possible embodiment of the inletting and agitation means of the electrolytic solution of an apparatus according to the present invention suitable, in particular, for advancing the metal semi-finished product at high-speed lines (speed > 1 m/s);

figure 1A represents a detail of figure 1 in an enlarged scale;

figure 2 schematically represents another possible embodiment of the inletting and agitation means of the electrolytic solution of an apparatus according to the present invention suitable, in particular, for advancing the metal semi-finished product at low-speed lines (speed < 1 m/s);

figure 2A represents a detail of figure 2 in an enlarged scale;

figure 3 represents a schematic longitudinal section of an apparatus according to the present invention of the "horizontal" type;

figure 4 is a section of the apparatus of figure 3 according to the plane IV-IV;

figures 5A and 5B respectively show the details VA and VB of figure 3 in an enlarged scale;

figure 5C shows an alternative embodiment of the detail of figure 5A or 5B in an enlarged scale;

figure 6 represents a schematic longitudinal section of an apparatus according to the present invention of the "vertical" type;

figure 7 shows the detail VII of figure 6 in an enlarged scale.

[0022] With reference to the attached figures, it is illustrated an apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, wholly indicated with 10.

[0023] The apparatus 10 is applicable for carrying out surface electrolytic treatments in continuous and by so-

called "immersion", i.e. wherein the metal semi-finished product 11 advances continuously in a tank 12 containing an electrolytic solution SE in which are immersed both the semi-finished product 11 itself and the electrodes arranged opposite to each other and between which the semi-finished product 11 is made to pass and which, in the case in which the semi-finished product 11 is flat, are arranged at the opposite faces thereof.

[0024] By surface electrolytic treatment it is meant, for example, a degreasing, pickling, passivation, coating, galvanization, deposition or similar treatment.

[0025] By metal semi-finished product it is meant to indicate in particular a flat metal semi-finished product, i.e. a continuous two-dimensional semi-finished product of the type of a plate, a strip, a billet or similar that has two opposite plane faces; although the possibility of applying the apparatus 10 according to the present invention also for treatments of one-dimensional continuous semi-finished products such as wires, rods or wire rods, is not excluded.

[0026] In the attached figures the metal semi-finished product 11 is a flat metal semi-finished product and consists of a continuous strip of metal, typically steel, which has two opposite faces 11a, 11b corresponding to the larger surfaces of the strip itself.

[0027] With reference to the figures, the apparatus 10 comprises a containment tank 12 containing the electrolytic solution SE and inside which the semi-finished product 11 is made to pass in continuous along a direction and in the advancing sense indicated by the arrow F.

[0028] The apparatus 10 also comprises immersion means 13 for immersing the semi-finished product 11 in the electrolytic solution SE and at least one pair of electrodes 14 opposite to each other and between which the semi-finished product 11 is made to pass in continuous.

[0029] Preferably, there is a plurality of pairs of electrodes 14 that follow one another along the advancing path of the semi-finished product 11.

[0030] Each pair of electrodes 14 comprises at least one first electrode 15 facing one of the two faces 11a, 11b of the semi-finished product 11 and at a defined distance from the latter so as to define a first interspace 16 and at least one second electrode 17 facing the other one of the two faces 11a, 11b of the semi-finished product 11 and at a defined distance from the latter so as to define a second interspace 18. In the case in which the semi-finished product 11 is of the type of a wire, a rod or a wire rod, the first electrode 15 and the second electrode 17 are opposite to each other and face the opposite faces of the advancement plane of the semi-finished product 11 at a predefined distance from the semi-finished product 11. For the sake of simplicity, in the rest of the description reference will be made to the case in which the semi-finished product 11 is of the flat type and to the opposite plane faces 11a, 11b thereof.

[0031] The first electrode 15 and the second electrode 17 are both immersed in the electrolytic solution SE and are associable with an electric power supply group that

is not represented, since it is of the known type.

[0032] Each pair of electrodes 14, moreover, has, with respect to the direction and to the advancing sense F of the semi-finished product 11, an inlet end schematically represented by the line 14a and an outlet end schematically indicated by the line 14b.

[0033] The apparatus 10 also comprises inletting and agitation means 19 of the electrolytic solution SE contained in the tank 12.

[0034] According to a characteristic feature of the present invention, the inletting and agitation means 19 comprise at least one duct 20 that is arranged at at least one of the pairs of electrodes 14, preferably at each of them, and that is associated with and in fluid communication with at least one nozzle 21, preferably with a plurality of nozzles 21, for inletting the electrolytic solution SE fed by feeding means 22. Usefully, for each pair of electrodes 14 there is a pair of ducts 20 each of which is associated with respective nozzles 21 and that are symmetrically arranged with respect to the advancement plane of the semi-finished product 11, so as not to alter the movement thereof.

[0035] In greater detail, each duct 20 has a delivery end 20a that faces one of the two faces 11a, 11b at respectively the first interspace 16 or the second interspace 18 and a suction end 20b that is opposite the delivery end 20a, open and immersed in the electrolytic solution SE. The suction end 20b is axially opposite the delivery end 20a or in any case opposite the latter with respect to the axial development of the duct 20, in particular the development of the duct 20 considered on a plane orthogonal to the advancement plane of the semi-finished product and parallel to the advancing direction thereof.

[0036] Advantageously, both the suction end 20b and the delivery end 20a extend by the entire width of the semi-finished product 11 and the nozzles 21 are arranged in succession one after the other for the entire extension of the suction end 20b of the respective duct 20.

[0037] Each nozzle 21 is arranged so that its outlet mouth 21a is arranged at and in fluid communication with the suction end 20b of the corresponding duct 20.

[0038] The outlet mouth 21a of the nozzles 21 can be arranged at the inlet of the suction end 20b of the respective duct 20 or downstream thereof towards the inside of the respective duct 20.

[0039] The suction end 20b of each duct 20 remains open and in fluid communication with the inside of the tank 12 and immersed in the electrolytic solution SE without being occluded by the nozzles 21 arranged at it. In particular, the suction end 20b of each duct 20 has a portion that is free from the at least one nozzle 21 and that is immersed in the electrolytic solution contained in the tank 12. In this way, the jet of electrolytic solution that is emitted by each nozzle 21 draws, from the inside of the tank 12, an electrolytic solution current that enters the respective duct 20 through its suction end 20b, i.e. through the portion of such a suction end 20b that is free

(i.e. not occupied by the at least one nozzle 21). The electrolytic solution current thus drawn from the inside of the tank 12 towards the inside of each duct 20 mixes with the jet of electrolytic solution emitted by each nozzle 21 associated with the duct 20 itself and exit from the delivery end 20a of the latter at the first interspace 16 or the second interspace 18, where it creates turbulence and mixing of the electrolytic solution SE promoting the removal and taking away of the residues and treatment waste products in the form of scales, powders or gases, as well as the removal of the heat that possibly is generated, from the semi-finished product 11, from the first electrode 15, and from the second electrode 17.

[0040] There is thus a "flow rate multiplication" effect with respect to that emitted by the single nozzles 21 without using further energy beyond that necessary to operate the feeding means 22.

[0041] In a preferred embodiment, each duct 20 comprises a converging section 20' converging towards the delivery end 20a and that originates from the suction end 20b.

[0042] The nozzles 21 associated with each duct 20 are arranged so that their outlet mouth 21a is at or upstream of the smaller section of the converging section 20'.

[0043] Advantageously, downstream, with respect to the direction of the current of the electrolytic solution that flows through the duct 20, of the converging section 20' there is a diverging section 20'' diverging towards the delivery end 20a. Such a diverging section 20'' is joined to the converging section 20' and makes it possible to increase the pressure of the current deriving from the mixing of the jets of electrolytic solution emitted by the nozzles 21 and of the electrolytic solution current sucked from the inside of the tank 12 through the suction end 20b of the duct 20. Each duct 20, that is, has, seen in section on a plane orthogonal to the advancement plane of the semi-finished product 11 and parallel to the advancing direction F thereof, the shape of a convergent-divergent Venturi tube.

[0044] In a possible embodiment, moreover, each duct 20 can comprise a deviator section 20''' that opens at its delivery end 20a to deviate the electrolytic solution current that flows through it along a direction having a non-null component on the advancement plane of the semi-finished product 11 and in the same advancing sense thereof. In practice, the direction along which the electrolytic solution current exiting each duct 20 is deviated hits the advancement plane of the semi-finished product 11 with a non-null incidence angle α (figures 5A-5C).

[0045] Alternatively or in addition to the provision of the deviator section 20''', each duct 20, considered in section along a plane orthogonal to the advancement plane of the semi-finished product 11 and parallel to the advancing direction F thereof, has a longitudinal axis or axial development A incident such an advancement plane with an incidence angle $\alpha \leq 90^\circ$ as a function of the forward speed of the semi-finished product 11 as will

be described later on.

[0046] In function of the type of surface treatment to be carried out and, in particular, the forward speed of the semi-finished product 11, as will be described later on, the duct 20 associated with each pair of electrodes 14 can be arranged at one of the two opposite ends of the latter, advantageously at the inlet end 14a thereof, or in a position intermediate to them.

[0047] In a preferred and advantageous embodiment, the first electrode 15 and the second electrode 17 of each pair of electrodes 14 has a "discontinuous" structure and comprises a plurality of rods or plates 150, 170 which extend by the width of the semi-finished product 11 and which are arranged parallel to each other and spaced at a defined distance from each other to form openings for taking away and removing the residues and the treatment waste products. The rods or plates 150, 170 are arranged parallel to each other on planes orthogonal to the advancement plane of the semi-finished product 11 and incident the advancing direction F thereof.

[0048] In this case, each duct 20 is advantageously delimited by a pair of such rods or plates 150, 170 that are adjacent to one another or, in particular if defined at one of the inlet or outlet ends 14a, 14b of each pair of electrodes 14, by one of such rods or plates 150, 170 and by a facing rod or plate 23 made of electrically insulating material.

[0049] It is clear that in this case the plates 150, 170 that delimit the duct 20 can have an increased thickness and are arranged with its face having greatest extension parallel to a plane orthogonal to the advancement plane of the semi-finished product 11 and incident the advancing direction F.

[0050] In this case, the faces of the two adjacent rods or plates 150, 170 or of such a rod or plate 150, 170 and of the facing rod or plate 23 made of electrically insulating material facing one another define the walls of the duct 20 and are shaped so as to define the converging section 20', the diverging section 20" and the deviator section 20''' thereof, if present. Alternatively, each of the first electrode 15 and the second electrode 17 comprises a plate 250, 270 which extends parallel to the advancement plane of the semi-finished product 11 and which has at least one slot 251, 271 that extends by the width of the semi-finished product 11 and at which the respective duct 20 is defined or associated (figures 6 and 7).

[0051] According to a further characteristic feature of the present invention, at the inlet end 14a of each pair of electrodes 14 there is an entrance 24 for guiding the semi-finished product 11 between the first electrode 15 and the second electrode 17.

[0052] The entrance 24 is immersed in the electrolytic solution SE and, seen on a plane orthogonal to the advancement plane of the semi-finished product 11 and parallel to the advancing direction F thereof, has a first section 24' converging in the advancing sense of the semi-finished product 11.

[0053] Downstream of the first section 24' there is a

second section 24" for joining with the surfaces of the first electrode 15 and of the second electrode 17 of the respective pair of electrodes 14 facing the respective face 11a, 11b of the semi-finished product 11.

[0054] The second section 24" can have a constant or diverging cross section.

[0055] The entrance 24 has the opposite ends, and of these, in particular, the inlet end defined at the larger cross section of the first section 24', open and immersed in the electrolytic solution SE.

[0056] As a consequence of the forward movement of the semi-finished product 11 through the entrance 24, an electrolytic solution current is sucked into the entrance 24 through its inlet end. Such a current flows towards the first interspace 16 and the second interspace 18 where it contributes creating turbulence to promote the mixing of the electrolytic solution and taking away the residues, waste products and gases that generate from the semi-finished product 11 and from the electrodes of the pair of electrodes 14 as a consequence of their treatment.

[0057] The entrance 24 is made of electrically insulating material and consists of a first body 240 and of a second body 241 which extend by the width of the semi-finished product 11 and which are conformed and arranged symmetrically with respect to the advancement plane of the semi-finished product 11 itself.

[0058] The feeding means 22 that feed the electrolytic solution SE to the nozzles 21 comprise pump means 26 that suck from a tank 27 of fresh or regenerated electrolytic solution or from a recirculation line of the electrolytic solution present in the tank 12 and not shown.

[0059] At each pair of electrodes 14, the tank 12 has a hopper 28 which is provided on its bottom with discharge means 29 for discharging waste materials produced during the surface electrolytic treatment, the discharge means being connected to a collection and removal line 30, as described for example in WO2011/039596 here referred to.

[0060] The immersion means 13 comprise at least one deflector roller 31 arranged at the inlet end of the tank 12, at least one deflector roller 32 at the outlet end of the tank 12 and at least one immersing roller 33 for immersing the semi-finished product 11 in the electrolytic solution and that is interposed between the inlet deflector roller 31 and the outlet deflector roller 32.

[0061] Upstream and downstream, with respect to the advancing sense F of the semi-finished product 11, of each immersing roller 33 there is a respective pair of electrodes 14, as described in WO2011/039596 here referred to.

[0062] The attached figures show different embodiments of an apparatus 10 according to the present invention that will now be described in greater detail.

[0063] Figures 1 and 1A schematically show an apparatus 10 of the "horizontal" type suitable for treatments of the semi-finished product 11 advancing at high-speed, i.e. at speeds greater than 1m/s.

[0064] Such figures show a single pair of electrodes

14 arranged downstream of the immersing roller 33 at the inlet of the tank 12.

[0065] At the inlet end 14a of the pair of electrodes 14 there is the entrance 24; the pair of electrodes 14 and the entrance 24 are immersed in the electrolytic solution SE contained in the tank 12.

[0066] Each of the first electrode 15 and the second electrode 17 consists of a plurality of plates 150,170 which extend by the width of the semi-finished product 11 and which are arranged parallel to each other on planes orthogonal to the advancement plane of the semi-finished product 11 and incident the advancing direction F of the semi-finished product 11 spaced apart from one another so as to define openings for taking away the waste, the residues and the gases that generate from the surface treatment.

[0067] Between the first two adjacent plates 150,170 of each of the first electrode 15 and the second electrode 17 a respective duct 20 of the convergent-divergent type (of the "Venturi" type) is defined having the delivery end 20a respectively facing the first interspace 16 and the second interspace 18 and the suction end 20b open and immersed in the electrolytic solution SE contained in the tank 12.

[0068] The two ducts 20 are configured and arranged symmetrically with respect to the advancement plane of the semi-finished product 11.

[0069] The diverging section of the two ducts 20 has an axis A incident the advancement plane of the semi-finished product 11 with an incidence angle $\alpha < 90^\circ$ in the advancing sense F of the semi-finished product 11. The incidence angle α is advantageously comprised between 20° and 90° and preferably equal to 45° .

[0070] At the suction end 20b of each of the two ducts 20 there is a plurality of nozzles 21 which are arranged in succession along the width of the semi-finished product 11 and fed by the feeding means 22 through a common manifold 34. The nozzles 21 are arranged so that a portion of the suction end 20b of each duct 20 is free, open and immersed in the electrolytic solution present in the tank 12. As an alternative to a plurality of nozzles 21, there could be a single nozzle of the blade type.

[0071] The solution schematised in figures 2 and 2A differs from the one shown in figures 1 and 1A, in absence of the entrance 24 and in the different arrangement and orientation of the ducts 20.

[0072] The ducts 20, indeed, are defined in an intermediate zone of the pair of electrodes 14 or rather in an intermediate zone of the first electrode 15 and of the second electrode 17.

[0073] Each duct 20, indeed, is delimited by a pair of successive plates 150, 170 respectively, substantially arranged in central position of the first electrode 15 and of the second electrode 17.

[0074] Each duct 20 has a longitudinal axis A orthogonal to the advancement plane of the semi-finished product 11 (incidence angle $\alpha = 90^\circ$).

[0075] Such an embodiment of the apparatus 10 is suitable

for treatments of the semi-finished product 11 advancing at low-speed ($<1\text{m/s}$).

[0076] Figures 3 to 5B show an apparatus 10 of the "horizontal" type that reproduces the characteristics of the configuration and of the arrangement of the tank 12 as described in WO2011/039596.

[0077] The tank 12, indeed, has a main treatment portion 120 delimited at the opposite ends by an inlet portion 121 and by an outlet portion 122 that are separated from the internal space of the main treatment portion 120 by corresponding walls 123.

[0078] The electrolytic solution SE is contained in just the main treatment portion 120.

[0079] At the inlet portion 121 there is an inlet deflector roller 31 and at the outlet portion 122 there is an outlet deflector roller 32.

[0080] Between the inlet deflector roller 31 and the outlet deflector roller 32 there is a pair of immersing rollers 33 that push the semi-finished product 11, which moves forward along the direction and in the sense F, towards the bottom of the tank 12 keeping it immersed in the electrolytic solution SE.

[0081] Upstream and downstream of each immersing roller 33 there is a respective pair of electrodes 14.

[0082] At each pair of electrodes 14 the tank 12, i.e. the main treatment portion 120 thereof, is conformed like a hopper 28 which is provided with discharging means 29 connected to a collection and removal line 30.

[0083] As shown in figures 5A and 5B both the first electrode 15 and the second electrode 17 of each pair of electrodes 14 consists of a plurality of plates, 150 and 170 respectively, which extend with their length in the direction of the width of the semi-finished product 11 and which are arranged parallel to each other on planes orthogonal to the advancement plane of the semi-finished product 11 and incident the advancing direction F and which are spaced apart from one another to define openings to facilitate the mixing of the electrolytic solution and the removal of waste, residues and gases both from the semi-finished product 11 and from the plates 150,170 themselves.

[0084] At the inlet end 14a of each pair of electrodes 14 there is a pair of ducts 20 configured and arranged symmetrically with respect to the advancement plane of the semi-finished product 11.

[0085] Each of the two ducts 20 is delimited on one side by the respective head plate 150', 170' respectively of the first electrode 15 and of the second electrode 17 and on the other side by a plate 23 made of electrically insulating material.

[0086] Each of the two ducts 20 has a converging section 20' that originates at the respective suction end 20b and that is joined to a diverging section or diffusor 20'' which extends in a deviator section 20''' that opens at the respective delivery end 20a.

[0087] The two ducts 20 have the delivery end 20a arranged respectively at the first interspace 16 and at the second interspace 18.

[0088] The deviator section 20''' is inclined according to a direction incident the advancement plane of the semi-finished product 11 with an incidence angle $\alpha < 90^\circ$ so as to direct the electrolytic solution current exiting the ducts 20 in the same advancing sense of the semi-finished product 11 (equicurrent).

[0089] The plates 150, 170 are supported by armatures 35 anchored to the tank 12.

[0090] At the suction end 20b of each of the two ducts 20 there is a plurality of nozzles 21 which are arranged in succession one after the other for the entire width of the semi-finished product 11.

[0091] The nozzles 21 derive from a common manifold 34 fed by the feeding means 22.

[0092] Also in this case, the nozzles 21 are arranged so that a portion of the suction end 20b of each duct 20 is free, open and immersed in the electrolytic solution present in the tank 12. Also in this case, instead of a plurality of nozzles 21 there could be a single nozzle of the blade type.

[0093] In a possible alternative embodiment represented in figure 5C, the ducts 20 defined at the inlet end 14a of each pair of electrodes 14 are delimited by the head plate 150', 170' of the first electrode 15 and of the second electrode 17 and by the plate immediately adjacent to it.

[0094] In this case, the head plate 150', 170' is supported by a protection 36 made of electrically insulating material.

[0095] The apparatus 10 according to figures 3 to 5C can be advantageously applied to carry out degreasing treatments with alkaline electrolytic solution SE kept at temperatures comprised between 20°C and 90°C with the four pairs of electrodes 14 having "grid-to-grid" configuration fed in direct current (DC) with alternating polarity according to the sequence cathode-anode-anode-cathode, so that the semi-finished product 11, in particular if made of steel, comes out with anodic polarity so as to avoid it absorbing hydrogen. Advantageously, in the configuration of the apparatus 10 shown in figures 3 to 5C, the distance between each pair of electrodes 14 and the adjacent immersing roller 33 and measured between the end of the anode and between the projection of the axis of the immersing roller on the advancement plane of the semi-finished product 11 is comprised between 150 mm and 1500 mm, whereas the distance between two immersing rollers 33 is comprised between 1500 mm and 3500 mm for degreasing treatments and between 2000 mm and 7000 mm for pickling, passivation or electrodeposition treatments.

[0096] The height of the first and second interspace 16 and 18, i.e. the distance between the surface of the first and second electrode 15 and 17 facing the respective face 11a, 11b of the semi-finished product 11 and the same face 11a, 11b is comprised between 25mm and 100mm, preferably between 50 mm and 80 mm, for degreasing treatments (carried out on cold rolled sections) and between 80 mm and 300 mm for pickling treatments (carried out on cold or hot rolled sections) according to

the planarity of the semi-finished product 11 so as to minimise the drop in voltage in solution. This makes it possible to reduce the voltage applied to the electrodes of each pair of electrodes 14 with a consequent decrease in energy consumption and, moreover, to reduce the overall bulk of the apparatus 10 to the benefit of the *layout* of the plant in which it is inserted.

[0097] Such a configuration makes it possible to apply a current density comprised between 40 A/dm^2 and 150 A/dm^2 with charge density always $>1 \text{ C/dm}^2$, in the case of degreasing treatments, and between 8 A/dm^2 and 50 A/dm^2 , in the case of pickling treatments with exposure times comprised between 1s and 15s, against, respectively, usually known values of 15-20 A/dm^2 and of 8-14 A/dm^2 . In the case of electrodeposition treatments, on the other hand, the current density is comprised between 5 A/dm^2 and 100 A/dm^2 with variable exposure times as a function of the number of pairs of electrodes present and the thickness of the coating that is wished to be obtained.

[0098] Laboratory tests have indeed demonstrated that thanks to the particular "discontinuous" structure of the electrodes and to the presence of inletting and agitation means 19 consisting in practice of "Venturi" ducts 20 associated with a respective plurality of nozzles 21 for inletting electrolytic solution, it is possible to increase the current density up to 4-5 times the conventional densities maintaining a good evacuation of the gases and of the treatment waste and a good degree of cleaning of the electrodes themselves. The efficiency of cleaning of the semi-finished products 11 can thus increase by 10-25% and even up to 50% with respect to conventional treatments and the electrical energy consumption can thus be reduced by 20-30%.

[0099] Figures 6 and 7 show an apparatus 10 of the "vertical" type, i.e. in which the semi-finished product 11 follows a path along vertical planes with a descending branch and an ascending branch inside each tank 12.

[0100] At the opposite faces 11a, 11b of the descending branch and the ascending branch of the semi-finished product 11 there is a respective pair of electrodes 14, the first electrode 15 and second electrode 17 of which consist of plates 250, 270 that are flat and parallel to the faces 11a, 11b.

[0101] At the inlet end 14a of each pair of electrodes 14 there is a respective pair of ducts 20 configured and arranged symmetrically with respect to the advancement plane of the semi-finished product 11.

[0102] Each duct 20 is obtained at a slot 251, 271 made in the respective plate 250, 270.

[0103] Advantageously, the distance between the immersing roller 33 and the inlet and outlet deflecting rollers 31, 32 is comprised between 1500 mm and 4000 mm.

[0104] Also in this case the tank 12 advantageously is configured like a hopper 28 which is arranged below the pairs of electrodes 14 and which is provided with discharging means 29 associated with an evacuation and removal line 30.

[0105] In light of the attached figures and the previous description the person skilled in the art will have no difficulty understanding the operation of the apparatus 10 object of the present invention.

[0106] The semi-finished product 11 is made to pass inside the tank 12 at a defined advancement speed and is kept immersed inside the electrolytic solution SE by means of the immersing rollers 33.

[0107] Direct current (DC), alternating current (AC) or mixed current is applied to the pairs of electrodes 14 in function of the type of treatment to be carried out and the electrolytic solution SE used for it.

[0108] While the semi-finished product 11 advances between the first electrode 15 and the second electrode 17 of each pair of electrodes 14, the inletting and agitation means 19 are active so as to keep the electrolytic solution SE homogeneous and agitated in particular at the first interspace 16 and the second interspace 18 so as to promote the removal therefrom of the waste and of the treatment residues and of the gases that are generated during it.

[0109] In particular, the jets of electrolytic solution injected by each nozzle 21 into the respective duct 20, or rather the depression created by them, draw from the inside of the tank 12 further electrolytic solution SE that is sucked into the duct 20 through the suction end 20b of the duct 20 itself (or rather through the portion of such a suction end 20b that is free, i.e. not occupied by the nozzles 21 themselves) where it mixes with the jets inlet there by the nozzles 21.

[0110] The electrolytic solution current that comes out from the delivery end 20a of each duct 20 thus has an amplified flow rate with respect to that corresponding to the sum of the jets therein injected by each nozzle 21 without any further energy use to create it besides that necessary for the operation of the pump means 26 that feed the nozzles 21 and already usually used.

[0111] The electrolytic solution current inlet by each duct 20 at respectively the first interspace 16 and the second interspace 18 creates a turbulence such as to promote, together with the "discontinuous" conformation or the "vertical" arrangement of the first electrode 15 and of the second electrode 17, the removal of the residues and of the treatment wastes, of the gases that are generated during the course of the treatment itself and the removal of the heat possibly produced.

[0112] This allows, on the one hand, to increase the current density even up to 5 times the usual current densities, whilst still ensuring effective cleaning of the electrodes, and on the other hand to increase the efficiency of the treatment even by up to 50% with respect to usual treatments with energy consumption reduced even by 30% with respect to conventional treatments.

[0113] Such effects are then amplified in the case in which at the inlet end of each pair of electrodes 14 there is a guiding entrance 24 also configured like a "Venturi" and which, following the motion of the semi-finished product 11, draws an electrolytic solution current that is inlet

into the first interspace 16 and into the second interspace 18 creating further turbulence.

[0114] The symmetrical configuration and arrangement of the ducts 20 contributes keeping in position and stabilizing the semi-finished product 11 during its forward motion.

[0115] The apparatus for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, thus conceived can undergo numerous modifications and variants, moreover, all of the details can be replaced by technically equivalent elements as long as they are within the scope of the appended claims. In practice, the materials used, as well as the sizes, can be whatever according to the technical requirements.

Claims

1. Apparatus (10) for the surface electrolytic treatment in continuous of metal semi-finished products, in particular flat metal semi-finished products, comprising:

- a containment tank (12) containing an electrolytic solution (SE) and inside which a metal semi-finished product (11) is made to advance in continuous along an advancement plane,
- immersion means (31, 32, 33) for immersing said metal semi-finished product (11) into said electrolytic solution,
- at least one pair of electrodes (14) opposite to each other and between which said metal semi-finished product (11) is made to advance in continuous, wherein said pair of electrodes (14) comprises at least one first electrode (15) facing one of the two opposite plane faces of said advancement plane and at a defined distance from said semi-finished product (11) so as to define with it a first interspace (16) and at least one second electrode (17) facing the other one of said two opposite plane faces of said advancement plane and at a defined distance from said semi-finished product (11) so as to define with it a second interspace (18) and wherein said at least one pair of electrodes (14) is immersed in said electrolytic solution and is associable with an electric power supply group,
- inletting and agitation means (19) for inletting and agitating said electrolytic solution in said tank (12), **characterised in that**
- said inletting and agitation means (19) comprise at least one duct (20) arranged at said at least one pair of electrodes (14) and provided with a delivery end (20a) facing one of said two opposite plane faces at respectively said first interspace (16) or said second interspace (18) and with a suction end (20b) that is opposite to said delivery end (20a) and open and immersed

- in the electrolytic solution contained in said tank (12), and at least one inletting nozzle (21) for inletting said electrolytic solution which is associable with feeding means (22) of said electrolytic solution and the outlet mouth (21a) of which is arranged at said suction end (20b) of said at least one duct (20), wherein said suction end (20b) of said at least one duct (20) has a portion that is free from said at least one nozzle (21) and that is immersed in the electrolytic solution contained in said tank (12) and wherein the jet of electrolytic solution emitted by said at least one nozzle (21) draws, from the inside of said tank (12), an electrolytic solution current that enters said at least one duct (20) through said suction end portion (20b), said jet and said current mixed together exiting from said delivery end (20a) at said first interspace (16) or said second interspace (18).
2. Apparatus (10) according to claim 1, **characterized in that** said at least one duct (20) comprises a section converging (20') towards said delivery end (20a).
 3. Apparatus (10) according to claim 2, **characterized in that** said at least one duct (20) comprises a section diverging (20'') towards said delivery end (20a) that is arranged downstream, with respect to the sense of the electrolytic solution current which flows through said at least one duct, of said converging section (20').
 4. Apparatus (10) according to one or more of the previous claims, **characterized in that** said at least one duct (20) comprises a deviator section (20''') which opens at said delivery end (20a) for deviating the electrolytic solution current that flows through said at least one duct (20) along a direction having a non-null component on the advancement plane of said metal semi-finished product (11) and in the same advancing sense of said metal semi-finished product (11).
 5. Apparatus (10) according to one or more of the previous claims, **characterized in that** considering said at least one duct (20) in section along a plane orthogonal to the advancement plane of said metal semi-finished product (11) and parallel to the advancing direction (F) of said metal semi-finished product, the axial development (A) of said at least one duct is incident said advancement plane with an incidence angle (α) comprised between 20° and 90°.
 6. Apparatus (10) according to one or more of the previous claims, **characterized in that** said delivery end (20a) and said suction end (20b) of said at least one duct (20) extend by the width of said metal semi-finished product (11), wherein said inletting and agitation means (19) comprise a plurality of said nozzles (21) arranged in succession along the width of said metal semi-finished product (11).
 7. Apparatus (10) according to one or more of the previous claims, **characterized in that** said at least one pair of electrodes (14) has, with respect to the advancing sense (F) of said metal semi-finished product (11), an inlet end (14a) and an outlet end (14b), wherein said at least one duct (20) is defined at said inlet end (14a).
 8. Apparatus (10) according to one or more of the previous claims, **characterized in that** said at least one pair of electrodes (14) has, with respect to the advancing sense (F) of said metal semi-finished product (11), an inlet end (14a) and an outlet end (14b), wherein said at least one duct (20) is defined at an intermediate zone between said inlet end (14a) and said outlet end (14b).
 9. Apparatus (10) according to one or more of the previous claims, **characterized in that** each of said first electrode (15) and said second electrode (17) comprises a plurality of rods or plates (150, 170) which extend by the width of said metal semi-finished product (11) and which are arranged parallel to each other and spaced at a definite distance from each other so as to form openings.
 10. Apparatus (10) according to claim 9, **characterized in that** said at least one duct (20) is delimited by a pair of said rods or plates (150, 170; 150', 170') adjacent each other or by one of said rods or plates and by a facing rod or plate (23) made of electrically insulating material, the faces of said two adjacent rods or plates (150, 170; 150', 170') or of said one rod or plate (150, 170; 150', 170') and of said facing rod or plate (23) made of electrically insulating material facing each other defining the walls of said at least one duct (20).
 11. Apparatus (10) according to one or more of claims 1 to 8, **characterized in that** each of said first electrode (15) and said second electrode (17) comprises a plate (250, 270) which extends parallel to said advancement plane of said metal semi-finished product (11) and which has at least one slot (251, 271) that extends by the width of said metal semi-finished product (11), wherein said at least one duct (20) is defined at said slot.
 12. Apparatus (10) according to one or more of the previous claims, **characterized in that** said inletting and agitation means (19) comprise at least one pair of said ducts (20) arranged symmetrically with respect to the advancement plane of said metal semi-finished product (11).

13. Apparatus (10) according to one or more of the previous claims, **characterized in that** said at least one pair of electrodes (14) has, with respect to the advancing sense of said metal semi-finished product (11), an inlet end (14a) and an outlet end (14b) and **in that** at said inlet end (14a) a guiding entrance (24) for guiding said metal semi-finished product (11) is present between said first electrode (15) and said second electrode (17), wherein said guiding entrance (24) is immersed in said electrolytic solution (SE) and, seen on a plane orthogonal to the advancement plane of said metal semi-finished product and parallel to the advancing direction (F) of said metal semi-finished product (11), has a first converging section (24') in the advancing sense (F) of said metal semi-finished product (11) and crossed by said metal semi-finished product.
14. Apparatus (10) according to claim 13, **characterized in that** said guiding entrance (24) has downstream, with respect to the advancing sense (F) of said metal semi-finished product (11), of said first converging section (24') a second diverging or constant cross-section portion (24'') which connects respectively with the surface of said first electrode (15) and of said second electrode (17) facing the respective plane face of said advancement plane of metal semi-finished product.
15. Apparatus (10) according to one or more of the previous claims, **characterized in that** said immersion means comprise at least one deflector roller (31) at the inlet end of said tank, at least one deflector roller (32) at the outlet end of said tank and at least one immersing roller (33) of said metal semi-finished product (11) in said electrolytic solution (SE) which is interposed between said inlet deflector roller (31) and said outlet deflector roller (32), wherein upstream and/or downstream with respect to the advancing sense (F) of said metal semi-finished product (11), of said at least one immersing roller (33) a respective said pair of electrodes (14) is present.

Patentansprüche

1. Vorrichtung (10) für die kontinuierliche elektrolytische Oberflächenbehandlung von halbfertigen Metallprodukten, insbesondere halbfertigen flachen Metallprodukten, umfassend:

- einen Aufnahmetank (12), der eine Elektrolytlösung (SE) enthält und innerhalb dem ein halbfertiges Metallprodukt (11) kontinuierlich entlang einer Vorschubebene vorgeschoben wird,
- ein Tauchmittel (31, 32, 33) zum Tauchen des halbfertigen Metallproduktes (11) in die Elektrolytlösung,

- zumindest ein Paar von einander gegenüberliegenden Elektroden (14), zwischen denen das halbfertige Metallprodukt (11) kontinuierlich vorgeschoben wird, wobei das Paar von Elektroden (14) zumindest eine erste Elektrode (15), die zu einer der zwei gegenüberliegenden ebenen Flächen der Vorschubebene und unter einer definierten Distanz von dem halbfertigen Produkt (11) weist, um so mit dieser einen ersten Zwischenraum (16) zu definieren, und zumindest eine zweite Elektrode (17) umfasst, die zu der anderen der zwei gegenüberliegenden ebenen Flächen der Vorschubebene und unter einer definierten Distanz von dem halbfertigen Produkt (11) weist, um so damit einen zweiten Zwischenraum (18) zu definieren, wobei das zumindest ein Paar von Elektroden (14) in die Elektrolytlösung getaucht und mit einer elektrischen Leistungsversorgungsgruppe verbindbar ist,
- ein Einlass- und Rührmittel (19) zum Einlassen und Rühren der Elektrolytlösung in dem Tank (12),

dadurch gekennzeichnet, dass

- das Einlass- und Rührmittel (19) zumindest einen Kanal (20) umfasst, der an dem zumindest einen Paar von Elektroden (14) angeordnet und mit einem Lieferende (20a) versehen ist, das zu einer der zwei gegenüberliegenden ebenen Flächen an jeweils dem ersten Zwischenraum (16) oder dem zweiten Zwischenraum (18) weist, und mit einem Saugende (20b), das dem Lieferende (20a) gegenüberliegt und offen ist und in die Elektrolytlösung eingetaucht ist, die in dem Tank (12) enthalten ist, und zumindest einer Einlassdüse (21) zum Einlassen der Elektrolytlösung, die mit einem Zufuhrmittel (22) für die Elektrolytlösung verbindbar ist, und deren Auslassmündung (21a) an dem Saugende (20b) des zumindest einen Kanals (20) angeordnet ist, wobei das Saugende (20b) des zumindest einen Kanals (20) einen Abschnitt aufweist, der von der zumindest einen Düse (21) frei ist und der in die in dem Tank (12) enthaltene Elektrolytlösung getaucht ist, wobei der Strahl von Elektrolytlösung, der durch die zumindest eine Düse (21) ausgestoßen wird, von dem Innern des Tanks (12) einen Elektrolytlösungsstrom zieht, der in den zumindest einen Kanal (20) durch den Saugendabschnitt (20b) eintritt, wobei der Strahl und der Strom miteinander gemischt werden und von dem Lieferende (20a) an dem ersten Zwischenraum (16) oder dem zweiten Zwischenraum (18) austreten.

2. Vorrichtung (10) nach Anspruch 1, **dadurch gekennzeichnet, dass** der zumindest eine Kanal (20) einen Abschnitt umfasst, der zu dem Lieferende (20a) konvergiert (20').

3. Vorrichtung (10) nach Anspruch 2,
dadurch gekennzeichnet, dass
der zumindest eine Kanal (20) einen Abschnitt umfasst, der zu dem Lieferende (20a) divergiert (20''), das stromabwärts in Bezug auf die Richtung des Elektrolytlösungsstroms angeordnet ist, der durch den zumindest einen Kanal des konvergierenden Abschnitts (20') fließt. 5
4. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
der zumindest eine Kanal (20) einen Ablenkschnitt (20''') umfasst, der sich an dem Lieferende (20a) zum Ablenken des Elektrolytlösungsstroms öffnet, der durch den zumindest einen Kanal (20) entlang einer Richtung, die eine Nicht-Null-Komponente an der Vorschubebene des halbfertigen Metallproduktes (11) ist, und in derselben Vorschubrichtung des halbfertigen Metallproduktes (11) fließt. 10
5. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
bei Betrachtung des zumindest einen Kanals (20) im Schnitt entlang einer Ebene orthogonal zu der Vorschubebene des halbfertigen Metallproduktes (11) und parallel zu der Vorschubrichtung (F) des halbfertigen Metallproduktes die axiale Entwicklung (A) des zumindest einen Kanals auf die Vorschubebene mit einem Einfallswinkel (α) einfällt, der zwischen 20° und 90° umfasst. 15
6. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
das Lieferende (20a) und das Saugende (20b) des zumindest einen Kanals (20) sich durch die Breite des halbfertigen Metallproduktes (11) erstrecken, wobei das Einlass- und Rührmittel (19) eine Mehrzahl von Düsen (21) umfasst, die in Folge entlang der Breite des halbfertigen Metallproduktes (11) angeordnet sind. 20
7. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
das zumindest eine Paar von Elektroden (14) in Bezug auf die Vorschubrichtung (F) des halbfertigen Metallproduktes (11) ein Einlassende (14a) und ein Auslassende (14b) aufweist, wobei der zumindest eine Kanal (20) an dem Einlassende (14a) definiert ist. 25
8. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
das zumindest eine Paar von Elektroden (14) in Bezug auf die Vorschubrichtung (F) des halbfertigen Metallproduktes (11) ein Einlassende (14a) und ein Auslassende (14b) aufweist, wobei der zumindest eine Kanal (20) an einer Zwischenzone zwischen dem Einlassende (14a) und dem Auslassende (14b) definiert ist. 30
9. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
jede von der ersten Elektrode (15) und der zweiten Elektrode (17) eine Mehrzahl von Stangen oder Platten (150, 170) umfasst, die sich durch die Breite des halbfertigen Metallproduktes (11) erstrecken und die parallel zueinander angeordnet und unter einer festgelegten Distanz voneinander beabstandet sind, um so Öffnungen zu bilden. 35
10. Vorrichtung (10) nach Anspruch 9, **dadurch gekennzeichnet, dass**
der zumindest eine Kanal (20) durch ein Paar von Stangen oder Platten (150, 170; 150', 170') benachbart zueinander oder durch eine der Stangen oder Platten und durch eine zugewandte Stange oder Platte (23) begrenzt ist, die aus elektrisch isolierendem Material besteht, wobei die Flächen der zumindest zwei benachbarten Stangen oder Platten (150, 170; 150', 170') oder der einen Stange oder Platte (150, 170; 150', 170') und der zugewandten Stange oder Platte (23), die aus elektrisch isolierendem Material besteht, die zueinander weisen, die Wände des zumindest einen Kanals (20) definieren. 40
11. Vorrichtung (10) nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass**
jede von der ersten Elektrode (15) und der zweiten Elektrode (17) eine Platte (250, 270) umfasst, die sich parallel zu der Vorschubebene des halbfertigen Metallproduktes (11) erstreckt und die zumindest einen Schlitz (251, 271) aufweist, der sich durch die Breite des halbfertigen Metallproduktes (11) erstreckt, wobei der zumindest eine Kanal (20) an dem Schlitz definiert ist. 45
12. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
das Einlass- und Rührmittel (19) zumindest ein Paar von Kanälen (20) umfasst, die symmetrisch in Bezug auf die Vorschubebene des halbfertigen Metallproduktes (11) angeordnet sind. 50
13. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**
das zumindest eine Paar von Elektroden (14) in Bezug auf die Vorschubrichtung des halbfertigen Metallproduktes (11) ein Einlassende (14a) und ein Auslassende (14b) aufweist, wobei der zumindest eine Kanal (20) an dem Einlassende (14a) definiert ist. 55

Auslassende (14b) aufweist, und dass an dem Einlassende (14a) ein Führungseintritt (24) zum Führen des halbfertigen Metallproduktes (11) zwischen der ersten Elektrode (15) und der zweiten Elektrode (17) vorhanden ist, wobei der Führungseintritt (24) in die Elektrolytlösung (SE) getaucht ist und bei Betrachtung an einer Ebene orthogonal zu der Vorschubebene des halbfertigen Metallproduktes und parallel zu der Vorschubrichtung (F) des halbfertigen Metallproduktes (11) einen ersten konvergierenden Abschnitt (24') in der Vorschubrichtung (F) des halbfertigen Metallproduktes (11) aufweist, die von dem halbfertigen Metallprodukt durchkreuzt ist.

14. Vorrichtung (10) nach Anspruch 13, **dadurch gekennzeichnet, dass** der Führungseintritt (24) stromabwärts in Bezug auf die Vorschubrichtung (F) des halbfertigen Metallproduktes (11) des ersten konvergierenden Abschnittes (24') einen zweiten divergierenden Abschnitt oder Abschnitt mit konstantem Querschnitt (24'') aufweist, der jeweils mit der Fläche der ersten Elektrode (15) und der zweiten Elektrode (17) verbunden ist, die zu der jeweiligen ebenen Seite der Vorschubebene des halbfertigen Metallproduktes weist.
15. Vorrichtung (10) nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Eintauchmittel zumindest eine Ablenkwalze (31) an dem Einlassende des Tanks, zumindest eine Ablenkwalze (32) an dem Auslassende des Tanks und zumindest eine Tauchwalze (33) für das halbfertige Metallprodukt (11) in der Elektrolytlösung (SE) umfasst, die zwischen der Einlassablenkwalze (31) und der Auslassablenkwalze (32) angeordnet ist, wobei stromaufwärts und/oder stromabwärts in Bezug auf die Vorschubrichtung (F) des halbfertigen Metallproduktes (11) von der zumindest einen Tauchwalze (33) ein jeweiliges Paar von Elektroden (14) vorhanden ist.

Revendications

1. Appareil (10) pour le traitement électrolytique de surface en continu de produits métalliques semi-finis, notamment de produits métalliques semi-finis plats, comprenant :
- une cuve de confinement (12) contenant une solution électrolytique (SE) et dans laquelle on fait avancer en continu un produit métallique semi-fini (11) le long d'un plan d'avance,
 - un moyen d'immersion (31, 32, 33) pour immerger ledit produit métallique semi-fini (11) dans ladite solution électrolytique,
 - au moins une paire d'électrodes (14) l'une en

face de l'autre et entre lesquelles on fait avancer en continu ledit produit métallique semi-fini (11), dans lequel ladite paire d'électrodes (14) comprend au moins une première électrode (15) orientée vers l'une des deux faces de plan opposées dudit plan d'avance et à une distance définie dudit produit semi-fini (11) afin de définir avec lui un premier intervalle (16) et au moins une deuxième électrode (17) orientée vers l'autre desdites deux faces de plan opposées dudit plan d'avance et à une distance définie dudit produit semi-fini (11) afin de définir avec lui un deuxième intervalle (18) et dans lequel ladite au moins une paire d'électrodes (14) est immergée dans ladite solution électrolytique et peut être associée à un groupe d'alimentation électrique,

- un moyen d'entrée et d'agitation (19) pour introduire et agiter ladite solution électrolytique dans ladite cuve (12),

caractérisé en ce que

- ledit moyen d'entrée et d'agitation (19) comprend au moins une conduite (20) placée au niveau de ladite au moins une paire d'électrodes (14) et pourvue d'une extrémité de distribution (20a) orientée vers l'une desdites deux faces de plan opposées respectivement audit premier intervalle (16) ou audit deuxième intervalle (18) et d'une extrémité d'aspiration (20b) qui est à l'opposé de ladite extrémité de distribution (20a) et qui est ouverte et immergée dans la solution électrolytique contenue dans ladite cuve (12), et au moins une buse d'entrée (21) pour introduire ladite solution électrolytique pouvant être associée à un moyen d'alimentation (22) de ladite solution électrolytique et dont l'orifice de sortie (21a) est placé au niveau de ladite extrémité d'aspiration (20b) de ladite au moins une conduite (20), dans lequel ladite extrémité d'aspiration (20b) de ladite au moins une conduite (20) comporte une partie qui est exempte de ladite au moins une buse (21) et qui est immergée dans la solution électrolytique contenue dans ladite cuve (12) et dans lequel le jet de solution électrolytique émis par ladite au moins une buse (21) entraîne, depuis l'intérieur de ladite cuve (12), un courant de solution électrolytique qui entre dans ladite au moins une conduite (20) par ladite partie d'extrémité d'aspiration (20b), ledit jet et ledit courant mélangés sortant par ladite extrémité de distribution (20a) au niveau dudit premier intervalle (16) ou dudit deuxième intervalle (18).

2. Appareil (10) selon la revendication 1, **caractérisé en ce que** ladite au moins une conduite (20) comprend une section convergeant (20') vers ladite extrémité de distribution (20a).

3. Appareil (10) selon la revendication 2, **caractérisé en ce que** ladite au moins une conduite (20) comprend une section divergeant (20'') vers ladite extrémité de distribution (20a) qui est placée en aval, par rapport au sens du courant de solution électrolytique qui circule dans ladite au moins une conduite, de ladite section convergente (20').
4. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ladite au moins une conduite (20) comprend une section de déviation (20''') qui débouche au niveau de ladite extrémité de distribution (20a) pour dévier le courant de solution électrolytique qui circule dans ladite au moins une conduite (20) le long d'une direction ayant une composante non nulle sur le plan d'avance dudit produit métallique semi-fini (11) et dans le même sens d'avance que celui dudit produit métallique semi-fini (11).
5. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que**, en observant ladite au moins une conduite (20) en section suivant un plan orthogonal au plan d'avance dudit produit métallique semi-fini (11) et parallèle à la direction d'avance (F) dudit produit métallique semi-fini, le développement axial (A) de ladite au moins une conduite forme une incidence avec ledit plan d'avance selon un angle d'incidence (α) compris entre 20° et 90°.
6. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ladite extrémité de distribution (20a) et ladite extrémité d'aspiration (20b) de ladite au moins une conduite (20) s'étendent sur la largeur dudit produit métallique semi-fini (11), dans lequel ledit moyen d'entrée et d'agitation (19) comprend une pluralité desdites buses (21) disposées les unes à la suite des autres dans la largeur dudit produit métallique semi-fini (11).
7. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ladite au moins une paire d'électrodes (14) a, par rapport au sens d'avance (F) dudit produit métallique semi-fini (11), une extrémité d'entrée (14a) et une extrémité de sortie (14b), dans lequel ladite au moins une conduite (20) est définie au niveau de ladite extrémité d'entrée (14a).
8. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ladite au moins une paire d'électrodes (14) a, par rapport au sens d'avance (F) dudit produit métallique semi-fini (11), une extrémité d'entrée (14a) et une extrémité de sortie (14b), dans lequel ladite au moins une conduite (20) est définie au niveau d'une zone intermédiaire entre ladite extrémité d'entrée (14a) et ladite extrémité de sortie (14b).
9. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ladite première électrode (15) et ladite deuxième électrode (17) comprennent chacune une pluralité de tiges ou de plaques (150, 170) qui s'étendent sur la largeur dudit produit métallique semi-fini (11) et qui sont disposées parallèlement entre elles et espacées à une distance définie les unes des autres afin de former des ouvertures.
10. Appareil (10) selon la revendication 9, **caractérisé en ce que** ladite au moins une conduite (20) est délimitée par une paire desdites tiges ou plaques (150, 170 ; 150', 170') voisines l'une de l'autre ou par l'une desdites tiges ou plaques et par une tige ou plaque en vis-à-vis (23) faite d'un matériau électriquement isolant, les faces desdites deux tiges ou plaques voisines (150, 170 ; 150', 170') ou de ladite tige ou plaque (150, 170 ; 150', 170') et de ladite tige ou plaque en vis-à-vis (23) faite d'un matériau électriquement isolant qui se font face définissant les parois de ladite au moins une conduite (20).
11. Appareil (10) selon l'une ou plusieurs des revendications 1 à 8, **caractérisé en ce que** ladite première électrode (15) et ladite deuxième électrode (17) comprennent chacune une plaque (250, 270) qui s'étend parallèlement audit plan d'avance dudit produit métallique semi-fini (11) et qui comporte au moins une fente (251, 271) qui s'étend sur la largeur dudit produit métallique semi-fini (11), dans lequel ladite au moins une conduite (20) est définie au niveau de ladite fente.
12. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ledit moyen d'entrée et d'agitation (19) comprend au moins une paire desdites conduites (20) disposées de façon symétrique par rapport au plan d'avance dudit produit métallique semi-fini (11).
13. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ladite au moins une paire d'électrodes (14) a, par rapport au sens d'avance dudit produit métallique semi-fini (11), une extrémité d'entrée (14a) et une extrémité de sortie (14b) et **en ce que** au niveau de ladite extrémité d'entrée (14a), une entrée de guidage (24) pour guider ledit produit métallique semi-fini (11) est présente entre ladite première électrode (15) et ladite deuxième électrode (17), dans lequel ladite entrée de guidage (24) est immergée dans ladite solution électrolytique (SE) et comporte, vue dans un plan orthogonal au plan d'avance dudit produit métallique semi-fini et parallèle à la direction d'avance

(F) dudit produit métallique semi-fini (11), une première section convergente (24') dans le sens d'avance (F) dudit produit métallique semi-fini (11) et croisée par ledit produit métallique semi-fini.

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14. Appareil (10) selon la revendication 13, **caractérisé en ce que** ladite entrée de guidage (24) comporte en aval de ladite première section convergente (24'), par rapport au sens d'avance (F) dudit produit métallique semi-fini (11), une deuxième section divergente ou de section constante (24'') qui se connecte respectivement à la surface de ladite première électrode (15) et à la surface de ladite deuxième électrode (17) qui se trouve devant la face de plan respective dudit plan d'avance du produit métallique semi-fini.
15. Appareil (10) selon l'une ou plusieurs des revendications précédentes, **caractérisé en ce que** ledit moyen d'immersion comprend au moins un rouleau déflecteur (31) à l'extrémité d'entrée de ladite cuve, au moins un rouleau déflecteur (32) à l'extrémité de sortie de ladite cuve et au moins un rouleau d'immersion (33) dudit produit métallique semi-fini (11) dans ladite solution électrolytique (SE) qui est intercalé entre ledit rouleau déflecteur d'entrée (31) et ledit rouleau déflecteur de sortie (32), dans lequel en amont et/ou en aval dudit au moins un rouleau d'immersion (33) par rapport au sens d'avance (F) dudit produit métallique semi-fini (11), une paire respective desdites électrodes (14) est présente.

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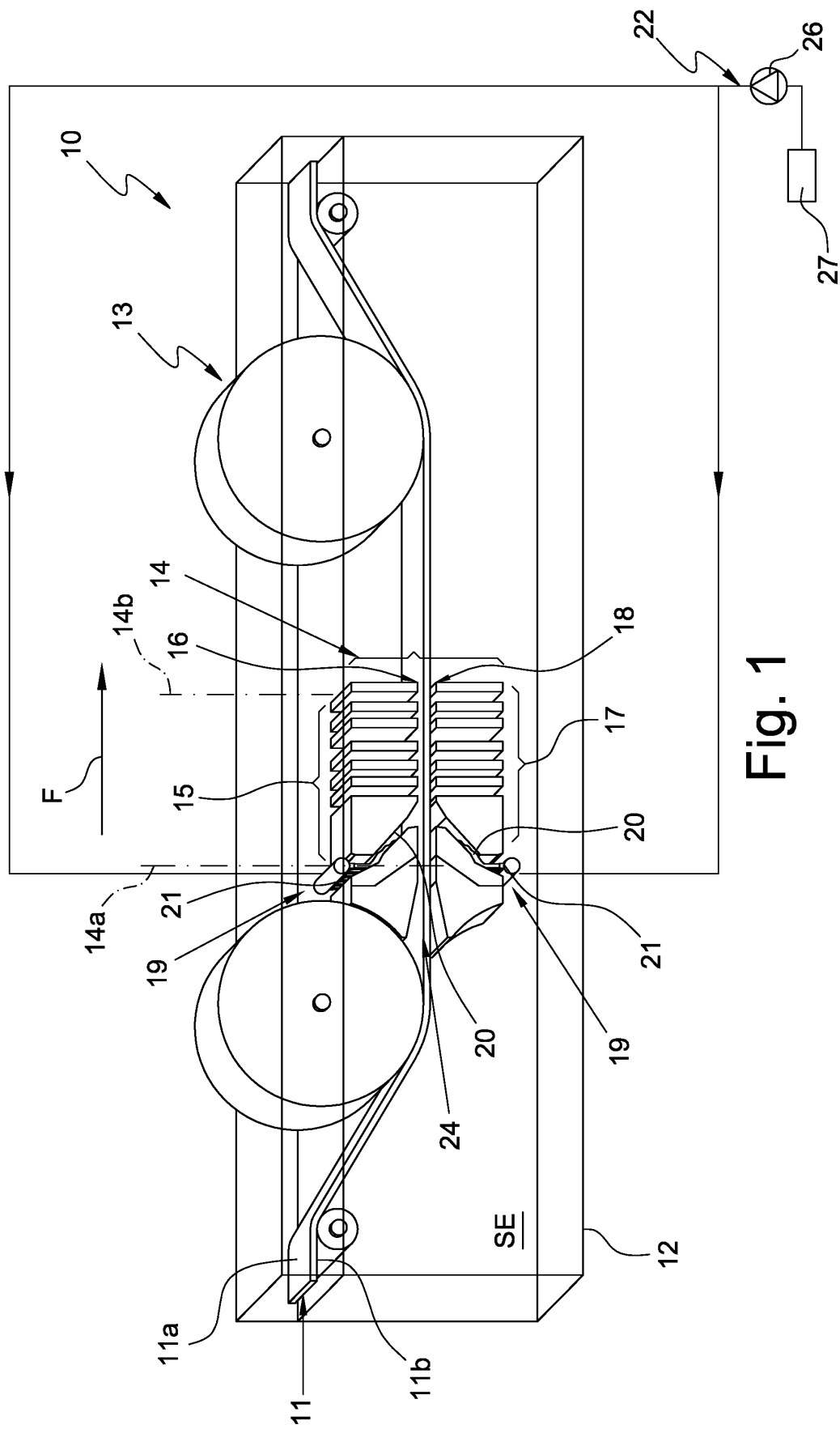
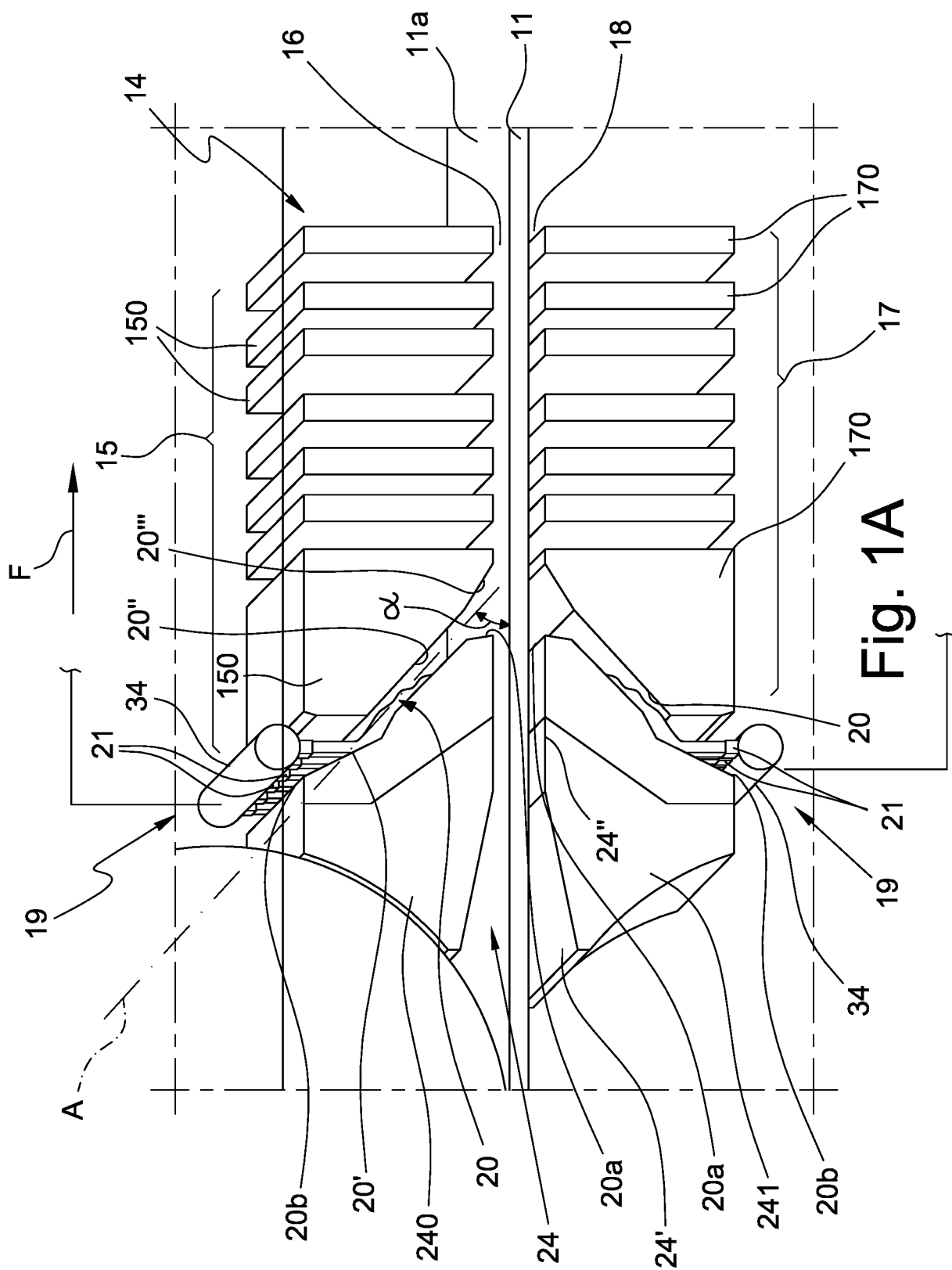


Fig. 1



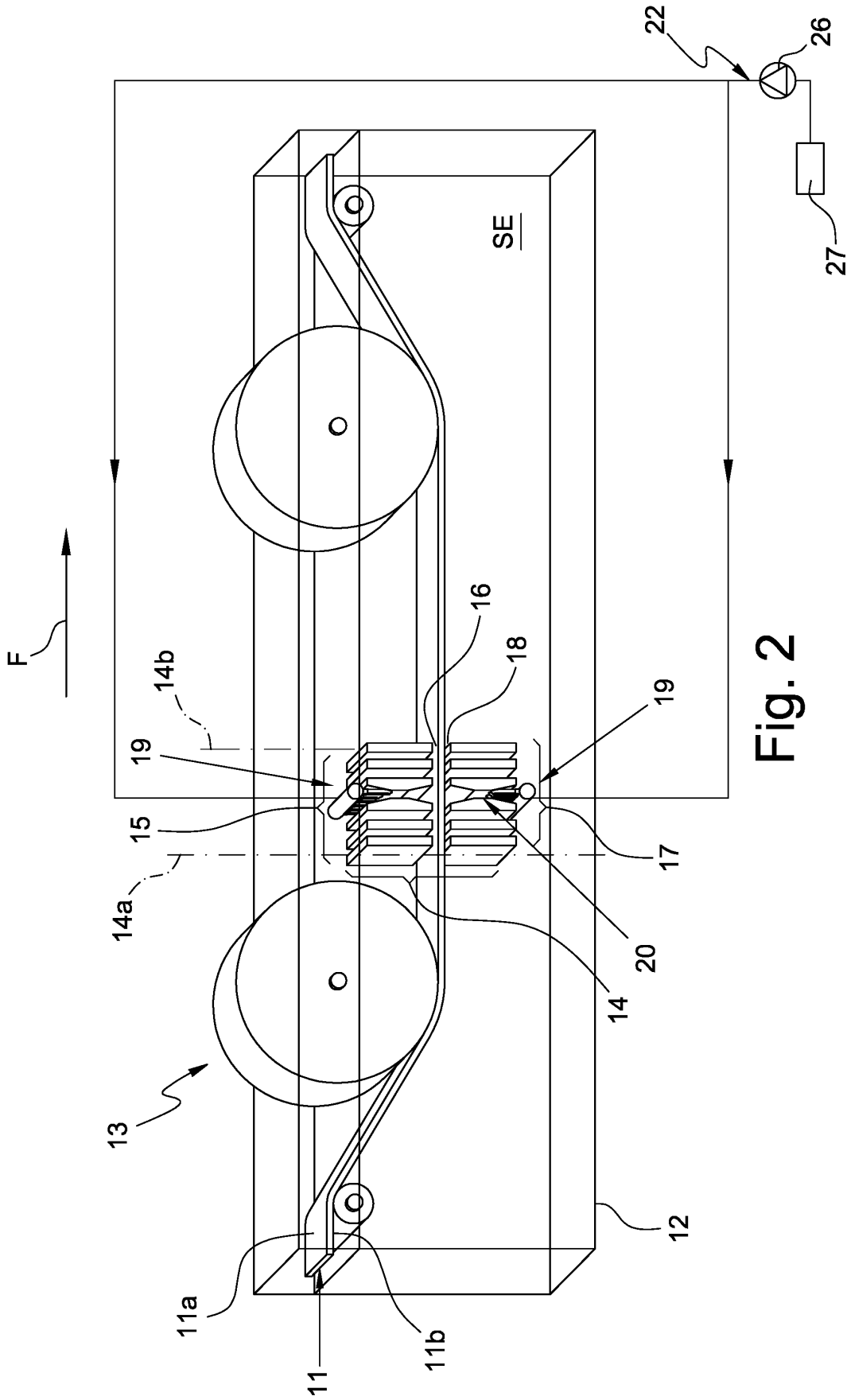


Fig. 2

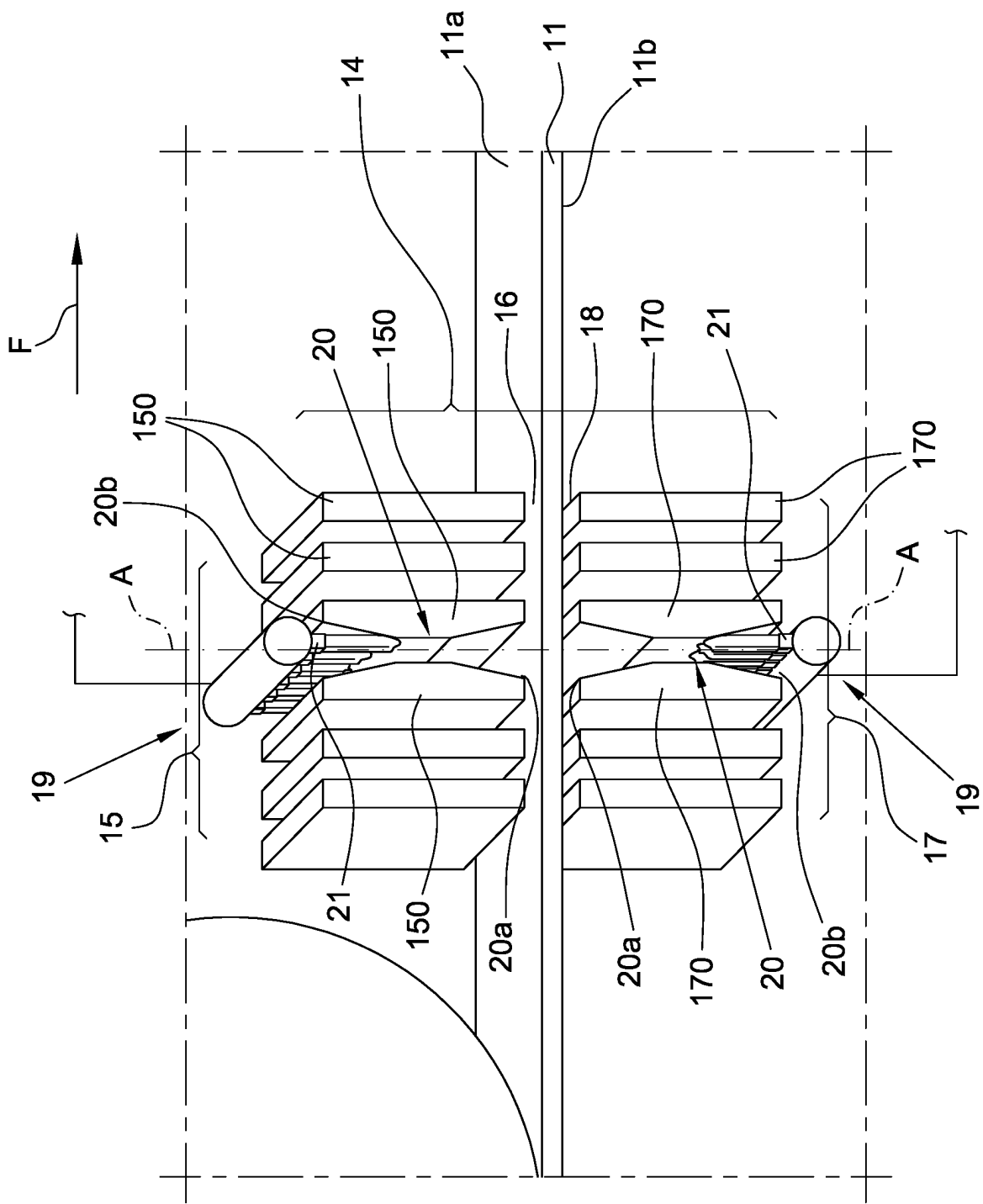


Fig. 2A

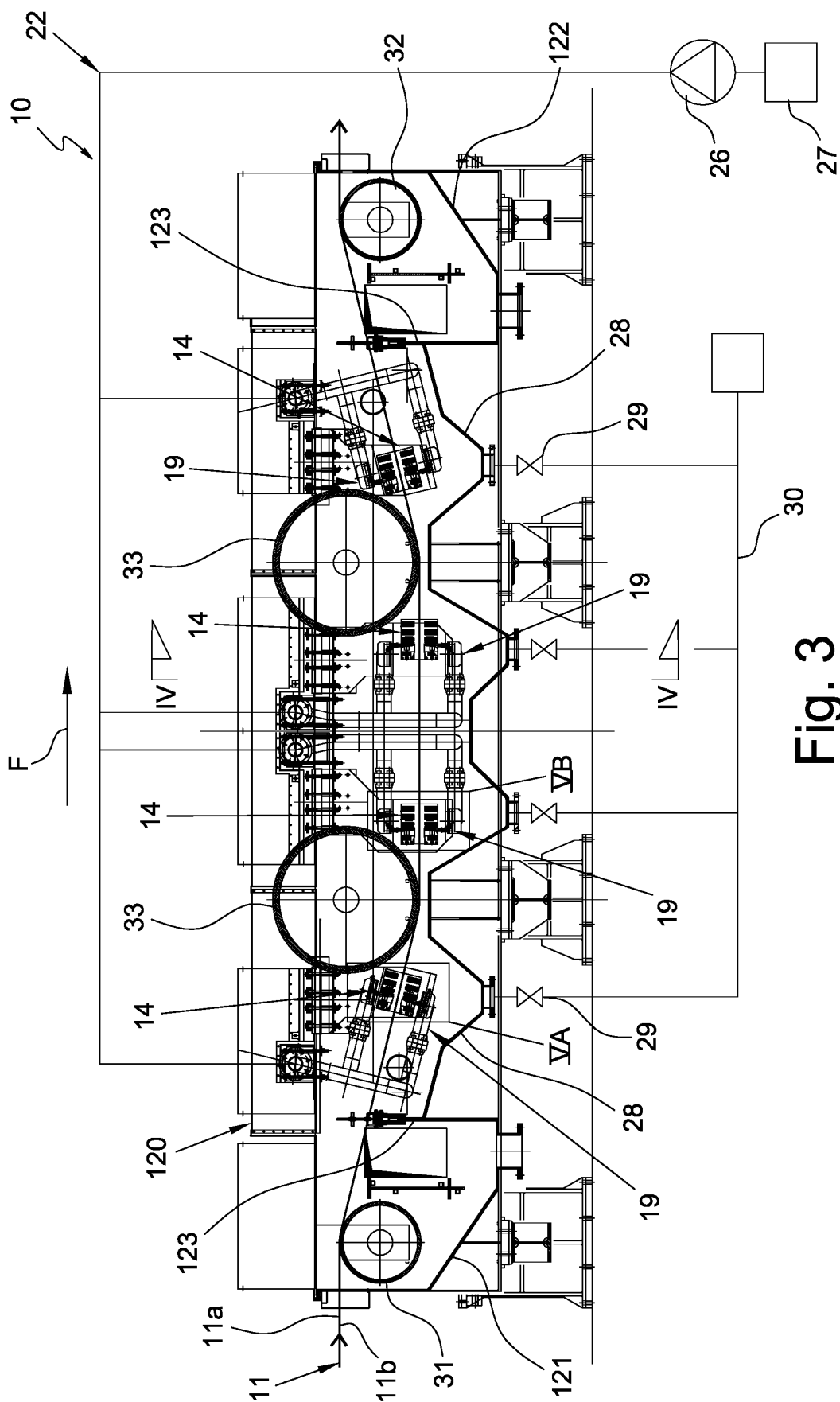


Fig. 3

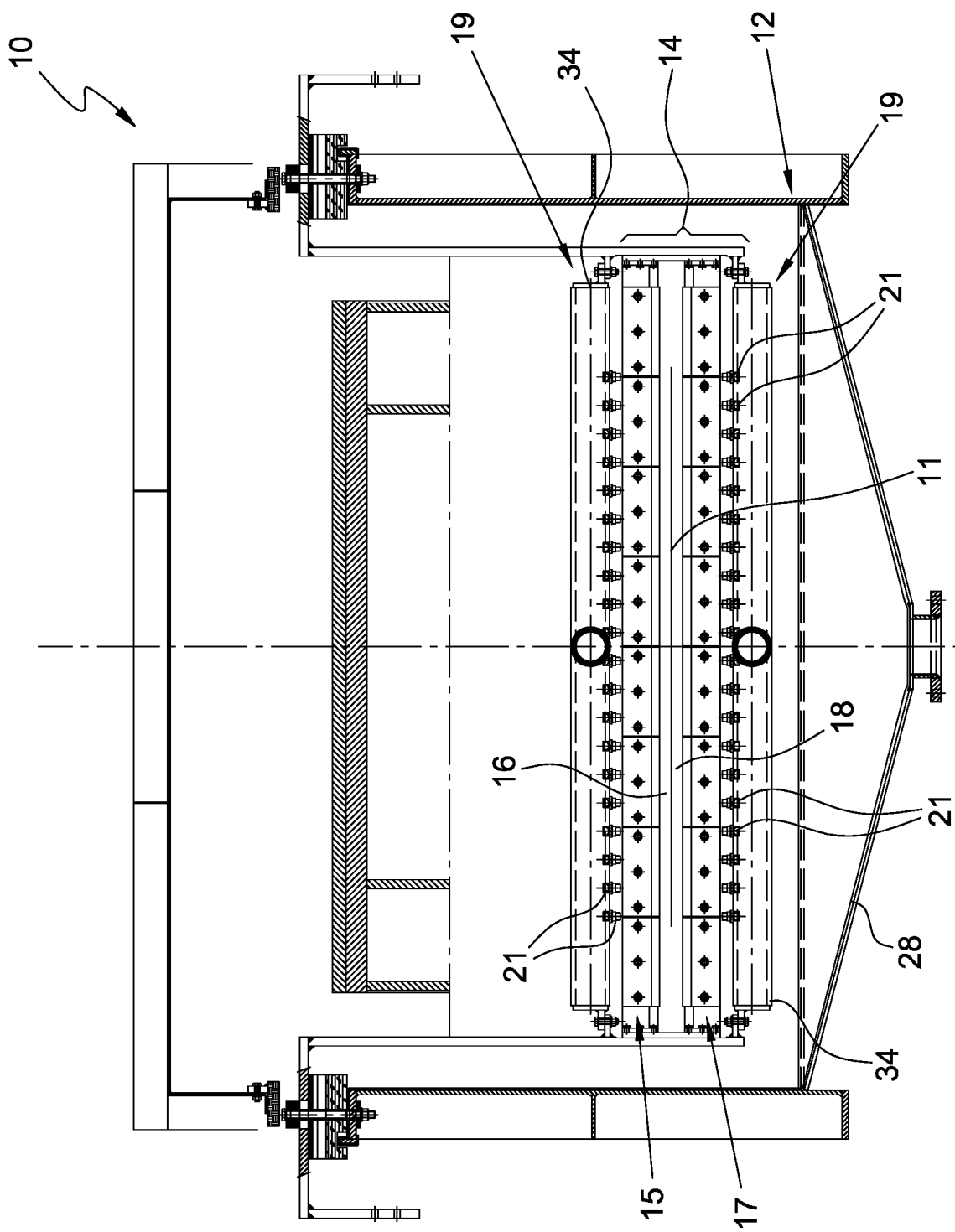
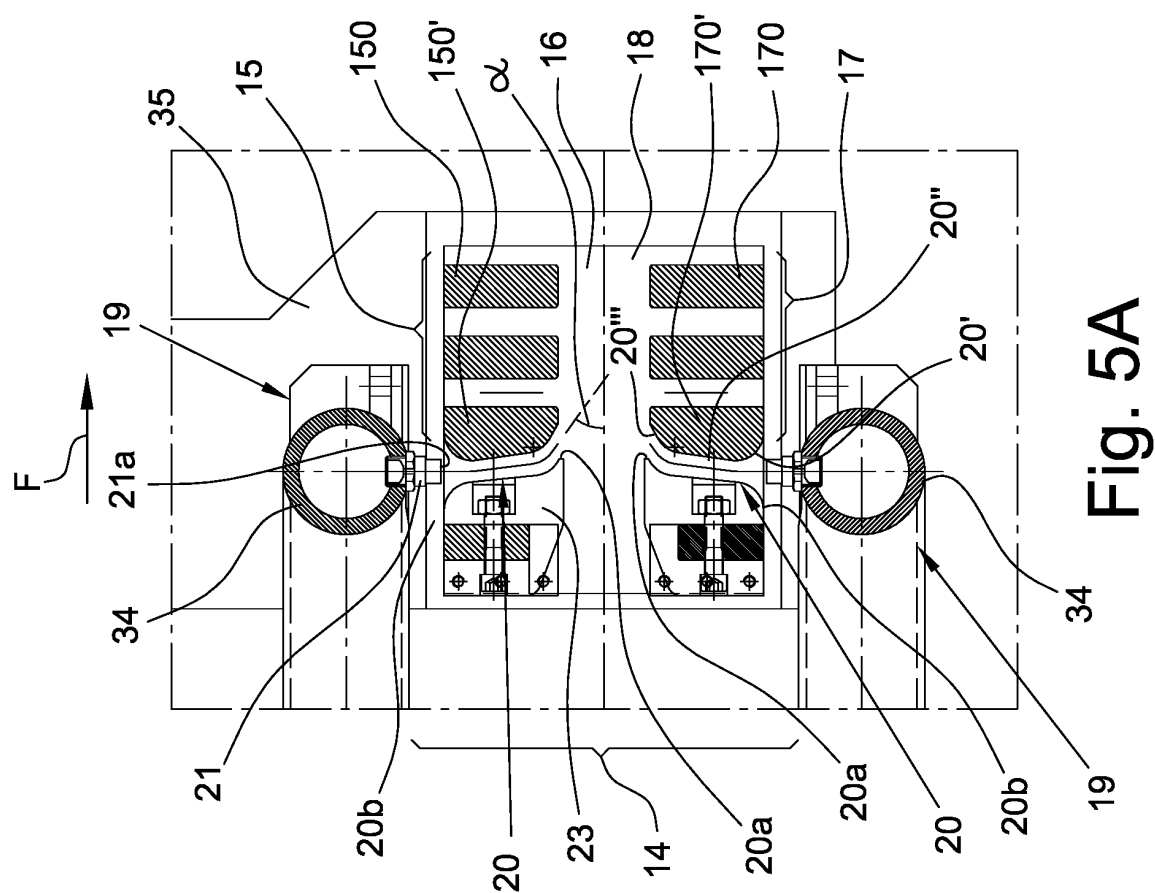
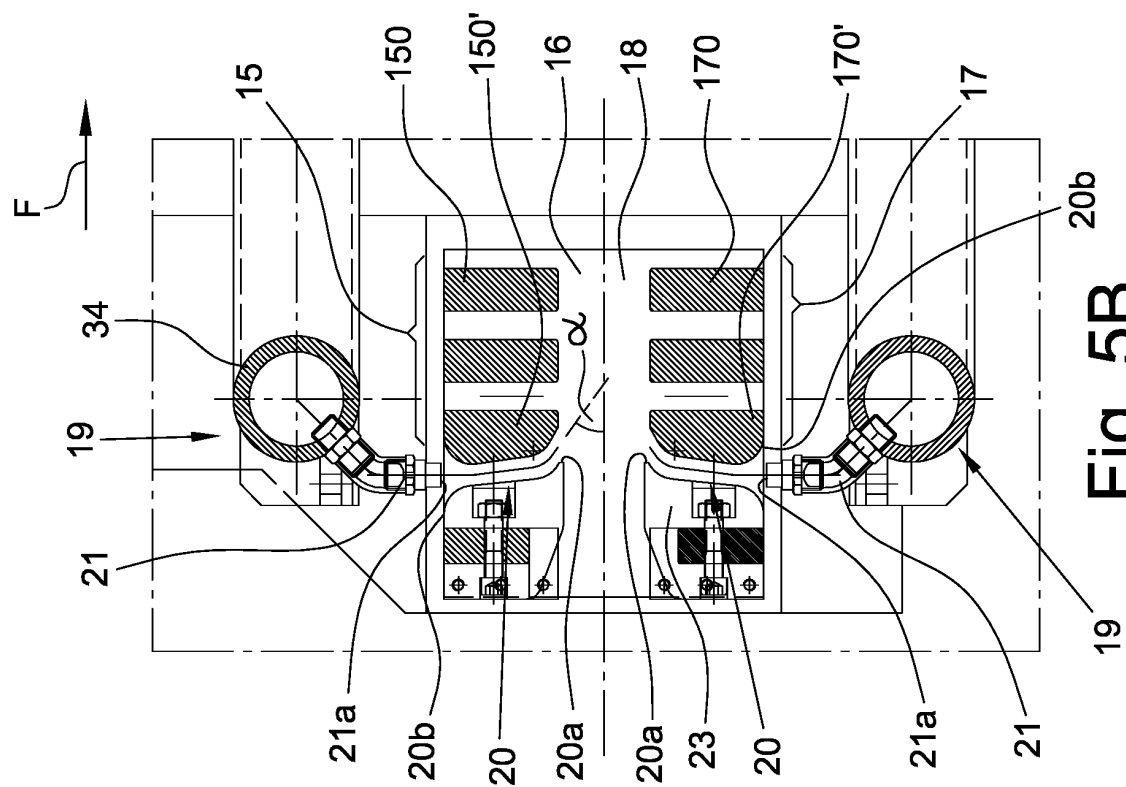


Fig. 4



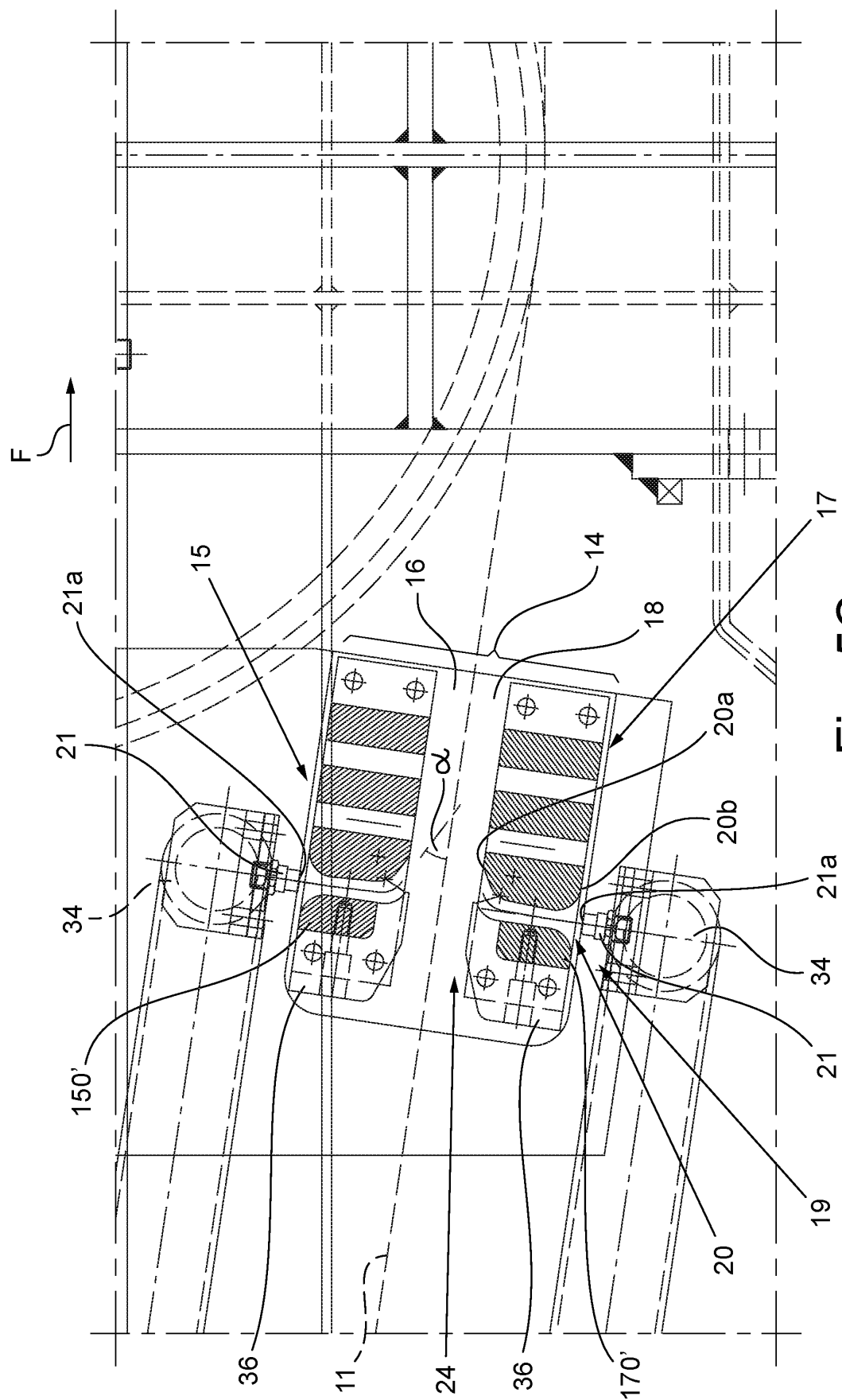


Fig. 5C

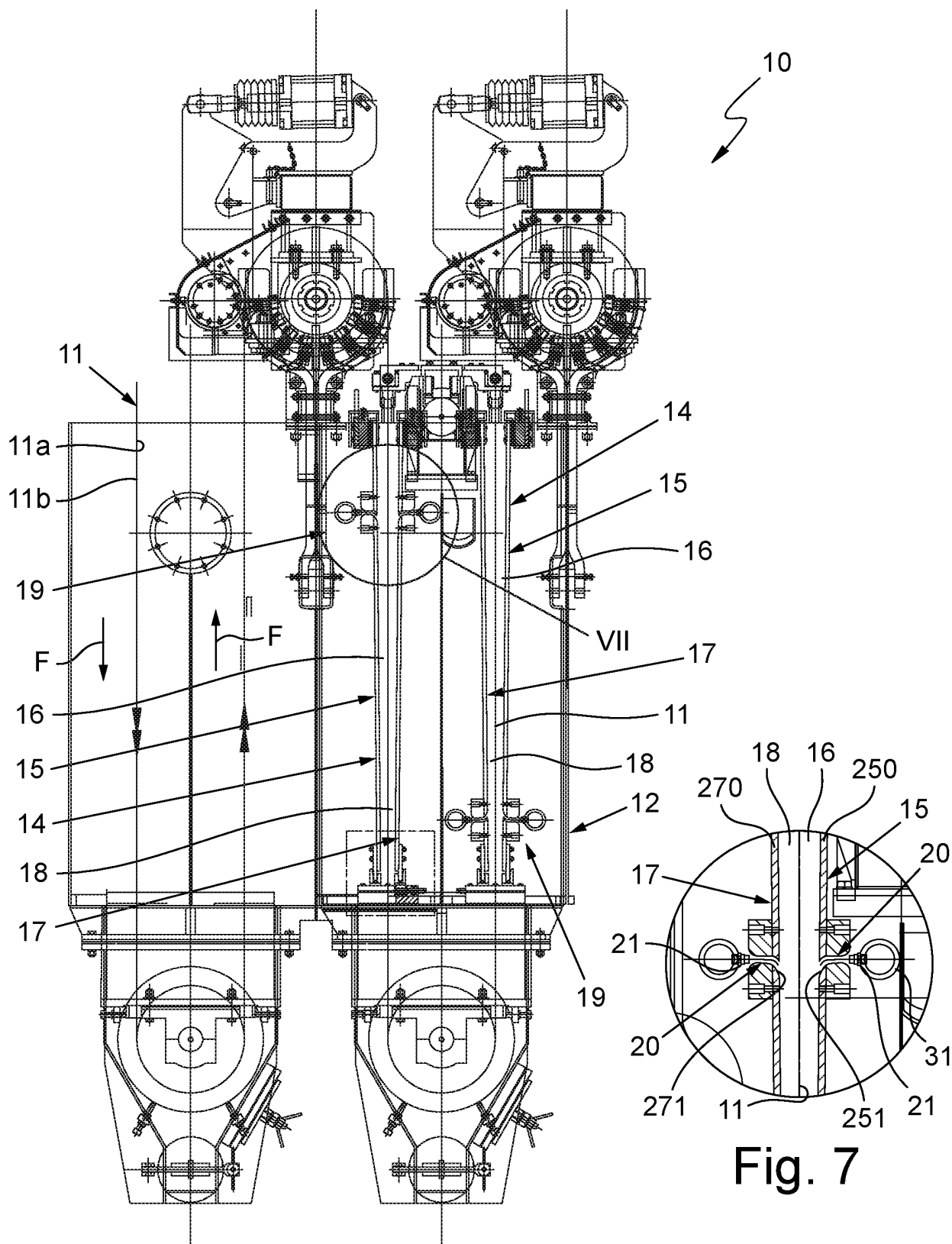


Fig. 6

Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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