

Process for the Electrolytic Processing Especially of Flat Items and Arrangement for Implementing the Process

The invention relates, first, to a process for the electrolytic processing of flat and perforated items, especially in the form of printed circuit boards with drillings, which are taken through a treatment bath or to a processing station by conveyor means, in which there are means for reducing the thickness of a metal-ion-depleted region (diffusion zone), which are in contact with the items to be processed. The preferred area of use for the invention is galvanization, which will be discussed in more detail below. The invention can also be used in electrolytic etching.

The surface of the items to be processed or their diffusion layer becomes depleted of metal ions in a disadvantageous manner

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during processing, because the cathode draws more ions to it than usually come out of the surrounding treatment bath. This leads to a reduction in the acceptable specific current density, and thus means that in order to achieve such a metal coating having a particular thickness, a correspondingly long treatment time is needed.

In order to overcome this disadvantage, the so-called "high-speed" process can be used, in which the electrolyte is conducted at great speed and in great quantity along the cathodic surface between this surface and the anode (see European Patent 0 142 010 and German Patent 35 25 183, for example). It is true that using this process, an improved, i.e. increased, current density of the metal coating on the cathodic item is achieved. However, the production, control and discharge of such an electrolytic current is relatively expensive. The creation of the flow channels necessary for this requires added constructive expenditures. In addition, the manner of conveying the items to be processed can be complicated. For these reasons, it has become known only for continuous items to be processed, such as bands or wires.

From DE-OS 36 03 856, a process and a device for galvanizing flat items such as printed circuit boards are known. The flat items are grasped and transported by a roller pair rotating at a relatively slow rotational speed and cathodically connected. The electrolyte is applied to the item by an anodically connected roller pair, the surface of which can absorb fluid. A small

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distance is deliberately maintained between the surface of the item and the surface of the anodic rollers. The rotational speed of the anodic rollers is relatively high, in order to attain a correspondingly fast electrolytic movement along the surface of the item. In this way, an increase in current density is achieved, compared to conventional immersion bath galvanization. Thus rotating, insoluble roller pairs as anodes are described. The metal is supplied in soluble fashion via the electrolyte. The anodic roller pairs are not located below the level of the bath; therefore the electrolyte must continuously be applied to the galvanization location. The quantity of supplied electrolyte is limited, not least of all due to the close plastic screenings over the rollers. This also limits the possible galvanization current density. The plastic screenings are needed, however, in order to delay an undesired galvanization of the other, cathodically-connected roller pairs, which serve to transport the circuit boards.

Because the rotating anodic roller pairs do not touch the upper sides of the circuit boards, the diffusion layer located on the surface is not mechanically disturbed. However, the space between the anodic roller and the upper side of the circuit boards and thus the space between the pairs themselves is needed, to allow the galvanizing currents for the two sides of the circuit boards to be individually set. During galvanization of the conductor path image, this is always necessary, because the two sides of the circuit board, in practice, have uneven copper areas. For this reason, the anodes of the upper side of the circuit board are fed from one bath current rectifier and the anodes of the bottom side are fed from a

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different rectifier. Each rectifier can be individually set in respect to current.

Another disadvantage of the aforementioned invention is the very poor flow through fine holes in the printed circuit boards. On board sides located opposite to one another, electrolyte is applied in a small quantity in an almost pressure-free manner. This prevents the flow from going through the holes, resulting in inadequate galvanization of the hole walls even to the point of burns in the holes.

The invention is based on the problem of designing a generic process so as to achieve the desired reduction in thickness of the ion-depleted border layer on the anode surface or cathode surface (diffusion layer), and to thus attain a correspondingly increased current density of the galvanization current flowing from the electrolyte onto the anodic or cathodic item, while avoiding, however, the constructive and process-related expenses of the so-called "high-speed" flow technique.

This problem is solved and this object attained, first, starting from the generic prior art, in that in the presence of an anode and cathodic items to be processed, or in the presence of anodic items to be processed and a cathode, the surface to be treated of the items is wiped continuously by machine and the electrolyte is conveyed by a component vertical to the plane of the items and is passed through the drillings or drill holes (referred to hereinafter for the sake of simplicity as "drill holes") of the items.

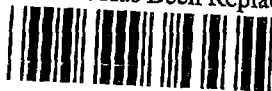
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This wiping of the area or areas in question serves, in a simple, advantageous and industrially implementable manner, to counteract the disadvantageous depletion of metal ions in the diffusion layer. The diffusion layer is largely destroyed, and thus the ion-depleted zone on the surface or surfaces in question is completely or at least largely eliminated. The metal ions of the electrolyte can therefore make their way directly onto the surface of the items in question, or, during etching, can be removed therefrom. In respect to further advantages, reference is made to the discussions below of the various possible designs of the invention, in respect to both process and object. By means of the combination according to the invention of the aforementioned wiping and the metallization of the surface which this achieves with the metallization of the inner walls of the drill holes based on conveying the electrolyte through the drill holes, an adequate treatment of the inner wall of the drill holes is simultaneously achieved, and thus the metallization of the treatment items is achieved on all required areas (surfaces and drill holes) with satisfactory results in one work step and using relatively simple measures. In this connection, the aforementioned combination has the advantage that the wiping sequence destroys any surface tension existing on the fluid in the drill holes, making it even easier to metallize the drill hole inner wall. As the examples of this invention show, the structural means for wiping, on the one hand, and for conducting the electrolyte through the drill holes (so-called "flooding"), on the other,

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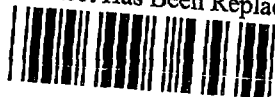
can be provided together in a simple and space-saving manner, and in the preferred design of the invention are even combined. Here reference is made, for example, to the design according to Fig. 15. A further advantage is that with the aforementioned flooding—particularly when this is still done by supporting a pressing of the electrolyte, e.g., by means of a pump, into the drill holes and/or a drawing of the electrolyte out of the drill holes by means of a suction device—any particles that might still be present in the drill holes can be extracted from the drill holes and transported away. This avoids the danger of particles trapped in the drill holes becoming embedded through metallization and of the drill hole in question becoming clogged, which leads to rejection of that particular circuit board.

Furthermore, in this connection, the danger is avoided of abrasive or chip particles still adhering to the edge of the drill holes being grasped by the wiping coatings and transported along the surface of the items to be processed, which can damage and even render unusable the delicate surface of the items to be processed.

A complementary attainment of the object is represented by a process in which an appropriate relative movement between the cathodic or anodic items to be processed on the one hand and an anode-side or cathode-side wiping device on the other hand achieves the effect according to the invention.

In achieving this relative movement, the transport movement of the items to be processed may be used

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as an alternative when the items are taken by conveyor means through a treatment bath.

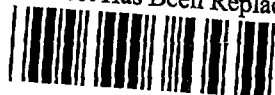
The further subclaims present preferred designs of the invention.

The possible process measures provided according to the invention for the attainment of the object may preferably be used for galvanization, but may also be used for electrolytic etching. The items (work pieces) to be processed thereby has an anodic function, i.e., it is anodically connected. The etched-away metal is precipitated on a counter-electrode (cathode). The counter-electrode can be the wiping device. Then, in a later work step, the precipitated metal is carried away and re-obtained. Electrolytic etching of this type is an alternative to purely chemical etching. During electrolytic etching, a simultaneous wiping of the anodes disrupts a border layer appearing there.

In order to simplify the presentation of the invention, the invention will be discussed below, and in the description of the examples related to the drawings, in reference to processes and devices for galvanization.

The movement of the coated anode relative to the item to be galvanized, whereby the coating bears against the item, largely destroys the diffusion layer (see above) and thus completely or largely eliminates the metal-ion-depleted region on the surface of the items to be processed.

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The ions of the electrolyte can make their way directly through the coating of the anode to the surface of the item to be processed and metallize it. In this way, relatively high current densities can be achieved, and with good quality, particularly with an even strength of metal layer precipitated on the item surface, e.g., a copper layer. This is a significant advantage, which is especially important when it is not the entire area that is to be coated, but only the surface of conductor paths located on a circuit board of this type. A further significant advantage of the invention is that the distance between the anode and the cathodic item is still determined only by the thickness of the coating on the wiping device, whereby this thickness, however, can be relatively small. Due to the very small distance thus achieved between the anode and the cathode, different field line concentrations of the galvanization current flowing from the anode to the cathode practically do not exist, or at least exist to a considerably lesser extent than in arrangements in which a comparatively large distance exists between the anode and the cathode. In previously known arrangements with a relatively large distance between the anode and cathode, it was necessary, in order to avoid damaging effects such as increased metal precipitations on edge regions, e.g., the so-called "dog-bone" effect, to make appropriate expenditures, e.g., to provide "blendings." This is especially true in the case of flat items to be processed, such as electronic printed circuit boards, which have a great many drillings. Here, considerable scatterings (known as drill hole scatterings) can result on the edge region of the boards and in the drill holes.

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A significant advantage of the invention is that it achieves higher current density values, without the depletion of metal ions causing so-called "burns" or the like of the metal to be deposited. Blendings or similar measures against excessive scatterings of the galvanizing current are not needed. A further significant advantage of the invention is that it is suitable for the automatic galvanization of items running continuously through a unit (perforated boards or the like). This will preferably occur in the case of items arranged and transported horizontally (see, for example, DE-OS 36 24 481, discussed below). However, the invention can be used not only with horizontal, but also with vertical or slanted runs, and such usage will be accompanied by the advantages discussed above, particularly the avoidance of damaging scatterings at high current densities. When it is possible for higher current densities to be applied, as they can be as a result of this invention, the transport speed also becomes faster or the treatment route shorter. In particular, it is not necessary to ensure a disturbingly high flow rate of the electrolyte.

With the invention, a wiping effect is automatically achieved on the entire surface to be treated, in particular, on both sides or surfaces of flat items. For the sake of completeness, it should be mentioned that in manual galvanization, the process referred to as tampon galvanizing is known, used particularly for the processing, repair or improvement of larger components which cannot

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be processed or can be processed only with great difficulty in a galvanizing unit. Typical examples of this are the improvement or galvanization of metal church roofs, large monuments and the like. For details, reference is made to the publications of RUBINSTEIN in the journal *Galvanotechnik* ("Galvano-Technology") No. 73 (1982), pp. 120 ff; No. 79 (1988) pp. 2876 ff and pp. 3263 ff. Such a tampon process, however, can be used only for the aforementioned special cases, not for the industrial production of printed circuit boards with drillings and the like.

In a preferred design form of the invention, not only the transport speed of the processed items, but also the speed of the coated anodic device itself is used to achieve an intensive wiping effect. Depending on requirements and design, a great variety of effects and wiping speeds can be achieved.

The aforementioned relative speed may be low, e.g., almost approaching zero. Furthermore, in implementing the process according to the invention, pressure can be exercised by the wiping device on the items to be processed. In the presence of an elastic coating on the wiping device, the coating can be flattened or pressed. Apart from the fact that irregularities in the thickness of the items can be smoothed out in this way, this helps to reinforce the effect according to the invention of disrupting the diffusion layer. This is especially true for the disclosed combination of features.

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Further process measures promote the passage of the electrolyte through the drill holes and thus the metallization of the inner walls of the drill holes. Furthermore, they contribute to extracting from the drill holes particles or the like present therein.

The invention is also based on the object of creating an arrangement for the electrolytic processing of flat and perforated items, particularly of printed circuit boards provided with drill holes, which are taken by conveyor means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, which arrangement achieves flawless electrolytic processing, possible with simple means, of one or both surfaces of the items to be processed as well as of the drillings or drill holes (hereinafter called "drill holes") located therein. This is possible in particular with the process measures according to one or more of the process claims of the present invention.

To attain these objects and solve these problems, first of all, the arrangement has means for wiping the surface or surfaces of either cathodic items or anodic items, and also has means for conducting the electrolyte, in a flow roughly vertical to the plane of the items to be processed, through the drill holes of the latter (flooding means). This principle of the invention is to be realized in a structurally simple form, as

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will be seen in greater detail in the discussion which follows, particularly the discussion of the examples.

Wiping devices with the coating are an especially advantageous design form of the invention for mechanical wiping.

It is recommended that the coating be allowed to bear against the surface of the items to be processed with a certain pressure force. This is especially advantageous in processing conductor paths and drill holes, because the fluid in the drill holes has on its surfaces a certain surface tension that is disturbed by this wiping, thus clearing the way for ions, in order to form a metal layer (during galvanization) on the surfaces. Such a pressure force can, for example, be achieved through spring bearings of the wiping device, especially the aforementioned rollers.

Flat items are especially suitable for being conveyed between rollers. Rollers per se are known in their structure and their use in units for processing flat objects; however, they are known not in this form of wiping rollers according to the principle of the invention, but only as conveyor and guide rollers and as squeeze rolls for sealing. The rollers have the advantage of their simple and robust structure and insertion into a processing unit. In contrast to known conveyor rollers or pressure rollers, however, these wiping rollers with their coatings have the function of achieving the discussed mechanical wiping effect, i.e., their rotational speed deviates deliberately

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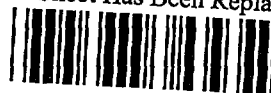
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from the transport speed of the items to be processed which bear against them. At the same time, these rollers can also be designed as a counter-electrode to the object to be processed. The aforementioned deviation in speed can be achieved by means of the respective values of the aforementioned speeds and/or their respective directions. At this point, it should also be noted that the aforementioned speed deviation and/or relative speed may be low, almost zero. Furthermore, reference is made in this context to the possible design of the invention according to Claims 23 and 43 as well as to the process measures according to Claims 10 and 11.

Furthermore, the wiping rollers with their coating can mechanically favor the carrying away of particles. This is especially true when the rollers are pressed with a certain pressure force onto the surface of the items to be processed. In this way, disruptive layers on the cathode, such as gas bubbles suspended on the surface, can also be removed.

Further preferred design forms for reinforcing the metallization of the inner wall of drill holes consist of means and devices for conveying the

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electrolyte through the drill holes (flooding) with appropriate overpressure or underpressure. Reference is made here to the flooding means and associated arrangements of Claims 27 and those following. In particular, an arrangement according to Claims 31 to 34 is advisable here.

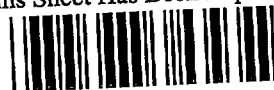
Further advantages and features of the invention are found in the other subclaims, as well as in the description which follows and in the accompanying drawings of possible designs according to the invention. The essentially schematic drawings show:

- Fig. 1 A depiction, partially in section, of the process according to the invention in principle;
- Fig. 2 A design for implementing the process or processes according to the invention, in front view and partially in section;
- Fig. 3 The side view associated with Fig. 2;
- Fig. 4 A top view of the conveyor device in Figs. 2 and 3;

Compared to Figs. 2 to 4, the following figures are drawn in larger scale.

- Fig. 5 The conveyor device according to Line V-V in Fig. 4, in section;
- Fig. 6 The Detail VI circled in Fig. 2, in enlarged scale and partially in section;
- Fig. 7 A first example

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- of the embodiment and arrangement of the wiping rollers;
- Fig. 8 A second example of the embodiment and arrangement of the wiping rollers and the flooding;
- Fig. 9 A third example of the embodiment and arrangement of the wiping rollers, also showing the supply and extraction of electrolytic fluid and the flooding;
- Fig. 10 A fourth example of the design and embodiment of wiping rollers, as well and the supply and extraction of electrolytic fluid and the flooding;
- Fig. 11 A fifth example of the embodiment and arrangement of wiping and carrying rollers and the supply of electrolytic fluid, as well as the flooding;
- Figs. 12, 13 A sixth and seventh example of the invention with wiping and flooding means;
- Fig. 14 An eighth example of the embodiment and arrangement of wiping and carrying rollers and the supply of electrolytic fluid, as well as the flooding;
- Fig. 15 A ninth example of the invention showing the design of the wiping rollers and an associated conduction of the electrolyte, as well as the flooding;
- Fig. 16 A further (tenth) example of the invention for achieving the flooding and

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wiping effect;

Fig. 17 A further (eleventh) example of the invention for achieving the flooding and wiping effect.

The diagram in Fig. 1 shows the principle of the invention. In schematic fashion, Fig. 1 shows the principle of the invention in the case of a cathodic item K with the area K1 to be treated and the wiping device W associated with this. This wiping device W has the anodic function. The aforementioned wiping device may be wiping rollers according to the examples below or may be another wiping device. In any case, the wiping process is carried out mechanically. This process may be carried out on a item conveyed through a series of treatment baths, i.e., essentially continuously, but it may also be carried out on an item which is introduced into one of the treatment stations or into a treatment bath and processed there. In the latter case, the wiping operation and the flooding operation explained below are discontinuous. In the case of a flat item, either one of its two surface or both of its surface can be wiped. At the same time, the electrolyte is conducted through the drill holes ("flooding"). The examples discussed below will make refer to details of the above sequence..

Figures 2 to 6 show the aforementioned main possibility for use of the invention, namely, a bath station of a galvanization unit that is designed according to the invention, including the conveyor means for the items to be processed. A series of such bath stations can be provided one behind the other, in order to allow processes to be carried out with various baths.

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The bath container 1 contains a bath liquid, not shown. An item to be processed which is introduced in the direction of the arrow 2 is conducted between guide rollers, conveyor rollers and the wiping rollers, which will be discussed in more detail below. The item can be transported and processed horizontally according to this example of the invention. After processing, the item emerges from the unit in the arrow direction 3. In the areas 4 and 5, only conveyor and/or guide rollers are present and shown, whereas in area 6, in addition to any conveyor and/or guide rollers, there are also wiping rollers according to the invention. The wiping rollers are explained in detail in reference to several examples in Figs. 6 to 12, whereby Section 6 in Fig. 3 corresponds to the examples in Figs. 7, 8 and 9.

The movement path for the items to be treated has the position and breadth designated in Fig. 2 as "a." In Fig. 2, the movement direction 2-3 runs vertical to the plane of projection. In this example, a conveyor device 7 is located next to the movement path of the items to be treated, which uses conveyor means in the form of a clamp 9 to grasp in clamping fashion a flat item 8 on a lateral edge 8' and move the item 8 in the movement direction 2-3. Such a conveyor device is the subject of DE-OS 36 23 481, to the disclosed contents of which reference is hereby made. However, the invention is not limited to the use of a conveyor device designed in this manner. This lateral grasp of the flat item by the clamps 9 has a special advantage, especially in conjunction with the discussed "flooding," i.e., pressing or drawing electrolyte through the drill holes of the item. During flooding, a corresponding pressure on the item arises in the flooding direction. The clamps with their firm lateral grasp on the item prevent

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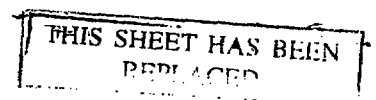


the board in question from being pushed by the flooding pressure. The aforementioned drill holes and the means for flooding are not shown in Figs. 2 to 6, for the sake of simplicity. Reference is again made to the examples which follow. A clamp 9, consisting of two clips 11, forms a conveyor means 10. All conveyor means are attached to a continuously rotating conveyor belt 12, 12', which rotates in the direction of the arrow 13 (see Fig. 4). When the conveyor means 10 are located on the side of the strand 12' (see Fig. 3) of the conveyor belt, then the clamps 9 are in the holding position (see the drawing of the left side of the conveyor device 7 in Fig. 2). As soon as the conveyor means 10 move out of the area of the strand 12' into the upper strand 12 in Fig. 4, the two clips 11 of the clamps 9 are pulled somewhat apart, so that a space exists between them (see the right side of the conveyor device 7 in Fig. 2). This conveyor device moves the items at a particular and if necessary adjustable speed in the direction 2-3.

Fig. 5 shows the conveyor device in detail. It can be seen that in the area of the strand 12, through the ascent of one of the clips 11 of a clamp onto a guide part 29, the associated clamps 9 are moved into the open position. In contrast, in the path area of the strand 12', such a guide part 29 is not present, and the clips of the clamps 9 lie, under the influence of a pressure spring, with corresponding clamping force at the edge 8' of the item (transport position).

Detail VI in Fig. 2, as well as Fig. 6, which depicts this detail, partially in section, show two wiping rollers 15, which are moved in opposite directions by a drive via a toothed gear 16, 17. For this purpose, there are two spur wheels 17, which sit on the axles 13, 14 of the wiping rollers 15 and mesh with one another. The anodic wiping rollers 15 are

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connected via contact disks 20 and current contacts 19 which slide thereon as well as by leads 18 to the positive pole of the current source. The cathodic item 8, shown here only partially, is connected to the negative pole of the current source (not shown). Each of the wiping rollers is, on its outer circumference, provided with a coating 31 of a material which absorbs and is permeated by the electrolyte and the metal ions of the electrolyte. This material should be elastic and have a certain softness, in order not to damage the surface of the items during the course of sliding along. The coating must be chemically resistive against the electrolyte. The material preferably used for this is a felt-type plastic, e.g., of polypropylene. Here the term "felt-type" refers not to the textile felt, but to a structure of interwoven components. Such materials are also known for use in filters. The coating may also consist of an open-pore plastic which has good liquid permeability and is friction-proof. This wiping coating should—as should wiping coatings of other materials—be elastic, so that during application to the surface to be wiped it compresses somewhat and then can return to its original form. The aforementioned permeability to fluids is at least necessary when, according to one of the following examples, the electrolyte is pressed from the roller interior through the coating to the outside, or is drawn in in the opposite direction.

While any drive rollers and/or guide rollers (see Number 3 and 4) which might be present have a rotational speed which corresponds in value and direction to the transport direction 2-3 and the transport speed of the conveyor means 10, the rotational speed and/or running direction of the wiping rollers is such that the circumference of the wiping rollers 15 moves relative to the respective surface of the transported items 8. In this way, a wiping effect is exercised on the surfaces of the items 8 along the entire length of the wiping rollers 15.

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The length of the wiping rollers 15 extends across the breadth of the items to be processed, which runs at a right angle to the transport direction, i.e., approximately the amount "a" in Fig. 2. However, an item of lesser breadth can also be processed, whereby a partial length of the wiping device 15 simply goes unused. The level of the electrolytic bath is indicated with a broken line by reference number 25, whereby the item to be processed as well as the wiping devices are located below the level in the bath fluid. This also holds true for the other examples. As the present example shows, it is advisable, or is as a rule necessary, to process an item according to the invention on both of its sides or surfaces, i.e., on the upper surface in Figs. 2, 3 and 6 as well as on the lower surface, as reflected by the arrangement of two wiping rollers 15, which bear against the respective surfaces of an item from above and from below. In cases in which only one of the surfaces of an item needs to be processed, then the use of one wiping roller suffices in principle. The fact that more than two wiping rollers can be used is illustrated by the examples in Figs. 7 to 15.

As a rule, a certain pressure force is recommended between the coatings 31 of the wiping rollers and the surfaces of the items to be processed, which pressure force, for example, can be applied by a spring 23 pressing in arrow direction 22 and indicated schematically in Fig. 6. In order to be able to process items of varying thickness, the upper roller of the wiping rollers 15 is mounted in a slot guide 24 and can therefore, when there is an increase in the thickness of the items to be processed, give way opposite to the arrow direction 22. The bath level 25 of the electrolyte is higher than the lower edge of the slot. Excess electrolyte can therefore run out through the slot guide 24 and a space 26 between the side wall of the bath container 1 and another externally located wall 27 according to arrow direction 28.

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The rotational speed and/or rotational direction of the anodic wiping rollers 15 at their contact points with items having a certain transport speed may be altered and adjusted to the desired value through a control of the drive unit of the wiping rollers. It is also possible to adjust the pressure force of the spring 23 or other pressure means. In this way, particular requirements can be matched with the goal of achieving the most extensive possible disruption of the diffusion layer on the surface of the items in which ion depletion usually occurs.

In the description which follows of examples according to the invention in the design and arrangement of wiping rollers 15 or wiping parts which act accordingly, only these components of the invention, including supply and extraction conduits for the electrolyte, are depicted and explained. Of course, this includes conveyor means for the items and drive means for the wiping parts as well as current feeds, which are depicted in Figs. 2 to 6, for example, and discussed above. In addition to the conveyor means described there, or instead of these conveyor means, it is also possible, for example, to provide conveyor rollers between every pair of wiping rollers, whereby the cathodic current feed occurs by means of loop contacts on an edge area of the items to be processed. If not already depicted in the drawing, the items to be processed has drill holes, and means are provided for "flooding" these drill holes, i.e., for passing the electrolyte through them.

Basically, the parts located in the electrolytic bath, such as the tube 30 and the expanded metal piece or wire screen 32 described below, must consist of a material which is not attacked in the bath under the electrolytic conditions. Suitable materials include, for example, titanium, titanium coated with platinum, noble metal, noble metal coating or

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noble metal oxides. This can be done, e.g., according to the example in Fig. 7, in such a way that wiping rollers in the form of metal tubes 30 are provided with the aforementioned felt-type coating 31 and an expanded metal piece 32 located therebetween, which positively connects the tube 30 and the coating 31. Instead of the preferred tubular expanded metal piece mentioned above, a preferred tubular wire screen that is welded at the wire crossing points can also be used or a perforated tube can be provided. In this example, the tube 30 constitutes an insoluble anode, which does not give off metal itself, but rather has emits only current. In this case, the metal to be deposited is located in the electrolyte. However, it is also possible to store the metal to be deposited as a soluble anode in the tube 30 or in another wiping element. When the items 8 are run through, the coatings 31 are somewhat compressed. The electrolyte is supplied according to the arrows 33. This can also be done under pressure. Here, too, the electrolyte passes through the drill holes (not shown) of the board to be processed. As will be mentioned later (at the end of the description), any feature or detail depicted in one of the examples may also be used in the other examples. This applies especially to the means for implementing the flooding of the drill holes 42 of the items to be processed. This example and the others show that the distance between the anode (here the titanium tube 31) and the cathode (identical to item 8) is very small, so that practically no scatterings occur.

The example in Fig. 8 resembles that in Fig. 7. However, Fig. 8 shows one of the possible designs for allowing the electrolyte to flow through drill holes 42 of the items to be processed. For this purpose, the tubes 30 are provided with perforations, which have several functions. First of all, the electrolyte is supplied in the tube interior 35 and passed along through the perforations 34 to the coating 31. Furthermore, the electrolyte is conducted from the interior of the tube 30 through the perforations 34 of the tube

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and the wiping coating to the drill holes 42 of the board 8; the electrolyte then flows through the latter and reaches the interior of the counter-roller in question, the tube 30 of which is likewise provided with perforations 34. The electrolyte in one tube can thereby be under pressure from a pump and the electrolyte in the counter-roller located on the other side of the items to be processed can be drawn out of the drill holes. In addition, the perforations 34 can also serve to ensure that the material of the coating 31 clings within them. In this preferred design, only the inner tube 30 and the outer coating 31 are provided. Instead of the tube 30 with the perforations 34, a tubular expanded metal piece or wire screen can also be used.

Of course, the wiping coating 31 surrounds the wiping roller 15 in question on its entire circumference. This is true for all examples that show wiping rollers. The wiping rollers are generally indicated by the reference number 15 and an associated arrow, regardless of their somewhat different embodiments.

In the example shown in Figs. 9 to 14, the structure of the wiping rollers is the same as in Fig. 7, [consisting] namely of an inner tube 30, an expanded metal piece or the like (see above) 32 and the coating 31 which surrounds the wiping roller and thus the tube 30 as well.

In the example shown in Fig. 9, the electrolyte is supplied by means of supply tubes 37 having perforations or slits 36, which are located above the free space 38 between two wiping rollers 15. After the electrolyte runs through the intermediate spaces 38, the drill holes 42 and the intermediate spaces (39) located thereunder, it is collected by collection containers 40 and conducted to a filter pump.

When an upper wiping roller and a lower wiping roller located opposite to one another are provided (for example, in the design according to Fig. 9, then, in alternating fashion, the upper

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wiping roller can be connected anodically and the wiping roller located under it can be connected as the cathode, and vice versa. Such a process and an associated arrangement are depicted and described in the older patent application P 41 06 333.3-45 of the applicant. Reference is hereby made to its disclosed contents.

The example in Fig. 10 also shows wiping rollers 15 in the design according to Fig. 7 during the processing of flat items 8, especially printed circuit boards, which are provided with drill holes 42. The electrolyte is conveyed with pressure through the slit 41 of a flow nozzle 63 upward (arrow 43) through the drill holes 42 located thereover and from here conveyed back by means of underpressure through the drill holes 42 (arrow 44) located near the flow nozzle 63. As this happens, a certain pool 45 of electrolyte (with the electrolytic surface 45') builds up above the items 8 to be processed, and this pool provides electrolyte to the coatings of the two wiping rollers located above the items 8, while the wiping rollers below the items 8 are moistened through the electrolytic flows 44 as well as through the electrolyte flowing across the edge of the flow nozzle top. The latter electrolyte achieves a high speed in the narrow gap between the items 8 and the flow nozzle, as the result of which lower pressure is created than exists in the electrolyte above the flat items. This difference in pressure causes the electrolyte to be drawn through the drill holes 42. Such a flow nozzle arrangement can be provided, alone or in combination with other means which facilitate "flooding" (see the other examples in this regard), in order to convey the electrolyte through the drill holes 42.

The means which can be used for the purpose of flooding according to the invention can also eliminate diffusion-poor layers in the drill holes 42, so that sufficient metal precipitation takes place on the inner walls of the drill holes. In addition, the wiping effect of the coatings of the wiping rollers

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on the upper and bottom sides of the items, disturbs the surface tension of the fluid columns located in the drill holes 42, thus supporting the desired effect. As mentioned earlier, the process measures and the means for wiping the surfaces of the flat items to be processed and for flooding the drill holes 42 of the flat items therefore work together functionally and synergistically.

The example in Fig. 11 is a variant of the example in Fig. 10. Here the left roller pair has an upper wiping roller 15 and a lower pressure roller 64, and the roller pair shown on the right has an upper pressure roller 64 and a lower wiping roller 15. The pressure rollers can function as conveyor rollers or support rollers, which accordingly bear with pressure against the items to be processed. Each of the anodic wiping rollers 15 wipes, in the sense of the invention, the surface of the item 8 which faces it and also wipes, at the same time, the end of the drill holes 42 which faces it. Furthermore, a flow nozzle 63 is also provided here, as in Fig. 10. A sequential galvanization of the drill holes 42 from alternating sides in the transport direction 2-3 is achieved. The aforementioned conveyor rollers 64, at least on the upper side of the item, are designed as rollers which extend across the entire breadth of the items or the treatment path, so that the electrolyte becomes blocked up on the items 8, while the conveyor rollers on the bottom side of the item may also consist of several disks arranged on one axis, between which the electrolyte can flow.

Figures 12 and 13 show further possibilities for the use of a flow nozzle 63. According to Fig. 12, two pairs of wiping rollers 15 are provided in front of or behind an arrangement which has the flow nozzle 63 with the anode 48 arranged therein. The electrolyte flow enters in direction 79 through a connection piece 65, passes through a pre-chamber 68 and a distribution mask 69 with perforations 66, flows (reference number 67)

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along the anodes 48 consisting of individual pieces, passes through the slot 41 and the nozzle area 70 as well as through the drill holes 42 of the items 8 downward (arrow 71) into the area below the items 8. In detail, reference is made here to the disclosed contents of DE-OS 39 16 693.7. These examples also involve flat and perforated items to be processed, preferably printed circuit boards.

Fig. 13 shows a design similar to the arrangement according to Fig. 12, and the same reference numbers are used. The difference is that in the object in Fig. 12 the electrolyte, after passing through the drill holes 42, flows freely downward, while in the object in Fig. 13, a suction segment 72 with the housing 75 is provided between this outflow 71 and the exit of the electrolyte from the drill holes 42. An underpressure is produced in this via the suction connection piece 73, so that the electrolyte, after passing a further anode 48, is drawn into the space 74 under low pressure and then is extracted from there through the connection piece 73. In connection with the object in Fig 13, reference is made to the disclosed contents of DE-OS 39 16 694.5.

In the examples in Figs. 10 to 13, the flow nozzle 63 extends across the entire breadth of the treatment items, i.e., the breadth "a" in the example from Fig. 2. The same applies for the space 68 (Fig. 12 and 13), in which the electrolytic fluid enters via a series of connection pieces 65 arranged one behind the other at a right angle to the items. In the example in Fig. 13, the suction segment 72 of the suction side extends likewise across the entire breadth "a." In these examples with the flow nozzle 63, it is thus ensured that, according to the invention, in addition to the surface treatment of the items 8 through the wiping roller 15, there occurs an intensive flowing through of the item drill holes 42 by the electrolyte, which in fact flows the entire breadth "a" of the work pieces conveyed in direction 2-3. This type of intensive electrolyte flow through the item drill holes 42

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and the correspondingly heavier deposit of metallization on the inner walls of these drill holes, in combination with the previously described galvanization of the surfaces of the items due to the wiping effect, would not be possible in the arrangement according to the prior art, in which the electrolytic flow is conducted at great speed parallel to and along the work piece surface. In this case, it would not be verifiable in terms of flow engineering that the electrolytic flow passed through the drill holes at a right angle to the flow direction.

The example in Fig. 14 contains a combination of the arrangement of wiping rollers and pressure rollers according to the example in Fig. 11, with a conduction of the electrolyte as in the example in Fig. 9. The same reference numbers are used as in Figs. 9 and 11. In addition, lower conduits 37' with exit openings 36' for the electrolyte are also provided, which convey the electrolyte upward from below.

The example in Fig. 15 shows a modification of the example in Fig. 15. The wiping rollers 15 here, analogous to the design discussed in reference to Fig. 8, consist of an inner tube 30 provided with perforations 34 or a tubular expanded metal piece or a tubular wire screen in which the wires are welded at their crossing points, as well as of the discussed coating 31. Within the tube 30 which encircles its axis 76, there is a non-rotating supply tube 77, into which the electrolyte is introduced in a manner not shown here; the electrolyte then emerges through passage openings (e.g. perforations) or passage slots 78 in the wall of the tube 77 which are arranged one behind the other in the longitudinal direction of the tube. Of course, the supply tube 77 with the passage openings or slits 78 extends across the entire length of the tube 30 and thus the entire breadth of the items 8 to be processed. The

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passage openings or slits 78 point with their inlets or outlets toward the movement path 2-3 of the items 8, so that the electrolyte flowing through these passage openings or slits 78 of the supply tube 77 emerges through the perforations (or corresponding slits) 34 of the tube 30 vertical to the items 8 onto the latter and passes through the drill holes 42. Thus the flow speed of the electrolyte through the perforations or slits 78 and the perforations 34 causes a corresponding vertical flow through the drill holes 42 of the boards 8 and therefore also causes improvement in the metal precipitation there. In this example, the electrolyte in the supply tube 77 may either be under pressure and pressed through the perforations or slits 78 and the drill holes 42, or else a lower pressure and thus a suction effect is produced in the interior of the tube 77, which draws the electrolyte through the drill holes 42 and the perforations or slits 78. In the latter case, any particles of the wiping coat that have gotten into the drill holes 42 can be removed and carried away via the tube 77 and later filtered out of the extracted electrolyte. Of course, in the example in Fig. 15 as well as in the other example, a series of holes 34 are distributed continuously around the circumference of the roller 30. The aforementioned tube 77 can be located in a wiping roller or above or under the items to be processed. Pressure rollers or disks 64 are also shown here, which rotate around the axis 64' and serve as support roller or transport rollers for the items 8 conveyed through.

Fig. 8 shows, schematically, above a flat item 8 provided with drill holes 42, e.g., a printed circuit board, a wiping roller 15 in the form of a flooding anode, which corresponds to the parts 30, 31, 77, 78 of the example in Fig. 15. These parts are only indicated here in schematic fashion. If a pressure of the electrolyte is formed in the supply tube 77, the electrolyte flows downward, according to the

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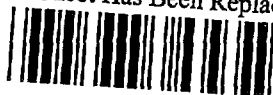


arrows, through the drill holes 42. If, on the other hand, an underpressure is created in the tube interior 77, then the electrolyte flows opposite to the indicated arrow direction. This example shows, as counter or pressure rollers, two counter rollers 48 driven in the arrow direction and thus also in the transport direction 3 of the board 8, which rollers leave such a broad space 60 free under the perforations or slits 78 of the supply pipe 77—and thus in the flow direction of the electrolyte—that the electrolyte can flow unobstructed between the counter rollers 48. Nonetheless, due to the arrangement of two counter rollers symmetrical to the wiping roller 15, even distribution of the pressure of the wiping roller 15 on the counter rollers 48 is ensured. These counter rollers are provided on their surface with insulation, or else they consist of plastic.

In longitudinal section, Fig. 17 shows the example of a flooding anode shown only schematically in Figs. 15 and 16 and identified by the reference numbers 30, 31, 77, 78. The same reference numbers are used as in Figs. 5, 6, 15 and 16. Reference is made to the associated descriptions of these figures. The flooding anode 30, 31, 77, 78 depicted in the upper area of Fig. 17 can be moved in the vertical direction against the pressure of springs 23 with its bearings and its drive shaft 49. This permits height compensation, so that boards 8 of varying thickness can be processed. The current feeds occur via clips 9, 11, which are connected to one pole of the rectifier and connect the latter to the items to be processed, as well as through loop contacts 50, which are connected to the other rectifier pole and connect the latter to the drive shaft 49 of the flooding anode.

Furthermore, there is a pressure or counter roller 51 consisting, at least on its surface, of a material that is not electrically conductive and provided at its circumference with drainage grooves 52, whereby these grooves

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form an angle, here an acute angle, with the longitudinal axis 53 of this roller 51. In this way, the electrolyte emerging downward from the drill holes 42 is conveyed away. In this case, as the arrows show, the electrolyte is conveyed through pressure in arrow direction 55 and, according to the arrows 54, is passed through the perforations or slits 78 and then through the drill holes 42 and conducted into the drainage grooves 52. Instead of this, it is also possible for suction to occur at the upper end 77' of the flood tube opposite to the direction of the arrow 55, by means of which the electrolyte is drawn upward from the drainage grooves 52 through the holes 78 and opposite to the arrow direction 54. The flooding anode is driven by its shaft 49 in a rotational direction (see arrow 57) opposite to the rotational direction (arrow 58) of the drive shaft 56 of the counter roller 51. The reference number 50 indicates a loop contact of the current supply to the drive shaft 49. The flooding anode is equipped at one end with inner and outer side slide bearings 59 and 59' for the 30 and the drive shaft 49, respectively. The aforementioned slide bearings 59, 59' are located on the circumference or on the inner diameter of a stationary bearing shell 79, which is held via a stay 80 on a frame of this arrangement not described in more detail and is conducted so as to be vertically movable in a recess 81 by a certain path segment.

In some cases, e.g., in the case of printed circuit boards, in which the drill hole walls are first coated only with a conductive layer that cannot tolerate larger current densities, lower current densities are to be used at the beginning in the first part of the processing section 6 (see Fig. 3). Once a sufficient metal layer has been deposited there, then, as items move through Section 6 in direction 2-3, the current density of the galvanization process is increased by measures that are known in themselves.

The process and the arrangement according to the invention are also suitable for the processing of flat items

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which are suspended vertically in treatment baths and remain there during the treatment. In this way, the invention provides not only for continuous runs of the items to be processed, but also for discontinuous operation, in which the items are placed in a station and undergo processing there. During this processing, wiping and flooding are carried out. Thus "periodic" wiping and flooding take place during the periods of the bath treatment in question.

All depicted and described features and their combination with one another are essential to the invention for different design forms. Features and details described in one of the examples can also be used analogously in other examples.

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Patent Claims

1. Process for the electrolytic processing of flat and perforated items, particularly in the form of printed circuit boards provided with drill holes, which are moved by transport means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, characterized by the fact that in the presence of an anode and cathodic items (K) to be processed or in the presence of anodic items to be processed and a cathode, the surface (K1) to be treated of the item is continuously mechanically wiped, and that the electrolyte is moved by a movement component which is substantially perpendicular to the plane of the item to be processed and is conveyed through the drillings or drill holes (42) of the latter.
2. Process for the electrolytic processing of flat and perforated items, especially of printed circuit boards provided with drill holes, which are moved by transport means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, especially as in Claim 1, characterized by the fact

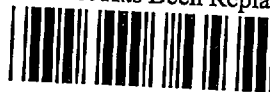




that a relative movement occurs between cathodic or anodic items to be processed (8) on the one hand and an anode-side or cathode-side mechanical wiping device (15; 46; 47; 53; 59) on the other, which, in order to disturb and at least partially destroy the diffusion layer, is brought to bear directly in a sliding fashion on the surface of the items to be processed, and that the electrolyte is moved with a component which is substantially perpendicular to the plane of the items to be processed and is conveyed through the drill holes (42) of the latter.

3. Process as in Claim 2, characterized by the fact that the aforementioned relative movement is created by a transport movement (2-3) of the cathodic or anodic item to be processed (8) to the anode-side or cathode-side wiping device (15; 46; 47; 53; 59).
4. Process as in Claim 2 or 3, characterized by the fact that the movement of the cathodic items to be processed (8) occurs relative to an anode-side wiping device (15; 46; 47; 53; 59), which has a coating (31; 54; 61) of a material that absorbs the electrolyte and allows it to permeate, and that for the purpose of disturbing, and at least reducing, the diffusion layer, the coating is brought directly to bear in a sliding fashion on the surface of the items to be processed, while in order to reduce the diffusion layer in the drill holes of the items, the electrolyte is at the same time moved by a movement component which is substantially perpendicular to the plane of the item to be processed

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and conveyed through the drill holes (42) of the latter.

5. Process as in one of the Claims 1 to 4, characterized by the fact that either one surface or both surfaces of a flat item are wiped.
6. Process as in one of the Claims 2 to 5, characterized by the fact that the anode-side wiping device (15; 46; 47; 53; 59) has, at its point or surface which bears on the surface of the items to be processed (8), a movement of its own, which deviates from the transport movement in value and/or direction.
7. Process as in one of the Claims 1 to 6, characterized by the fact that in the case of a two-sided treatment of the items (8) to be processed, the speed of the latter relative to the wiping device on one its surfaces is opposite to its speed relative to the wiping device on its other surface.
8. Process as in one of the Claims 2 to 6, characterized by the fact that in the case of a two-sided treatment of the item to be processed (8), the relative speed of the latter to that of the wiping devices is the same on both of its surfaces.
9. Process as in one of the Claims 2 to 8, characterized by the fact that the relative speed between the items to be processed and

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the wiping device is small, in particular, approaching almost to zero.

10. Process as in one of the Claims 1 to 9, characterized by the fact that the wiping device exercises pressure on the items to be processed.
11. Process as in one of the Claims 4 to 10, characterized by the fact that in the presence of a resilient coating of the wiping device the coating is flattened or pressed.
12. Process as in one of the Claims 1 to 11, characterized by the fact that during the course of the movement (2-3) of the items (8) to be processed through the treatment line, the current density of the galvanizing current is increased.
13. Process as in one of the Claims 1 to 12, characterized by the fact that the electrolyte is conducted through the drill holes (42) with pressure.
14. Process as in one of the Claims 1 to 13, characterized by the fact that the electrolyte is drawn out from the drill holes (42) by means of underpressure.
15. Process as in one of the Claims 1 to 14, characterized by the fact that the wiping of the surface and the conducting of the electrolyte through the drill holes occurs below the bath level (25) and thus within the bath fluid.

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16. Arrangement for the electrolytic processing of flat and perforated items, especially of printed circuit board provided with drill holes, which are moved by transport means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, especially for carrying out the process according to one or more of the Claims 1 to 15, characterized by the fact that means (W) for wiping the surface or the surfaces either of cathodic items to be processed (K) or anodic items to be processed and further means for conveying the electrolyte in a flow which runs substantially perpendicular to the plane of the treatment items (8) through the drill holes (42) of the latter are provided.
17. Arrangement as in Claim 16, characterized by the fact that for the application of metal, the wiping device is provided on the anode.
18. Arrangement as in Claim 16 or 17, characterized by the fact that the anode-side or cathode-side wiping device (15; 46; 47; 53; 59) is provided with a coating (31) and bear against the surface of the cathodic or anodic item to be processed (8) at least during a relative movement between the item to be processed and the wiping device.

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19. Arrangement as in Claim 18, characterized by the fact that the wiping device or multiple wiping devices is or are extended across the entire breadth, running roughly at a right angle to the transport direction or the circumference of the transported items to be processed and that at least the items to be processed are movable relative to a wiping device.
20. Arrangement as in one of the Claims 16 to 19, characterized by the fact that the coating (31) bears against the surface of the item (8) to be processed with an adjustable pressure force.
21. Arrangement as in one of the Claims 16 to 20, characterized by the fact that the coating (31) consists of a material, especially a plastic, which is chemically resistive against the electrolyte.
22. Arrangement as in Claim 21, characterized by the fact that the coating consists of an open-pore plastic that is liquid-permeable and abrasion-proof.
23. Arrangement as in Claim 21 or 22, characterized by the fact that the coating (31) consists of an elastic material.
24. Arrangement as in one of the Claims 16 to 23, characterized by the fact that the wiping device consists of at least one wiping roller (15), the circumference of which has the coating (31), that there is a drive for rotating at least one wiping roller, the rotational direction

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and/or circumferential speed of which is selectable in order to produce a relative speed between the bearing-point or bearing surface of the wiping device and the surface of the item (8) to be processed.

25. Arrangement as in Claim 24, characterized by the fact that the wiping roller or the wiping rollers (15) consist(s) of a perforated metal tube (30) or an expanded metal tube or wire screen tube and a cylindrical coating (31) surrounds the wiping roller, whereby the supply or extraction of the electrolyte occurs inside the tube, expanded metal tube or wire screen tube.
26. Arrangement as in Claim 24, characterized by the fact that the wiping roller or the wiping rollers consist(s) of a metal tube and a cylindrical coating (31) surrounding the wiping roller, whereby the coating and the tube are held to one another by expanded metal (32) or a wire screen located between them, and that the supply of electrolyte runs from a point (33) outside the wiping roller or wiping rollers to the drillings (42) of the item (8) to be processed.
27. Arrangement as in one of the Claims 24 to 26, characterized by the fact that, opposite to a wiping roller (15) with flooding means which bears against one surface of the item to be processed, there is a pressure roller (64) which bears against on the other surface.
28. Arrangement as in Claim 27, characterized by the fact that in the case of two-sided galvanization of the

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item to be processed, pairs of opposing rollers are arranged one behind the other in the processing direction (3), whereby, in alternating fashion, in the case of one pair a wiping roller (15) with flooding means is provided above the item (8) to be processed and a pressure roller (64) is provided below the item (8) and in the case of the next pair, a wiping roller with flooding means is provided below the item (8) to be processed and a pressure roller is provided above the item (8).

29. Arrangement as in one of the Claims 24 to 26, characterized by the fact that there is at least one pair of opposing wiping rollers, whereby one of the rollers is located above the item (8) to be processed and the other roller is located below the item (8) and the flow direction of the electrolyte is the same for both wiping rollers.
30. Arrangement as in one of the Claims 24 to 29, characterized by the fact that a conduction of the electrolyte exists in the interior of the tube (30) of a wiping roller and a passage of the electrolyte exists between the tube interior, its wall and the coating (31) surrounding the .
31. Arrangement as in Claim 30, characterized by the fact that a series of passage openings (34) is provided in the tube wall.
32. Arrangement as in one of the Claims 24 to 31, characterized by the fact that inside of the rotating tube (30) provided with passage openings (34) for the electrolyte, there is a supply tube (77) conducting the electrolyte with

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passage openings or slits (78), whereby the passage openings or slits (78) point with their passage end areas toward the movement path (2-3) of the items (8) to be processed, and that the supply tube (77) extends, as does the rotating tube (30), across the entire breadth (a) of the path of the item to be processed.

33. Arrangement as in Claim 32, characterized by the fact that the passage opening or slits (78) of the supply tube (77) are located at close as possible to the item (8) to be processed.
34. Arrangement as in Claim 32 or 33, characterized by the fact that the supply tube (77) is arranged in the tube (30) in a non-rotating fashion.
35. Arrangement as in one of the Claims 32 or 34, characterized by the fact that the rotating tube (30), together with the supply tube (77) located therein, is mounted so as to be movable substantially perpendicular to the plane of the item (8) to be processed.
36. Arrangement as in one of the Claims 24 to 35, characterized by the fact that for the supply of the electrolyte into the areas (38, 39), one or more tubes (37) with openings (36) for the electrolyte is or are arranged between two wiping rollers (15), and that collection devices (40) for the electrolyte are provided below the areas (38, 39).
37. Arrangement as in one of the Claims 16 to 36, characterized by the fact that pressure-producing

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means are provided for the supply of the electrolyte to the drill holes (42) of the items to be processed.

38. Arrangement as in one of the Claims 16 to 37, characterized by the fact that means for drawing the electrolyte out of the drill holes (42) of the item to be processed are provided.
39. Arrangement as in Claim 37 or 38, characterized by the fact that for the galvanization of items (8) with drill holes, there is a flow nozzle (63) which presses the electrolyte through drill holes (42) located in the area of the flow nozzle opening or slot (41), while the backflow of the electrolyte through other drill holes (42) occurs in the edge area of the flow nozzle with the help of a underpressure that exists on the underside of the item to be processed, whereby the flow nozzle extends across the entire breadth of the item (8) to be processed.
40. Arrangement as in Claim 39, characterized by the fact that anodes (48) are located within the flow nozzle (63) and specifically are located preferably within a pre-chamber (68) surrounded by a housing, to which the electrolyte is supplied (65).
41. Arrangement as in Claim 39 or 40, characterized by the fact that, on the exit side of the drill holes (42) to which the electrolyte is conducted with pressure by the flow nozzle (63), there is a suction device, the housing (75) of which is under an underpressure and extends

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across the entire breadth (a) of the items to be processed.

42. Arrangement as in one of the Claims 16 to 35, 37 to 41, characterized by the fact that lower tubes (37') which convey the electrolyte from the bottom upward are provided with passage openings (36').
43. Arrangement as in one of the Claims 16 to 42, characterized by the fact that the wiping device or wiping devices lies or lie under spring force (23, 55) on the respective surface of the item to be processed.
44. Arrangement as in one of the Claims 16 to 43, characterized by the fact that the items (8) to be processed lie in the horizontal position in the treatment station and are conveyed in the horizontal position.
45. Arrangement as in Claim 44, characterized by the fact that in order to convey the item to be processed in the horizontal position, transport means (10) are provided, preferably clips (9) which fasten on at least one of its side edges (8').
46. Arrangement as in one of the Claims 16 to 45, characterized by the fact that the pressure rollers (51) located opposite to a wiping roller (15) in the form of a flooding roller (30, 31, 77, 78) are provided with drainage grooves (52), which serve for the extraction of the electrolyte.
47. Arrangement as in one of the Claims 16 to 45, characterized by the fact that the wiping

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and flooding rollers (15; 31, 77, 78) are mounted on the other side of the item to be processed opposite to two counter rollers (48) and are positioned in such a way that a flow-through space (60) is formed between them for the electrolyte, which is either pressed through pressure from the flooding roller into the drill holes (42) of the item to be processed or drawn through the drill holes (42) into the flooding roller.

48. Arrangement as in one of the Claims 16 to 47, characterized by the fact that the thickness of the coating (31) is relatively slight, preferably 1-4 mm.
49. Arrangement as in one of the Claims 16 to 48, characterized by the fact that various wiping devices are provided in combination with one another for the electrolytic processing of the same items.
50. Arrangement for carrying out the process according to one of the Claims 1 to 15, characterized by individual or all new features or combinations of the disclosed features.

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Method of Electrolytically Treating in particular Flat
Material for Treatment, and Apparatus, particularly for
carrying out the Process.

5 Abstract:

The invention relates to a method of electrolytically treating plate-shaped material for treatment provided with holes, particularly in the form of printed circuit boards provided with boreholes, which is passed by transport means
10 through a treatment bath, or is passed to a treatment station, means being provided for reducing the diffusion zone depleted in ions which is situated in front of the surface of the material for treatment. The object is achieved in that, when an anode and a cathodic material for
15 treatment (K) are present. or in the presence of a cathode and of an anodic material for treatment, the surface (K) of the material for treatment is continuously and mechanically wiped, and in that the electrolyte moves with a component of movement substantially perpendicular to the plane of the
20 material for treatment, and is passed through the holes or boreholes (42) therein.

Further described is an apparatus for carrying out the method, which includes means (W) for wiping the surfaces of

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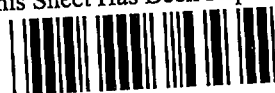


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the material for treatment, and means for moving the electrolyte through the boreholes therein.

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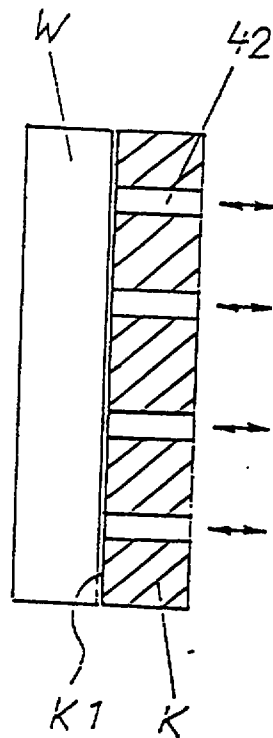
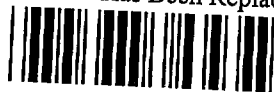


Fig. 1

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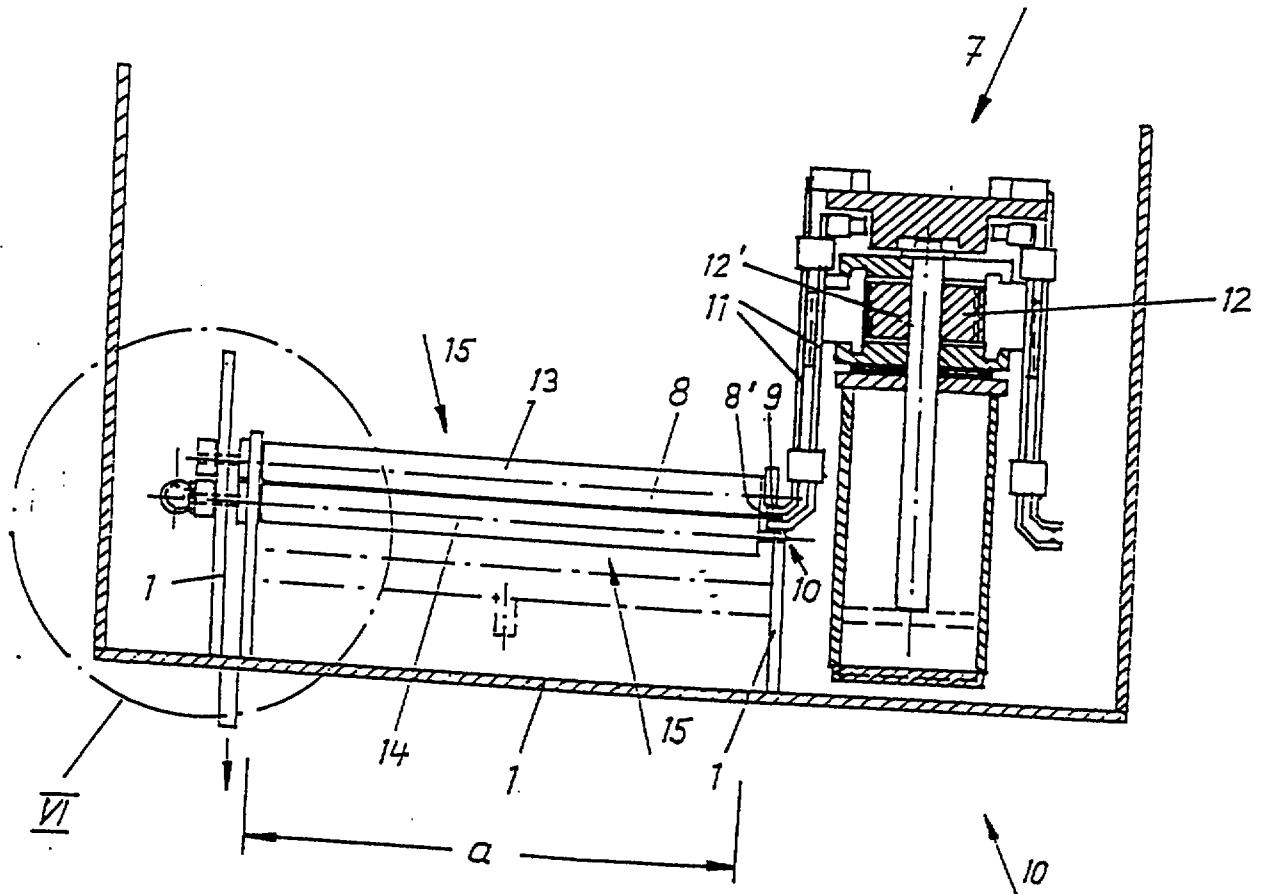


Fig. 2

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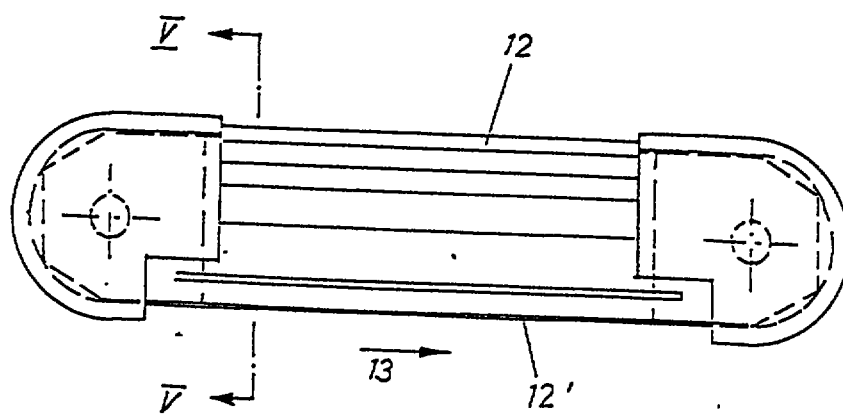


Fig. 4

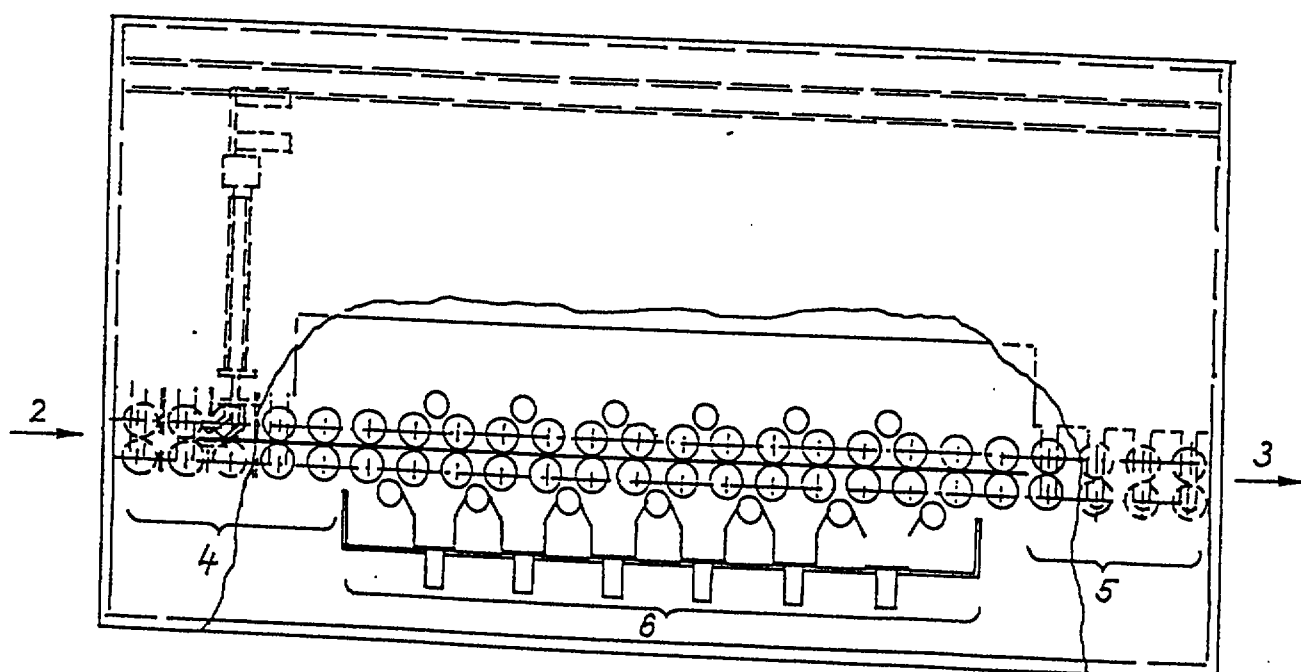


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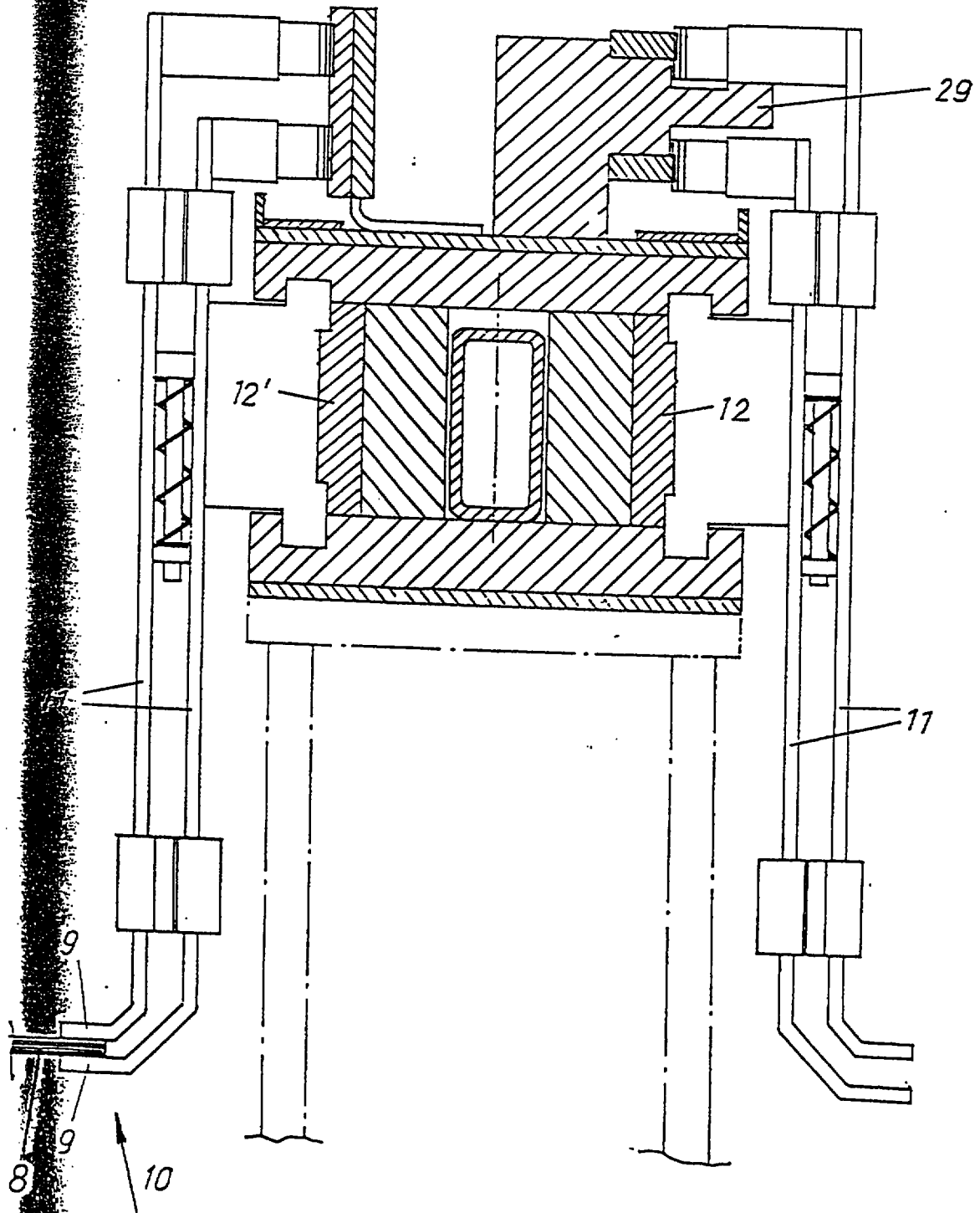


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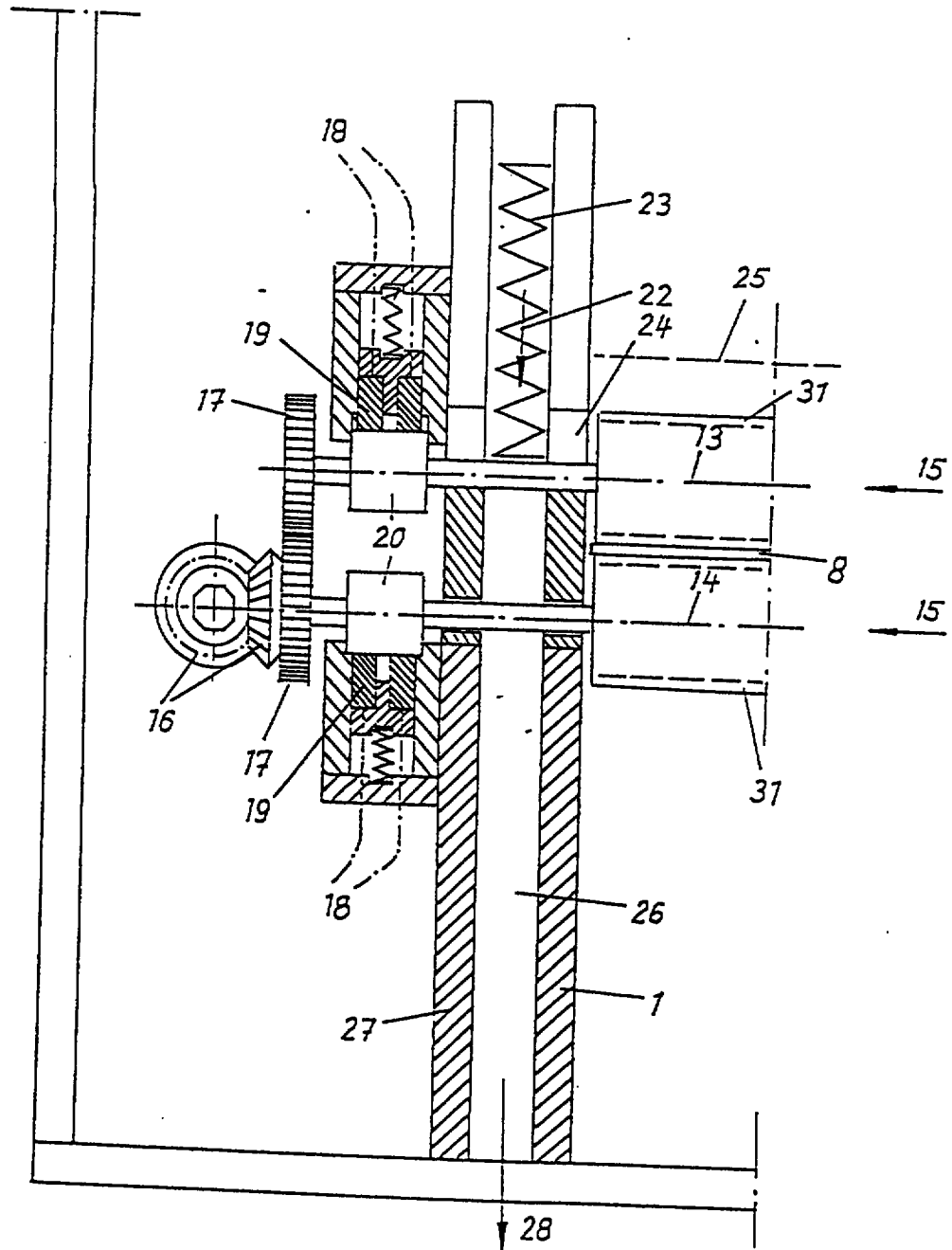
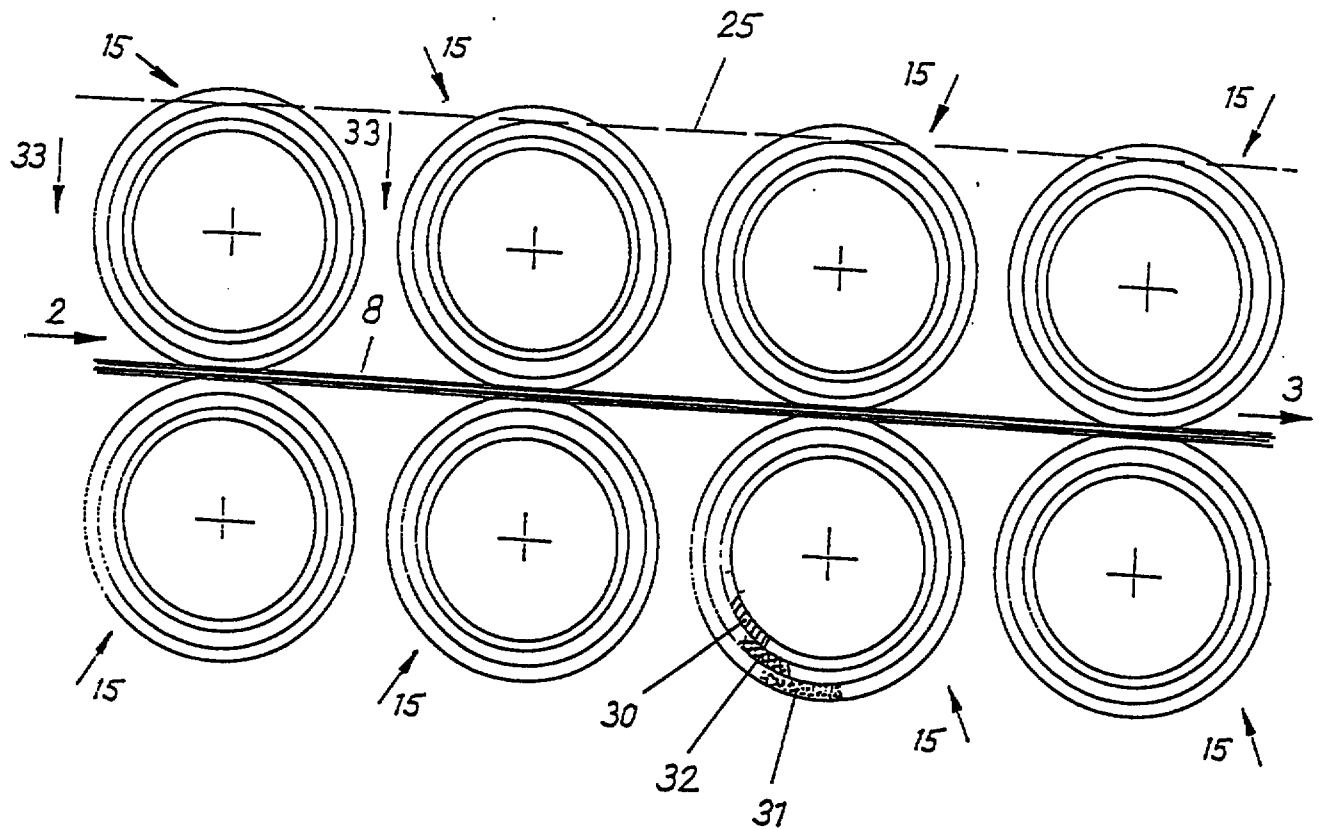


Fig. 6

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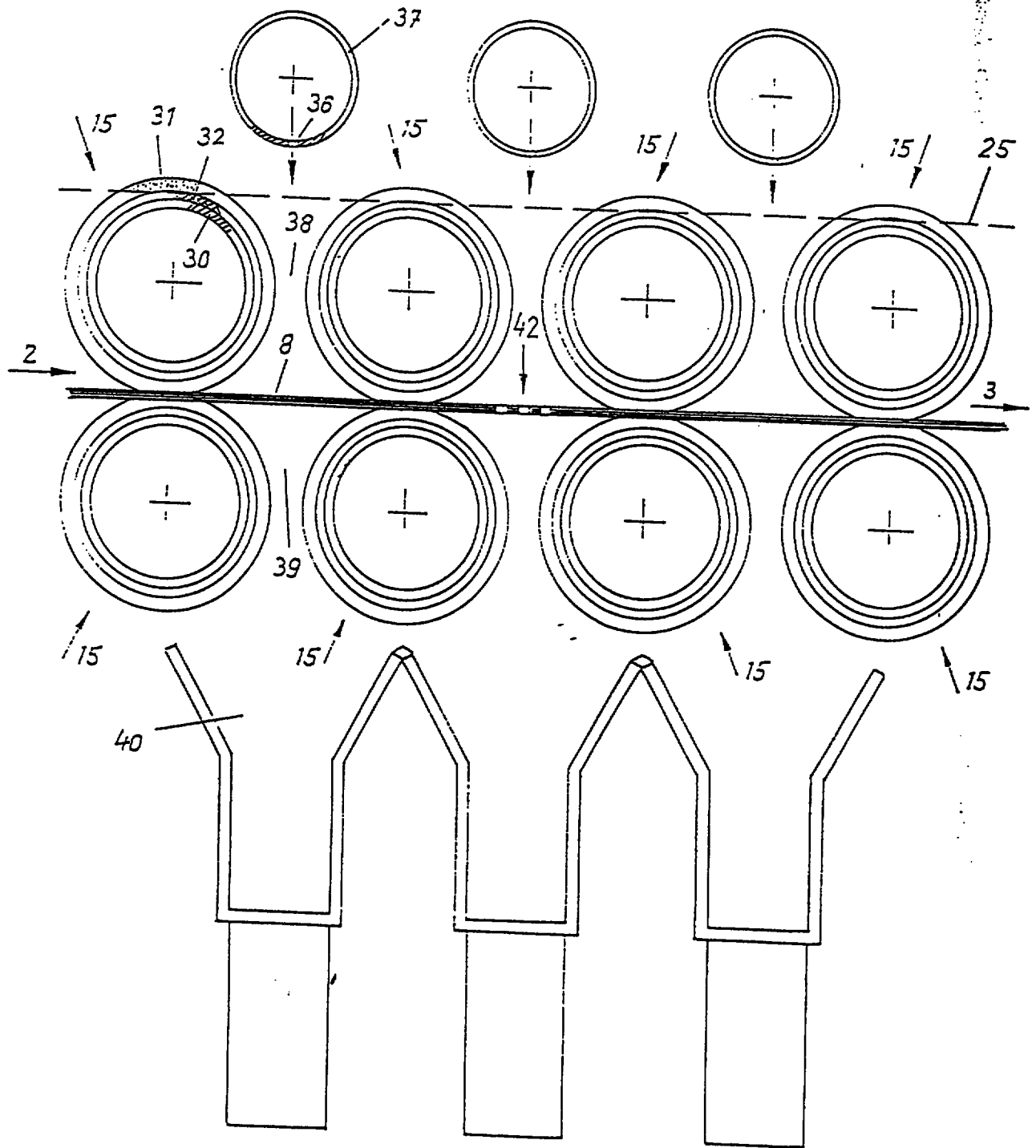


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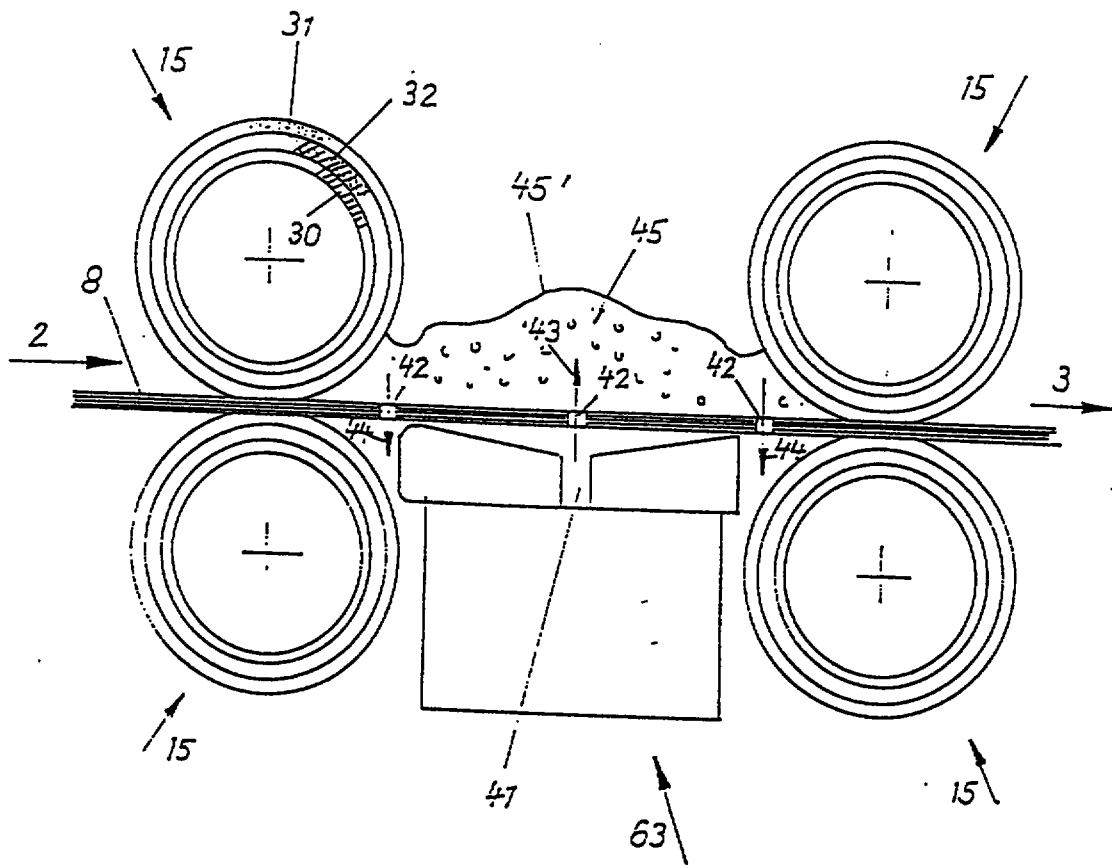


Fig. 10

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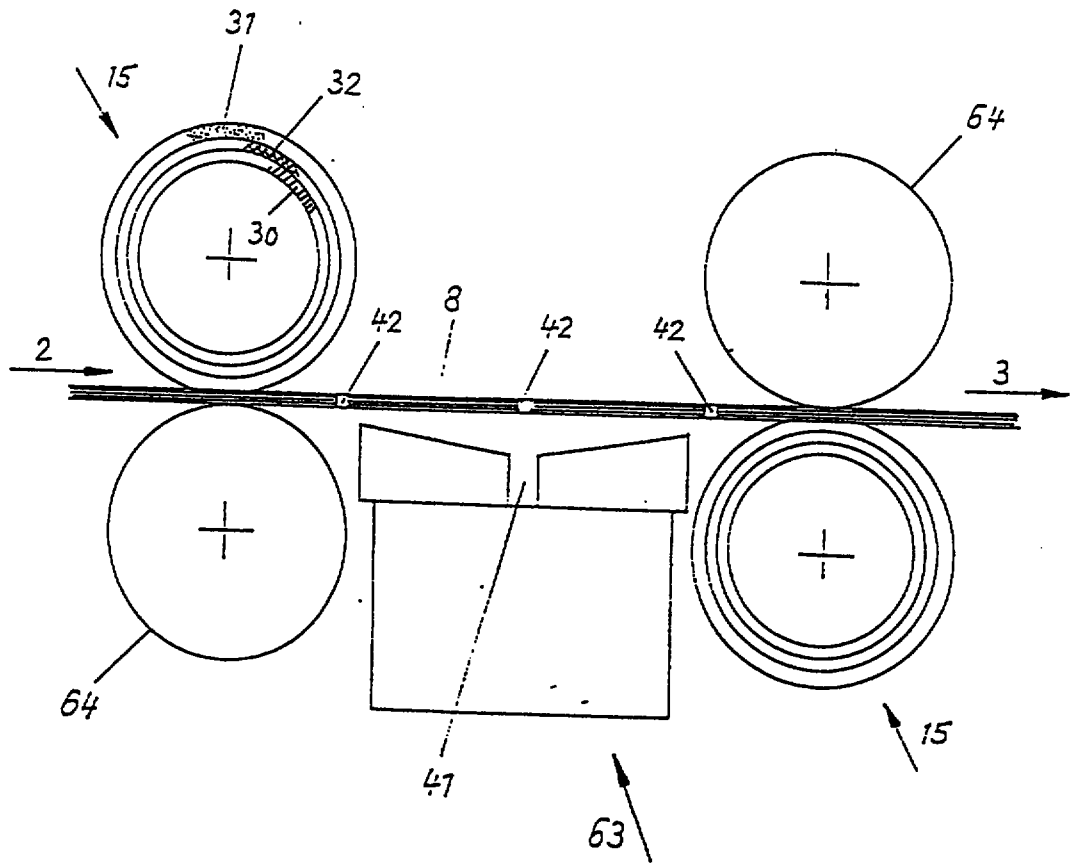


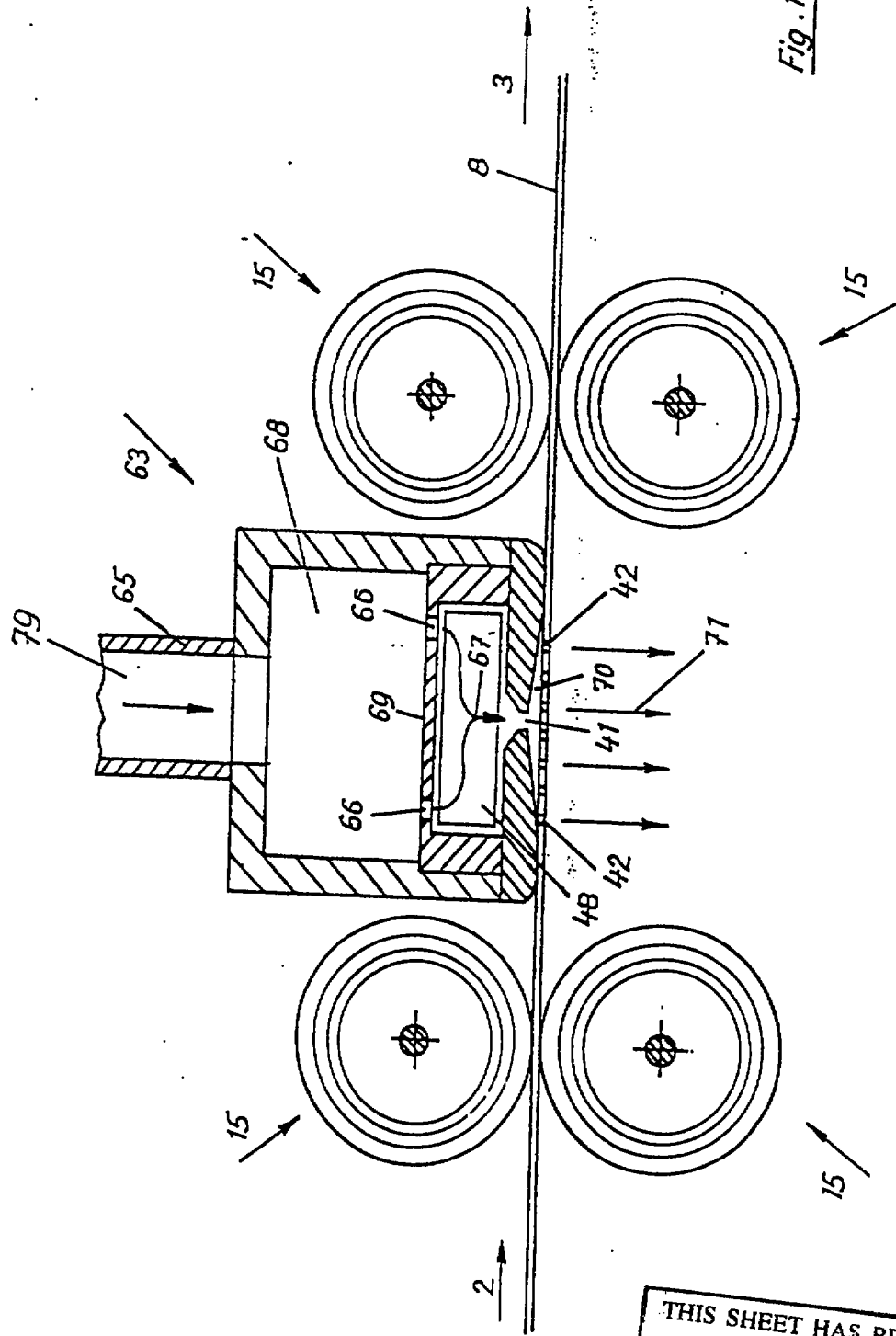
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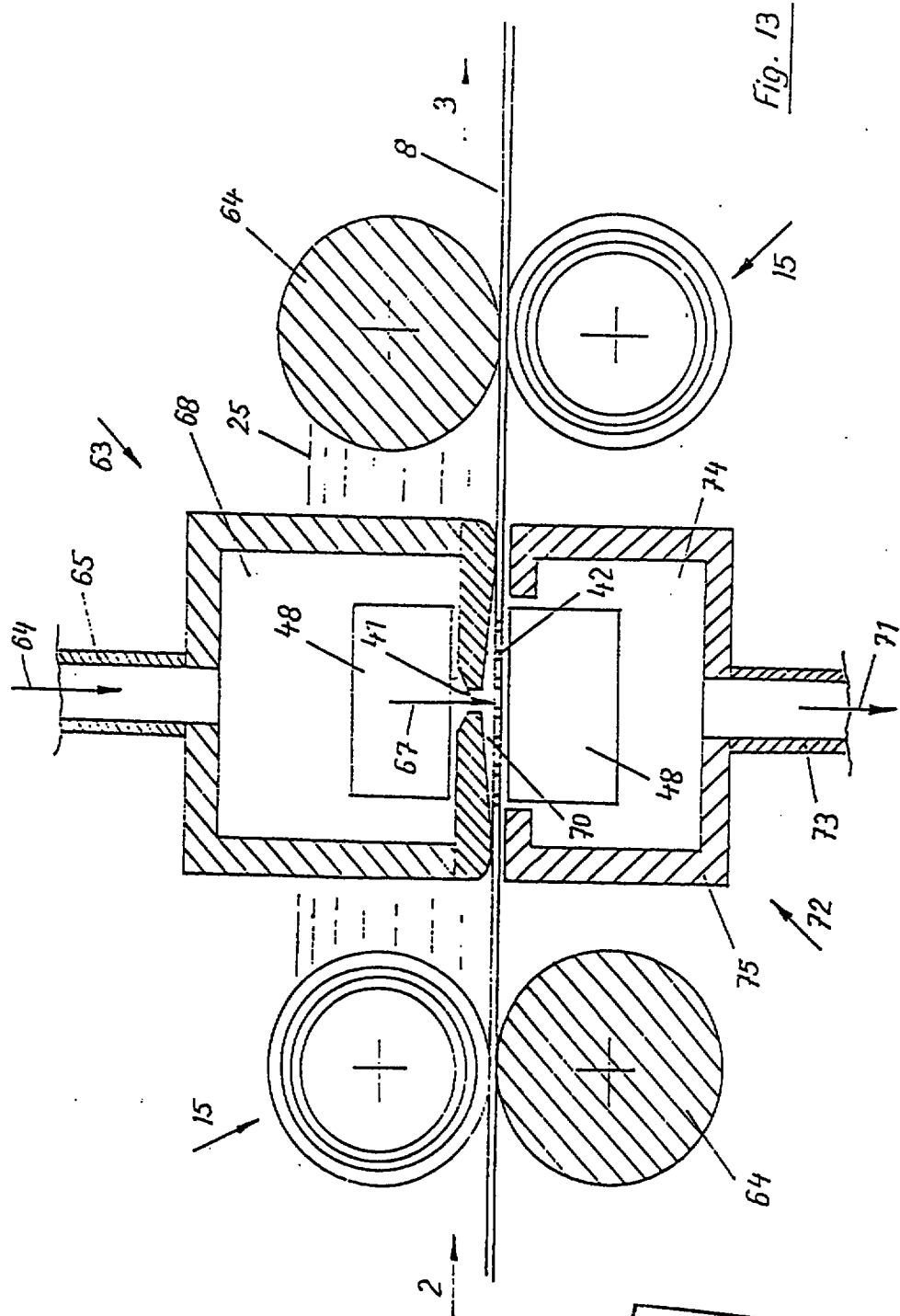
Fig. 12



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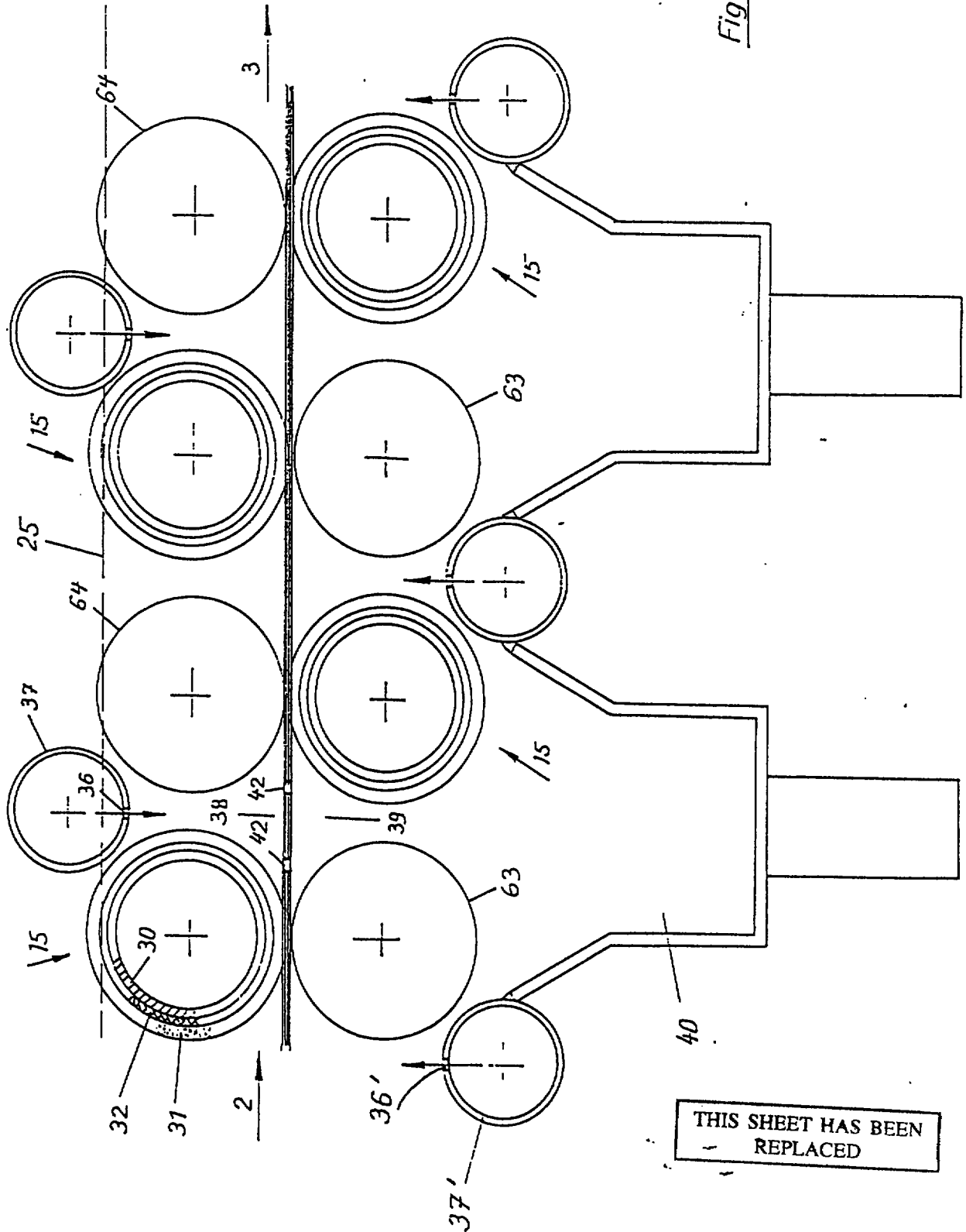




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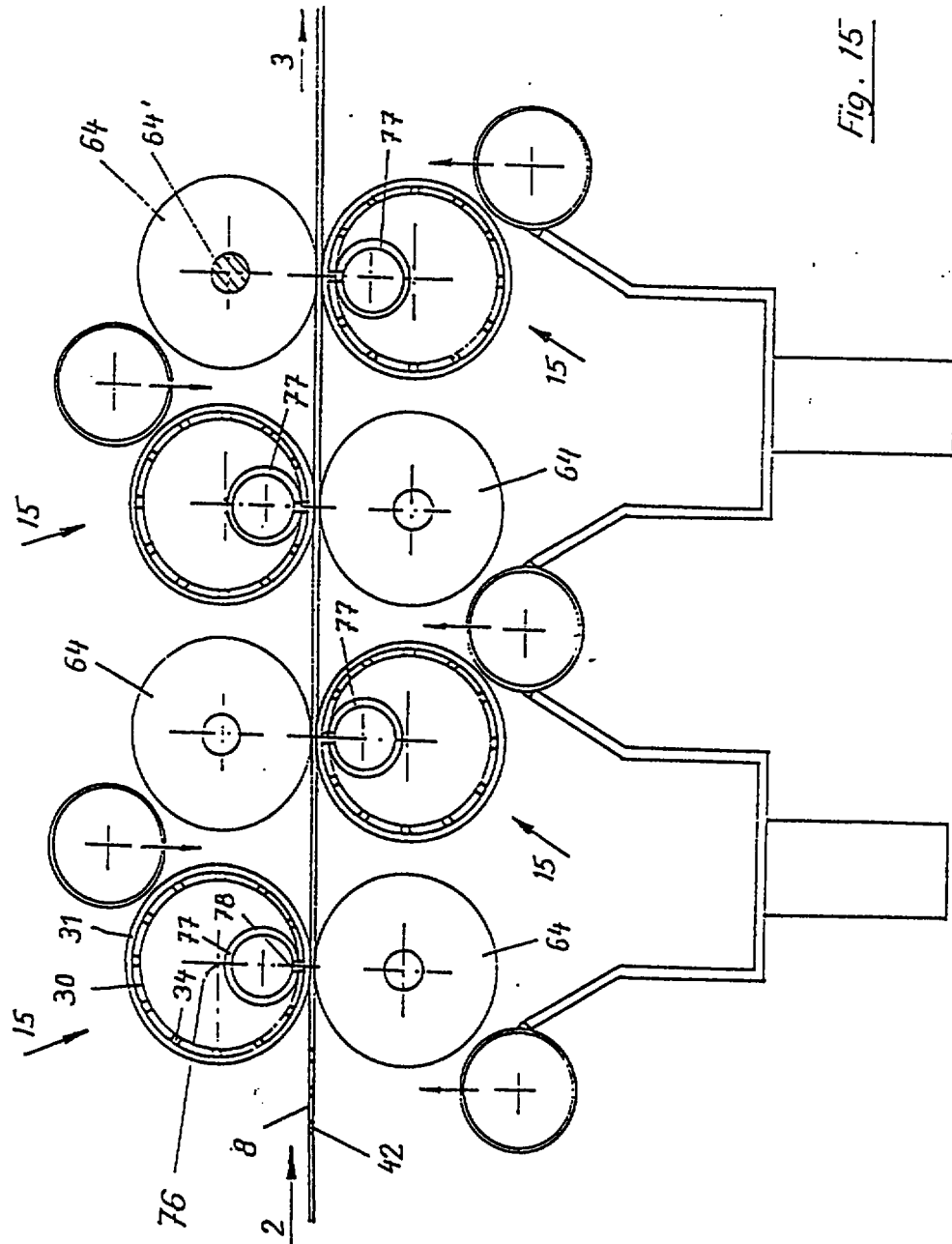


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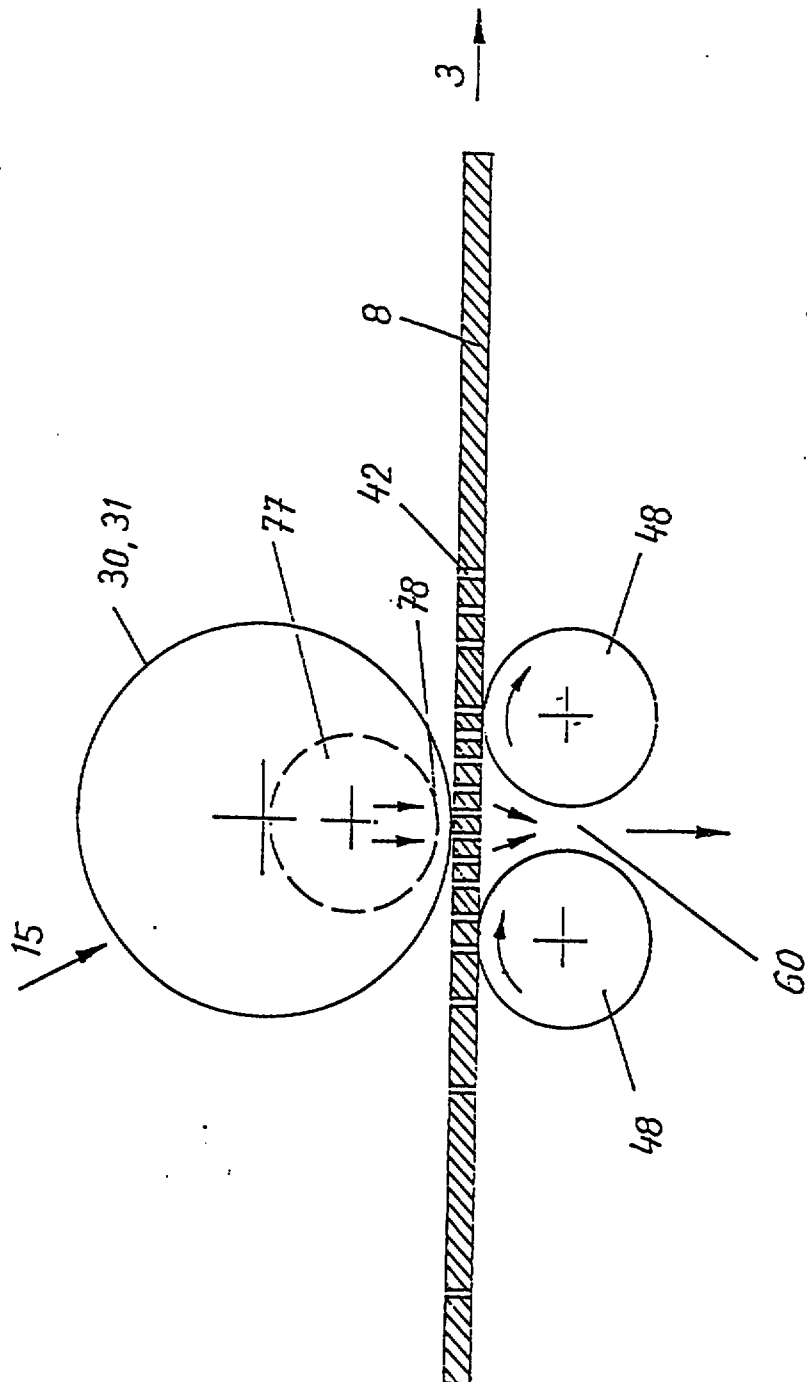
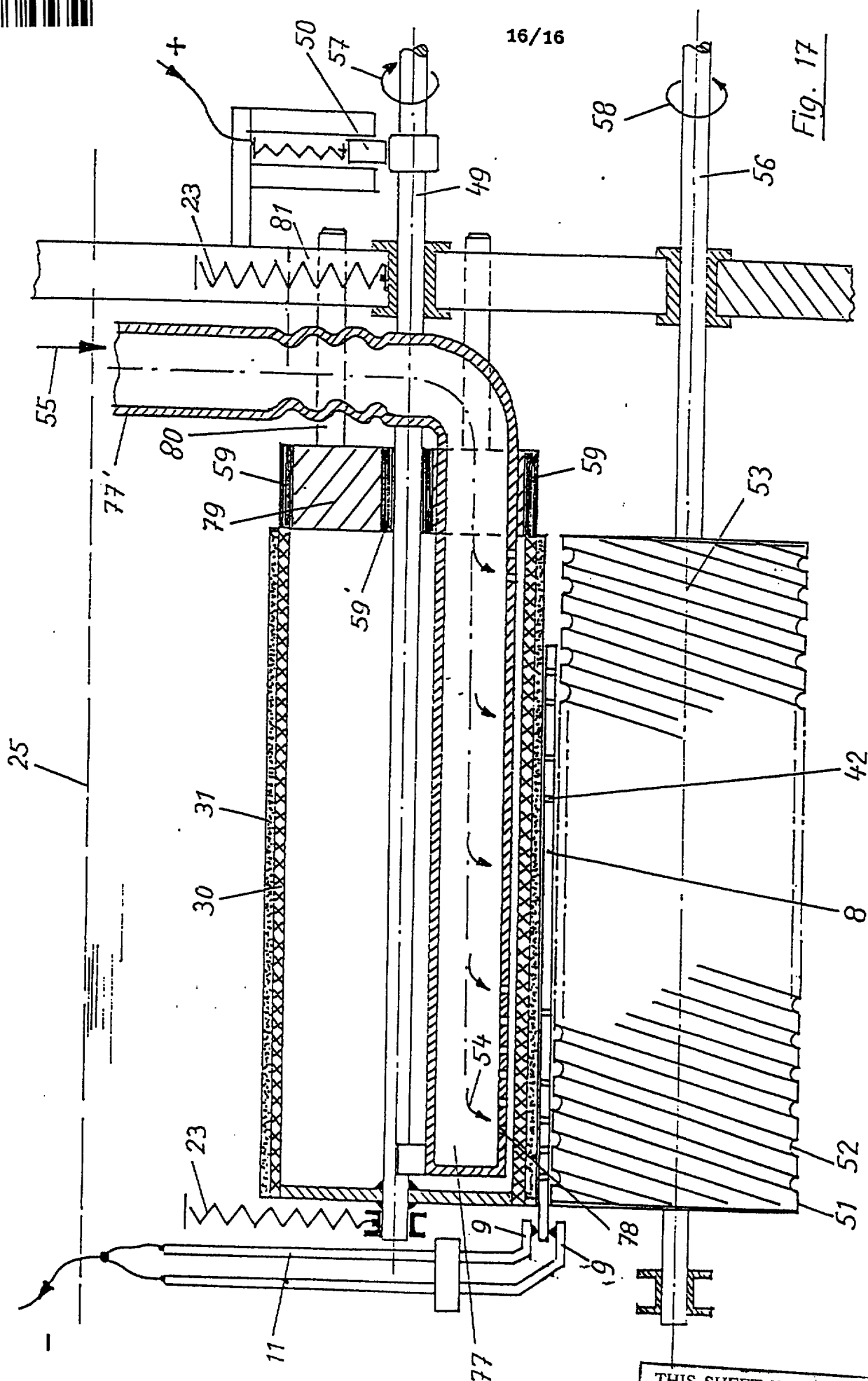


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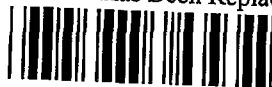
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Process for the Electrolytic Processing Especially of Flat Items and Arrangement for
Implementing the Process

The invention relates, first, to a process for the electrolytic processing of flat and perforated items, especially in the form of printed circuit boards with drillings, which are taken through a treatment bath or to a processing station by conveyor means, in which there are means for reducing the thickness of a metal-ion-depleted region (diffusion zone), which are in contact with the items to be processed. The preferred area of use for the invention is galvanization, which will be discussed in more detail below. The invention can also be used in electrolytic etching.

The surface of the items to be processed or their diffusion layer becomes depleted of metal ions in a disadvantageous manner

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during processing, because the cathode draws more ions to it than usually come out of the surrounding treatment bath. This leads to a reduction in the acceptable specific current density, and thus means that in order to achieve such a metal coating having a particular thickness, a correspondingly long treatment time is needed.

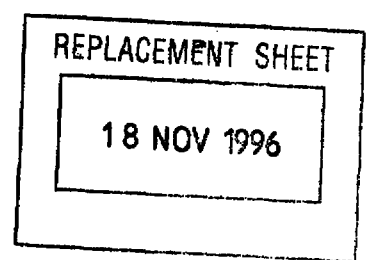
In order to overcome this disadvantage, the so-called "high-speed" process can be used, in which the electrolyte is conducted at great speed and in great quantity along the cathodic surface between this surface and the anode (see European Patent 0 142 010 and German Patent 35 25 183, for example). It is true that using this process, an improved, i.e. increased, current density of the metal coating on the cathodic item is achieved. However, the production, control and discharge of such an electrolytic current is relatively expensive. The creation of the flow channels necessary for this requires added constructive expenditures. In addition, the manner of conveying the items to be processed can be complicated. For these reasons, it has become known only for continuous items to be processed, such as bands or wires.

From DE-OS 36 03 856, a process and a device for galvanizing flat items such as printed circuit boards are known. The flat items are grasped and transported by a roller pair rotating at a relatively slow rotational speed and cathodically connected. The electrolyte is applied to the item by an anodically connected roller pair, the surface of which can absorb fluid. A small

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distance is deliberately maintained between the surface of the item and the surface of the anodic rollers. The rotational speed of the anodic rollers is relatively high, in order to attain a correspondingly fast electrolytic movement along the surface of the item. In this way, an increase in current density is achieved, compared to conventional immersion bath galvanization. Thus rotating, insoluble roller pairs as anodes are described. The metal is supplied in soluble fashion via the electrolyte. The anodic roller pairs are not located below the level of the bath; therefore the electrolyte must continuously be applied to the galvanization location. The quantity of supplied electrolyte is limited, not least of all due to the close plastic screenings over the rollers. This also limits the possible galvanization current density. The plastic screenings are needed, however, in order to delay an undesired galvanization of the other, cathodically-connected roller pairs, which serve to transport the circuit boards.

Because the rotating anodic roller pairs do not touch the upper sides of the circuit boards, the diffusion layer located on the surface is not mechanically disturbed. However, the space between the anodic roller and the upper side of the circuit boards and thus the space between the pairs themselves is needed, to allow the galvanizing currents for the two sides of the circuit boards to be individually set. During galvanization of the conductor path image, this is always necessary, because the two sides of the circuit board, in practice, have uneven copper areas. For this reason, the anodes of the upper side of the circuit board are fed from one bath current rectifier and the anodes of the bottom side are fed from a

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different rectifier. Each rectifier can be individually set in respect to current.

Another disadvantage of the aforementioned invention is the very poor flow through fine holes in the printed circuit boards. On board sides located opposite to one another, electrolyte is applied in a small quantity in an almost pressure-free manner. This prevents the flow from going through the holes, resulting in inadequate galvanization of the hole walls even to the point of burns in the holes.

The invention is based on the problem of designing a generic process so as to achieve the desired reduction in thickness of the ion-depleted border layer on the anode surface or cathode surface (diffusion layer), and to thus attain a correspondingly increased current density of the galvanization current flowing from the electrolyte onto the anodic or cathodic item, while avoiding, however, the constructive and process-related expenses of the so-called "high-speed" flow technique.

This problem is solved and this object attained, first, starting from the generic prior art, in that in the presence of an anode and cathodic items to be processed, or in the presence of anodic items to be processed and a cathode, the surface to be treated of the items is wiped continuously by machine and the electrolyte is conveyed by a component vertical to the plane of the items and is passed through the drillings or drill holes (referred to hereinafter for the sake of simplicity as "drill holes") of the items.

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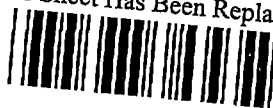
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This wiping of the area or areas in question serves, in a simple, advantageous and industrially implementable manner, to counteract the disadvantageous depletion of metal ions in the diffusion layer. The diffusion layer is largely destroyed, and thus the ion-depleted zone on the surface or surfaces in question is completely or at least largely eliminated. The metal ions of the electrolyte can therefore make their way directly onto the surface of the items in question, or, during etching, can be removed therefrom. In respect to further advantages, reference is made to the discussions below of the various possible designs of the invention, in respect to both process and object. By means of the combination according to the invention of the aforementioned wiping and the metallization of the surface which this achieves with the metallization of the inner walls of the drill holes based on conveying the electrolyte through the drill holes, an adequate treatment of the inner wall of the drill holes is simultaneously achieved, and thus the metallization of the treatment items is achieved on all required areas (surfaces and drill holes) with satisfactory results in one work step and using relatively simple measures. In this connection, the aforementioned combination has the advantage that the wiping sequence destroys any surface tension existing on the fluid in the drill holes, making it even easier to metallize the drill hole inner wall. As the examples of this invention show, the structural means for wiping, on the one hand, and for conducting the electrolyte through the drill holes (so-called "flooding"), on the other,

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can be provided together in a simple and space-saving manner, and in the preferred design of the invention are even combined. Here reference is made, for example, to the design according to Fig. 15. A further advantage is that with the aforementioned flooding--particularly when this is still done by supporting a pressing of the electrolyte, e.g., by means of a pump, into the drill holes and/or a drawing of the electrolyte out of the drill holes by means of a suction device--any particles that might still be present in the drill holes can be extracted from the drill holes and transported away. This avoids the danger of particles trapped in the drill holes becoming embedded through metallization and of the drill hole in question becoming clogged, which leads to rejection of that particular circuit board.

Furthermore, in this connection, the danger is avoided of abrasive or chip particles still adhering to the edge of the drill holes being grasped by the wiping coatings and transported along the surface of the items to be processed, which can damage and even render unusable the delicate surface of the items to be processed.

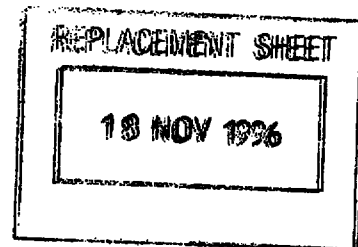
A complementary attainment of the object is represented by a process in which an appropriate relative movement between the cathodic or anodic items to be processed on the one hand and an anode-side or cathode-side wiping device on the other hand achieves the effect according to the invention.

In achieving this relative movement, the transport movement of the items to be processed may be used

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as an alternative when the items are taken by conveyor means through a treatment bath.

The further subclaims present preferred designs of the invention.

The possible process measures provided according to the invention for the attainment of the object may preferably be used for galvanization, but may also be used for electrolytic etching. The items (work pieces) to be processed thereby has an anodic function, i.e., it is anodically connected. The etched-away metal is precipitated on a counter-electrode (cathode). The counter-electrode can be the wiping device. Then, in a later work step, the precipitated metal is carried away and re-obtained. Electrolytic etching of this type is an alternative to purely chemical etching. During electrolytic etching, a simultaneous wiping of the anodes disrupts a border layer appearing there.

In order to simplify the presentation of the invention, the invention will be discussed below, and in the description of the examples related to the drawings, in reference to processes and devices for galvanization.

The movement of the coated anode relative to the item to be galvanized, whereby the coating bears against the item, largely destroys the diffusion layer (see above) and thus completely or largely eliminates the metal-ion-depleted region on the surface of the items to be processed.

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The ions of the electrolyte can make their way directly through the coating of the anode to the surface of the item to be processed and metallize it. In this way, relatively high current densities can be achieved, and with good quality, particularly with an even strength of metal layer precipitated on the item surface, e.g., a copper layer. This is a significant advantage, which is especially important when it is not the entire area that is to be coated, but only the surface of conductor paths located on a circuit board of this type. A further significant advantage of the invention is that the distance between the anode and the cathodic item is still determined only by the thickness of the coating on the wiping device, whereby this thickness, however, can be relatively small. Due to the very small distance thus achieved between the anode and the cathode, different field line concentrations of the galvanization current flowing from the anode to the cathode practically do not exist, or at least exist to a considerably lesser extent than in arrangements in which a comparatively large distance exists between the anode and the cathode. In previously known arrangements with a relatively large distance between the anode and cathode, it was necessary, in order to avoid damaging effects such as increased metal precipitations on edge regions, e.g., the so-called "dog-bone" effect, to make appropriate expenditures, e.g., to provide "blendings." This is especially true in the case of flat items to be processed, such as electronic printed circuit boards, which have a great many drillings. Here, considerable scatterings (known as drill hole scatterings) can result on the edge region of the boards and in the drill holes.

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A significant advantage of the invention is that it achieves higher current density values, without the depletion of metal ions causing so-called "burns" or the like of the metal to be deposited. Blendings or similar measures against excessive scatterings of the galvanizing current are not needed. A further significant advantage of the invention is that it is suitable for the automatic galvanization of items running continuously through a unit (perforated boards or the like). This will preferably occur in the case of items arranged and transported horizontally (see, for example, DE-OS 36 24 481, discussed below). However, the invention can be used not only with horizontal, but also with vertical or slanted runs, and such usage will be accompanied by the advantages discussed above, particularly the avoidance of damaging scatterings at high current densities. When it is possible for higher current densities to be applied, as they can be as a result of this invention, the transport speed also becomes faster or the treatment route shorter. In particular, it is not necessary to ensure a disturbingly high flow rate of the electrolyte.

With the invention, a wiping effect is automatically achieved on the entire surface to be treated, in particular, on both sides or surfaces of flat items. For the sake of completeness, it should be mentioned that in manual galvanization, the process referred to as tampon galvanizing is known, used particularly for the processing, repair or improvement of larger components which cannot

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be processed or can be processed only with great difficulty in a galvanizing unit. Typical examples of this are the improvement or galvanization of metal church roofs, large monuments and the like. For details, reference is made to the publications of RUBINSTEIN in the journal *Galvanotechnik* ("Galvano-Technology") No. 73 (1982), pp. 120 ff; No. 79 (1988) pp. 2876 ff and pp. 3263 ff. Such a tampon process, however, can be used only for the aforementioned special cases, not for the industrial production of printed circuit boards with drillings and the like.

In a preferred design form of the invention, not only the transport speed of the processed items, but also the speed of the coated anodic device itself is used to achieve an intensive wiping effect. Depending on requirements and design, a great variety of effects and wiping speeds can be achieved.

The aforementioned relative speed may be low, e.g., almost approaching zero. Furthermore, in implementing the process according to the invention, pressure can be exercised by the wiping device on the items to be processed. In the presence of an elastic coating on the wiping device, the coating can be flattened or pressed. Apart from the fact that irregularities in the thickness of the items can be smoothed out in this way, this helps to reinforce the effect according to the invention of disrupting the diffusion layer. This is especially true for the disclosed combination of features.

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Further process measures promote the passage of the electrolyte through the drill holes and thus the metallization of the inner walls of the drill holes. Furthermore, they contribute to extracting from the drill holes particles or the like present therein.

The invention is also based on the object of creating an arrangement for the electrolytic processing of flat and perforated items, particularly of printed circuit boards provided with drill holes, which are taken by conveyor means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, which arrangement achieves flawless electrolytic processing, possible with simple means, of one or both surfaces of the items to be processed as well as of the drillings or drill holes (hereinafter called "drill holes") located therein. This is possible in particular with the process measures according to one or more of the process claims of the present invention.

To attain these objects and solve these problems, first of all, the arrangement has means for wiping the surface or surfaces of either cathodic items or anodic items, and also has means for conducting the electrolyte, in a flow roughly vertical to the plane of the items to be processed, through the drill holes of the latter (flooding means). This principle of the invention is to be realized in a structurally simple form, as

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will be seen in greater detail in the discussion which follows, particularly the discussion of the examples.

Wiping devices with the coating are an especially advantageous design form of the invention for mechanical wiping.

It is recommended that the coating be allowed to bear against the surface of the items to be processed with a certain pressure force. This is especially advantageous in processing conductor paths and drill holes, because the fluid in the drill holes has on its surfaces a certain surface tension that is disturbed by this wiping, thus clearing the way for ions, in order to form a metal layer (during galvanization) on the surfaces. Such a pressure force can, for example, be achieved through spring bearings of the wiping device, especially the aforementioned rollers.

Flat items are especially suitable for being conveyed between rollers. Rollers per se are known in their structure and their use in units for processing flat objects; however, they are known not in this form of wiping rollers according to the principle of the invention, but only as conveyor and guide rollers and as squeeze rolls for sealing. The rollers have the advantage of their simple and robust structure and insertion into a processing unit. In contrast to known conveyor rollers or pressure rollers, however, these wiping rollers with their coatings have the function of achieving the discussed mechanical wiping effect, i.e., their rotational speed deviates deliberately

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from the transport speed of the items to be processed which bear against them. At the same time, these rollers can also be designed as a counter-electrode to the object to be processed. The aforementioned deviation in speed can be achieved by means of the respective values of the aforementioned speeds and/or their respective directions. At this point, it should also be noted that the aforementioned speed deviation and/or relative speed may be low, almost zero. Furthermore, reference is made in this context to the possible design of the invention according to Claims 23 and 43 as well as to the process measures according to Claims 10 and 11.

Furthermore, the wiping rollers with their coating can mechanically favor the carrying away of particles. This is especially true when the rollers are pressed with a certain pressure force onto the surface of the items to be processed. In this way, disruptive layers on the cathode, such as gas bubbles suspended on the surface, can also be removed.

Further preferred design forms for reinforcing the metallization of the inner wall of drill holes consist of means and devices for conveying the

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electrolyte through the drill holes (flooding) with appropriate overpressure or underpressure. Reference is made here to the flooding means and associated arrangements of Claims 27 and those following. In particular, an arrangement according to Claims 31 to 34 is advisable here.

Further advantages and features of the invention are found in the other subclaims, as well as in the description which follows and in the accompanying drawings of possible designs according to the invention. The essentially schematic drawings show:

- Fig. 1 A depiction, partially in section, of the process according to the invention in principle;
- Fig. 2 A design for implementing the process or processes according to the invention, in front view and partially in section;
- Fig. 3 The side view associated with Fig. 2;
- Fig. 4 A top view of the conveyor device in Figs. 2 and 3;

Compared to Figs. 2 to 4, the following figures are drawn in larger scale.

- Fig. 5 The conveyor device according to Line V-V in Fig. 4, in section;
- Fig. 6 The Detail VI circled in Fig. 2, in enlarged scale and partially in section;
- Fig. 7 A first example

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- of the embodiment and arrangement of the wiping rollers;
- Fig. 8 A second example of the embodiment and arrangement of the wiping rollers and the flooding;
- Fig. 9 A third example of the embodiment and arrangement of the wiping rollers, also showing the supply and extraction of electrolytic fluid and the flooding;
- Fig. 10 A fourth example of the design and embodiment of wiping rollers, as well and the supply and extraction of electrolytic fluid and the flooding;
- Fig. 11 A fifth example of the embodiment and arrangement of wiping and carrying rollers and the supply of electrolytic fluid, as well as the flooding;
- Figs. 12, 13 A sixth and seventh example of the invention with wiping and flooding means;
- Fig. 14 An eighth example of the embodiment and arrangement of wiping and carrying rollers and the supply of electrolytic fluid, as well as the flooding;
- Fig. 15 A ninth example of the invention showing the design of the wiping rollers and an associated conduction of the electrolyte, as well as the flooding;
- Fig. 16 A further (tenth) example of the invention for achieving the flooding and

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wiping effect;

Fig. 17 A further (eleventh) example of the invention for achieving the flooding and wiping effect.

The diagram in Fig. 1 shows the principle of the invention. In schematic fashion, Fig. 1 shows the principle of the invention in the case of a cathodic item K with the area K1 to be treated and the wiping device W associated with this. This wiping device W has the anodic function. The aforementioned wiping device may be wiping rollers according to the examples below or may be another wiping device. In any case, the wiping process is carried out mechanically. This process may be carried out on a item conveyed through a series of treatment baths, i.e., essentially continuously, but it may also be carried out on an item which is introduced into one of the treatment stations or into a treatment bath and processed there. In the latter case, the wiping operation and the flooding operation explained below are discontinuous. In the case of a flat item, either one of its two surface or both of its surface can be wiped. At the same time, the electrolyte is conducted through the drill holes ("flooding"). The examples discussed below will make refer to details of the above sequence..

Figures 2 to 6 show the aforementioned main possibility for use of the invention, namely, a bath station of a galvanization unit that is designed according to the invention, including the conveyor means for the items to be processed. A series of such bath stations can be provided one behind the other, in order to allow processes to be carried out with various baths.

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The bath container 1 contains a bath liquid, not shown. An item to be processed which is introduced in the direction of the arrow 2 is conducted between guide rollers, conveyor rollers and the wiping rollers, which will be discussed in more detail below. The item can be transported and processed horizontally according to this example of the invention. After processing, the item emerges from the unit in the arrow direction 3. In the areas 4 and 5, only conveyor and/or guide rollers are present and shown, whereas in area 6, in addition to any conveyor and/or guide rollers, there are also wiping rollers according to the invention. The wiping rollers are explained in detail in reference to several examples in Figs. 6 to 12, whereby Section 6 in Fig. 3 corresponds to the examples in Figs. 7, 8 and 9.

The movement path for the items to be treated has the position and breadth designated in Fig. 2 as "a." In Fig. 2, the movement direction 2-3 runs vertical to the plane of projection. In this example, a conveyor device 7 is located next to the movement path of the items to be treated, which uses conveyor means in the form of a clamp 9 to grasp in clamping fashion a flat item 8 on a lateral edge 8' and move the item 8 in the movement direction 2-3. Such a conveyor device is the subject of DE-OS 36 23 481, to the disclosed contents of which reference is hereby made. However, the invention is not limited to the use of a conveyor device designed in this manner. This lateral grasp of the flat item by the clamps 9 has a special advantage, especially in conjunction with the discussed "flooding," i.e., pressing or drawing electrolyte through the drill holes of the item. During flooding, a corresponding pressure on the item arises in the flooding direction. The clamps with their firm lateral grasp on the item prevent

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the board in question from being pushed by the flooding pressure. The aforementioned drill holes and the means for flooding are not shown in Figs. 2 to 6, for the sake of simplicity. Reference is again made to the examples which follow. A clamp 9, consisting of two clips 11, forms a conveyor means 10. All conveyor means are attached to a continuously rotating conveyor belt 12, 12', which rotates in the direction of the arrow 13 (see Fig. 4). When the conveyor means 10 are located on the side of the strand 12' (see Fig. 3) of the conveyor belt, then the clamps 9 are in the holding position (see the drawing of the left side of the conveyor device 7 in Fig. 2). As soon as the conveyor means 10 move out of the area of the strand 12' into the upper strand 12 in Fig. 4, the two clips 11 of the clamps 9 are pulled somewhat apart, so that a space exists between them (see the right side of the conveyor device 7 in Fig. 2). This conveyor device moves the items at a particular and if necessary adjustable speed in the direction 2-3.

Fig. 5 shows the conveyor device in detail. It can be seen that in the area of the strand 12, through the ascent of one of the clips 11 of a clamp onto a guide part 29, the associated clamps 9 are moved into the open position. In contrast, in the path area of the strand 12', such a guide part 29 is not present, and the clips of the clamps 9 lie, under the influence of a pressure spring, with corresponding clamping force at the edge 8' of the item (transport position).

Detail VI in Fig. 2, as well as Fig. 6, which depicts this detail, partially in section, show two wiping rollers 15, which are moved in opposite directions by a drive via a toothed gear 16, 17. For this purpose, there are two spur wheels 17, which sit on the axles 13, 14 of the wiping rollers 15 and mesh with one another. The anodic wiping rollers 15 are

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connected via contact disks 20 and current contacts 19 which slide thereon as well as by leads 18 to the positive pole of the current source. The cathodic item 8, shown here only partially, is connected to the negative pole of the current source (not shown). Each of the wiping rollers is, on its outer circumference, provided with a coating 31 of a material which absorbs and is permeated by the electrolyte and the metal ions of the electrolyte. This material should be elastic and have a certain softness, in order not to damage the surface of the items during the course of sliding along. The coating must be chemically resistive against the electrolyte. The material preferably used for this is a felt-type plastic, e.g., of polypropylene. Here the term "felt-type" refers not to the textile felt, but to a structure of interwoven components. Such materials are also known for use in filters. The coating may also consist of an open-pore plastic which has good liquid permeability and is friction-proof. This wiping coating should—as should wiping coatings of other materials—be elastic, so that during application to the surface to be wiped it compresses somewhat and then can return to its original form. The aforementioned permeability to fluids is at least necessary when, according to one of the following examples, the electrolyte is pressed from the roller interior through the coating to the outside, or is drawn in in the opposite direction.

While any drive rollers and/or guide rollers (see Number 3 and 4) which might be present have a rotational speed which corresponds in value and direction to the transport direction 2-3 and the transport speed of the conveyor means 10, the rotational speed and/or running direction of the wiping rollers is such that the circumference of the wiping rollers 15 moves relative to the respective surface of the transported items 8. In this way, a wiping effect is exercised on the surfaces of the items 8 along the entire length of the wiping rollers 15.

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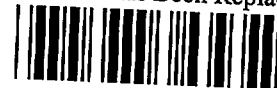
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The length of the wiping rollers 15 extends across the breadth of the items to be processed, which runs at a right angle to the transport direction, i.e., approximately the amount "a" in Fig. 2. However, an item of lesser breadth can also be processed, whereby a partial length of the wiping device 15 simply goes unused. The level of the electrolytic bath is indicated with a broken line by reference number 25, whereby the item to be processed as well as the wiping devices are located below the level in the bath fluid. This also holds true for the other examples. As the present example shows, it is advisable, or is as a rule necessary, to process an item according to the invention on both of its sides or surfaces, i.e., on the upper surface in Figs. 2, 3 and 6 as well as on the lower surface, as reflected by the arrangement of two wiping rollers 15, which bear against the respective surfaces of an item from above and from below. In cases in which only one of the surfaces of an item needs to be processed, then the use of one wiping roller suffices in principle. The fact that more than two wiping rollers can be used is illustrated by the examples in Figs. 7 to 15.

As a rule, a certain pressure force is recommended between the coatings 31 of the wiping rollers and the surfaces of the items to be processed, which pressure force, for example, can be applied by a spring 23 pressing in arrow direction 22 and indicated schematically in Fig. 6. In order to be able to process items of varying thickness, the upper roller of the wiping rollers 15 is mounted in a slot guide 24 and can therefore, when there is an increase in the thickness of the items to be processed, give way opposite to the arrow direction 22. The bath level 25 of the electrolyte is higher than the lower edge of the slot. Excess electrolyte can therefore run out through the slot guide 24 and a space 26 between the side wall of the bath container 1 and another externally located wall 27 according to arrow direction 28.

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The rotational speed and/or rotational direction of the anodic wiping rollers 15 at their contact points with items having a certain transport speed may be altered and adjusted to the desired value through a control of the drive unit of the wiping rollers. It is also possible to adjust the pressure force of the spring 23 or other pressure means. In this way, particular requirements can be matched with the goal of achieving the most extensive possible disruption of the diffusion layer on the surface of the items in which ion depletion usually occurs.

In the description which follows of examples according to the invention in the design and arrangement of wiping rollers 15 or wiping parts which act accordingly, only these components of the invention, including supply and extraction conduits for the electrolyte, are depicted and explained. Of course, this includes conveyor means for the items and drive means for the wiping parts as well as current feeds, which are depicted in Figs. 2 to 6, for example, and discussed above. In addition to the conveyor means described there, or instead of these conveyor means, it is also possible, for example, to provide conveyor rollers between every pair of wiping rollers, whereby the cathodic current feed occurs by means of loop contacts on an edge area of the items to be processed. If not already depicted in the drawing, the items to be processed has drill holes, and means are provided for "flooding" these drill holes, i.e., for passing the electrolyte through them.

Basically, the parts located in the electrolytic bath, such as the tube 30 and the expanded metal piece or wire screen 32 described below, must consist of a material which is not attacked in the bath under the electrolytic conditions. Suitable materials include, for example, titanium, titanium coated with platinum, noble metal, noble metal coating or

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noble metal oxides. This can be done, e.g, according to the example in Fig. 7, in such a way that wiping rollers in the form of metal tubes 30 are provided with the aforementioned felt-type coating 31 and an expanded metal piece 32 located therebetween, which positively connects the tube 30 and the coating 31. Instead of the preferred tubular expanded metal piece mentioned above, a preferred tubular wire screen that is welded at the wire crossing points can also be used or a perforated tube can be provided. In this example, the tube 30 constitutes an insoluble anode, which does not give off metal itself, but rather has emits only current. In this case, the metal to be deposited is located in the electrolyte. However, it is also possible to store the metal to be deposited as a soluble anode in the tube 30 or in another wiping element. When the items 8 are run through, the coatings 31 are somewhat compressed. The electrolyte is supplied according to the arrows 33. This can also be done under pressure. Here, too, the electrolyte passes through the drill holes (not shown) of the board to be processed. As will be mentioned later (at the end of the description), any feature or detail depicted in one of the examples may also be used in the other examples. This applies especially to the means for implementing the flooding of the drill holes 42 of the items to be processed. This example and the others show that the distance between the anode (here the titanium tube 31) and the cathode (identical to item 8) is very small, so that practically no scatterings occur.

The example in Fig. 8 resembles that in Fig. 7. However, Fig. 8 shows one of the possible designs for allowing the electrolyte to flow through drill holes 42 of the items to be processed. For this purpose, the tubes 30 are provided with perforations, which have several functions. First of all, the electrolyte is supplied in the tube interior 35 and passed along through the perforations 34 to the coating 31. Furthermore, the electrolyte is conducted from the interior of the tube 30 through the perforations 34 of the tube

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and the wiping coating to the drill holes 42 of the board 8; the electrolyte then flows through the latter and reaches the interior of the counter-roller in question, the tube 30 of which is likewise provided with perforations 34. The electrolyte in one tube can thereby be under pressure from a pump and the electrolyte in the counter-roller located on the other side of the items to be processed can be drawn out of the drill holes. In addition, the perforations 34 can also serve to ensure that the material of the coating 31 clings within them. In this preferred design, only the inner tube 30 and the outer coating 31 are provided. Instead of the tube 30 with the perforations 34, a tubular expanded metal piece or wire screen can also be used.

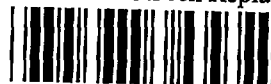
Of course, the wiping coating 31 surrounds the wiping roller 15 in question on its entire circumference. This is true for all examples that show wiping rollers. The wiping rollers are generally indicated by the reference number 15 and an associated arrow, regardless of their somewhat different embodiments.

In the example shown in Figs. 9 to 14, the structure of the wiping rollers is the same as in Fig. 7, [consisting] namely of an inner tube 30, an expanded metal piece or the like (see above) 32 and the coating 31 which surrounds the wiping roller and thus the tube 30 as well.

In the example shown in Fig. 9, the electrolyte is supplied by means of supply tubes 37 having perforations or slits 36, which are located above the free space 38 between two wiping rollers 15. After the electrolyte runs through the intermediate spaces 38, the drill holes 42 and the intermediate spaces (39) located thereunder, it is collected by collection containers 40 and conducted to a filter pump.

When an upper wiping roller and a lower wiping roller located opposite to one another are provided (for example, in the design according to Fig. 9, then, in alternating fashion, the upper

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wiping roller can be connected anodically and the wiping roller located under it can be connected as the cathode, and vice versa. Such a process and an associated arrangement are depicted and described in the older patent application P 41 06 333.3-45 of the applicant. Reference is hereby made to its disclosed contents.

The example in Fig. 10 also shows wiping rollers 15 in the design according to Fig. 7 during the processing of flat items 8, especially printed circuit boards, which are provided with drill holes 42. The electrolyte is conveyed with pressure through the slit 41 of a flow nozzle 63 upward (arrow 43) through the drill holes 42 located thereover and from here conveyed back by means of underpressure through the drill holes 42 (arrow 44) located near the flow nozzle 63. As this happens, a certain pool 45 of electrolyte (with the electrolytic surface 45') builds up above the items 8 to be processed, and this pool provides electrolyte to the coatings of the two wiping rollers located above the items 8, while the wiping rollers below the items 8 are moistened through the electrolytic flows 44 as well as through the electrolyte flowing across the edge of the flow nozzle top. The latter electrolyte achieves a high speed in the narrow gap between the items 8 and the flow nozzle, as the result of which lower pressure is created than exists in the electrolyte above the flat items. This difference in pressure causes the electrolyte to be drawn through the drill holes 42. Such an flow nozzle arrangement can be provided, alone or in combination with other means which facilitate "flooding" (see the other examples in this regard), in order to convey the electrolyte through the drill holes 42.

The means which can be used for the purpose of flooding according to the invention can also eliminate diffusion-poor layers in the drill holes 42, so that sufficient metal precipitation takes place on the inner walls of the drill holes. In addition, the wiping effect of the coatings of the wiping rollers

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on the upper and bottom sides of the items, disturbs the surface tension of the fluid columns located in the drill holes 42, thus supporting the desired effect. As mentioned earlier, the process measures and the means for wiping the surfaces of the flat items to be processed and for flooding the drill holes 42 of the flat items therefore work together functionally and synergistically.

The example in Fig. 11 is a variant of the example in Fig. 10. Here the left roller pair has an upper wiping roller 15 and a lower pressure roller 64, and the roller pair shown on the right has an upper pressure roller 64 and a lower wiping roller 15. The pressure rollers can function as conveyor rollers or support rollers, which accordingly bear with pressure against the items to be processed. Each of the anodic wiping rollers 15 wipes, in the sense of the invention, the surface of the item 8 which faces it and also wipes, at the same time, the end of the drill holes 42 which faces it. Furthermore, a flow nozzle 63 is also provided here, as in Fig. 10. A sequential galvanization of the drill holes 42 from alternating sides in the transport direction 2-3 is achieved. The aforementioned conveyor rollers 64, at least on the upper side of the item, are designed as rollers which extend across the entire breadth of the items or the treatment path, so that the electrolyte becomes blocked up on the items 8, while the conveyor rollers on the bottom side of the item may also consist of several disks arranged on one axis, between which the electrolyte can flow.

Figures 12 and 13 show further possibilities for the use of a flow nozzle 63. According to Fig. 12, two pairs of wiping rollers 15 are provided in front of or behind an arrangement which has the flow nozzle 63 with the anode 48 arranged therein. The electrolyte flow enters in direction 79 through a connection piece 65, passes through a pre-chamber 68 and a distribution mask 69 with perforations 66, flows (reference number 67)

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along the anodes 48 consisting of individual pieces, passes through the slot 41 and the nozzle area 70 as well as through the drill holes 42 of the items 8 downward (arrow 71) into the area below the items 8. In detail, reference is made here to the disclosed contents of DE-OS 39 16 693.7. These examples also involve flat and perforated items to be processed, preferably printed circuit boards.

Fig. 13 shows a design similar to the arrangement according to Fig. 12, and the same reference numbers are used. The difference is that in the object in Fig. 12 the electrolyte, after passing through the drill holes 42, flows freely downward, while in the object in Fig. 13, a suction segment 72 with the housing 75 is provided between this outflow 71 and the exit of the electrolyte from the drill holes 42. An underpressure is produced in this via the suction connection piece 73, so that the electrolyte, after passing a further anode 48, is drawn into the space 74 under low pressure and then is extracted from there through the connection piece 73. In connection with the object in Fig. 13, reference is made to the disclosed contents of DE-OS 39 16 694.5.

In the examples in Figs. 10 to 13, the flow nozzle 63 extends across the entire breadth of the treatment items, i.e., the breadth "a" in the example from Fig. 2. The same applies for the space 68 (Fig. 12 and 13), in which the electrolytic fluid enters via a series of connection pieces 65 arranged one behind the other at a right angle to the items. In the example in Fig. 13, the suction segment 72 of the suction side extends likewise across the entire breadth "a." In these examples with the flow nozzle 63, it is thus ensured that, according to the invention, in addition to the surface treatment of the items 8 through the wiping roller 15, there occurs an intensive flowing through of the item drill holes 42 by the electrolyte, which in fact flows the entire breadth "a" of the work pieces conveyed in direction 2-3. This type of intensive electrolyte flow through the item drill holes 42

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and the correspondingly heavier deposit of metallization on the inner walls of these drill holes, in combination with the previously described galvanization of the surfaces of the items due to the wiping effect, would not be possible in the arrangement according to the prior art, in which the electrolytic flow is conducted at great speed parallel to and along the work piece surface. In this case, it would not be verifiable in terms of flow engineering that the electrolytic flow passed through the drill holes at a right angle to the flow direction.

The example in Fig. 14 contains a combination of the arrangement of wiping rollers and pressure rollers according to the example in Fig. 11, with a conduction of the electrolyte as in the example in Fig. 9. The same reference numbers are used as in Figs. 9 and 11. In addition, lower conduits 37' with exit openings 36' for the electrolyte are also provided, which convey the electrolyte upward from below.

The example in Fig. 15 shows a modification of the example in Fig. 15. The wiping rollers 15 here, analogous to the design discussed in reference to Fig. 8, consist of an inner tube 30 provided with perforations 34 or a tubular expanded metal piece or a tubular wire screen in which the wires are welded at their crossing points, as well as of the discussed coating 31. Within the tube 30 which encircles its axis 76, there is a non-rotating supply tube 77, into which the electrolyte is introduced in a manner not shown here; the electrolyte then emerges through passage openings (e.g. perforations) or passage slots 78 in the wall of the tube 77 which are arranged one behind the other in the longitudinal direction of the tube. Of course, the supply tube 77 with the passage openings or slits 78 extends across the entire length of the tube 30 and thus the entire breadth of the items 8 to be processed. The

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passage openings or slits 78 point with their inlets or outlets toward the movement path 2-3 of the items 8, so that the electrolyte flowing through these passage openings or slits 78 of the supply tube 77 emerges through the perforations (or corresponding slits) 34 of the tube 30 vertical to the items 8 onto the latter and passes through the drill holes 42. Thus the flow speed of the electrolyte through the perforations or slits 78 and the perforations 34 causes a corresponding vertical flow through the drill holes 42 of the boards 8 and therefore also causes improvement in the metal precipitation there. In this example, the electrolyte in the supply tube 77 may either be under pressure and pressed through the perforations or slits 78 and the drill holes 42, or else a lower pressure and thus a suction effect is produced in the interior of the tube 77, which draws the electrolyte through the drill holes 42 and the perforations or slits 78. In the latter case, any particles of the wiping coat that have gotten into the drill holes 42 can be removed and carried away via the tube 77 and later filtered out of the extracted electrolyte. Of course, in the example in Fig. 15 as well as in the other example, a series of holes 34 are distributed continuously around the circumference of the roller 30. The aforementioned tube 77 can be located in a wiping roller or above or under the items to be processed. Pressure rollers or disks 64 are also shown here, which rotate around the axis 64' and serve as support roller or transport rollers for the items 8 conveyed through.

Fig. 8 shows, schematically, above a flat item 8 provided with drill holes 42, e.g., a printed circuit board, a wiping roller 15 in the form of a flooding anode, which corresponds to the parts 30, 31, 77, 78 of the example in Fig. 15. These parts are only indicated here in schematic fashion. If a pressure of the electrolyte is formed in the supply tube 77, the electrolyte flows downward, according to the

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arrows, through the drill holes 42. If, on the other hand, an underpressure is created in the tube interior 77, then the electrolyte flows opposite to the indicated arrow direction. This example shows, as counter or pressure rollers, two counter rollers 48 driven in the arrow direction and thus also in the transport direction 3 of the board 8, which rollers leave such a broad space 60 free under the perforations or slits 78 of the supply pipe 77--and thus in the flow direction of the electrolyte--that the electrolyte can flow unobstructed between the counter rollers 48. Nonetheless, due to the arrangement of two counter rollers symmetrical to the wiping roller 15, even distribution of the pressure of the wiping roller 15 on the counter rollers 48 is ensured. These counter rollers are provided on their surface with insulation, or else they consist of plastic.

In longitudinal section, Fig. 17 shows the example of a flooding anode shown only schematically in Figs. 15 and 16 and identified by the reference numbers 30, 31, 77, 78. The same reference numbers are used as in Figs. 5, 6, 15 and 16. Reference is made to the associated descriptions of these figures. The flooding anode 30, 31, 77, 78 depicted in the upper area of Fig. 17 can be moved in the vertical direction against the pressure of springs 23 with its bearings and its drive shaft 49. This permits height compensation, so that boards 8 of varying thickness can be processed. The current feeds occur via clips 9, 11, which are connected to one pole of the rectifier and connect the latter to the items to be processed, as well as through loop contacts 50, which are connected to the other rectifier pole and connect the latter to the drive shaft 49 of the flooding anode.

Furthermore, there is a pressure or counter roller 51 consisting, at least on its surface, of a material that is not electrically conductive and provided at its circumference with drainage grooves 52, whereby these grooves

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form an angle, here an acute angle, with the longitudinal axis 53 of this roller 51. In this way, the electrolyte emerging downward from the drill holes 42 is conveyed away. In this case, as the arrows show, the electrolyte is conveyed through pressure in arrow direction 55 and, according to the arrows 54, is passed through the perforations or slits 78 and then through the drill holes 42 and conducted into the drainage grooves 52. Instead of this, it is also possible for suction to occur at the upper end 77' of the flood tube opposite to the direction of the arrow 55, by means of which the electrolyte is drawn upward from the drainage grooves 52 through the holes 78 and opposite to the arrow direction 54. The flooding anode is driven by its shaft 49 in a rotational direction (see arrow 57) opposite to the rotational direction (arrow 58) of the drive shaft 56 of the counter roller 51. The reference number 50 indicates a loop contact of the current supply to the drive shaft 49. The flooding anode is equipped at one end with inner and outer side slide bearings 59 and 59' for the 30 and the drive shaft 49, respectively. The aforementioned slide bearings 59, 59' are located on the circumference or on the inner diameter of a stationary bearing shell 79, which is held via a stay 80 on a frame of this arrangement not described in more detail and is conducted so as to be vertically movable in a recess 81 by a certain path segment.

In some cases, e.g., in the case of printed circuit boards, in which the drill hole walls are first coated only with a conductive layer that cannot tolerate larger current densities, lower current densities are to be used at the beginning in the first part of the processing section 6 (see Fig. 3). Once a sufficient metal layer has been deposited there, then, as items move through Section 6 in direction 2-3, the current density of the galvanization process is increased by measures that are known in themselves.

The process and the arrangement according to the invention are also suitable for the processing of flat items

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which are suspended vertically in treatment baths and remain there during the treatment. In this way, the invention provides not only for continuous runs of the items to be processed, but also for discontinuous operation, in which the items are placed in a station and undergo processing there. During this processing, wiping and flooding are carried out. Thus "periodic" wiping and flooding take place during the periods of the bath treatment in question.

All depicted and described features and their combination with one another are essential to the invention for different design forms. Features and details described in one of the examples can also be used analogously in other examples.

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Patent Claims

1. Process for the electrolytic processing of flat and perforated items, particularly in the form of printed circuit boards provided with drill holes, which are moved by transport means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, characterized by the fact
that in the presence of an anode and cathodic items (K) to be processed or in the presence of anodic items to be processed and a cathode, the surface (K1) to be treated of the item is continuously mechanically wiped, and that the electrolyte is moved by a movement component which is substantially perpendicular to the plane of the item to be processed and is conveyed through the drillings or drill holes (42) of the latter.
2. Process for the electrolytic processing of flat and perforated items, especially of printed circuit boards provided with drill holes, which are moved by transport means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, especially as in Claim 1, characterized by the fact

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that a relative movement occurs between cathodic or anodic items to be processed (8) on the one hand and an anode-side or cathode-side mechanical wiping device (15; 46; 47; 53; 59) on the other, which, in order to disturb and at least partially destroy the diffusion layer, is brought to bear directly in a sliding fashion on the surface of the items to be processed, and that the electrolyte is moved with a component which is substantially perpendicular to the plane of the items to be processed and is conveyed through the drill holes (42) of the latter.

3. Process as in Claim 2, characterized by the fact that the aforementioned relative movement is created by a transport movement (2-3) of the cathodic or anodic item to be processed (8) to the anode-side or cathode-side wiping device (15; 46; 47; 53; 59).
4. Process as in Claim 2 or 3, characterized by the fact that the movement of the cathodic items to be processed (8) occurs relative to an anode-side wiping device (15; 46; 47; 53; 59), which has a coating (31; 54; 61) of a material that absorbs the electrolyte and allows it to permeate, and that for the purpose of disturbing, and at least reducing, the diffusion layer, the coating is brought directly to bear in a sliding fashion on the surface of the items to be processed, while in order to reduce the diffusion layer in the drill holes of the items, the electrolyte is at the same time moved by a movement component which is substantially perpendicular to the plane of the item to be processed

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and conveyed through the drill holes (42) of the latter.

5. Process as in one of the Claims 1 to 4, characterized by the fact that either one surface or both surfaces of a flat item are wiped.
6. Process as in one of the Claims 2 to 5, characterized by the fact that the anode-side wiping device (15; 46; 47; 53; 59) has, at its point or surface which bears on the surface of the items to be processed (8), a movement of its own, which deviates from the transport movement in value and/or direction.
7. Process as in one of the Claims 1 to 6, characterized by the fact that in the case of a two-sided treatment of the items (8) to be processed, the speed of the latter relative to the wiping device on one its surfaces is opposite to its speed relative to the wiping device on its other surface.
8. Process as in one of the Claims 2 to 6, characterized by the fact that in the case of a two-sided treatment of the item to be processed (8), the relative speed of the latter to that of the wiping devices is the same on both of its surfaces.
9. Process as in one of the Claims 2 to 8, characterized by the fact that the relative speed between the items to be processed and

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the wiping device is small, in particular, approaching almost to zero.

10. Process as in one of the Claims 1 to 9, characterized by the fact that the wiping device exercises pressure on the items to be processed.
11. Process as in one of the Claims 4 to 10, characterized by the fact that in the presence of a resilient coating of the wiping device the coating is flattened or pressed.
12. Process as in one of the Claims 1 to 11, characterized by the fact that during the course of the movement (2-3) of the items (8) to be processed through the treatment line, the current density of the galvanizing current is increased.
13. Process as in one of the Claims 1 to 12, characterized by the fact that the electrolyte is conducted through the drill holes (42) with pressure.
14. Process as in one of the Claims 1 to 13, characterized by the fact that the electrolyte is drawn out from the drill holes (42) by means of underpressure.
15. Process as in one of the Claims 1 to 14, characterized by the fact that the wiping of the surface and the conducting of the electrolyte through the drill holes occurs below the bath level (25) and thus within the bath fluid.

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16. Arrangement for the electrolytic processing of flat and perforated items, especially of printed circuit board provided with drill holes, which are moved by transport means through a treatment bath, or conducted to a treatment station, whereby means for reducing the thickness of a metal-ion-depleted zone (diffusion layer) are provided, which are in contact with the items to be processed, especially for carrying out the process according to one or more of the Claims 1 to 15, characterized by the fact that means (W) for wiping the surface or the surfaces either of cathodic items to be processed (K) or anodic items to be processed and further means for conveying the electrolyte in a flow which runs substantially perpendicular to the plane of the treatment items (8) through the drill holes (42) of the latter are provided.
17. Arrangement as in Claim 16, characterized by the fact that for the application of metal, the wiping device is provided on the anode.
18. Arrangement as in Claim 16 or 17, characterized by the fact that the anode-side or cathode-side wiping device (15; 46; 47; 53; 59) is provided with a coating (31) and bear against the surface of the cathodic or anodic item to be processed (8) at least during a relative movement between the item to be processed and the wiping device.

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19. Arrangement as in Claim 18, characterized by the fact that the wiping device or multiple wiping devices is or are extended across the entire breadth, running roughly at a right angle to the transport direction or the circumference of the transported items to be processed and that at least the items to be processed are movable relative to a wiping device.
20. Arrangement as in one of the Claims 16 to 19, characterized by the fact that the coating (31) bears against the surface of the item (8) to be processed with an adjustable pressure force.
21. Arrangement as in one of the Claims 16 to 20, characterized by the fact that the coating (31) consists of a material, especially a plastic, which is chemically resistive against the electrolyte.
22. Arrangement as in Claim 21, characterized by the fact that the coating consists of an open-pore plastic that is liquid-permeable and abrasion-proof.
23. Arrangement as in Claim 21 or 22, characterized by the fact that the coating (31) consists of an elastic material.
24. Arrangement as in one of the Claims 16 to 23, characterized by the fact that the wiping device consists of at least one wiping roller (15), the circumference of which has the coating (31), that there is a drive for rotating at least one wiping roller, the rotational direction

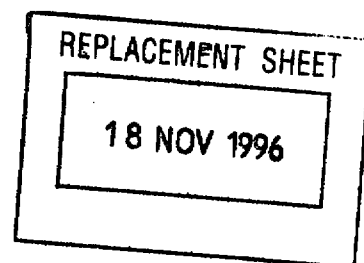
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and/or circumferential speed of which is selectable in order to produce a relative speed between the bearing-point or bearing surface of the wiping device and the surface of the item (8) to be processed.

25. Arrangement as in Claim 24, characterized by the fact that the wiping roller or the wiping rollers (15) consist(s) of a perforated metal tube (30) or an expanded metal tube or wire screen tube and a cylindrical coating (31) surrounds the wiping roller, whereby the supply or extraction of the electrolyte occurs inside the tube, expanded metal tube or wire screen tube.
26. Arrangement as in Claim 24, characterized by the fact that the wiping roller or the wiping rollers consist(s) of a metal tube and a cylindrical coating (31) surrounding the wiping roller, whereby the coating and the tube are held to one another by expanded metal (32) or a wire screen located between them, and that the supply of electrolyte runs from a point (33) outside the wiping roller or wiping rollers to the drillings (42) of the item (8) to be processed.
27. Arrangement as in one of the Claims 24 to 26, characterized by the fact that, opposite to a wiping roller (15) with flooding means which bears against one surface of the item to be processed, there is a pressure roller (64) which bears against on the other surface.
28. Arrangement as in Claim 27, characterized by the fact that in the case of two-sided galvanization of the

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item to be processed, pairs of opposing rollers are arranged one behind the other in the processing direction (3), whereby, in alternating fashion, in the case of one pair a wiping roller (15) with flooding means is provided above the item (8) to be processed and a pressure roller (64) is provided below the item (8) and in the case of the next pair, a wiping roller with flooding means is provided below the item (8) to be processed and a pressure roller is provided above the item (8).

29. Arrangement as in one of the Claims 24 to 26, characterized by the fact that there is at least one pair of opposing wiping rollers, whereby one of the rollers is located above the item (8) to be processed and the other roller is located below the item (8) and the flow direction of the electrolyte is the same for both wiping rollers.
30. Arrangement as in one of the Claims 24 to 29, characterized by the fact that a conduction of the electrolyte exists in the interior of the tube (30) of a wiping roller and a passage of the electrolyte exists between the tube interior, its wall and the coating (31) surrounding the .
31. Arrangement as in Claim 30, characterized by the fact that a series of passage openings (34) is provided in the tube wall.
32. Arrangement as in one of the Claims 24 to 31, characterized by the fact that inside of the rotating tube (30) provided with passage openings (34) for the electrolyte, there is a supply tube (77) conducting the electrolyte with

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passage openings or slits (78), whereby the passage openings or slits (78) point with their passage end areas toward the movement path (2-3) of the items (8) to be processed, and that the supply tube (77) extends, as does the rotating tube (30), across the entire breadth (a) of the path of the item to be processed.

33. Arrangement as in Claim 32, characterized by the fact that the passage opening or slits (78) of the supply tube (77) are located as close as possible to the item (8) to be processed.
34. Arrangement as in Claim 32 or 33, characterized by the fact that the supply tube (77) is arranged in the tube (30) in a non-rotating fashion.
35. Arrangement as in one of the Claims 32 or 34, characterized by the fact that the rotating tube (30), together with the supply tube (77) located therein, is mounted so as to be movable substantially perpendicular to the plane of the item (8) to be processed.
36. Arrangement as in one of the Claims 24 to 35, characterized by the fact that for the supply of the electrolyte into the areas (38, 39), one or more tubes (37) with openings (36) for the electrolyte is or are arranged between two wiping rollers (15), and that collection devices (40) for the electrolyte are provided below the areas (38, 39).
37. Arrangement as in one of the Claims 16 to 36, characterized by the fact that pressure-producing

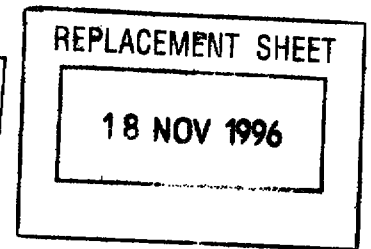
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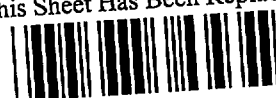
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means are provided for the supply of the electrolyte to the drill holes (42) of the items to be processed.

38. Arrangement as in one of the Claims 16 to 37, characterized by the fact that means for drawing the electrolyte out of the drill holes (42) of the item to be processed are provided.
39. Arrangement as in Claim 37 or 38, characterized by the fact that for the galvanization of items (8) with drill holes, there is a flow nozzle (63) which presses the electrolyte through drill holes (42) located in the area of the flow nozzle opening or slot (41), while the backflow of the electrolyte through other drill holes (42) occurs in the edge area of the flow nozzle with the help of a underpressure that exists on the underside of the item to be processed, whereby the flow nozzle extends across the entire breadth of the item (8) to be processed.
40. Arrangement as in Claim 39, characterized by the fact that anodes (48) are located within the flow nozzle (63) and specifically are located preferably within a pre-chamber (68) surrounded by a housing, to which the electrolyte is supplied (65).
41. Arrangement as in Claim 39 or 40, characterized by the fact that, on the exit side of the drill holes (42) to which the electrolyte is conducted with pressure by the flow nozzle (63), there is a suction device, the housing (75) of which is under an underpressure and extends

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- across the entire breadth (a) of the items to be processed.
42. Arrangement as in one of the Claims 16 to 35, 37 to 41, characterized by the fact that lower tubes (37') which convey the electrolyte from the bottom upward are provided with passage openings (36').
 43. Arrangement as in one of the Claims 16 to 42, characterized by the fact that the wiping device or wiping devices lies or lie under spring force (23, 55) on the respective surface of the item to be processed.
 44. Arrangement as in one of the Claims 16 to 43, characterized by the fact that the items (8) to be processed lie in the horizontal position in the treatment station and are conveyed in the horizontal position.
 45. Arrangement as in Claim 44, characterized by the fact that in order to convey the item to be processed in the horizontal position, transport means (10) are provided, preferably clips (9) which fasten on at least one of its side edges (8').
 46. Arrangement as in one of the Claims 16 to 45, characterized by the fact that the pressure rollers (51) located opposite to a wiping roller (15) in the form of a flooding roller (30, 31, 77, 78) are provided with drainage grooves (52), which serve for the extraction of the electrolyte.
 47. Arrangement as in one of the Claims 16 to 45, characterized by the fact that the wiping

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and flooding rollers (15; 31, 77, 78) are mounted on the other side of the item to be processed opposite to two counter rollers (48) and are positioned in such a way that a flow-through space (60) is formed between them for the electrolyte, which is either pressed through pressure from the flooding roller into the drill holes (42) of the item to be processed or drawn through the drill holes (42) into the flooding roller.

48. Arrangement as in one of the Claims 16 to 47, characterized by the fact that the thickness of the coating (31) is relatively slight, preferably 1-4 mm.
49. Arrangement as in one of the Claims 16 to 48, characterized by the fact that various wiping devices are provided in combination with one another for the electrolytic processing of the same items.
50. Arrangement for carrying out the process according to one of the Claims 1 to 15, characterized by individual or all new features or combinations of the disclosed features.

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PROCESS FOR THE ELECTROLYTIC PROCESSING ESPECIALLY OF FLAT
ITEMS AND ARRANGEMENT FOR IMPLEMENTING THE PROCESS

Abstract

The invention relates to a process for the electrolytic processing of flat and perforated items which are taken through a treatment bath to a processing station by conveyor means, in which there are means for reducing the metal-ion-depleted diffusion region in front of the surface of the items to be processed. For this purpose, in the presence of an anode and a cathodic item or a cathode and an anodic item, the surface of the item is continuously mechanically wiped and the electrolyte is moved in a component substantially perpendicular to the plane of the item and taken through its drillings. The description also relates to an arrangement for implementing the process.

FIGURE 8.

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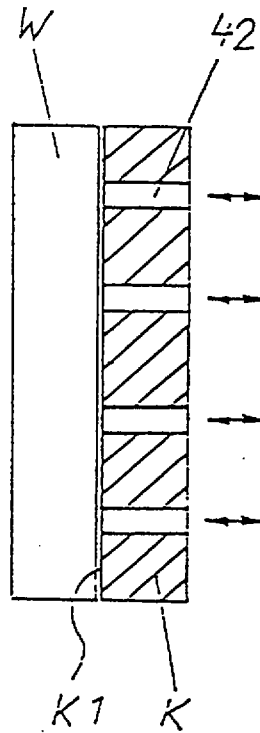


Fig. 1

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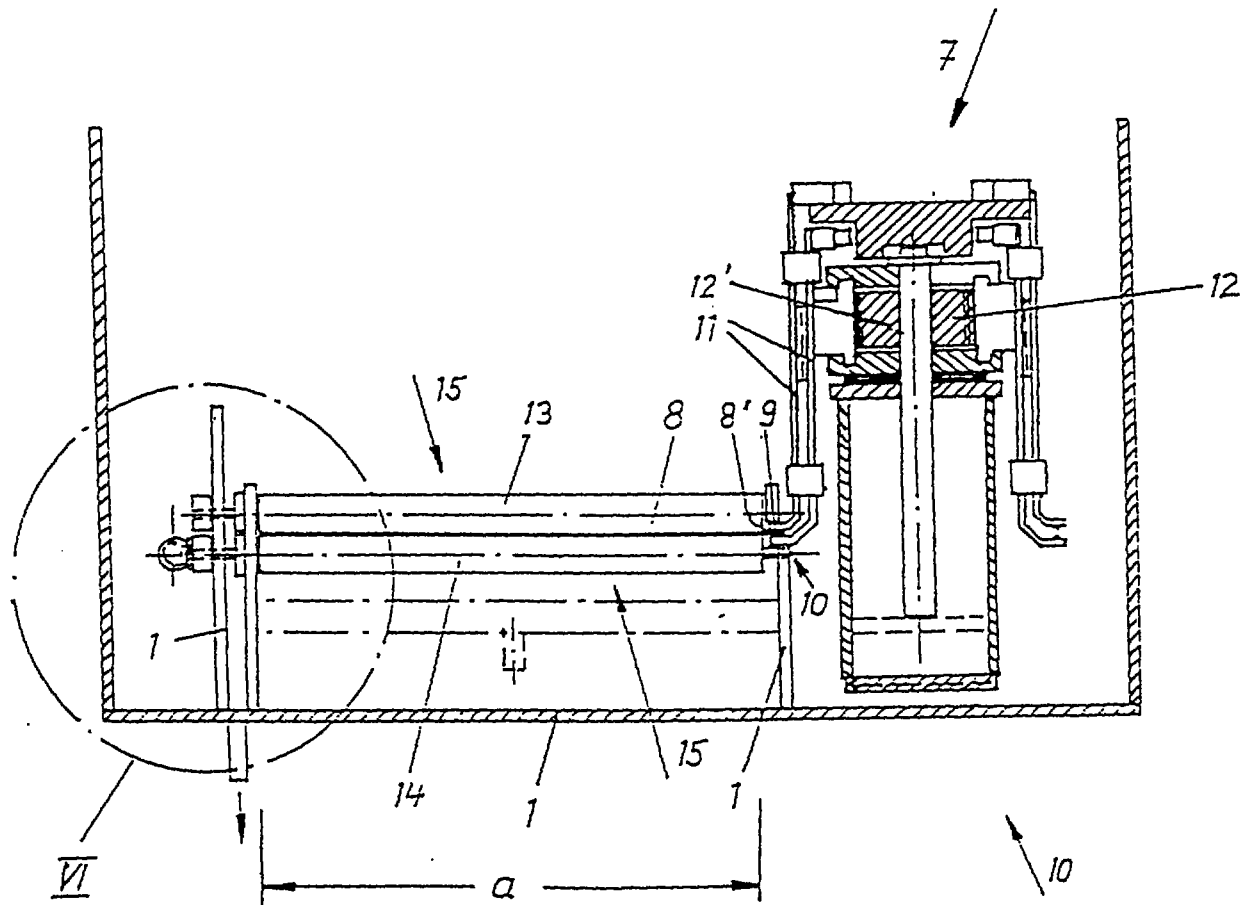


Fig. 2

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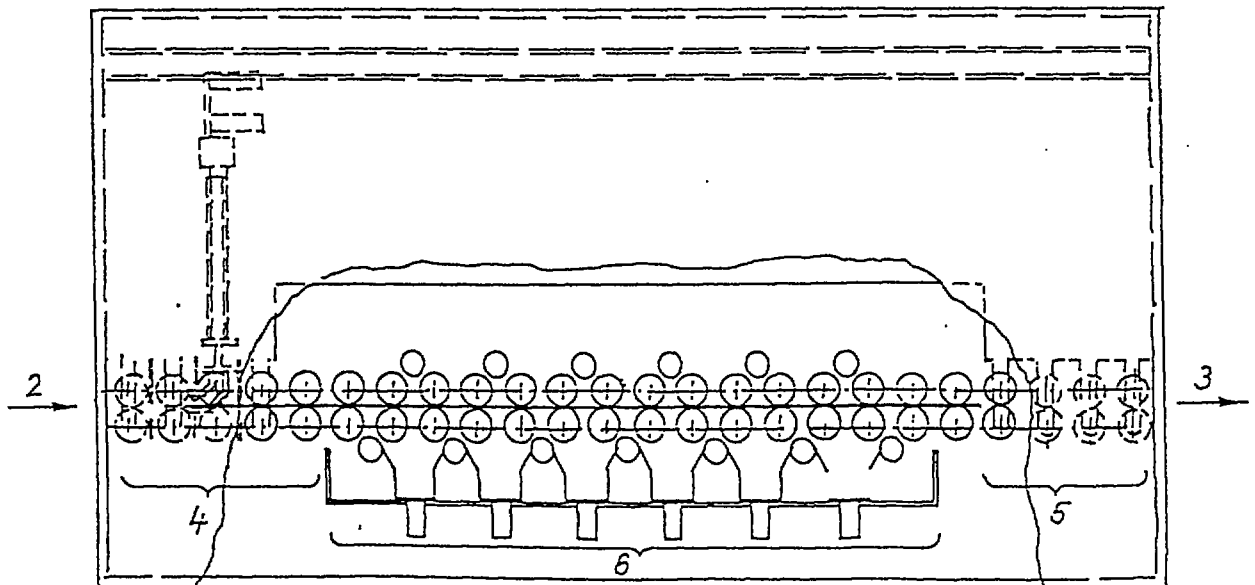
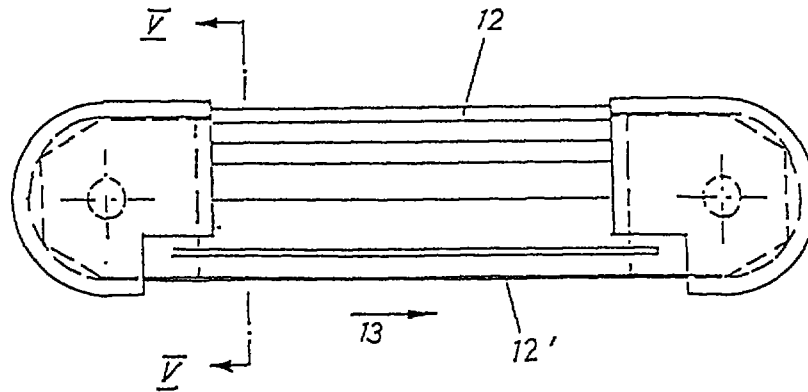


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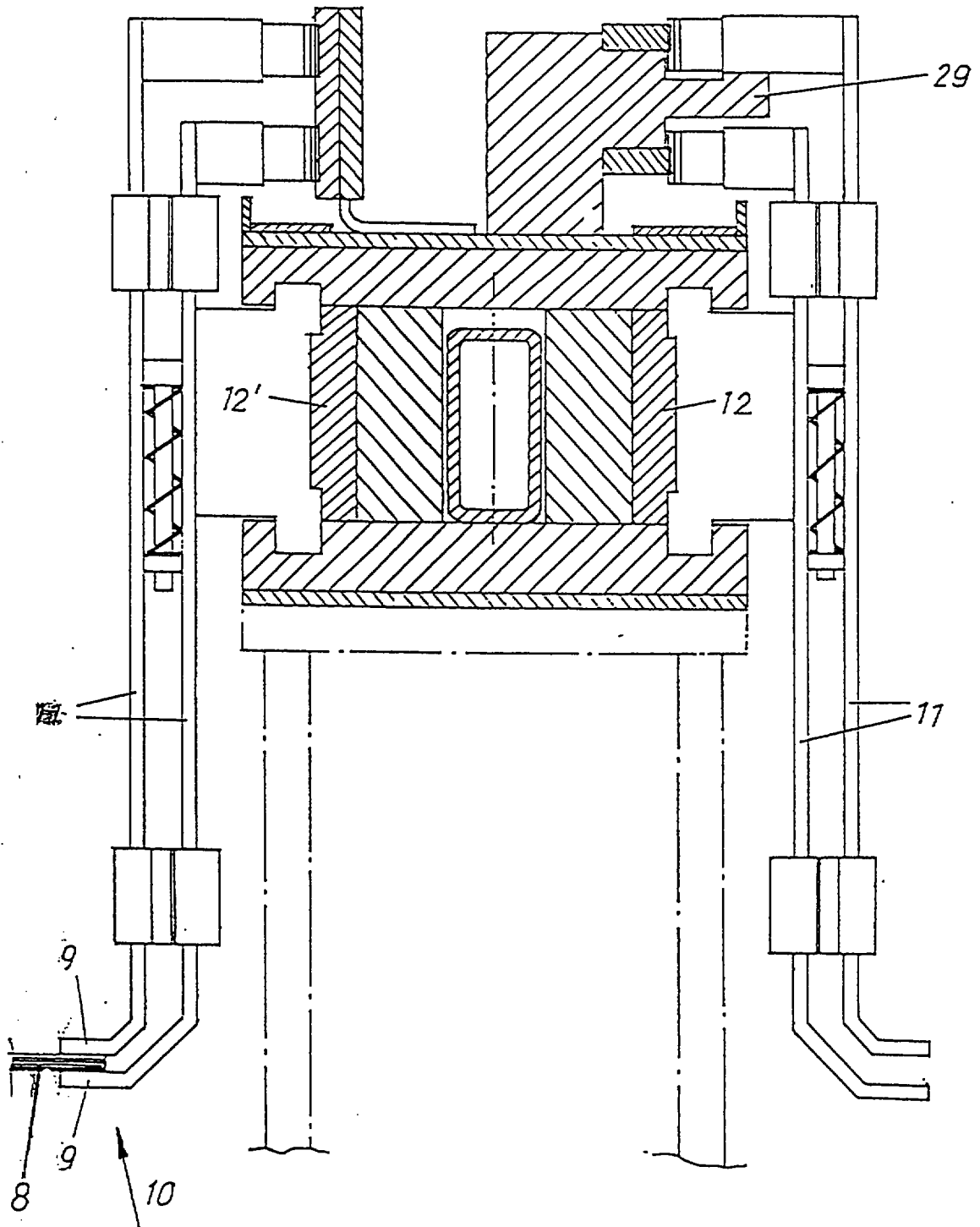


Fig. 5



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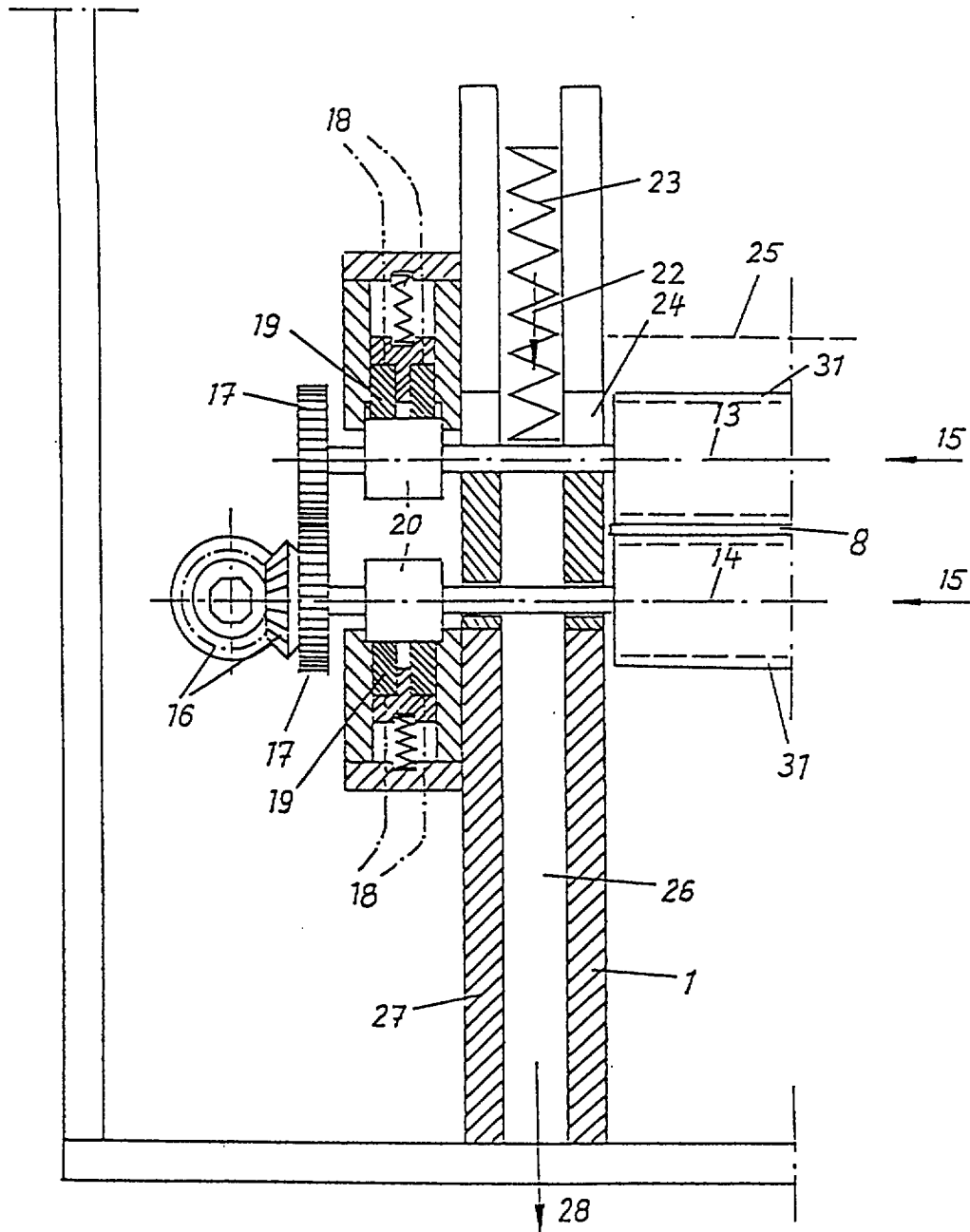


Fig. 6

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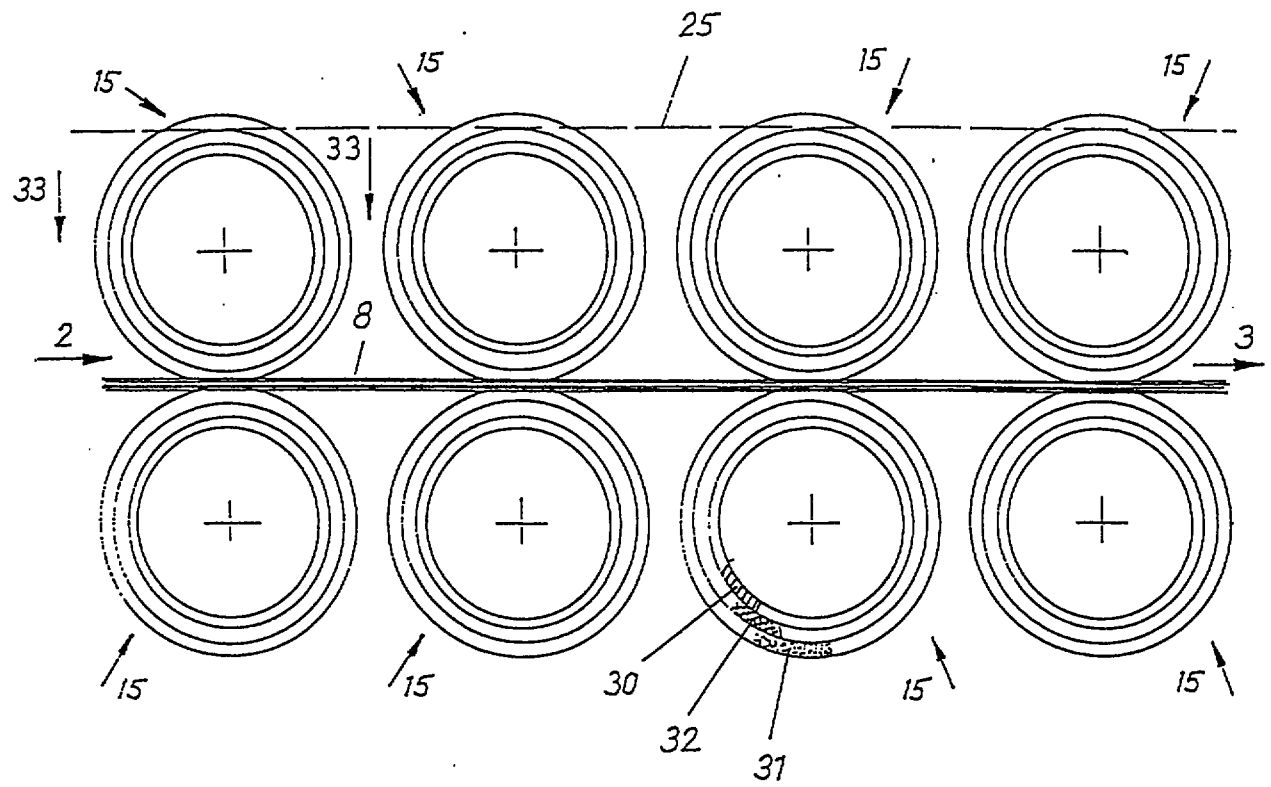
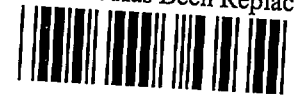


Fig. 7

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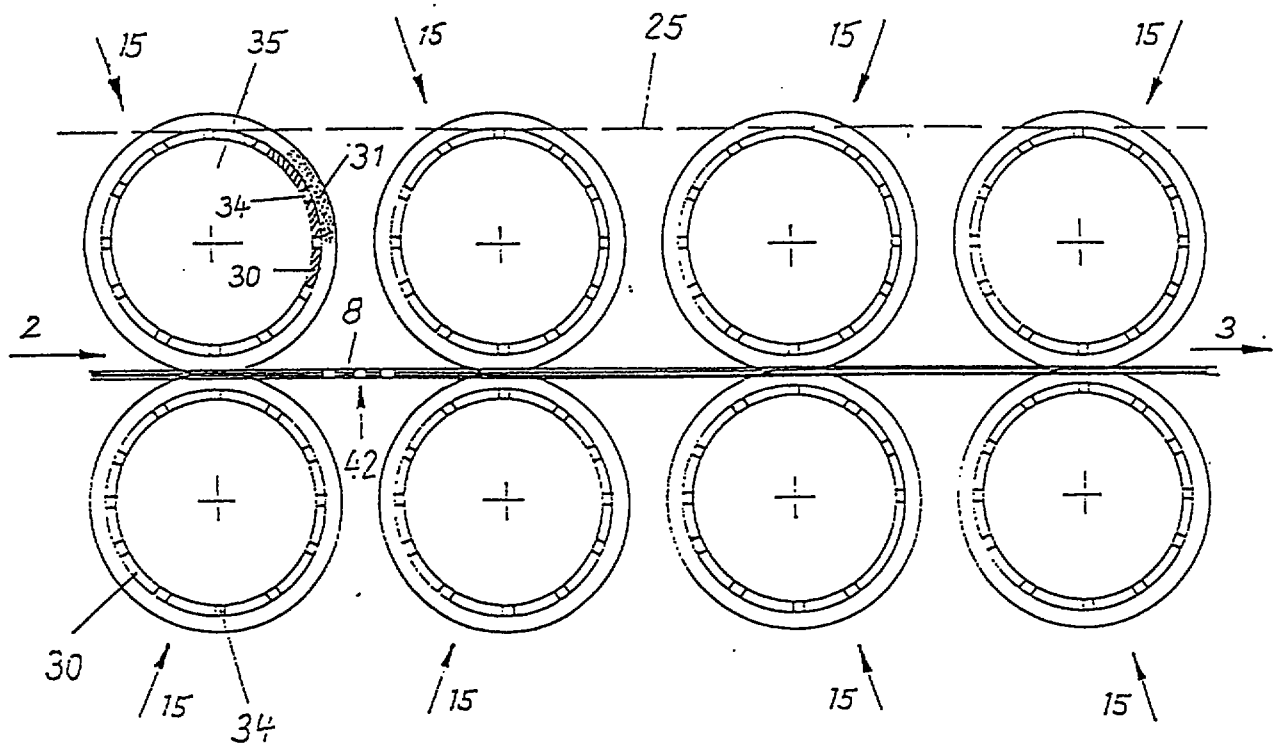


Fig. 8

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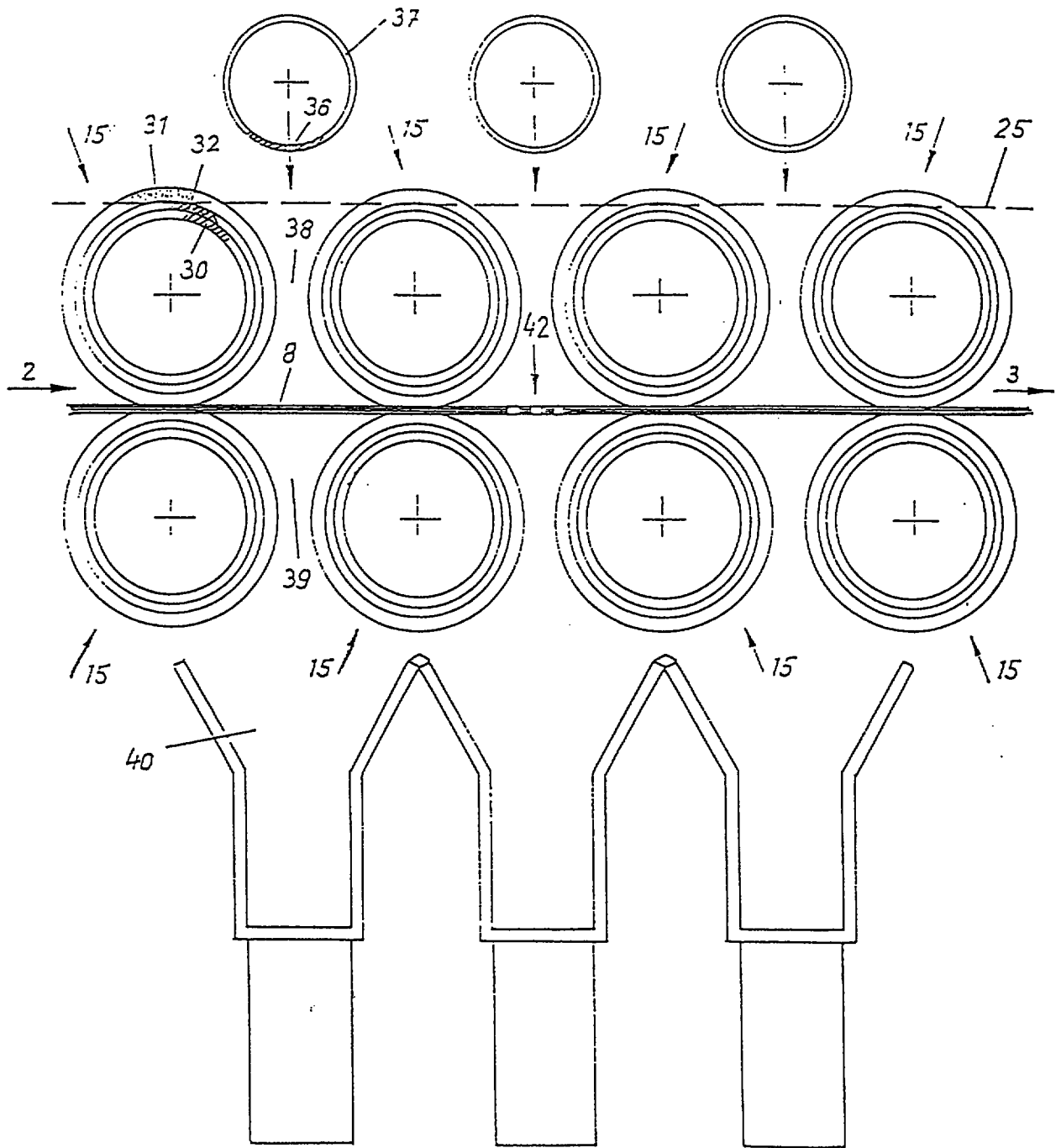


Fig. 9

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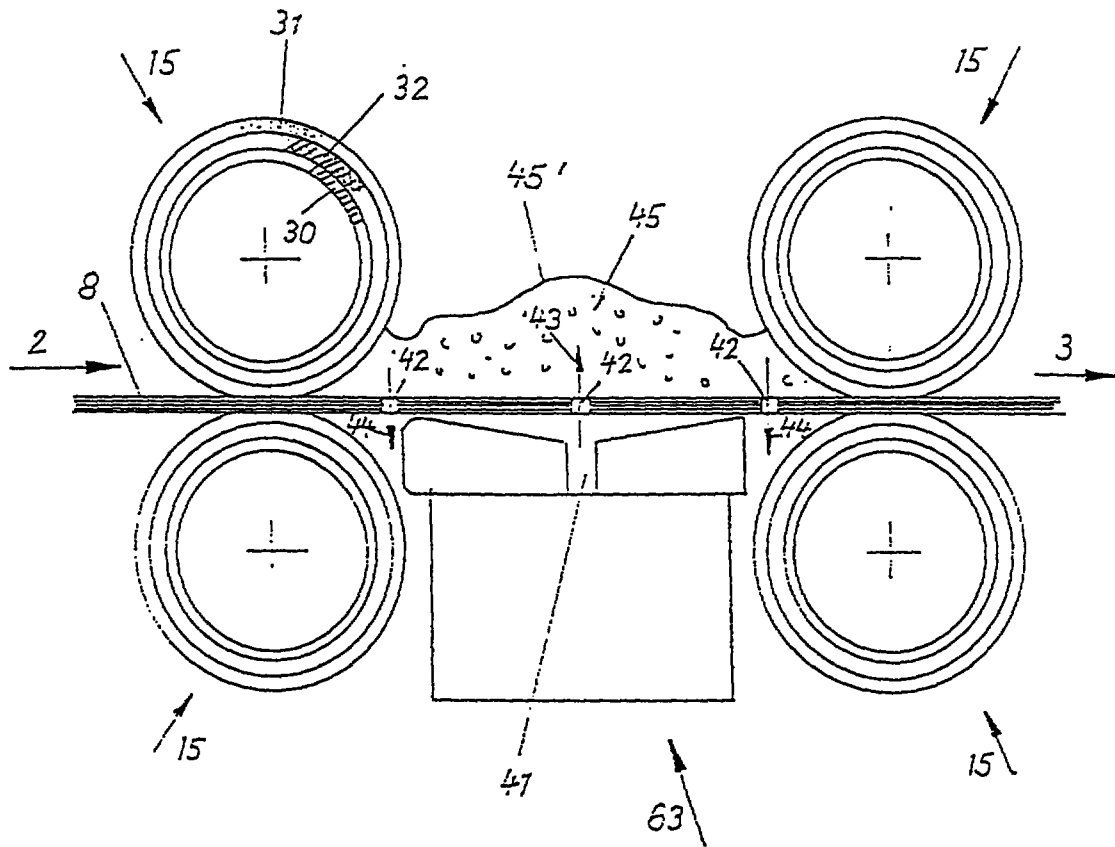


Fig. 10

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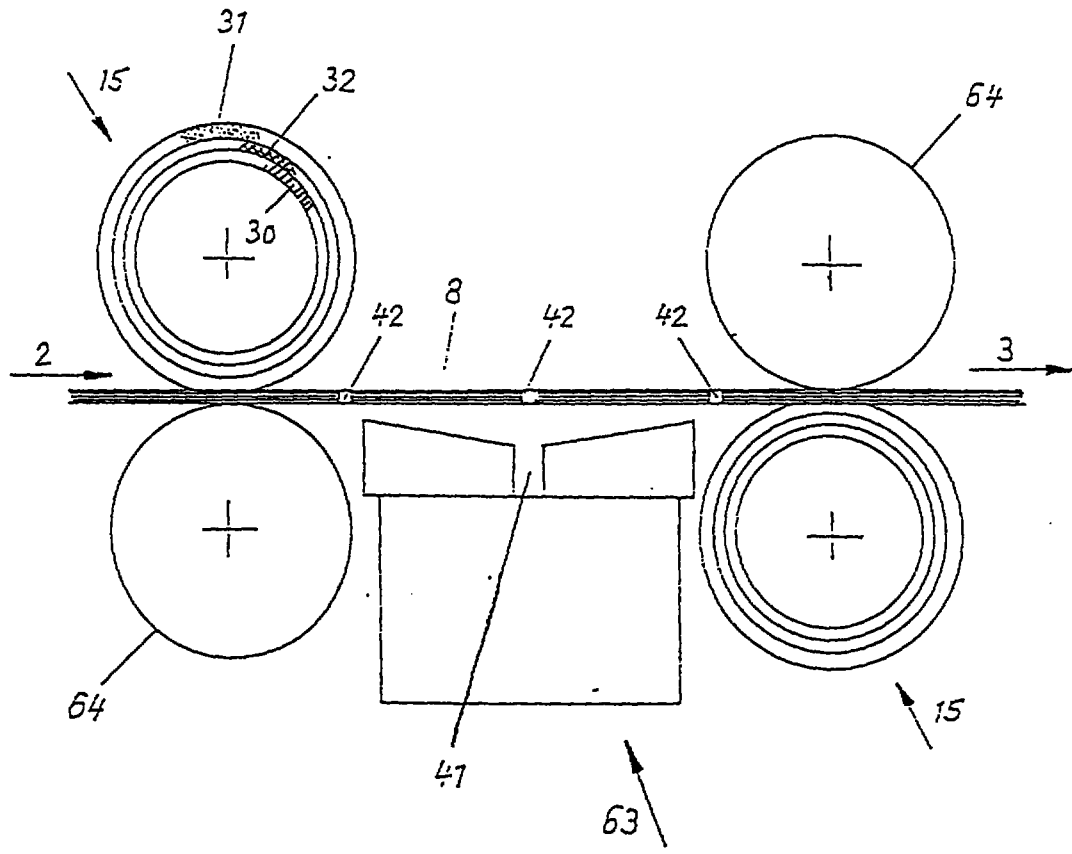
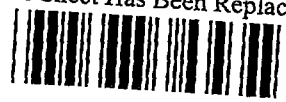


Fig. 11

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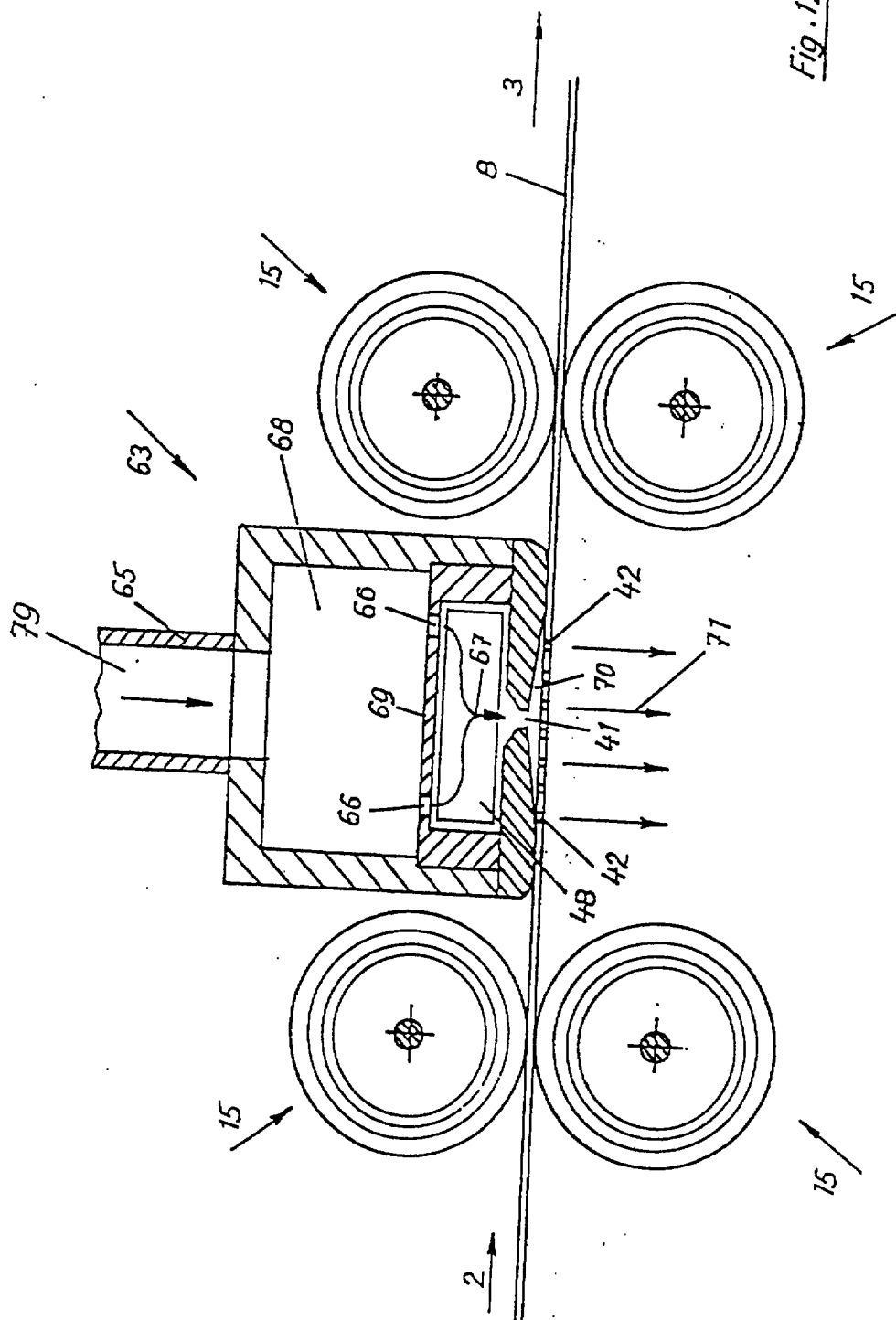
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Fig. 12



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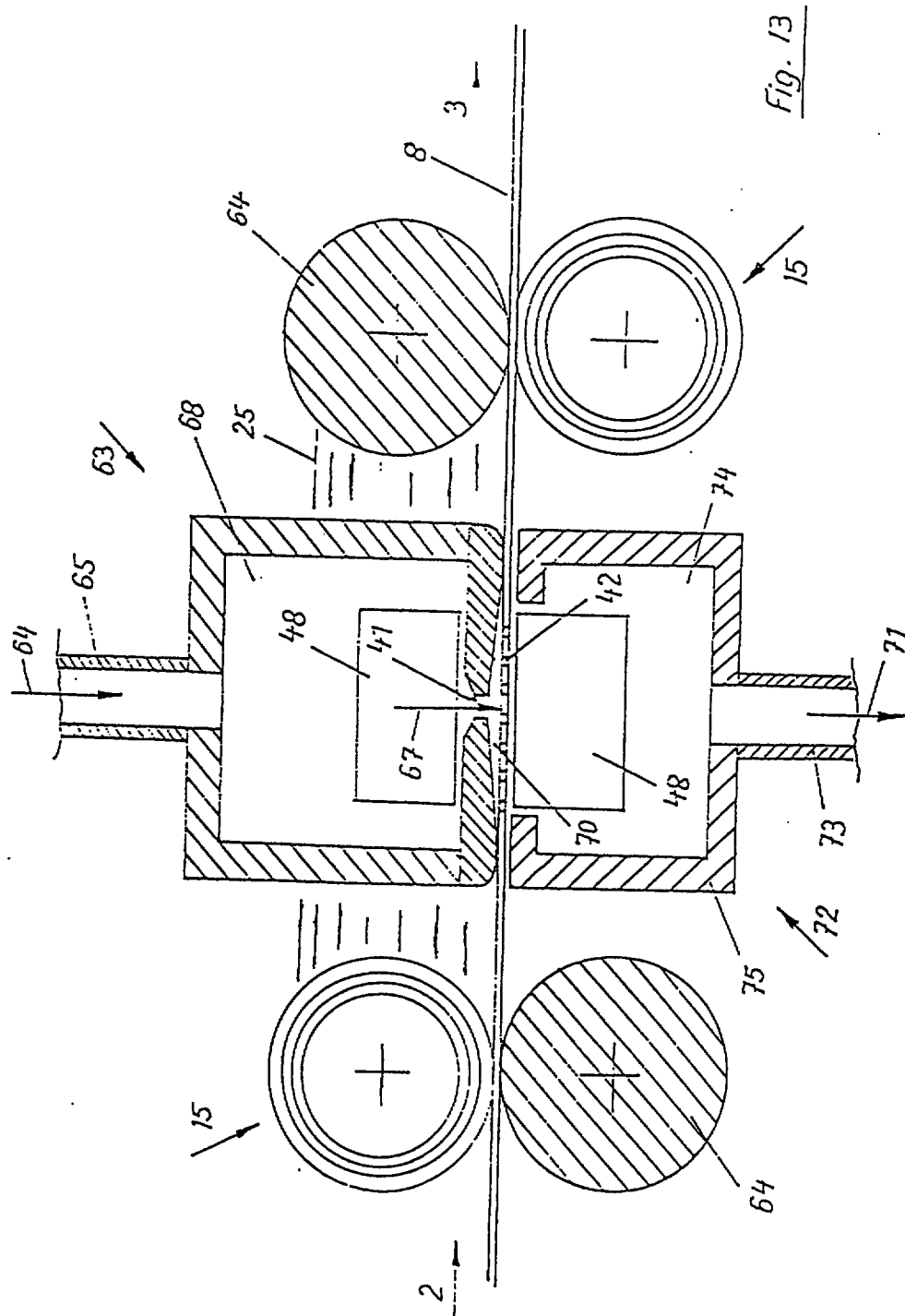
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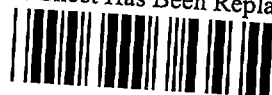
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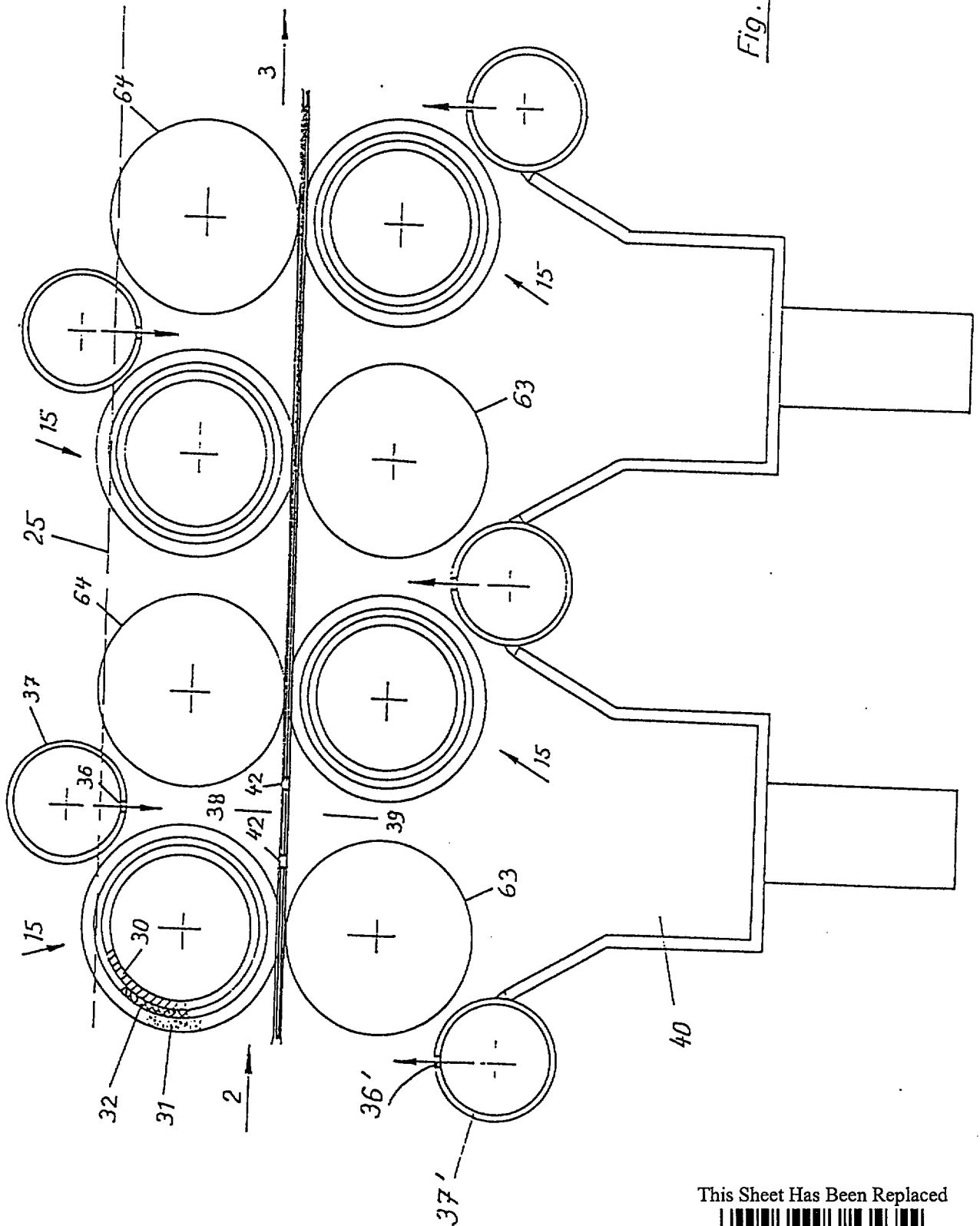


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Fig. 14



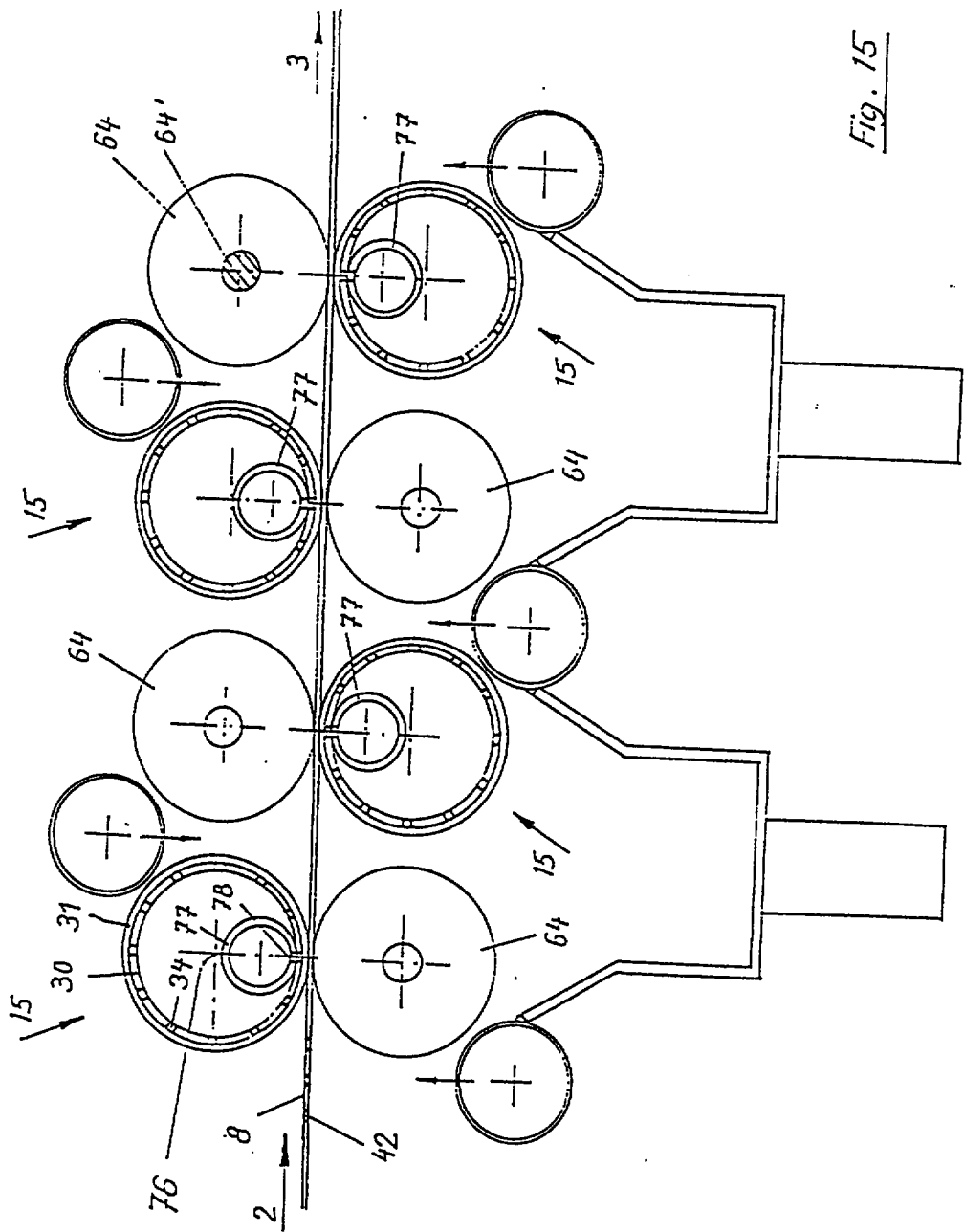
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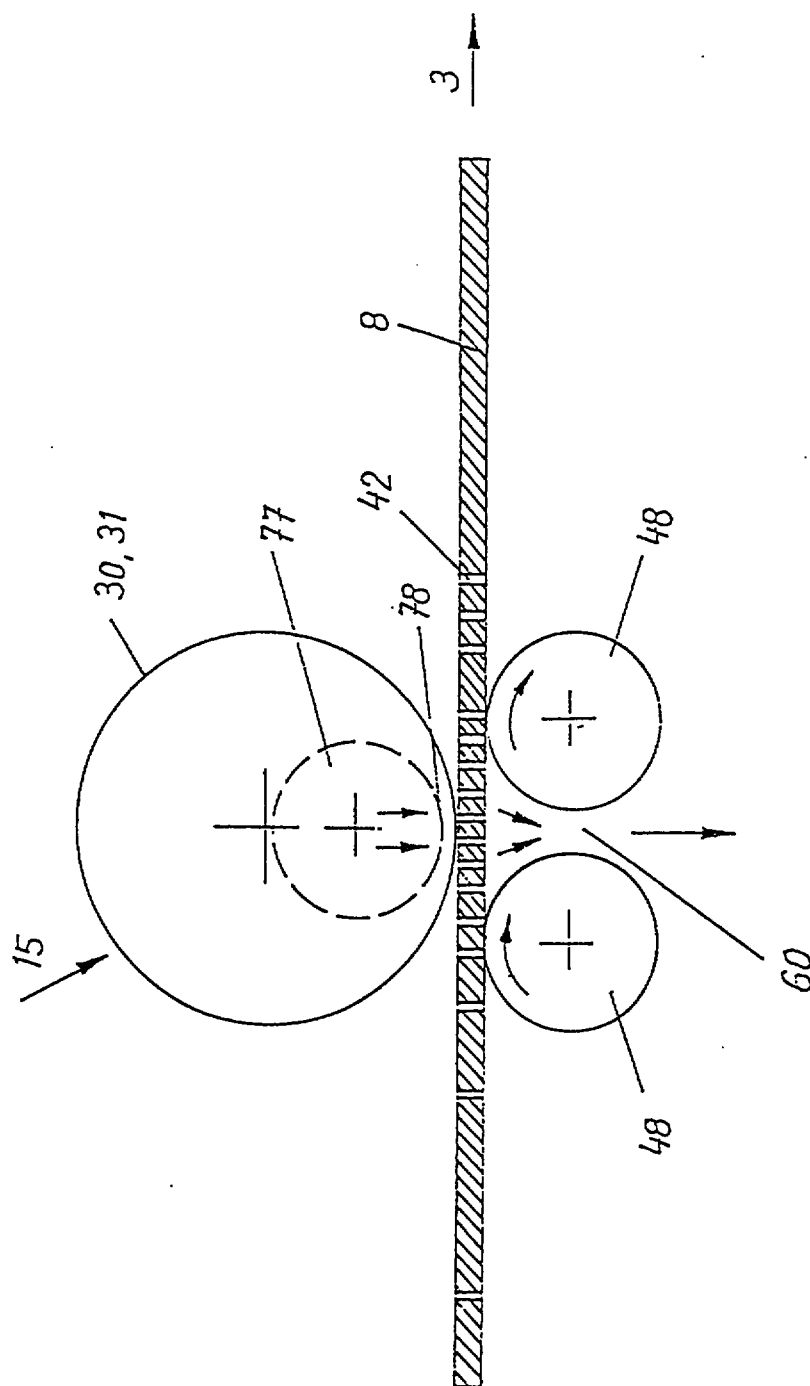


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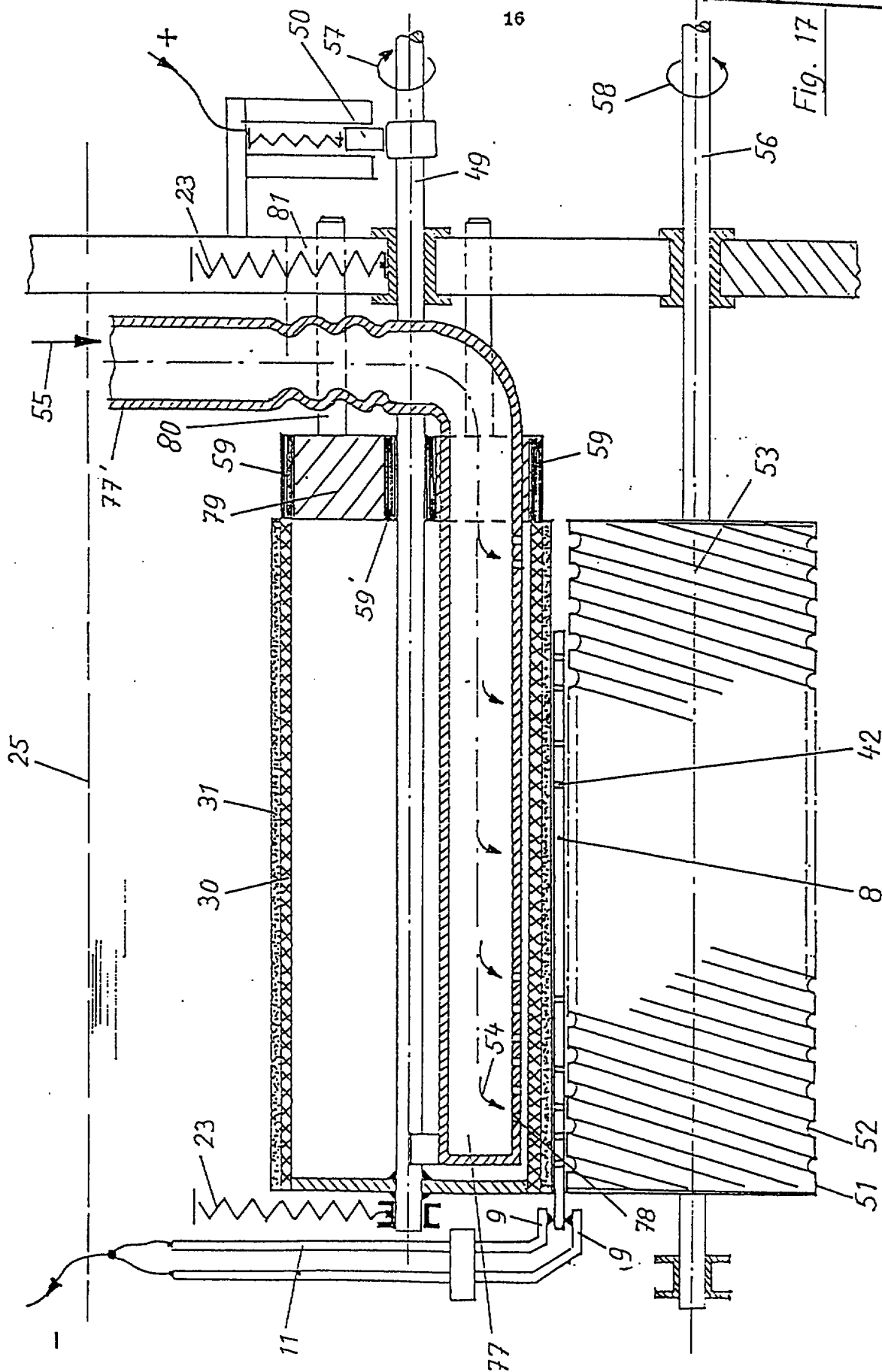


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CLAIMS

1. Method of electrolytically treating printed circuit boards, which are provided with bores and moved through a treatment bath by conveyor means or guided to a treatment station, means for reducing the thickness of a zone (diffusion layer), which is deprived of metal ions, being provided and in contact with the printed circuit boards, the areas (K1) of the printed circuit boards to be treated being continuously and mechanically wiped in the presence of an anode and cathodic printed circuit boards (K), or in the presence of anodic printed circuit boards and a cathode, and the electrolyte is moved with a movement component, which is substantially perpendicular to the plane of the printed circuit boards, and is conducted through the bores (42) in said boards.

2. Method of electrolytically treating printed circuit boards, which are provided with bores and moved through a treatment bath by conveyor means or guided to a treatment station, means for reducing the thickness of a zone (diffusion layer), which is deprived of metal ions, being provided and in contact with the printed circuit boards, a relative movement being effected between cathodic or anodic printed circuit boards (8), on the one hand, and a mechanical wiping device (15;46,47;53;59) at the anode end or cathode end, on the other hand, said wiping device being brought directly into sliding abutment on the surfaces of the printed circuit boards in order to disturb and at least partially destroy the diffusion layer, and the electrolyte is moved with a movement component, which is substantially perpendicular to the plane of the printed circuit boards, and is moved through the bores (42) in said boards.

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3. Method according to claim 2, characterised in that the above-mentioned relative movement is created by a conveyor movement (2-3) of the cathodic or anodic printed circuit boards (8) relative to the wiping device (15;46,47;53;59) at the anode end or cathode end.

4. Method according to claim 2 or 3, characterised in that the movement of the cathodic printed circuit boards (8) is effected relative to a wiping device (15;46,47;53;59) at the anode end, which device has a coating (31;54;61) formed from a material which absorbs the electrolyte and permits it to pass therethrough, and in that the coating is brought directly into sliding abutment on the surfaces of the printed circuit boards in order to disturb, or at least reduce the diffusion layer, while the electrolyte is simultaneously moved with a movement component substantially perpendicular to the plane of the printed circuit boards to reduce the diffusion layer in the bores in the printed circuit boards and is moved through the bores (42) in said boards.

5. Method according to one of claims 1 to 4, characterised in that either one surface is wiped, or both surfaces of the printed circuit boards are wiped.

6. Method according to one of claims 2 to 5, characterised in that the wiping device (15;46,47;53;59) at the anode end has an inherent movement at its abutment location or area relative to the surface of the printed circuit boards (8), which movement differs in size and/or direction from the conveyor movement.

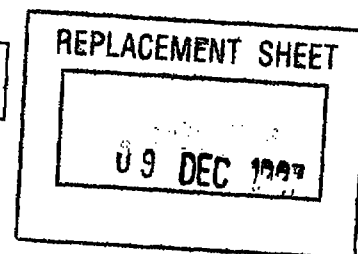
7. Method according to one of claims 1 to 6, characterised in that, in the case of a two-sided treatment of the printed circuit boards (8), their

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relative speed relative to the wiping device on their one surface is directed to the wiping device on their other surface in opposition to their relative speed.

8. Method according to one of claims 2 to 6, characterised in that, in the case of a two-sided treatment of the printed circuit boards (8), their relative speed relative to that of the wiping devices on their two surfaces is orientated in the same direction.

9. Method according to one of claims 2 to 8, characterised in that the relative speed between printed circuit board and wiping device is minimal, and more especially tends to virtually zero.

10. Method according to one of claims 1 to 9, characterised in that a pressure of the wiping device is exerted upon the printed circuit boards.

11. Method according to one of claims 4 to 10, characterised in that, with the presence of a resilient coating of the wiping device, the coating is compressed or pressed.

12. Method according to one of claims 1 to 11, characterised in that, during the course of the movement (2-3) of the printed circuit boards (8) through the treatment path, the current density of the galvanising current is increased.

13. Method according to one of claims 1 to 12, characterised in that the electrolyte is guided through the bores (42) with pressure.

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14. Method according to one of claims 1 to 13, characterised in that the electrolyte is sucked from the bores (42) by means of reduced pressure.

15. Method according to one of claims 1 to 14, characterised in that the wiping of the areas and the guidance of the electrolyte through the bores are effected beneath the level of the bath (25) and, in consequence, internally of the bath fluid.

16. Arrangement for electrolytically treating printed circuit boards, which are provided with bores and moved through a treatment bath by conveyor means or guided to a treatment station, means for reducing the thickness of a zone (diffusion layer), which is deprived of metal ions, being provided and in contact with the material being treated, more especially for accomplishing the method according to one or more of claims 1 to 15, and wherein means (W) for wiping the surface or the surfaces of either cathodic (K) or anodic printed circuit boards are provided, and means are also provided for moving the electrolyte in a flow through the bores (42) in the printed circuit boards (8), which flow extends substantially vertically relative to the plane of said boards.

17. Arrangement according to claim 16, characterised in that the wiping device is provided on the anode for the coating of metal.

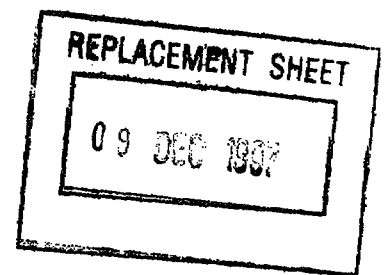
18. Arrangement according to claim 16 or 17, characterised in that the wiping device (15;46,47;53;59) at the anode end or cathode end is provided with a coating (31) and abuts against the surfaces of the cathodic or anodic printed circuit boards (8), at least

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during a relative movement between printed circuit board and wiping device.

19. Arrangement according to claim 18, characterised in that the wiping device or a plurality of wiping devices extends or extend over the entire width, which extends substantially at right angles to the direction of conveyance, or over the periphery of the conveyed printed circuit boards, and at least the printed circuit boards are displaceable relative to a wiping device.

20. Arrangement according to one of claims 16 to 19, characterised in that the coating (31) abuts against the surfaces of the printed circuit boards (8) with an adjustable compression force.

21. Arrangement according to one of claims 16 to 20, characterised in that the coating (31) is formed from a material, which is chemically resistant to the electrolyte, more especially a plastics material.

22. Arrangement according to claim 21, characterised in that the coating is formed from an open-pored plastics material, which is permeable to fluids and wear-resistant.

23. Arrangement according to claim 21 or 22, characterised in that the coating (31) is formed from a resilient material.

24. Arrangement according to one of claims 16 to 23, characterised in that the wiping device comprises at least one wiping roller (15), the periphery of which is provided with the coating (31), in that a drive is provided for rotating at least one wiping roller, the direction of rotation and/or circumferential speed of

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which roller is selectable to produce a relative speed between the abutment location or abutment area of the wiping device and the surfaces of the printed circuit boards (8).

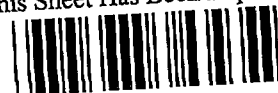
25. Arrangement according to claim 24, characterised in that the wiping roller or the wiping rollers (15) comprises or comprise a perforate, metallic tube (30) or an expanded metal tube or a wire grating tube and a cylindrical coating (31), which surrounds the wiping roller, the electrolyte being supplied or discharged internally of the tube, expanded metal or wire grating tube.

26. Arrangement according to claim 24, characterised in that the wiping roller or the wiping rollers comprises or comprise a metallic tube and a cylindrical coating (31), which surrounds the wiping roller, the coating and tube being held together by an expanded metal (32), situated therebetween, or by a wire grating, and in that the electrolyte is supplied from a location (33) externally of the wiping roller or wiping rollers to the bores (42) in the printed circuit boards (8).

27. Arrangement according to one of claims 24 to 26, characterised in that situated opposite a wiping roller (15), which abuts against a surface of the printed circuit boards and is provided with flow coating means, there is a pressure roller (64), which abuts against the other surface.

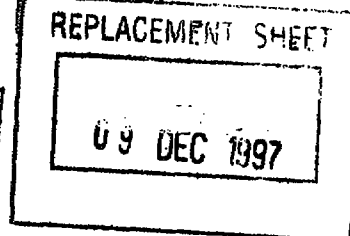
28. Arrangement according to claim 27, characterised in that, in the case of a two-sided galvanisation of the printed circuit boards, pairs of oppositely situated rollers are disposed one behind the other when viewed with respect to the direction of treatment (3), whereby,

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alternatively with one pair, a wiping roller (15) provided with flow-coating means is provided above the printed circuit boards (8) and a pressure roller (64) is provided beneath said printed circuit boards, and, in the case of the next pair, a wiping roller provided with flow-coating means is provided beneath the printed circuit boards and a pressure roller is provided above the printed circuit boards.

29. Arrangement according to one of claims 24 to 26, characterised in that at least one pair of wiping rollers are provided opposite one another, whereby one of the rollers is situated above the printed circuit boards (8) and the other roller is situated beneath said printed circuit boards, and the flow direction of the electrolyte is the same in both wiping rollers.

30. Arrangement according to one of claims 24 to 29, characterised in that the electrolyte is guided in the interior of the tube (30) of a wiping roller, and the electrolyte passes between the tube interior, the wall thereof and the coating (31) surrounding the tube.

31. Arrangement according to claim 30, characterised in that a number of through-apertures (34) are provided in the tube wall.

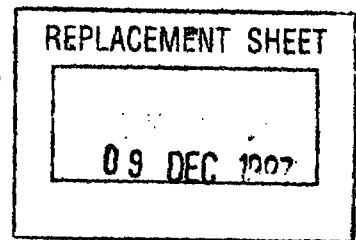
32. Arrangement according to one of claims 24 to 31, characterised in that, internally of the rotating tube (30) which is provided with through-apertures (34) for the electrolyte, a feed pipe (77), which guides the electrolyte, is provided with through-apertures or -slots (78), whereby the through-apertures or -slots (78) are orientated with their through-end faces towards the path of movement (2-3) of the printed circuit boards (8), and in that the feed pipe (77) as well as the

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rotating tube (30) extend over the entire width (a) of the path of the printed circuit boards.

33. Arrangement according to claim 32, characterised in that the through-apertures or -slots (78) of the feed pipe (77) are situated as close as possible to the printed circuit boards (8).

34. Arrangement according to claim 32 or 33, characterised in that the feed pipe (77) is mounted in a non-rotating manner in the tube (30).

35. Arrangement according to one of claims 32 to 34, characterised in that the rotating tube (30), together with the feed pipe (77) situated therein, is displaceably mounted substantially vertically relative to the plane of the printed circuit boards (8).

36. Arrangement according to one of claims 24 to 35, characterised in that one or more tubes (37) with apertures (36) for the electrolyte is or are provided for supplying the electrolyte to the spaces (38,39) between two wiping rollers (15), and in that collecting devices (40) for the electrolyte are provided beneath the spaces (38,39).

37. Arrangement according to one of claims 16 to 36, characterised in that pressure-producing means are provided for supplying the electrolyte to the bores (42) in the printed circuit boards.

38. Arrangement according to one of claims 16 to 37, characterised in that means are provided for sucking the electrolyte from the bores (42) in the printed circuit boards.

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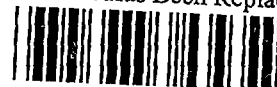
39. Arrangement according to claim 37 or 38, characterised in that a baffle nozzle (63) is provided for galvanising printed circuit boards (8), which are provided with bores (42), said nozzle urging the electrolyte through bores (42), which are situated in the region of the baffle nozzle aperture or slots (41), while the electrolyte is returned through other bores (42) in the edge region of the baffle nozzle by means of a reduced pressure on the underside of the printed circuit boards, the baffle nozzle extending over the entire width of the printed circuit boards (8) to be treated.

40. Arrangement according to claim 39, characterised in that anodes (48) are situated internally of the baffle nozzle (63), preferably internally of a preliminary chamber (68), which is surrounded by a housing and to which the electrolyte is supplied (65).

41. Arrangement according to claim 39 or 40, characterised in that a suction device (72) is situated on the outlet side of the bores (42), to which the electrolyte is supplied with pressure through the baffle nozzle (63), the housing (75) of said suction device being under reduced pressure and extending over the entire width (a) of the printed circuit boards to be treated.

42. Arrangement according to one of claims 16 to 35, 37 to 41, characterised in that lower tubes (37'), which convey the electrolyte upwardly from below, are provided with through-apertures (36').

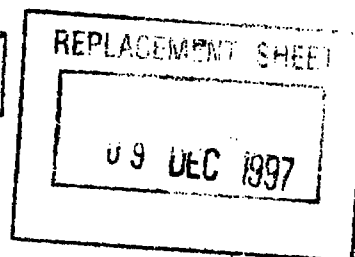
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43. Arrangement according to one of claims 16 to 42, characterised in that the wiping device or the wiping devices abut against the respective surfaces of the printed circuit boards with resilient force (23,55).

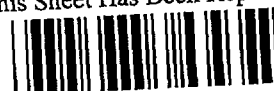
44. Arrangement according to one of claims 16 to 43, characterised in that the printed circuit boards (8) to be treated are placed and guided in a horizontal position in the treatment station.

45. Arrangement according to claim 44, characterised in that conveyor means (10), preferably clamps (9), are provided for the conveyance of the printed circuit boards in a horizontal position, such means gripping at least one of their lateral edges (8').

46. Arrangement according to one of claims 16 to 45, characterised in that the pressure rollers (51), which are situated opposite a wiping roller (15) in the form of a flow-coating roller (30,31,77,78), are provided with drainage grooves (52), which serve to conduct the electrolyte away.

47. Arrangement according to one of claims 16 to 45, characterised in that two counter-rollers (48) are mounted opposite the wiping and flow-coating roller (15;31,77,78) on the other side of the printed circuit boards and are so positioned that they form therebetween a throughflow chamber (60) for the electrolyte, such chamber either being urged by pressure from the flow-coating roller into the bores (42) in the printed circuit boards or being sucked into the flow-coating roller through the bores (42) by means of suction.

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48. Arrangement according to one of claims 16 to 47, characterised in that the thickness of the coating (31) is relatively small, and is preferably 1-4 mm.

49. Arrangement according to one of claims 16 to 48, characterised in that various wiping devices are provided in combination with one another for the electrolytic treatment of the same printed circuit boards.

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PROCESS FOR THE ELECTROLYTIC PROCESSING ESPECIALLY OF
FLAT ITEMS AND ARRANGEMENT FOR IMPLEMENTING THE PROCESS

The invention initially relates to a method of electrolytically treating printed circuit boards provided with holes, which are passed through a treatment bath by conveyor means, or are passed to a treatment station, means being provided for reducing the thickness of a zone (diffusion layer) depleted in metal ions which are in contact with the printed circuit boards. The preferred field of application of the invention is electroplating, which will be discussed in detail later. The invention may also be used for electrolytic etching.

The surface of the material for treatment or its diffusion layer disadvantageously depletes metal ions during the treatment procedure, as the cathode draws more ions to itself than would normally come from the surrounding treatment bath. This leads to a reduction in the acceptable specific current density, and thus to the fact that in order to achieve such a deposition of metal of a specific thickness, a correspondingly long treatment period is required.

In order to alleviate this disadvantage, the so-called "high-speed" method is known, in which the electrolyte is passed at high speed and in large quantities along the cathode surface between this and the anode (see for example European Patent 0 142 010 and German Patent 35 25 183). By

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these means an improved, i.e. increased current density of deposition of metal is in fact achieved on the cathodic material. Yet the generation, control and derivation of such an electrolysis current is relatively expensive. Provision of the flow ducts necessary for this purpose requires additional constructive outlay. Moreover, the type and method of guidance of the material for treatment can be complex in design. Therefore it has only become known for endless material such as strips or wires.

In the specialist article *Elektrolytische Hochleistungsverzinkung von Stahlband durch mechanische Grenzsichtbeeinflussung* (Electrolytic High-performance Galvanising by Mechanical Influence on Boundary Layers) by D. Meuthen and D. Wolfhardt in Metalloberfläche 36 (1982, 70 - 75) there is described a method for electrolytically galvanising steel strip, in which the strip surfaces to be galvanised are pressed against a plastics fibre fleece similarly to the so-called tampon of brush-galvanising method, and moved relative thereto. The coating electrolyte is washed through the fibre fleece on the surface of the steel. By means of this method a higher current density is achieved than with electrolytic zinc deposition.

A similar principle is described in the European Patent Application 0 210 072 for electrolytic coating of small

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metal particles which are in particular coated with noble metals for use as plug-in connectors.

A method is also known from US Patent 3 706 650, in which non-conductive liquid-retaining porous compressible means are pressed against the surface to be coated and moved relative thereto, the counter-electrode to the article to be coated being located in the interior of said means. The electrolyte liquid is flowed from the exterior on to the contact surfaces between the porous compressible means and the surfaces to be coated. The porous compressible means further includes hard non-conductive particles which slightly roughen the surfaces for treatment of the metallic workpiece.

In the unexamined German Application 14 46 045 there is disclosed a method for electroplating with simultaneous electrolytic cleaning of metallic surfaces and a device for carrying out this method. In this case there is involved the coating of large boreholes in the steel with the aid of an internal electrode, the outer surfaces of which are rubbed against the inner surfaces of the boreholes.

There are known from DE-OS 36 03 856 a method and apparatus for electroplating flat workpieces such as printed circuit boards. The plate-shaped workpieces are grasped and conveyed by a pair of rollers incorporated as cathode and rotating at

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a relatively low rotational speed. The electrolyte is transferred to the workpiece by a pair of rollers incorporated as anode, and the surface of which can absorb liquid. Thus a small interval is deliberately left between the workpiece surface and the surface of the anodic rollers. The rotational speed of the anodic rollers is relatively high, in order to obtain a correspondingly rapid movement of electrolyte along the surface of the workpiece. This is intended to achieve an increase in the current density compared to a previous dip bath electroplating. Thus rotating insoluble roller pairs are described as anodes. The metal is supplied in a dissolved state via the electrolyte. The anode roller pairs are not beneath the level of the bath; for this reason the electrolyte must be continuously supplied to the electroplating point. The quantity of electrolyte which may be supplied here is limited, not least by the narrow plastics screens above the rollers. The possible current density of electroplating is also limited by this restriction. The plastics screens are however necessary in order to delay undesired electroplating of the cathodically-incorporated further roller pairs which serve to convey the printed circuit boards.

Because the rotating anodic roller pairs do not contact the upper sides of the printed circuit boards, the diffusion layer present on the surface is not mechanically disturbed. The gap between the anodic rollers and the upper side of the

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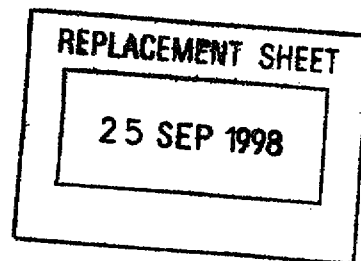
printed circuit board, and thus between the pairs, is however necessary in order to enable separate adjustment of the electroplating currents for both sides of the board. during electroplating of the conductor track pattern this is always necessary, as in practice both sides of the board will have irregular copper surfaces. For this reason the anodes of the upper side of the printer circuit board are powered from one bath current rectifier, and the anodes of the underside by another rectifier. The current of each rectifier may be adjusted independently.

A further disadvantage of the named invention is the extremely poor penetration through fine holes in the printed circuit boards. At mutually-opposed sides of the board, small amounts of electrolyte are applied in an almost pressure-free condition. This prevents penetration of the holes, resulting in insufficient electroplating of the walls of the holes, leading even to 'burning-on' in the holes.

The object of the invention is to design a method of the type in question in such a way that the desired reduction in the thickness of the ion-depleted diffusion layer is achieved, and thus a correspondingly increased current density of the electroplating current flowing out of the electrolyte on to the cathodic material, the outlay on method and construction of the so-called "high-speed" flow technology however being avoided.

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The solution to this set problem or task is firstly seen, proceeding from the prior art of the type in question, in the fact that, when an anode and a cathodic material for treatment are present, or in the presence of an anodic material for treatment and a cathode, the surface to be treated of the material is continuously and mechanically wiped, and in that the electrolyte moves with a component of movement perpendicular to the plane of the material for treatment, and is passed through the holes or boreholes therein (for reasons of simplicity, termed only "boreholes" in the following). By means of such wiping of the relevant surface or surfaces, the disadvantageous depletion of the diffusion layer in metal ions is counteracted in a simple, advantageous and industrially feasible way. The diffusion layer is extensively destroyed, and thus the ion-depleted zone at the relevant surface or surfaces is totally or at least predominantly removed. The metal ions of the electrolyte can thus pass directly to the surface of the relevant material or, during etching, can be removed therefrom. Further advantages may be seen from the following explanations of the various possible embodiments of the invention, both in terms of process and of the physical apparatus involved. By means of the combination according to the invention of the abovementioned wiping, and of the metallisation thus achieved of the surfaces, with metallisation of the inner wall of the boreholes, due to the



penetration of electrolyte through said boreholes, adequate treatment of the inner wall of the boreholes is achieved at the same time, and thus, in one working operation, metallisation of the material for treatment is achieved in all necessary areas (surfaces and boreholes) with satisfactory results and by relatively simple measures. In this connection, the abovementioned combination has the advantage that, by means of the wiping procedure, any surface tension present in the liquid in the boreholes is disrupted, further simplifying metallisation of the inner wall of the boreholes. As the embodiments of this invention show, the constructive means for wiping on the one hand and the penetration of the electrolyte through the boreholes (so-called flooding) on the other hand, may be provided together in a simple and at the same time compact way; in a preferred embodiment of the invention they may even be combined. Reference is made in this respect for example to the embodiment in Figure 15. A further advantage resides in the fact that, by means of the abovementioned flooding, particularly when this is effected by reinforcement of penetration of the electrolyte, e.g. by means of a pump, into the boreholes and/or of suction extraction of the electrolyte from the boreholes by means of a suction device, any particles still present in the boreholes can be brought out and carried away. This avoids the risk that particles trapped in the boreholes may become embedded by the

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metallisation and obstruct the relevant borehole, leading to scrapping of the board.

In this connection the danger is also avoided of abrasion or machining particles adhering to the edge of the boreholes being grasped and transported along the surface of the material for treatment, so that the extremely sensitive surface of the material could be damaged and thus even become unusable.

A supplementary solution of the purpose is represented by a method in which an appropriate relative movement between the cathodic or anodic material for treatment on the one hand and a wiping device on the anode side or on the cathode side on the other hand brings about the effect according to the invention.

In order to bring about this relative movement, the transport movement of the material for treatment may be used as an alternative, if the material for treatment is passed through a treatment bath by conveyor means.

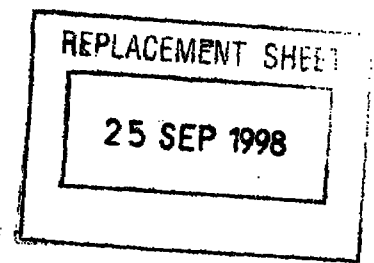
The further sub-claims represent preferred embodiments of the invention.

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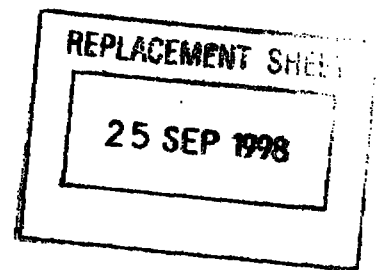
The possible process measures according to the invention, provided in order to fulfil the abovementioned purpose, may preferably be used in electroplating, but also for electrolytic etching. In this case the material for treatment (workpiece) has an anodic function, i.e. is incorporated as an anode. The etched-off metal is deposited on a counter-electrode (cathode). The counter-electrode may be the wiping device. It is then removed therefrom in a later operational stage, and recovered. Such electrolytic etching is an alternative to purely chemical etching. In electrolytic etching the boundary layer occurring at the anodes is disrupted by simultaneous wiping at that point.

In order to simplify the illustration of the invention, it will be explained in the following, and also in the description of embodiments in conjunction with the drawing, with reference to methods and apparatus for electroplating.

By means of movement of the anode, provided with a covering, relative to the material for treatment which is to be electroplated, the covering being in contact with the material for treatment, the diffusion layer (see above) is to a large extent destroyed, and thus the ion-depleted zone at the surface of the material for treatment is totally or at least mainly removed. The ions of the electrolyte can pass directly through the covering on the electrolyte on to the surface of the material for treatment, and metallise it.



In this way relatively high current densities may be achieved, providing high quality, and in particular uniform thickness of the metallic layer deposited on the surface of the material, e.g. a copper layer. This is a substantial advantage, which is of particular importance when it is intended to coat not the entire surface, but only the surface of conductive strips which are located on such a printed circuit board. A further, substantial advantage of the invention resides in the fact that the interval between the anode and the cathodic material is determined only by the thickness of the covering; this thickness, however, can be relatively small. Due to the extremely small interval thus achieved between anode and cathode, different field line concentrations of the electroplating current flowing from anode to cathode are practically absent, or are at least substantially less than in arrangements in which a comparatively large interval is left between anode and cathode. In order to avoid damaging effects, i.e. increased deposits of metal at lateral areas, e.g. the so-called "dog-bone" effect in previously-known apparatus with a relatively large interval between anode and cathode, corresponding measures, e.g. screening, had to be provided. This applies in particular to a plate-shaped material for treatment such as electronic printed circuit boards provided with a large number of holes. In this case dispersions (so-called "borehole dispersion values"), which are of considerable magnitude, can occur in the lateral region of the plates and



in the holes. It is a substantial advantage of the invention that by its means higher current values are achieved without so-called burning-on or the like of the metal to be deposited occurring, due to dispersions, at the cathode. Screening or similar measures to counteract excessive dispersions of the electroplating current are unnecessary. A further substantial advantage of the invention resides in the fact that it is suitable for automatic electroplating of a material for treatment (perforated plates or the like) passing continuously through a treatment installation. This will be effected with material for treatment which is disposed and conveyed horizontally (see in this respect DE-OS 36 24 481, discussed later). Yet the invention may be applied not only in horizontal but also in vertical or oblique passage, while achieving the advantages explained above, particularly the avoidance of damaging dispersions at high current densities. When higher current densities can be used, as results from the invention, the transport speed also becomes more rapid, or the treatment path shorter. In particular, it is not necessary to take account of a specific high flow speed of the electrolyte.

By means of the invention, a wiping effect is automatically achieved on the entire surface to be treated, particularly both sides or surfaces of the plate-shaped material. For the sake of completeness it should be mentioned that there is known for manual electroplating so-called tampon

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electroplating, as used especially for treatment, repair or refurbishment of larger components which could not be treated, or only under extremely difficult circumstances, in an electroplating installation. Typical examples of this are the repair or electroplating of metallic church roofs, larger monuments and the like. Reference is specifically made in this respect to the publications of RUBINSTEIN in the periodical "Galvanotechnik" (Electroplating Technology), No. 73 (1982), page 120 et seq., No. 79 (1988), page 2876 et seq. and page 3263 et seq. Such a tampon method may however only be used for the abovementioned special cases, and not, however, for industrial production of boards or the like provided with holes.

In a preferred embodiment of the invention, there are used, not only the transport speed of the material for treatment, but also an intrinsic speed of the anodic apparatus, provided with the covering, in order to achieve an intensive wiping effect. Depending on requirements and on the type of construction, the most varied effects and wiping speeds are obtainable.

The relative speed mentioned in the preceding claims can be small, e.g. almost zero. Furthermore, in carrying out the method a pressure may be exerted by the wiping device on the material for treatment. In the presence of a resilient covering, the covering may be compressed. Apart from the

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fact that in this way irregularities in the thickness of the material may be compensated for, this in addition contributes to reinforcing the effect according to the invention of disrupting the diffusion layer. This applies in particular to the disclosed combination of features.

Further process measures facilitate the passage of the electrolyte through the boreholes, and thus also metallisation of the inner walls of the boreholes. They also make a contribution to removal of particles or the like present in the boreholes.

A further purpose underlying the invention is to provide an apparatus for electrolytically treating printed circuit boards provided with holes, which are passed through a treatment bath by conveyor means, or are passed to a treatment station, means being provided for reducing the thickness of a zone (diffusion layer) depleted in metal ions which are in contact with the printed circuit boards, which achieves perfect electrolytic treatment, this at the same time being possible by simple means, of one or both surfaces of the printed circuit boards and also of the holes or boreholes located therein (briefly termed "boreholes" in the following). This is in particular possible with the process measures according to one or more of the process claims of the present invention.

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In fulfilment of this set purpose or problem, firstly the apparatus has means for wiping the surface or surfaces either of a cathodic material for treatment or of an anodic such material, and further means for moving the electrolyte in a flow extending perpendicularly to the plane of the material through the boreholes therein (flooding means). This theory of the invention may be realised in a constructively simple way, as will become more specifically apparent from the further embodiments, and particularly from the explanation of the embodiments.

Wiping devices with the covering are a particularly favourable embodiment of the invention for mechanical wiping.

It is recommended to have the covering bear against the surface of the material for treatment with a certain degree of contact pressure. This is of particular advantage in treating circuit boards and boreholes, as the liquid located in the boreholes has on its surfaces a certain degree of surface tension which is disrupted by this wiping, so that in this way the path is opened for ions to form a metal layer (during electroplating) on the surfaces. Such a contact pressure may be provided for example by resilient mountings of the wiping device, particularly of the abovementioned rollers.

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A flat material for treatment is particularly suitable to be passed through between rollers. In construction and use in installations, rollers are known per se for treating plate-shaped articles, yet not in accordance with the theory of this invention in this form, of wiper rollers, but only as conveyor and guide rollers and as squeeze rollers for sealing. They have the advantage of simple and robust construction, and ease of incorporation in a treatment installation. Contrary to known conveyor rollers or press rollers, the wiper rollers in this case, with their coverings, have the purpose of achieving the explained mechanically-generated wiping effect, i.e. their rotational speed deliberately deviates from the transport speed of the material for treatment in contact with them. They may also be designed as a counter-electrode to the article to be treated. This deviation in speed may be obtained by the respective magnitudes of the abovenamed speeds and/or their respective directions. It should also be noted at this point that the abovementioned deviation in speed or relative speed can be small, down to almost zero. Further, reference is made in this connection to the possible embodiment of the invention in claims 23 and 43, and to the process measures in claims 10 and 11.

Furthermore, the wiper rollers with their coverings may mechanically favour the removal of particles. This applies in particular when the wiper rollers are pressed with a

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certain degree of contact pressure against the surface of the material for treatment. In this way also disruptive layers on the cathode, such for example as gas bubbles adhering to the surface of the material for treatment, may be removed.

Further preferred embodiments for reinforcing the metallisation of the inner wall of the boreholes consist of means for passing (flooding) the electrolyte through the boreholes with a corresponding excess pressure or partial vacuum. The flooding means and associated apparatus of claims 27 and following are specifically referred to here. In this respect an apparatus according to claims 31 to 34 is particularly recommended.

Further advantages and features of the invention will become apparent from the further sub-claims, and from the following description with associated drawing of possible embodiments of the invention. The substantially diagrammatic drawing shows:

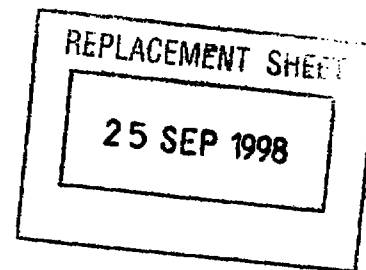
- Fig. 1: a theoretical illustration of the method according to the invention, in partial cross-section;
- Fig. 2: an end elevation and partial cross-section of a construction for carrying out the method or methods according to the invention;

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- Fig. 3: the side elevation associated with Fig. 2;
Fig. 4: a plan view of the conveyor device in Fig. 2
and Fig. 3;

The Figures which follow are in their entirety drawn to a scale larger than the illustrations in Figs. 2 to 4.

- Fig. 5: a cross-section of the conveyor device,
along line V-V in Fig. 4;
Fig. 6: the detail VI circled in Fig. 2, on an
enlarged scale and in partial section;
Fig. 7: a first embodiment of the layout and
disposition of the wiper rollers;
Fig. 8: a second embodiment of the layout and
disposition of the wiper rollers and of
flooding;
Fig. 9: a third embodiment of the layout and
disposition of the wiper rollers, and of the
feed and return of the electrolyte fluid and
of flooding;
Fig. 10: a fourth embodiment of the layout and
disposition of wiper rollers, and of the feed
and return of the electrolyte fluid and of
flooding;
Fig. 11: a fifth embodiment of the layout and
disposition of the wiper and support rollers,



and of the feed of the electrolyte fluid, and of flooding;

- Fig. 12, 13: a sixth and seventh embodiment of the invention, with wiping and flooding means;
- Fig. 14: an eighth embodiment of the layout and disposition of the wiper and support rollers, and of the feed of the electrolyte fluid, and of flooding;
- Fig. 15: a ninth embodiment of the invention in the design of the wiper rollers and an associated guide means for the electrolyte, and of flooding;
- Fig. 16: a further (tenth) embodiment of the invention for achieving the flooding and wiping effect;
- Fig. 17: a further (eleventh) embodiment of the invention for achieving the flooding and wiping effect.

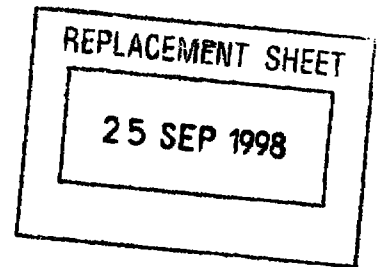
In the diagrammatic view in Figure 1 the principle of the invention is shown. Figure 1 shows diagrammatically the principle of the invention with reference to a cathodic material for treatment K with a surface K1 for treatment, and associated wiping device W. This wiping device W has an anodic function. The abovenamed wiping device may be wiper rollers according to the following embodiments, or other wiping devices. In any case, the wiping procedure is

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effected mechanically. This may be effected on a material for treatment passed through a series of treatment baths, i.e. substantially continuously, or with a material which is introduced into a treatment station or a treatment bath, and is treated at that point. In the latter case, the wiping operation and the flooding operation described in the following are discontinuous. In the case of a plate-shaped material for treatment, either one of the two surfaces or also both surfaces of the plate-shaped material for treatment can be wiped. Simultaneously, the electrolyte is passed through the boreholes (so-called "flooding"). Reference is made to the embodiments described in the following for details of the abovenamed procedure.

Figures 2 to 6 illustrate the main possible embodiment of the invention already mentioned, i.e. a bath station of an electroplating installation designed according to the invention, inclusive of the conveyor means for the material. A series of such bath stations may be provided in succession, in order to enable treatments with different baths to be carried out.

The bath liquor (not shown) is located in the bath container 1. The material for treatment, introduced in the direction of the arrow 2, is passed through between guide rollers, conveyor rollers and the wiper rollers which will be explained in detail later. According to this embodiment of



the invention, the material for treatment may be transported and treated horizontally. After the treatment, the material re-emerges from the installation in the direction of arrow 3. In areas 4 and 5, only conveyor and/or guide rollers are present and shown, while in area 6, in addition to any conveyor and/or guide rollers, wiper rollers according to the invention are provided. These are specifically explained with reference to a plurality of embodiments in Figs. 6 to 12, the section 6 in Fig. 3 corresponding to the embodiment in Figs. 7, 8 or 9.

The path of movement for the material for treatment has the position and width indicated by "a" in Fig. 2. In Fig. 2 the direction of movement 2-3 extends vertically to the plane of the drawing. In addition to the track of movement of the material in this example there is also a conveyor device 7, in order to grasp in a clamping manner a plate-shaped material for treatment indicated in Fig. 2 by 8 at one lateral edge 8' with conveyor means in the form of a clamp 9, and to move it in the direction of transport 2-3. Such a conveyor device forms the subject-matter of DE-OS 36 24 481; its disclosed content is hereby acknowledged. Yet the invention is not restricted to a conveyor device formed in this way. This lateral hold of the plate-shaped material by the clamps 9, particularly with respect to the "flooding" explained, i.e. forced penetration or suction of electrolyte through the boreholes in the material, has a particular

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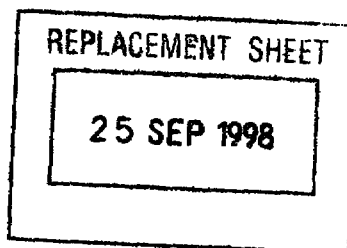
advantage. During this flooding, there arises, in the flooding direction, a corresponding pressure on the material for treatment. The clamps, securely engaging laterally on the material, prevent the relevant plate from being displaced by the flooding pressure. The abovementioned boreholes, and the flooding means, are however not shown in Figs. 2 to 6 for reasons of clarity. Reference is likewise made here to the following embodiments. A clamp 9 comprising two brackets 11 forms a conveyor means 10. All the conveyor means are secured on an endless revolving conveyor belt 12, 12', which revolves in the direction of arrow 13 (see Fig. 4). When the conveyor means are located on the side of the bight 12' (see Fig. 3) of the conveyor belt, the clamps 9 are in the holding position (see illustration on the left-hand side of the conveyor device 7 in Fig. 2). As soon as the conveyor means 10 pass out of the area of the bight 12' into that of the upper bight 12 in Fig. 4, the two brackets 11 of clamps 9 are drawn slightly apart, so that an interval results between them (see right-hand side of the conveyor device 7 in Fig. 2). This conveyor device moves the material at a specific speed, which may if necessary be adjusted, in the direction 2-3.

Fig. 5 shows the conveyor device in detail. It may be seen from this that in the region of the bight 12, by means of run-up of one of the brackets 11 of a clamp on to a guide portion 29, the associated clamps are moved into the open

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position. On the other hand, in the track region of bight 12', no such guide portion 29 is present, and the brackets of the clamps 9 act, under the effect of a compression spring, with a certain clamping force on the edge 8' of the material for treatment (transport position).

The detail VI in Fig. 2, and in Fig. 6, which shows this detail in partial section, shows two wiper rollers 15 which are moved in contrary directions by a drive system via a gear system 16, 17. For this purpose there are two spur gears 17, seated on the axes 13, 14 of the wiper rollers 15 and intermeshing with one another. The anodic wiper rollers 15 are connected to the positive pole of the current source by contact discs 20, current contacts 19 sliding thereon, and supply cables 18. The cathodic material for treatment 8, shown here only in part, is connected to the negative pole of the current source (not shown). Each of the wiper rollers is provided on its circumference with a covering 31 made of a material absorbing and permeable to the electrolyte and the metal ions of the electrolyte. This material should be resilient, and of a certain degree of softness, in order not to damage the surface of the material as it slides along it. The covering must be chemically resistant to the electrolyte. Preferably used for this purpose is a felt-like plastic, e.g. of polypropylene. The term 'felt-like' here does not indicate the textile material felt, but a structure of interweaving components. Such materials are



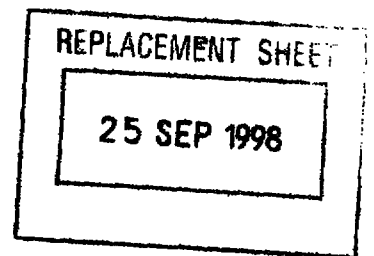
also known in practice for use in filters. The covering may also consist of an open-pored material which has good fluid permeability and is wear-resistant. This wiping covering, like wiping coverings of other materials, should be resilient, so that when it is applied against the surface to be wiped it compresses slightly, and can revert thereafter to its original shape. The liquid-permeability mentioned is at least necessary when, according to one of the later embodiments, the electrolyte is forced from the interior of the roller through the covering in an outward direction, or is sucked in the reverse direction.

While any drive rollers and/or guide rollers (see Nos. 4 and 5) have a peripheral speed corresponding in magnitude and direction with the direction 2-3 and speed of the conveyor means 10, the peripheral speed and/or running direction of the wiper rollers is such that the circumference of the wiper rollers 15 moves relative to the respective surface of the transported material for treatment 8. Thus a wiping effect is exerted over the entire length of the wiper rollers 15 on the surfaces of the material 8. The length of the wiper rollers 15 extends over the width of the material, transverse to the direction of transport, i.e. approximately the amount a in Fig. 2. Material of a lesser width may also however be processed; in this case only a partial length of the wiper device 15 is unused. The bath level of the electrolytic bath is shown in dotted lines by the numeral

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25, the material for treatment and the wiper devices being located beneath the bath level, in the bath liquor. This can also apply to the other embodiments. As the present embodiment shows, it is recommended, or it is as a rule necessary, to treat the material on both its sides or surfaces according to the invention, i.e. on the upper surface in Figs. 2, 3 and 6 and on the lower surface, as results from the disposition of two wiper rollers 15, which bear from above or from beneath on the surfaces of the material for treatment. In cases where treatment of only one of the surfaces is necessary, it is in theory then sufficient to use one wiper roller. The embodiments in Figs. 7 to 15 show that more than two wiper rollers may also be used.

As a rule, a certain contact pressure is recommended between the coverings 31 on the wiper rollers and the surfaces of the material for treatment; this may be applied for example by means of a spring 23 indicated diagrammatically in Fig. 6 and pressing in the direction of arrow 22. In order to be able to process material of varying thickness, the upper of the wiper rollers 15 is mounted in a slot guide 24, and, upon enlargement of the thickness of the material for treatment, can deviate contrary to the direction of arrow 22. The bath level 25 of electrolyte is higher than the lower edge of said slot. An excess of electrolyte can therefore flow out through the slot guide 24 and a space 26



between the side wall of the bath container 1 and a further, externally-situated wall 27 in the direction of arrow 28.

The circumferential speed and/or direction of rotation of the anodic wiper rollers 15 at their contact points with the material, which is moving at a specific transport speed, can be appropriately altered and set to the desired value by means of controlling the drive for these wiper rollers. Adjustments of the contact pressure of the spring 23 or of another contact-pressure means are also possible. Thus the system may be adapted to requirements at any moment with the purpose of achieving the maximum disruption of the boundary layer on the surface of the material, in which ion depletion normally takes place.

In the following description of embodiments of the invention, given by way of example, relating to the layout and disposition of wiper rollers 15 or correspondingly-operating wiper members, only those components of the invention, including feed and return pipes for the electrolyte, are illustrated and explained. Self-evidently, conveyor means for the material for treatment and drive means for the wiper parts, as well as current supply means, are also required, these being for example illustrated in Figs. 2 to 6 and explained above. In addition to the conveyor means there described, or instead of these conveyor means, it is for example also possible to provide conveyor

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rollers between every two wiper rollers, the cathodic current supply being effected by means of sliding contacts on a lateral area of the material for treatment. Where this is not already shown in the drawing, the material for treatment has boreholes, and means are provided for "flooding" these boreholes, i.e. passing the electrolyte through them.

Basically, the parts located in the electrolyte bath, such as the tube 30 and the metal mesh or wire grid 32, must consist of a material which is not attacked in the bath under conditions of electrolysis. Suitable materials for example are titanium, platinum-coated titanium, stainless steel, a stainless steel coating or oxides of noble metals. This may be effected for example according to the embodiment in Fig. 7, in that wiper rollers are provided in the form of metallic tubes 30 with a felt-like covering 31 and a metal mesh 32 therebetween, which interconnects the tube 30 and the covering 31 in an interengaging manner. Instead of the abovementioned preferably tubular metal mesh, a preferably tubular wire grid, welded at the intersection points of the wires, or a perforated tube can be provided. In this embodiment the tube forms an insoluble anode which itself does not give off metal, but merely has a current-emitting function. The metal to be deposited is in this case located in the electrolyte. It is however also possible to deposit the metal to be deposited as a soluble anode in the tube 30

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or in another wiper member. As the material for treatment 8 passes through, the coverings 31 are slightly compressed. The electrolyte is supplied in accordance with arrows 33. This also may be effected under pressure. Here also it penetrates through the boreholes (not shown) of the board to be treated. As mentioned later at the end of the description, it also applies here that features and details illustrated with reference to one of the embodiments may also be used with other embodiments. This applies in particular to the means for carrying out the flooding of boreholes 42 of the material for treatment. This embodiment, and also the other embodiments, show that the interval between the anode (here the titanium tube 31) and the cathode (= the material 8) is extremely small, so that practically no dispersions occur.

The embodiment in Fig. 8 is similar to that in Fig. 7. Figure 8 shows however one of the possible embodiments in order to cause the electrolyte to flow through boreholes 42 in the material. For this purpose the tubes 30 are provided with holes 34, which have a plurality of functions. On the one hand the electrolyte is supplied in the interior 35 of the tube and forwarded through the bores 34 to the covering 31. Further, the electrolyte is passed from the interior of tube 30 through the holes 34 in this tube and the wiping covering to the boreholes 42 in the plate 8, flows through these and passes into the interior of the relevant counter-

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roller, whose tube 30 is likewise provided with holes 34. In this case the electrolyte in one tube may be pressurised by a pump, and is sucked out of the boreholes in the counter-roller located on the other side of the material. Moreover, the bores 34 can serve securely to engage the material of the covering 31. In this preferred embodiment, only the inner tube 30 and the outer covering 31 are provided. A tubular metal mesh or wire grid can also replace the tube 30 with holes 34.

It is self-evident that the wiper covering 31 surrounds the respective wiper roller 15 over its entire circumference. This applies to all embodiments which contain wiper rollers. The wiper rollers are generally indicated by 15 and an associated arrow, irrespective of their slightly different designs.

In the embodiment in Figs. 9 to 14 the construction of the wiper rollers is like that in Fig. 7, i.e. an inner tube 30, a metal mesh or the like (see above) 32 and the covering 31 surrounding the wiper roller and thus also the tube 30.

Electrolyte is supplied in the example of Figure 9 by means of feed tubes 37 provided with holes or slots 36; said tubes 37 are located above the free space 38 between two wiper rollers 15. After passing through the intermediate spaces 38 and the intermediate spaces 39 lying beneath them, the

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electrolyte is taken up by collecting containers 40 and passed to a filter pump.

When an upper and a lower wiper roller are provided opposite one another (for example in the embodiment according to Fig. 9), the upper wiper roller might be alternately incorporated as anode and the wiper roller located underneath it as cathode, and vice versa. Such a procedure and an associated apparatus are illustrated and described in the prior Patent Application P 41 06 333.3-45 belonging to the Applicant. The disclosed content of this document is hereby acknowledged.

The embodiment in Fig. 10 shows wiper rollers 15 as in the embodiment in Fig. 7 in the treatment of plate-shaped material, particularly printed circuit boards, which are provided with holes 42. The electrolyte is conveyed under pressure through the slot 41 of a baffle nozzle 63 in an upward direction (arrow 43) through the boreholes 42 located thereabove, and is conveyed back from this point by means of a partial vacuum through boreholes (42) located near the baffle nozzle 63 (arrow 44). Thus a certain build-up 45 of electrolyte (with electrolyte surface 45') is formed above the material 8, supplying the coverings of both the wiper rollers located above the material 8 with electrolyte, while the wiper rollers located underneath the material are wetted by the electrolyte flows 44, and by the electrolyte flowing over the upper side of the edge of the baffle nozzle. The

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latter achieves a high velocity in the narrow gap between the material and the baffle nozzle, so that at that point a lower pressure results than in the electrolyte above the plate-shaped material for treatment. This pressure differential causes the electrolyte to be sucked through the boreholes 42. Such a baffle nozzle arrangement, alone or in combination with other means serving to produce "flooding" (see in this respect the other embodiments) can be provided to pass the electrolyte through the boreholes 42.

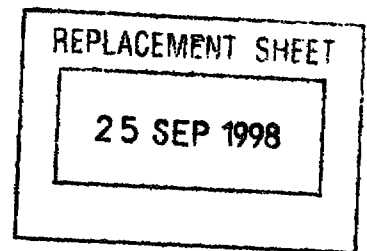
The means possible for flooding according to the invention can also remove low-diffusion layers in the holes 42, so that an adequate deposition of metal takes place in the inner walls of holes 42. In addition, due to the wiping effect of the coverings of the wiper rollers on the upper and lower sides of the material, the surface tension of the liquid columns present in holes 42 is disrupted, and thus the effect sought after is reinforced. As already mentioned, the process measures and means for wiping the surfaces of the plate-shaped material and for flooding the boreholes 42 in the plate-shaped material operate functionally and synergetically in unison.

The embodiment in Fig. 11 is a variant of the embodiment in Fig. 10. In this case there is provided in the left-hand roller pair an upper wiper roller 15 and a lower pressure roller 64, and in the roller pair shown on the right an

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upper pressure roller 64 and a lower wiper roller 15. The pressure rollers can have the function of conveyor rollers or of support rollers, bearing with a corresponding pressure on the material for treatment. Each of the anodic wiper rollers 15, in terms of the invention, wipes the surface facing it of the material 8, and at the same time the end facing it of the holes 42. Further, here also a baffle nozzle 63 as in Fig. 10 is provided. Successive electroplating in the transport direction 2-3 of the holes 42 is achieved from alternating sides. The abovementioned conveyor rollers 64, at least on the upper side of the material, are in the form of a roller extending over the entire width of the material or of the treatment track, so that in this way the electrolyte is built up on the material for treatment 8, while the conveyor rollers on the underside of the material can also consist of a plurality of discs disposed on one axis, between which the electrolyte can flow away.

Figures 12 and 13 show further possible uses of a baffle nozzle 63. According to Fig. 12, two pairs of wiper rollers 15 are provided in front of or behind an arrangement which has the baffle nozzle 63 with the anode 48 disposed therein. The electrolyte flows in, in the direction 79, through a nozzle 65, passes through an antechamber 68 and a distributor mask 69 with holes 66, flows (numeral 67) along the anodes 48 consisting of individual pieces, through the



slot 41 and the splash space 70 and the holes 42 in the material 8, in a downward direction (arrow 71) into the region beneath the material for treatment 8. The disclosed content of DE-OS 39 16 693.7 is specifically acknowledged hereby. In these embodiments also the material for treatment provided with holes preferably relates to printed circuit boards.

Figure 13 shows a construction similar to that according to Figure 12, the same reference numerals being used. The difference resides in the fact that in the subject-matter of Fig. 12 the electrolyte, after passing through the holes 42, flows freely downwards, whereas in the subject-matter of Fig. 13 there is provided between this outflow 71 and the outlet for the electrolyte from the holes 42 an additional suction path 72 with housing 75. At this point a partial vacuum is generated through a suction nozzle 73, which extracts the electrolyte by suction after passing a further anode 48, into the space 74 which is under the partial vacuum, and from this point extracts it through the nozzle 73. The disclosed content of DE-OS 39 16 694.5 is acknowledged with respect to the subject-matter of Figure 13.

In the embodiments of Figures 10 to 13, the baffle nozzle 63 extends across the entire width of the material for treatment, i.e. the width a in the embodiment in Fig. 2. The

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same applies to the space 68 (Figs. 12, 13), in which the electrolyte liquid enters through a row of nozzles 65 disposed one behind the other in the transverse direction of the material. In the embodiment in Fig. 13, the suction path 72 likewise extends across the entire width a. Thus these embodiments with baffle nozzle 63 ensure that, according to the invention, in addition to the surface treatment of the material 8 by the wiper roller 15, an intensive penetrative flow of the holes 42 in the material takes place by the electrolyte, across the entire width a of the workpieces conveyed in the direction 2-3. Such intensive penetration of the holes 42 in the material by the electrolyte flow, and thus a correspondingly intense deposition of the metallisation on the inner walls of these holes, in combination with the electroplating described before of the surfaces of the material for treatment due to the wiping effect, would not be possible with the apparatus according to prior art, in which the electrolyte flow is conveyed at high speed parallel to and along the surface of the workpiece. In fluidic terms it would not in this case be possible verifiably to pass an electrolyte flow through the holes transversely to this flow direction.

The embodiment in Figure 14 contains a combination of the arrangement of wiper rollers and pressure rollers according to the embodiment in Figure 11 with a system of guidance of the electrolyte according to the embodiment in Fig. 9. The

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same reference numerals are used as in Figs. 9, 11. In addition, further lower feed pipes 37' with outlet openings 36' for the electrolyte are provided, which convey the electrolyte from the bottom upwards.

The embodiment in Figure 15 shows a variation of the embodiment in Fig. 14. The wiper rollers 15 in this case, similarly to the construction explained with reference to Fig. 8, consist of an inner tube 30 provided with holes 34, or a tubular metal mesh or tubular wire grid in which the wires are welded at their intersection points, and of the covering 31 already explained. Inside the tube 30, rotating about its axis 76, is disposed a non-rotating feed tube 77, into which the electrolyte is introduced in a way not shown here, said electrolyte emerging again through passage openings, e.g. holes or passage slots 78 in the wall of the tube 77, which lie in succession along the tube 77. It is self-evident that the feed tube 77 with the passage openings or slots 78 extends over the entire length of the tube 30, and thus the entire width a of the material 8 for treatment. The passage openings or slots 78 are aligned with their outlet openings towards the track of movement 2-3 of the material 8, so that the electrolyte flowing through the holes or slots 78 impinges, through the holes (or corresponding slots) 34 in the tube 30 vertically to the material 8 on to said material, and penetrates its holes 42. Thus the flow speed of the electrolyte through the holes 78

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and the holes 34 causes a corresponding vertical flow through the holes 42 in the plate 8, and thus at that point also improves the deposition of metal. In this embodiment the electrolyte in the feed tube 77 can either be under pressure, and be correspondingly forced through the holes or slots 78 and the boreholes 42, or alternatively a partial vacuum is generated in the interior of the tube 77, and thus a suction effect, which sucks the electrolyte through the boreholes 42 and the bores or slots 78. In the latter case, any particles of the wiper covering which had passed into the boreholes 42 are sucked out and removed through the tube 77, and are later filtered out of the extracted electrolyte. It is self-evident that in the embodiment in Fig. 15 as in the other embodiments, a series of holes 34 are continuously distributed over the circumference of the roller 30. The abovementioned tube 77 may be located in a wiper roller both above or also below the material for treatment. The numeral 64 indicates here also pressure rollers or discs which rotate about the axis 64' and serve as contact or conveyor rollers for the passing material 8.

Figure 16 shows diagrammatically above the plate-shaped material 8 provided with holes 42, e.g. a printed circuit board, a wiper roller 15 in the form of a flow anode corresponding to the parts 30, 31, 77, 78 of the embodiment in Fig. 15. These parts are indicated only diagrammatically here. Where a pressure is formed in the electrolyte in the

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feed tube 77, it flows in the direction of the arrows entered in the drawing, downward through the boreholes 42. If on the other hand a partial vacuum is generated in the interior 77 of the tube, the electrolyte flows contrary to the direction of the arrows entered. This embodiment shows, as counter- or pressure rollers, two counter-rollers 48, driven in the direction of the arrows and thus also in the transport direction 3 of the printed circuit board 8, said counter-rollers 48 leaving free, beneath the holes or slots 78 in the feed tube 77 and thus in the flow direction of the electrolyte, a wide space 60 such that the electrolyte can flow unhindered through between the counter-rollers 48. Despite this, provision is made by the disposition of two counter-rollers mounted symmetrically to the wiper roller 15 for a uniform distribution of the pressure of the wiper roller 15 on the counter-rollers 48. These counter-rollers are provided on their surface with an insulating means, or they are made of plastics.

Figure 17 shows in a longitudinal section the embodiment of a flow anode as shown only diagrammatically in Figs. 15, 16, and indicated by the numerals 30, 31, 77, 78. The same reference numerals are used as in Figures 5, 6, 15 and 16. Reference is made to the associated descriptions of these Figures. The flow anode 30, 31, 77, 78 shown in the upper region of Fig. 17 is movable vertically with its bearings and its drive shaft 49 contrary to the pressure of the

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springs 23. This enables vertical compensation, so that plates 8 of differing thickness can be treated. The current supply is effected via clamps 9, 11, which are connected to one pole of the rectifier, and connect the latter to the material for treatment, and by means of sliding contacts 50, which are connected to the other rectifier pole and connect the latter with the drive shaft 49 of the flow anode.

Here also there is provided a pressure or counter-roller 51, consisting at least on the surface of electrically non-conductive material, and which is provided on its circumference with drainage grooves 52, these grooves forming with the longitudinal axis 53 of this roller 51 an angle, in this case an acute angle. By means of these, the electrolyte emerging downwards out of the boreholes 42 is conveyed away. In this case, as the arrows entered show, the electrolyte is conveyed by pressure in the direction of arrow 55, is passed in the direction of arrows 54 through the holes or slots 78 and then through the boreholes 42, and passed into the drainage grooves 52. Alternatively, suction could be applied at the upper end 77' of the flow tube, contrary to the direction of arrow 55, so that the electrolyte is sucked upwards from the drainage grooves 52 through the holes 78 and contrary to the direction of arrow 54. The flow anode is driven by its drive shaft 49 in a rotary direction (see arrow 57) which is oriented contrary to the rotary direction of arrow 58 of the drive shaft 56 of

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counter-roller 51. The numeral 50 indicates a sliding contact of the current supply for the drive shaft 49. The flow anode is provided at one of its ends with internal and external sliding bearings 59 for the tube 30 and 59' for the drive shaft 49. The said sliding bearings 59, 49' are located on the circumference or on the internal diameter of a stationary bearing shell 79, which is held by a crosspiece 80 on the framework, not shown in detail, of this arrangement, and is guided in a recess 81 to move vertically over a certain distance.

In the case of printed circuit boards, in which the borehole walls are initially coated only with a conductive layer which cannot support any higher current densities, it is necessary (see Fig. 3) to operate in the first portion of the treatment section 6 initially with lesser current densities. If at this point sufficient metal has been deposited, then during the transport of the material for treatment through the portion 6 in the direction 2-3, the current density of the electroplating process can be increased by measures known per se.

The method and apparatus according to the invention are also suitable for treating a plate-shaped material which is suspended vertically in treatment baths, and remains there during treatment. Thus there is provision not only for continuous passage of the material for treatment, but also

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discontinuous operation, the material being laid into a station and there being subjected to the treatment. During this treatment, wiping and flooding is carried out. Therefore a "periodic" wiping and flooding is effected during the period of the respective treatment.

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CLAIMS

1. Method of electrolytically treating printed circuit boards, which are provided with bores and moved through a treatment bath by conveyor means or guided to a treatment station, means for reducing the thickness of a zone (diffusion layer), which is deprived of metal ions, being provided and in contact with the printed circuit boards, the areas (K1) of the printed circuit boards to be treated being continuously and mechanically wiped in the presence of an anode and cathodic printed circuit boards (K), or in the presence of anodic printed circuit boards and a cathode, and the electrolyte is moved with a movement component, which is substantially perpendicular to the plane of the printed circuit boards, and is conducted through the bores (42) in said boards.

2. Method of electrolytically treating printed circuit boards, which are provided with bores and moved through a treatment bath by conveyor means or guided to a treatment station, means for reducing the thickness of a zone (diffusion layer), which is deprived of metal ions, being provided and in contact with the printed circuit boards, a relative movement being effected between cathodic or anodic printed circuit boards (8), on the one hand, and a mechanical wiping device (15;46,47;53;59) at the anode end or cathode end, on the other hand, said wiping device being brought directly into sliding abutment on the surfaces of the printed circuit boards in order to disturb and at least partially destroy the diffusion layer, and the electrolyte is moved with a movement component, which is substantially perpendicular to the plane of the printed circuit boards, and is moved through the bores (42) in said boards.



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3. Method according to claim 2, characterised in that the above-mentioned relative movement is created by a conveyor movement (2-3) of the cathodic or anodic printed circuit boards (8) relative to the wiping device (15;46,47;53;59) at the anode end or cathode end.

4. Method according to claim 2 or 3, characterised in that the movement of the cathodic printed circuit boards (8) is effected relative to a wiping device (15;46,47;53;59) at the anode end, which device has a coating (31;54;61) formed from a material which absorbs the electrolyte and permits it to pass therethrough, and in that the coating is brought directly into sliding abutment on the surfaces of the printed circuit boards in order to disturb, or at least reduce the diffusion layer, while the electrolyte is simultaneously moved with a movement component substantially perpendicular to the plane of the printed circuit boards to reduce the diffusion layer in the bores in the printed circuit boards and is moved through the bores (42) in said boards.

5. Method according to one of claims 1 to 4, characterised in that either one surface is wiped, or both surfaces of the printed circuit boards are wiped.

6. Method according to one of claims 2 to 5, characterised in that the wiping device (15;46,47;53;59) at the anode end has an inherent movement at its abutment location or area relative to the surface of the printed circuit boards (8), which movement differs in size and/or direction from the conveyor movement.

7. Method according to one of claims 1 to 6, characterised in that, in the case of a two-sided treatment of the printed circuit boards (8), their



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relative speed relative to the wiping device on their one surface is directed to the wiping device on their other surface in opposition to their relative speed.

8. Method according to one of claims 2 to 6, characterised in that, in the case of a two-sided treatment of the printed circuit boards (8), their relative speed relative to that of the wiping devices on their two surfaces is orientated in the same direction.

9. Method according to one of claims 2 to 8, characterised in that the relative speed between printed circuit board and wiping device is minimal, and more especially tends to virtually zero.

10. Method according to one of claims 1 to 9, characterised in that a pressure of the wiping device is exerted upon the printed circuit boards.

11. Method according to one of claims 4 to 10, characterised in that, with the presence of a resilient coating of the wiping device, the coating is compressed or pressed.

12. Method according to one of claims 1 to 11, characterised in that, during the course of the movement (2-3) of the printed circuit boards (8) through the treatment path, the current density of the galvanising current is increased.

13. Method according to one of claims 1 to 12, characterised in that the electrolyte is guided through the bores (42) with pressure.



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14. Method according to one of claims 1 to 13, characterised in that the electrolyte is sucked from the bores (42) by means of reduced pressure.

15. Method according to one of claims 1 to 14, characterised in that the wiping of the areas and the guidance of the electrolyte through the bores are effected beneath the level of the bath (25) and, in consequence, internally of the bath fluid.

16. Arrangement for electrolytically treating printed circuit boards, which are provided with bores and moved through a treatment bath by conveyor means or guided to a treatment station, means for reducing the thickness of a zone (diffusion layer), which is deprived of metal ions, being provided and in contact with the material being treated, more especially for accomplishing the method according to one or more of claims 1 to 15, and wherein means (W) for wiping the surface or the surfaces of either cathodic (K) or anodic printed circuit boards are provided, and means are also provided for moving the electrolyte in a flow through the bores (42) in the printed circuit boards (8), which flow extends substantially vertically relative to the plane of said boards.

17. Arrangement according to claim 16, characterised in that the wiping device is provided on the anode for the coating of metal.

18. Arrangement according to claim 16 or 17, characterised in that the wiping device (15;46,47;53;59) at the anode end or cathode end is provided with a coating (31) and abuts against the surfaces of the cathodic or anodic printed circuit boards (8), at least



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during a relative movement between printed circuit board and wiping device.

19. Arrangement according to claim 18, characterised in that the wiping device or a plurality of wiping devices extends or extend over the entire width, which extends substantially at right angles to the direction of conveyance, or over the periphery of the conveyed printed circuit boards, and at least the printed circuit boards are displaceable relative to a wiping device.

20. Arrangement according to one of claims 16 to 19, characterised in that the coating (31) abuts against the surfaces of the printed circuit boards (8) with an adjustable compression force.

21. Arrangement according to one of claims 16 to 20, characterised in that the coating (31) is formed from a material, which is chemically resistant to the electrolyte, more especially a plastics material.

22. Arrangement according to claim 21, characterised in that the coating is formed from an open-pored plastics material, which is permeable to fluids and wear-resistant.

23. Arrangement according to claim 21 or 22, characterised in that the coating (31) is formed from a resilient material.

24. Arrangement according to one of claims 16 to 23, characterised in that the wiping device comprises at least one wiping roller (15), the periphery of which is provided with the coating (31), in that a drive is provided for rotating at least one wiping roller, the direction of rotation and/or circumferential speed of



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which roller is selectable to produce a relative speed between the abutment location or abutment area of the wiping device and the surfaces of the printed circuit boards (8).

25. Arrangement according to claim 24, characterised in that the wiping roller or the wiping rollers (15) comprises or comprise a perforate, metallic tube (30) or an expanded metal tube or a wire grating tube and a cylindrical coating (31), which surrounds the wiping roller, the electrolyte being supplied or discharged internally of the tube, expanded metal or wire grating tube.

26. Arrangement according to claim 24, characterised in that the wiping roller or the wiping rollers comprises or comprise a metallic tube and a cylindrical coating (31), which surrounds the wiping roller, the coating and tube being held together by an expanded metal (32), situated therebetween, or by a wire grating, and in that the electrolyte is supplied from a location (33) externally of the wiping roller or wiping rollers to the bores (42) in the printed circuit boards (8).

27. Arrangement according to one of claims 24 to 26, characterised in that situated opposite a wiping roller (15), which abuts against a surface of the printed circuit boards and is provided with flow coating means, there is a pressure roller (64), which abuts against the other surface.

28. Arrangement according to claim 27, characterised in that, in the case of a two-sided galvanisation of the printed circuit boards, pairs of oppositely situated rollers are disposed one behind the other when viewed with respect to the direction of treatment (3), whereby,



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alternatively with one pair, a wiping roller (15) provided with flow-coating means is provided above the printed circuit boards (8) and a pressure roller (64) is provided beneath said printed circuit boards, and, in the case of the next pair, a wiping roller provided with flow-coating means is provided beneath the printed circuit boards and a pressure roller is provided above the printed circuit boards.

29. Arrangement according to one of claims 24 to 26, characterised in that at least one pair of wiping rollers are provided opposite one another, whereby one of the rollers is situated above the printed circuit boards (8) and the other roller is situated beneath said printed circuit boards, and the flow direction of the electrolyte is the same in both wiping rollers.

30. Arrangement according to one of claims 24 to 29, characterised in that the electrolyte is guided in the interior of the tube (30) of a wiping roller, and the electrolyte passes between the tube interior, the wall thereof and the coating (31) surrounding the tube.

31. Arrangement according to claim 30, characterised in that a number of through-apertures (34) are provided in the tube wall.

32. Arrangement according to one of claims 24 to 31, characterised in that, internally of the rotating tube (30) which is provided with through-apertures (34) for the electrolyte, a feed pipe (77), which guides the electrolyte, is provided with through-apertures or -slots (78), whereby the through-apertures or -slots (78) are orientated with their through-end faces towards the path of movement (2-3) of the printed circuit boards (8), and in that the feed pipe (77) as well as the



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rotating tube (30) extend over the entire width (a) of the path of the printed circuit boards.

33. Arrangement according to claim 32, characterised in that the through-apertures or -slots (78) of the feed pipe (77) are situated as close as possible to the printed circuit boards (8).

34. Arrangement according to claim 32 or 33, characterised in that the feed pipe (77) is mounted in a non-rotating manner in the tube (30).

35. Arrangement according to one of claims 32 to 34, characterised in that the rotating tube (30), together with the feed pipe (77) situated therein, is displaceably mounted substantially vertically relative to the plane of the printed circuit boards (8).

36. Arrangement according to one of claims 24 to 35, characterised in that one or more tubes (37) with apertures (36) for the electrolyte is or are provided for supplying the electrolyte to the spaces (38,39) between two wiping rollers (15), and in that collecting devices (40) for the electrolyte are provided beneath the spaces (38,39).

37. Arrangement according to one of claims 16 to 36, characterised in that pressure-producing means are provided for supplying the electrolyte to the bores (42) in the printed circuit boards.

38. Arrangement according to one of claims 16 to 37, characterised in that means are provided for sucking the electrolyte from the bores (42) in the printed circuit boards.



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39. Arrangement according to claim 37 or 38, characterised in that a baffle nozzle (63) is provided for galvanising printed circuit boards (8), which are provided with bores (42), said nozzle urging the electrolyte through bores (42), which are situated in the region of the baffle nozzle aperture or slots (41), while the electrolyte is returned through other bores (42) in the edge region of the baffle nozzle by means of a reduced pressure on the underside of the printed circuit boards, the baffle nozzle extending over the entire width of the printed circuit boards (8) to be treated.

40. Arrangement according to claim 39, characterised in that anodes (48) are situated internally of the baffle nozzle (63), preferably internally of a preliminary chamber (68), which is surrounded by a housing and to which the electrolyte is supplied (65).

41. Arrangement according to claim 39 or 40, characterised in that a suction device (72) is situated on the outlet side of the bores (42), to which the electrolyte is supplied with pressure through the baffle nozzle (63), the housing (75) of said suction device being under reduced pressure and extending over the entire width (a) of the printed circuit boards to be treated.

42. Arrangement according to one of claims 16 to 35, 37 to 41, characterised in that lower tubes (37'), which convey the electrolyte upwardly from below, are provided with through-apertures (36').



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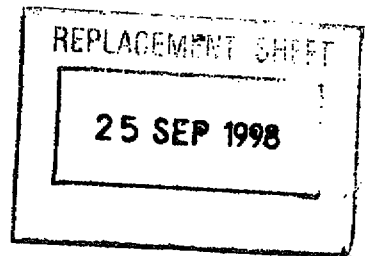
43. Arrangement according to one of claims 16 to 42, characterised in that the wiping device or the wiping devices abut against the respective surfaces of the printed circuit boards with resilient force (23,55).

44. Arrangement according to one of claims 16 to 43, characterised in that the printed circuit boards (8) to be treated are placed and guided in a horizontal position in the treatment station.

45. Arrangement according to claim 44, characterised in that conveyor means (10), preferably clamps (9), are provided for the conveyance of the printed circuit boards in a horizontal position, such means gripping at least one of their lateral edges (8').

46. Arrangement according to one of claims 16 to 45, characterised in that the pressure rollers (51), which are situated opposite a wiping roller (15) in the form of a flow-coating roller (30,31,77,78), are provided with drainage grooves (52), which serve to conduct the electrolyte away.

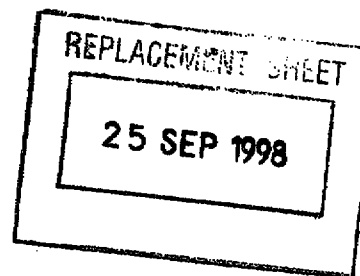
47. Arrangement according to one of claims 16 to 45, characterised in that two counter-rollers (48) are mounted opposite the wiping and flow-coating roller (15;31,77,78) on the other side of the printed circuit boards and are so positioned that they form therebetween a throughflow chamber (60) for the electrolyte, such chamber either being urged by pressure from the flow-coating roller into the bores (42) in the printed circuit boards or being sucked into the flow-coating roller through the bores (42) by means of suction.



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48. Arrangement according to one of claims 16 to 47, characterised in that the thickness of the coating (31) is relatively small, and is preferably 1-4 mm.

49. Arrangement according to one of claims 16 to 48, characterised in that various wiping devices are provided in combination with one another for the electrolytic treatment of the same printed circuit boards.



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PROCESS FOR THE ELECTROLYTIC PROCESSING ESPECIALLY OF
FLAT ITEMS AND ARRANGEMENT FOR IMPLEMENTING THE PROCESS

ABSTRACT

The invention relates to a process for the electrolytic processing of flat and perforated items which are taken through a treatment bath to a processing station by conveyor means, in which there are means for reducing the metal-ion-depleted diffusion region in front of the surface of the items to be processed. For this purpose, in the presence of an anode and a cathodic item or a cathode and an anodic item, the surface of the item is continuously mechanically wiped and the electrolyte is moved in a component substantially perpendicular to the plane of the item and taken through its drillings. The description also relates to an arrangement for implementing the process.

Figure 8.

1

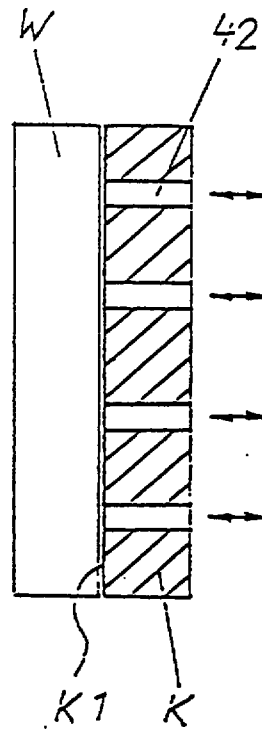
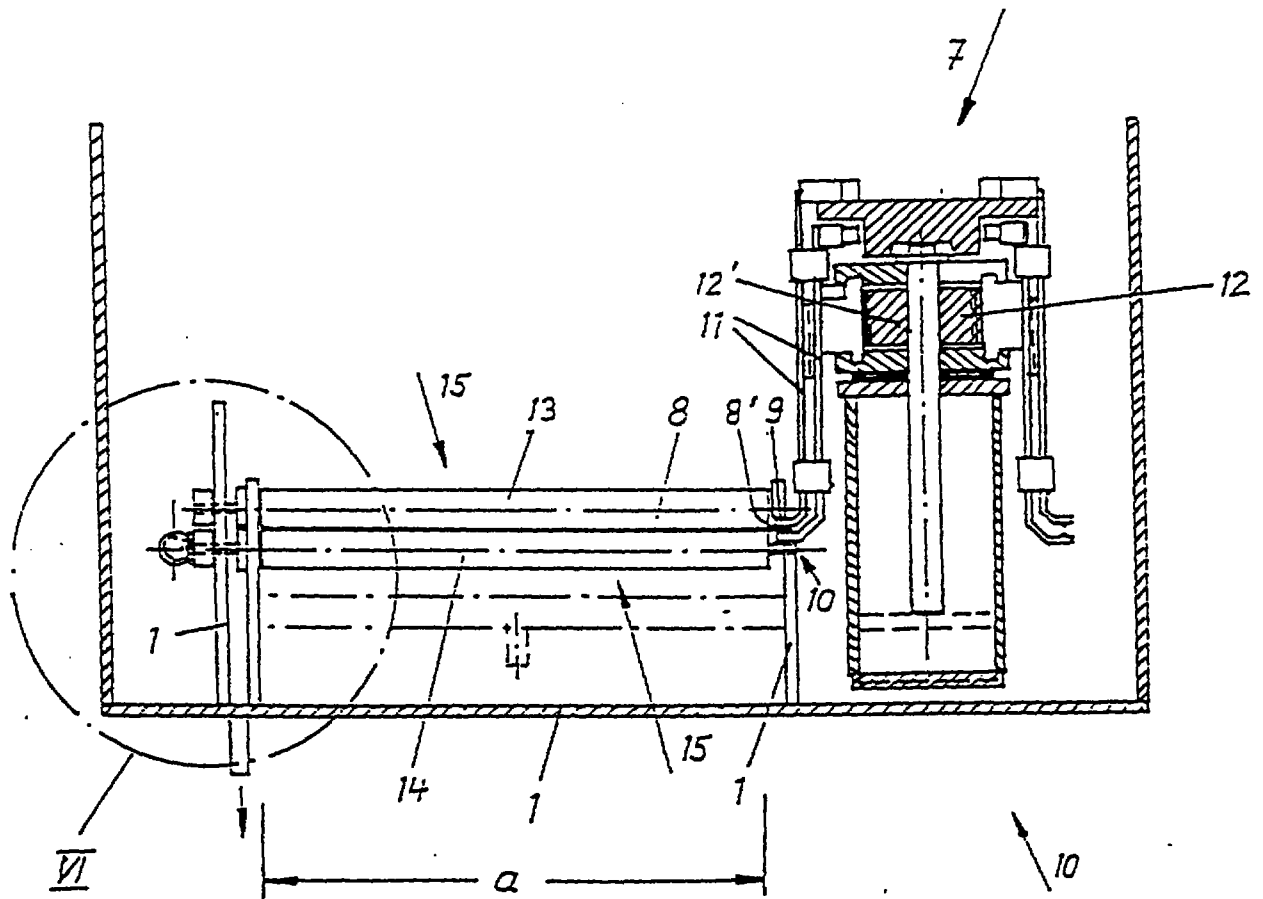


Fig. 1

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Fig. 2

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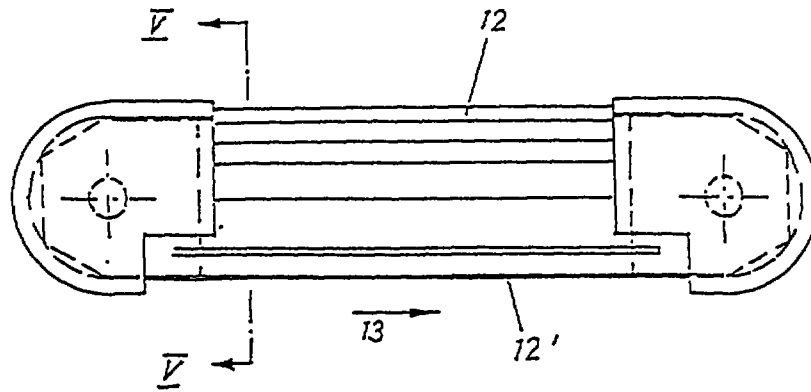


Fig. 4

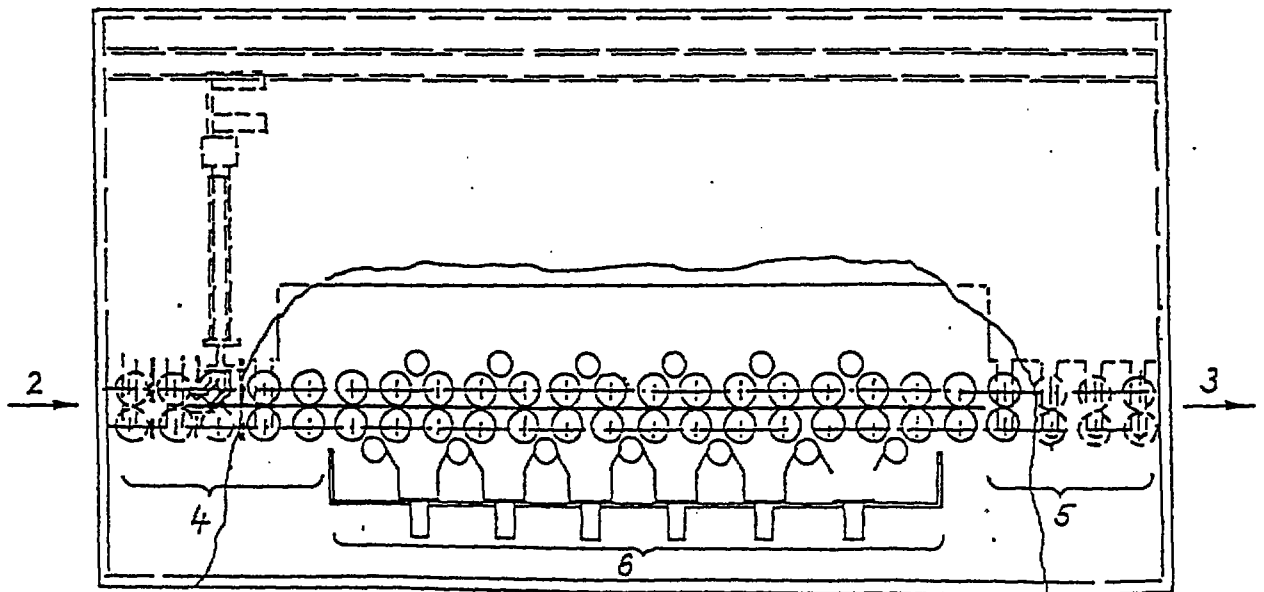


Fig. 3

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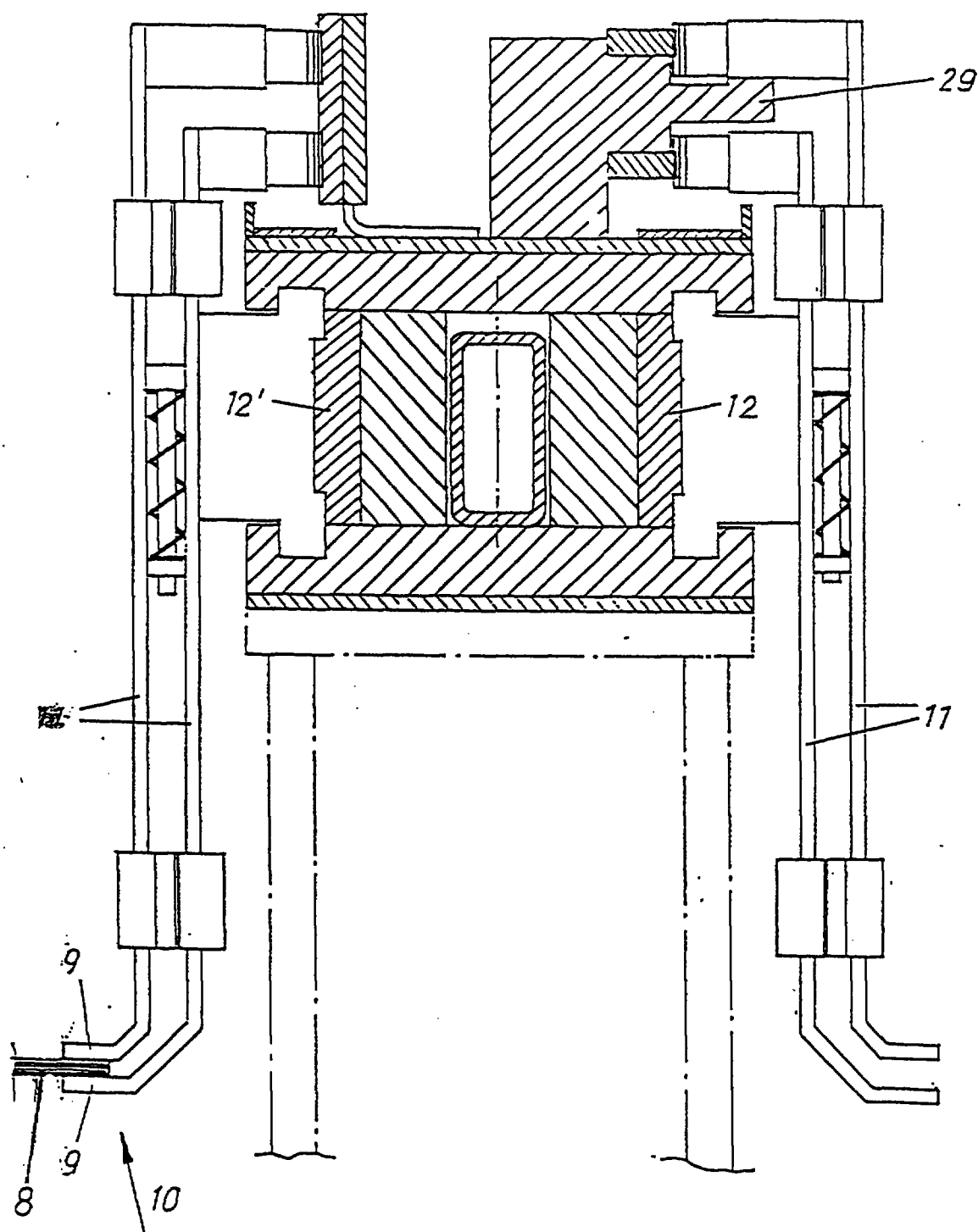


Fig. 5

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5

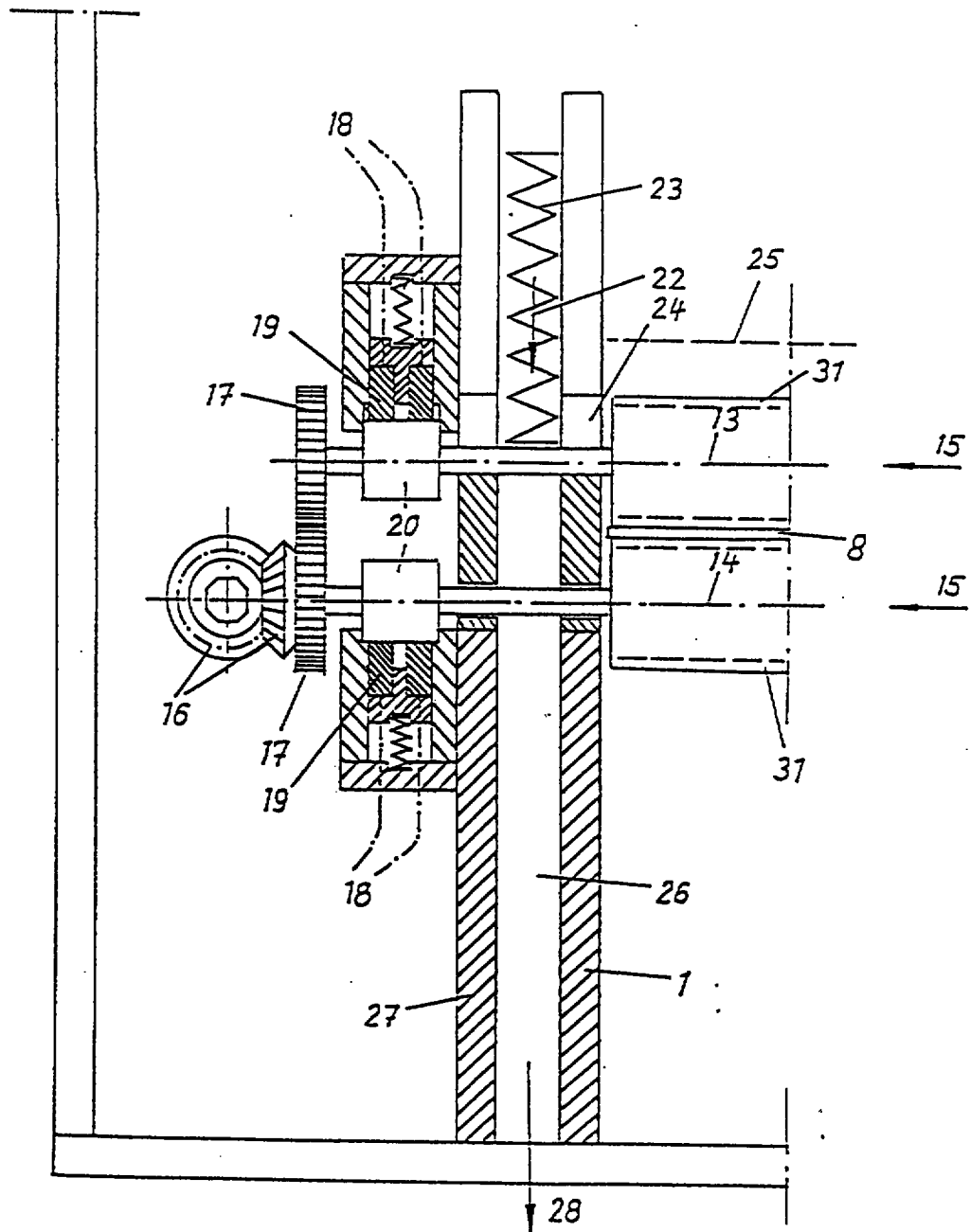


Fig. 6

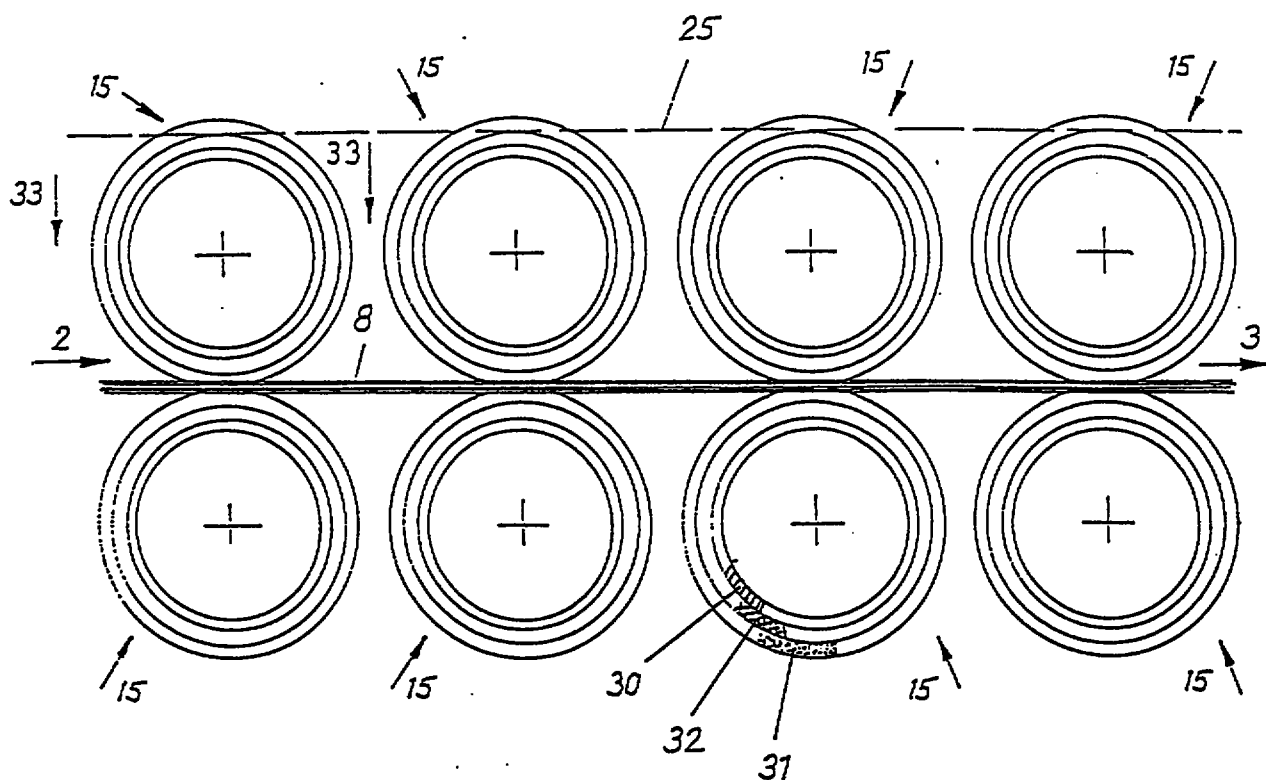


Fig. 7

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7

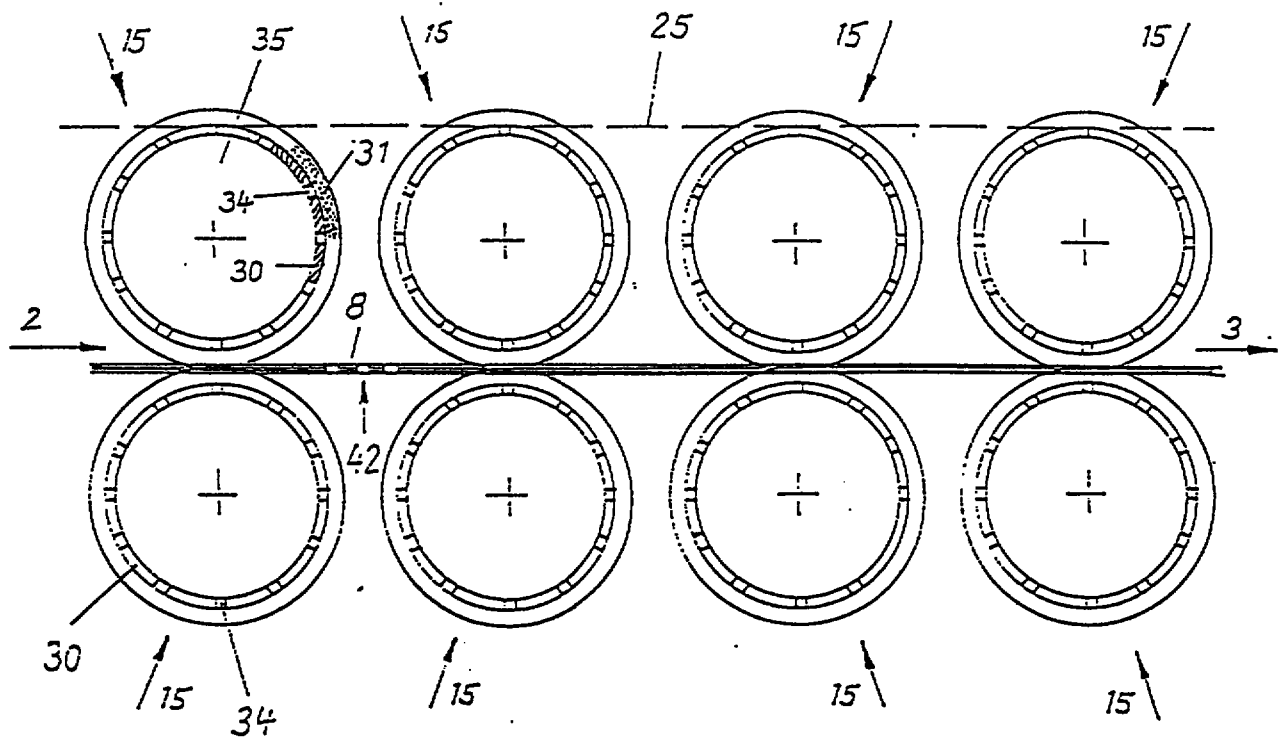


Fig. 8

8.

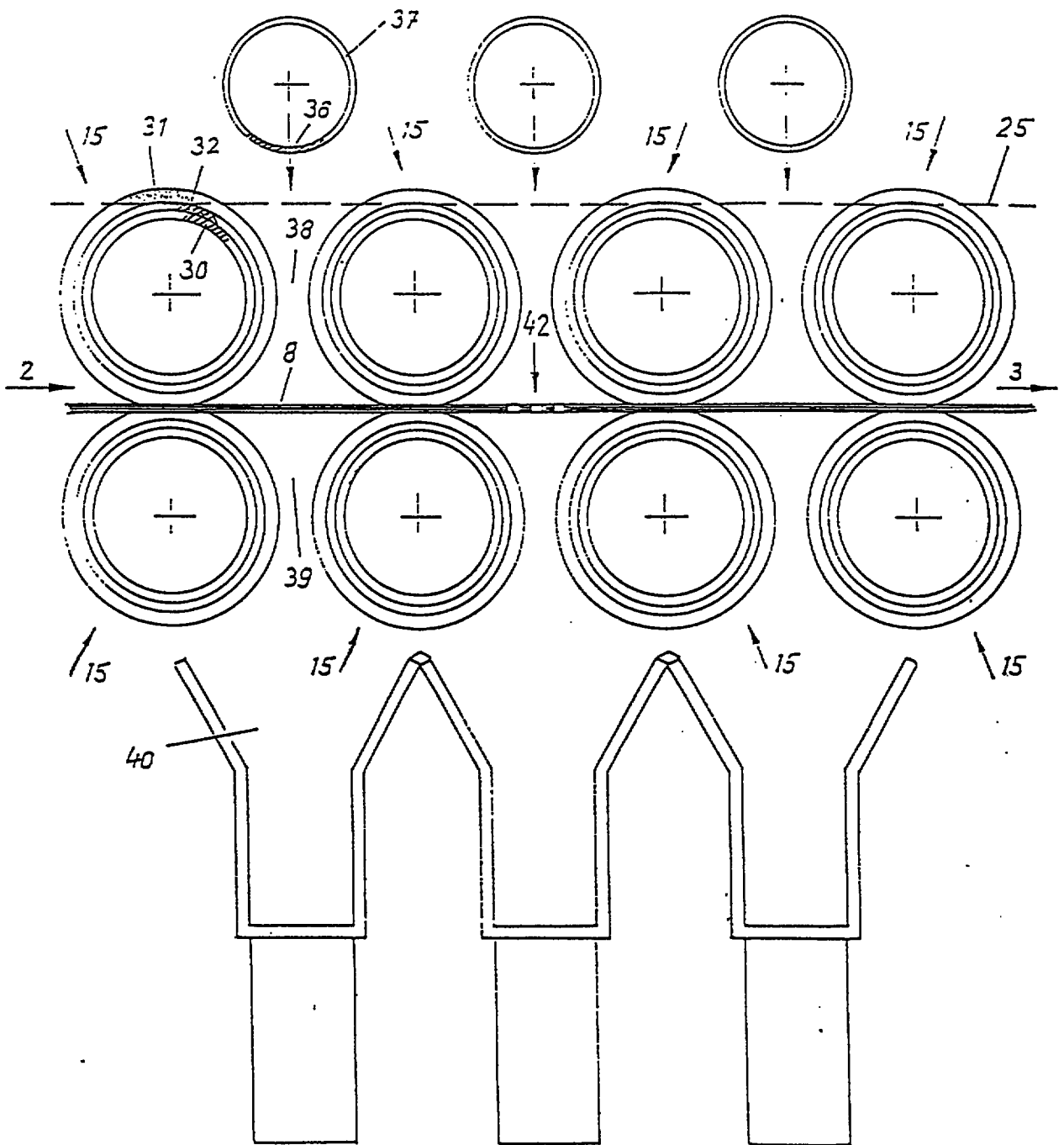


Fig. 9

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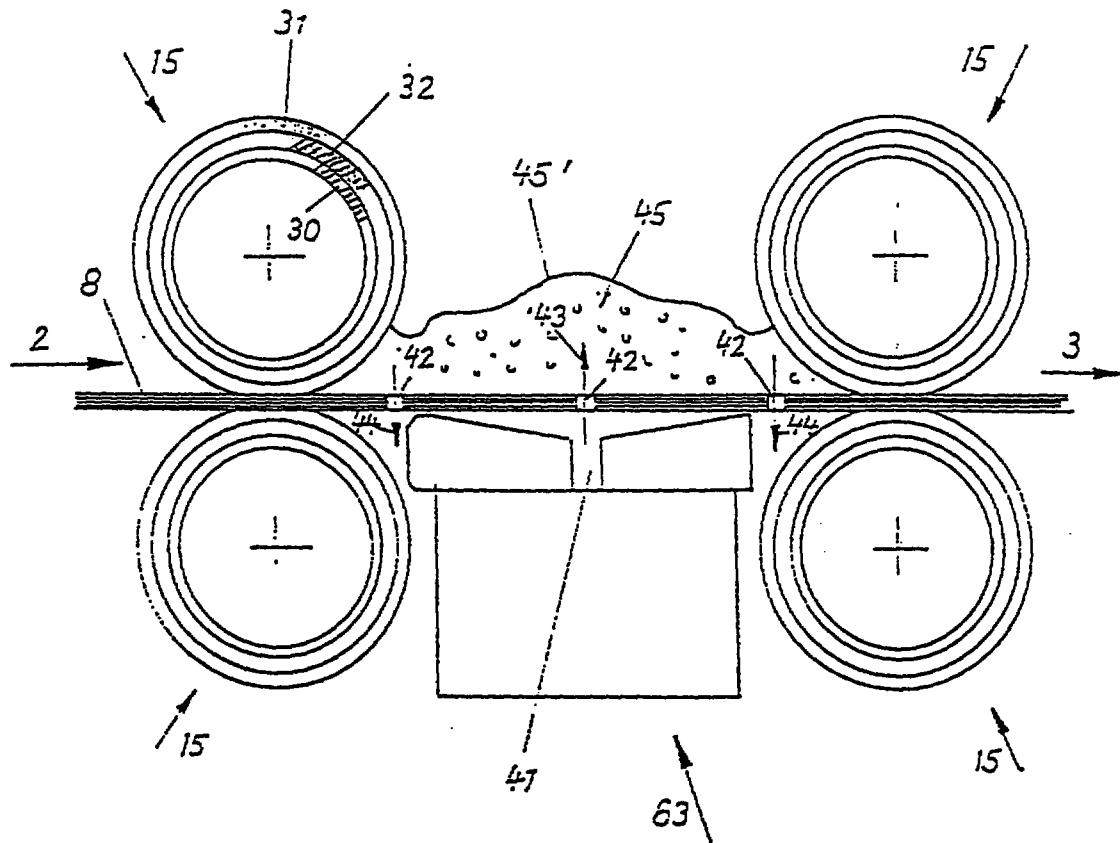
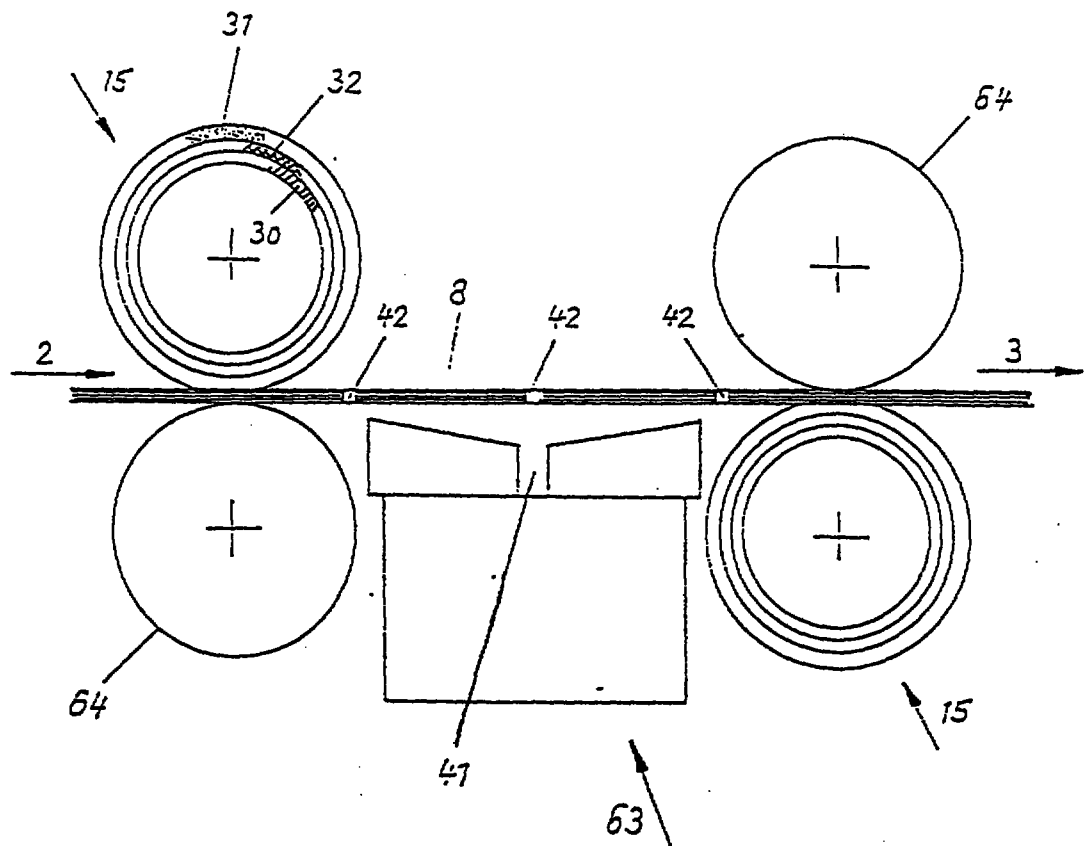


Fig. 10

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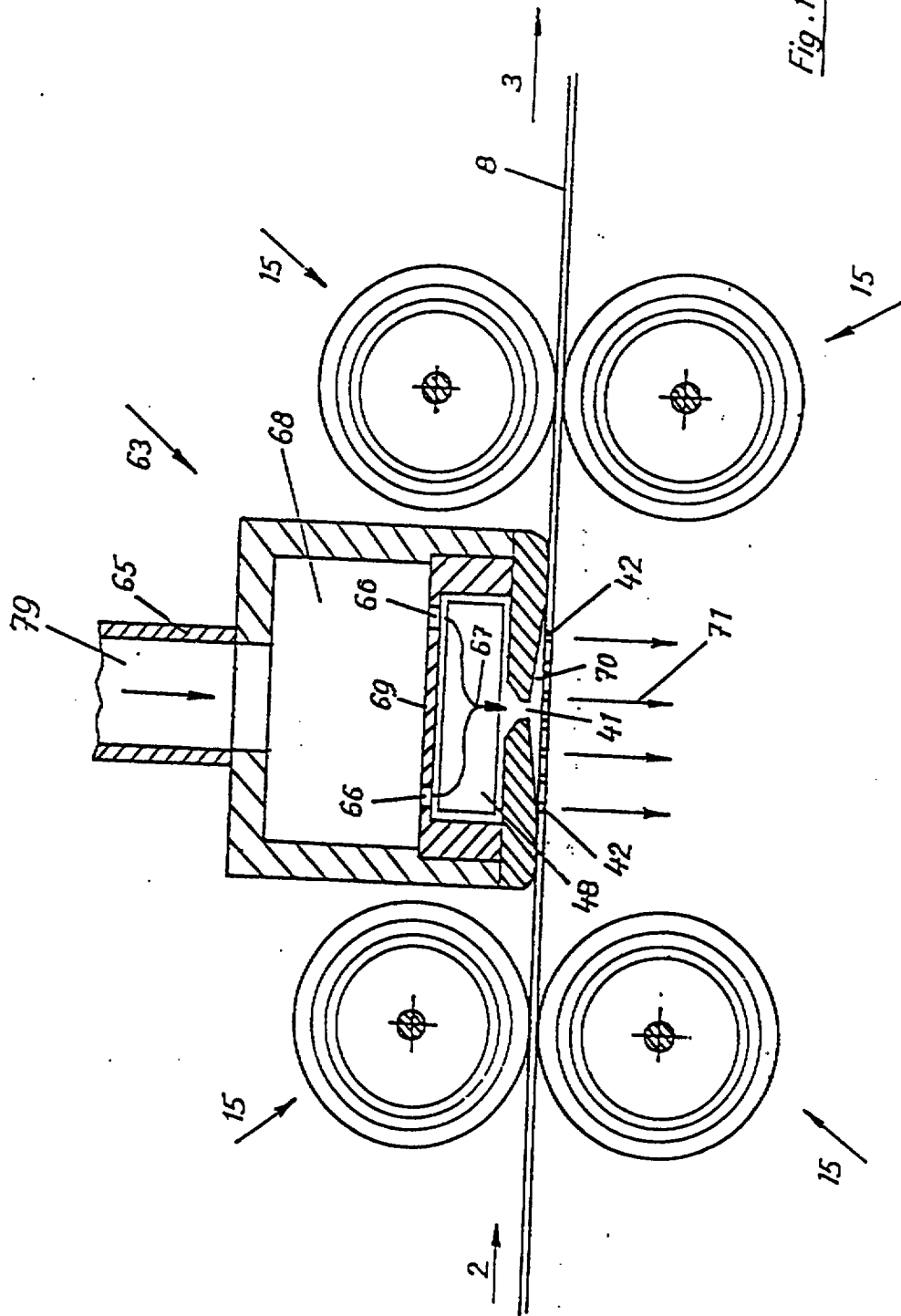
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Fig. 11

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Fig. 12



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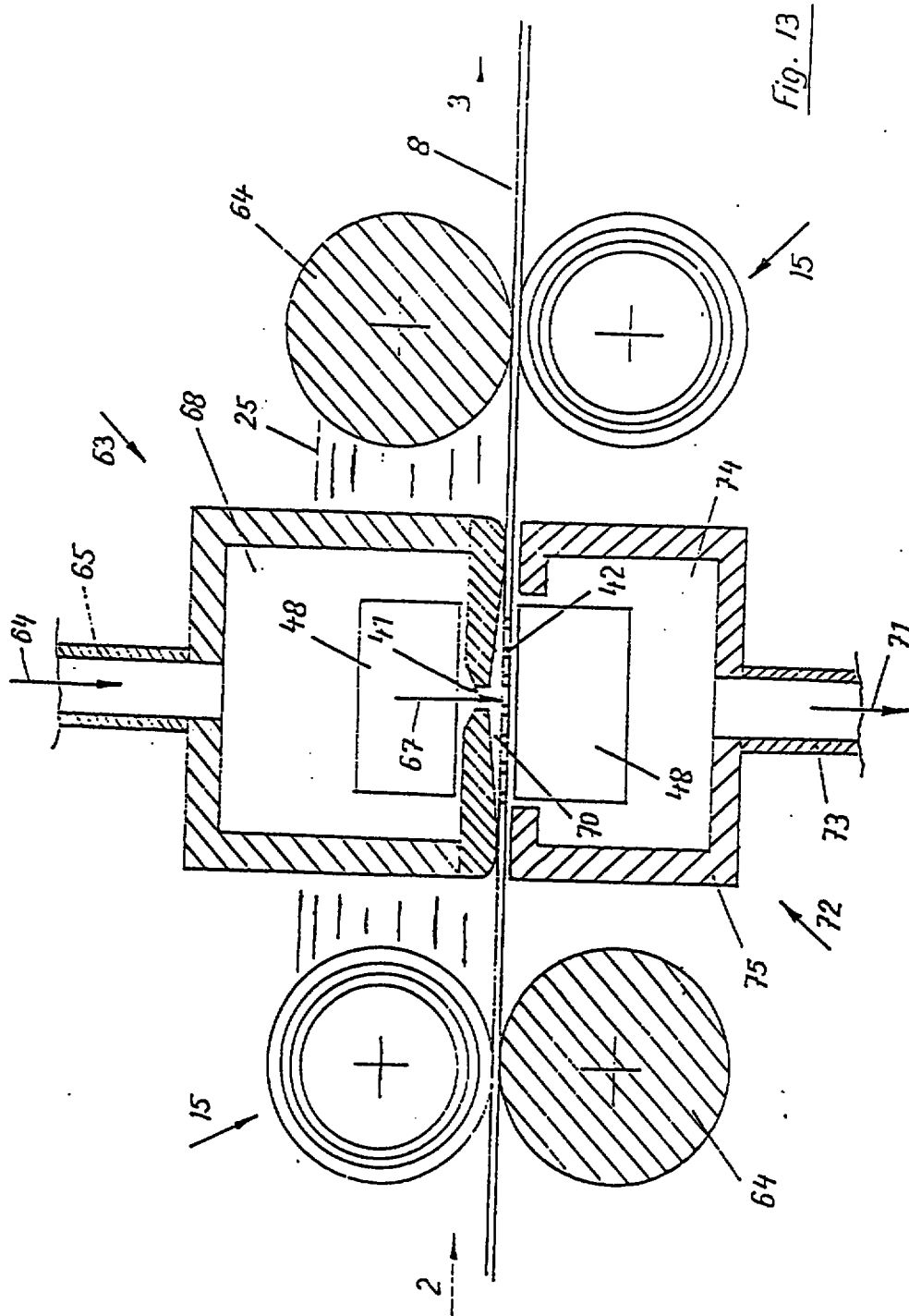
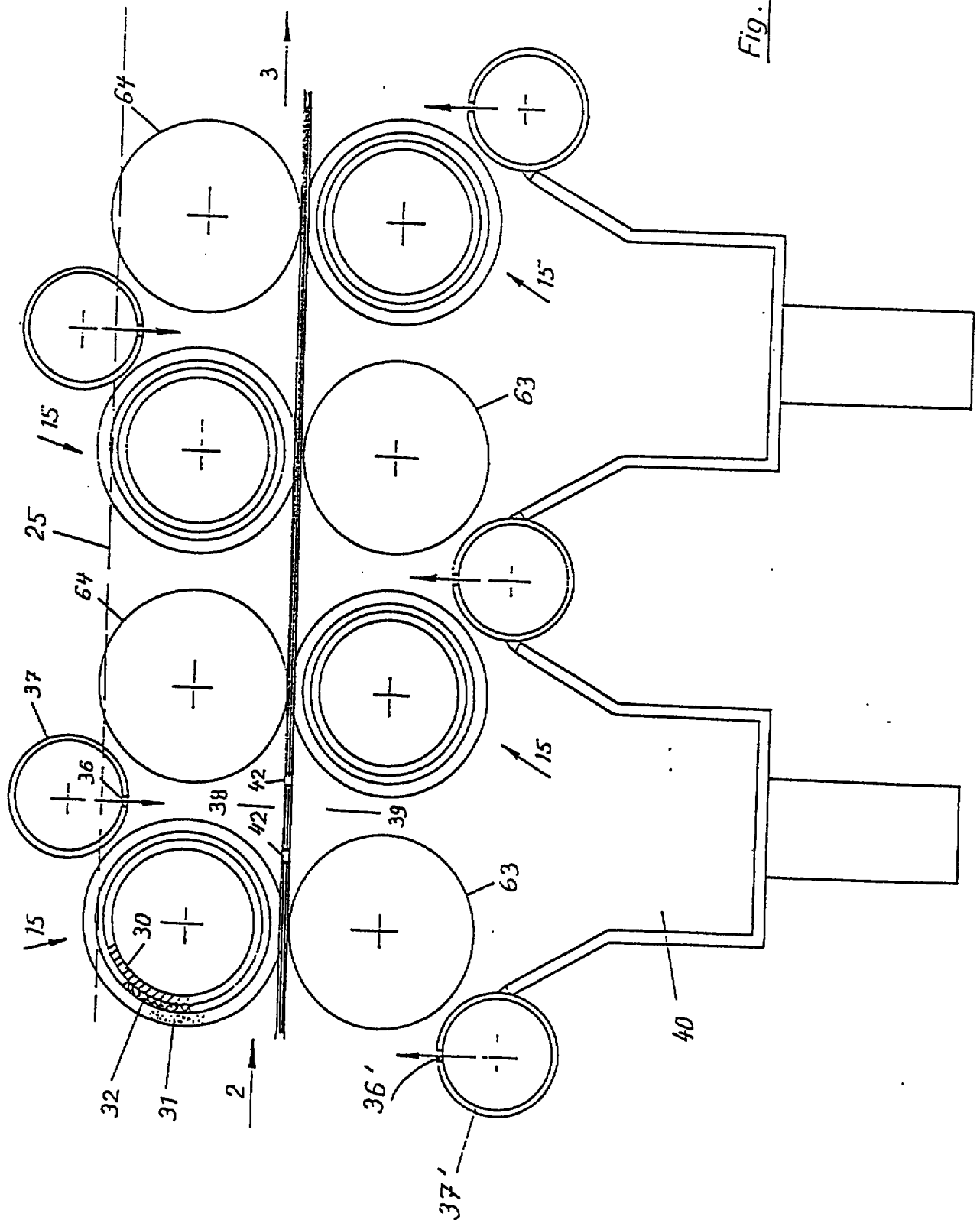
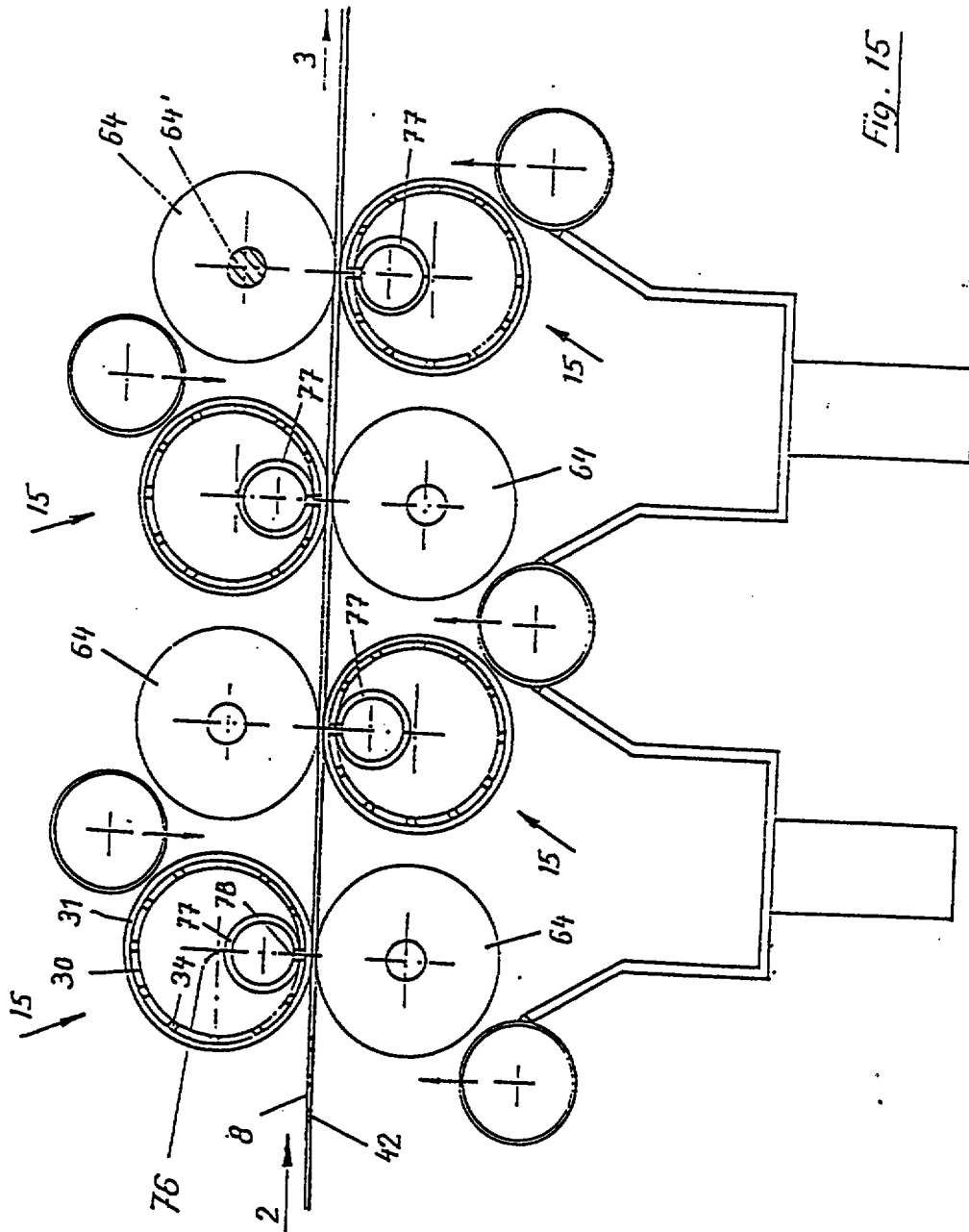


Fig. 14



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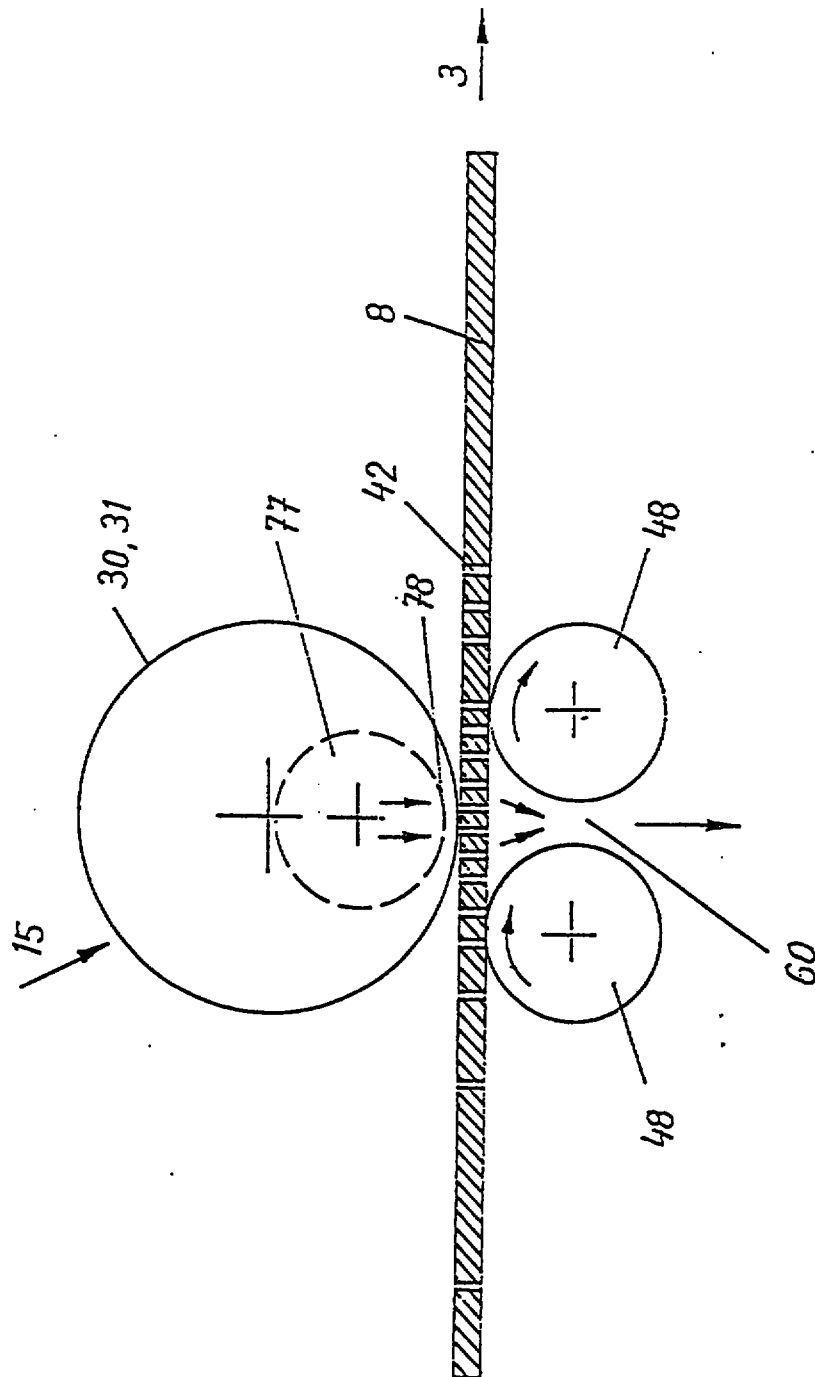


Fig. 16

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