(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 450 069 A1**

(12) **EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC**

(21) Application number: **89911880.6**

(51) Int. Cl.5: **C23C 2/00**

(22) Date of filing: **25.10.89**

(86) International application number:
PCT/JP89/01095

(87) International publication number:
WO 91/06687 (16.05.91 91/11)

(43) Date of publication of application:
09.10.91 Bulletin 91/41

(84) Designated Contracting States:
DE FR GB

(71) Applicant: **NKK CORPORATION**
**1-2, Marunouchi 1-chome Chiyoda-ku
Tokyo 100(JP)**

(72) Inventor: **ISHII, Toshio**
**NKK Corporation-nai 1-2, Marunouchi
1-chome
Chiyoda-ku Tokyo 100(JP)**
Inventor: **OKUBO, Yutaka**
**NKK Corporation-nai 1-2, Marunouchi
1-chome
Chiyoda-ku Tokyo 100(JP)**
Inventor: **SUGIYAMA, Syunichi**
**NKK Corporation-nai 1-2, Marunouchi
1-chome
Chiyoda-ku Tokyo 100(JP)**
Inventor: **ANDO, Yoshitsugu**
**NKK Corporation-nai 1-2, Marunouchi
1-chome
Chiyoda-ku Tokyo 100(JP)**
Inventor: **TAJIRI, Yasuhisa**
**NKK Corporation-nai 1-2, Marunouchi
1-chome
Chiyoda-ku Tokyo 100(JP)**
Inventor: **KUSAKA, Takeo**
**NKK Corporation-nai 1-2, Marunouchi
1-chome
Chiyoda-ku Tokyo 100(JP)**
Inventor: **SAKURAI, Mithitaka**
**NKK Corporation-nai 1-2, Marunouchi
1-chome
Chiyoda-ku Tokyo 100(JP)**

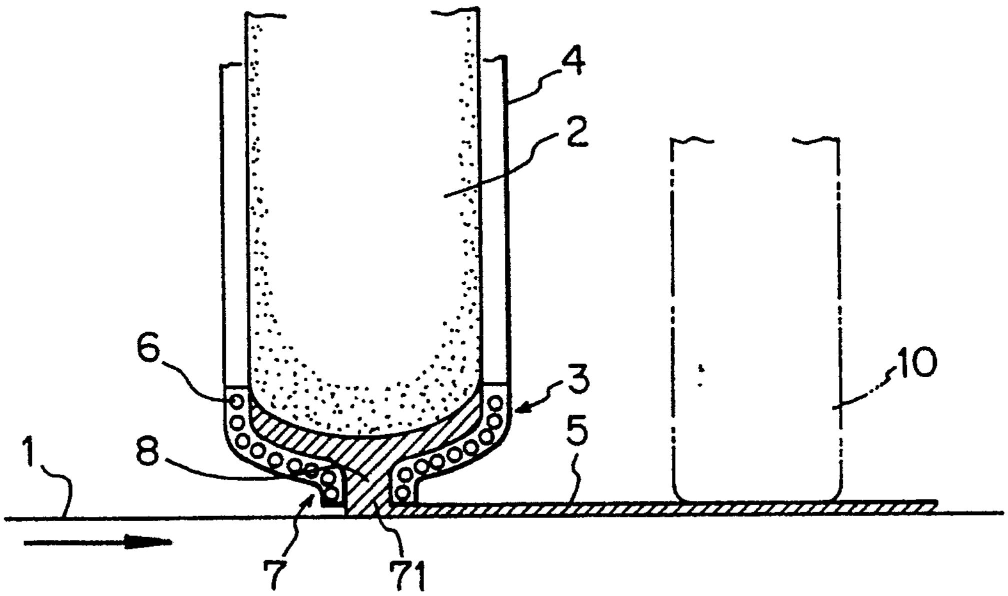
(74) Representative: **Heusler, Wolfgang, Dipl.-Ing. et al**
**Dr. Dieter von Bezold Dipl.-Ing. Peter Schütz
Dipl.-Ing. Wolfgang Heusler Brienner Strasse
52
W-8000 München 2(DE)**

(54) **METHOD OF CONTINUOUSLY PLATING METAL PLATES.**

(57) This invention relates to a plating method consisting of the steps of placing a solid phase plating metal in the vicinity of an object surface of a metal plate being fed, melting the plating metal as much a quantity as is required for plating the object surface, and depositing the molten plating metal in the form of a film on the object metal plate surface. According to this plating method, a molten metal bath is not required at all, and a plating film using molten metal can be obtained without troubling an operator about various problems arising from a plating operation using a molten metal bath.

EP 0 450 069 A1

Fig. 1



TECHNICAL FIELD

The present invention relates to a method of continuously plating metal sheets on the surfaces thereof without using a hot dip plating bath.

BACKGROUND OF THE INVENTION

Conventionally, hot dip platings where steel strips are immersed in previously molten plating metals, have been widely practised as methods of forming plated films on the strip surfaces.

A continuous hot dip zinc plating is a representative of this kind of platings. The steel strip is heat-treated in a pre-heating furnace and cleansed off the surface, immersed in a hot dip zinc bath so as to form a plated film, drawn out therefrom, controlled with respect to a plating adhesion amount by means of a gas squeezing, and adjusted on the surface by such as a galvanneal.

The accomplished plated steel sheet have beautiful appearances and excellent corrosion resistances, and are supplied to wide applications.

However existing hot dip zinc platings have various problems about using of the plating baths. Recently, uniformities, smoothnesses and beauties have been more required to the plated surfaces of the steel sheets, mainly in home appliances, outer panels of automobiles and others. New sorts of products such as platings different in thicknesses or one-side platings have been demanded. Problems have appeared with respect to the qualities of the hot dip plated steel sheets by the prior art and the plating processes themselves. Severals of such problems are as follows.

1) So-called drosses are much caused in that Fe eludes into the plating bath from the steel surface, or the plating metal is oxidized. Since those must be scooped up and removed, the plating metal is much lost other than adhering to the steel strip.

2) Impurities easily go into the plating bath, since the drosses are generated in the plating bath, or chips of bricks composing pots mix into the plating bath. Those adhere to the steel strip and degrade the strip faces.

3) Since there are differences in a component of plating metal matrix to be supplied into the bath, a component to be adhered to the steel strip and slight elements in the component to be exhausted as by-products outside of the bath, it is difficult to control the bath component to contain necessary elements as predetermined.

Therefore various defects arise in the platings, such as badness in the adhesion amount of the plating, inferiority in the alloying of the galvannealed materials and others.

4) It is necessary to bring steel-made mechanical parts as rolls for passing the strip, arms for supporting the rolls, bearings and others into the plating metal at high temperature and of high corrosion.

Thus, there appear problems of corrosions on these parts, generations of the drosses thereby, and degradations in the plated outer appearances by the corrosion on the outer parts of the rolls in the bath.

In addition, an operation stopping time must be taken for periodically reparing or exchangings the corroded or damaged parts of these mechanical parts, so that the produotivities of the facility could not be usefully demonstratesd to the maximum.

5) Group grooves of the rolls are easily translated to the plated surfaces by using the passing rolls in the plating bath, and the outer appearance of the strip is damaged.

6) Operators are burdened with heavy and dangerous workings around a good deal of the plating bath at high temperature, such as exhausting of bottomed drosses accumulated on the bath bottom, top drosses at the bath surface, initial passing of the strip into the plating bath, or repairing of the rolls in the bath.

7) Because of only one plating per one pot, it is necessary for different platings to change baths by scooping or prepare in advance a pot dissolving a different sort of plating metal, and move the pot.

8) When a steel material plated on the both sides thereof and that plated on one side are produced in a single apparatus, the plating facilities of the pot part must be changed, and it takes much time and labor for changing in addition to the facility load.

9) It is difficult to perform special platings such as the platings of different kinds on the both sides of multi-layers and of different thicknesses on the both sides.

In view of these conventional hot-dip plating methods, Japanese Patent Laid-Open No. 61-207555 teaches that the nozzle is approached to the running steel strip, and the molten metal supplied from a bath vessel is absorbed by the nozzle due to a wet adhesion between the molten metal and the strip surface, and is applied to the strip.

This method makes use of a coating technique of a paint of high viscosity, and is a practice of feeding the molten metal to the nozzle from the bath vessel, and since the plating adhesion amount is controlled by the head pressure of the molten metal bath vessel, changings in height of the bath surface in the vessel appear as differeces in the plating adhesion amount, resulting in a bad accuracy of the plating adhesion amount. Further, since it requires a molten metal vessel corresponding to the plating bath of the immersion type, the problems as stated above are still involved.

Thus, the conventional plating methods have many problems. In view of the above mentioned circumstances, the present invention is to provide a new plating method which may continuously carry out a hot dip plating metal on the metal sheet without using the hot dip plating metal bath as the prior art does, and control the adhesion amount at high precision.

DISCLOSURE OF THE INVENTION

The present invention continuously feeds the plating metal material toward the surface of the running metal strip, and melts the front end of the plating metal material by means of a melting device facing to the strip, so that the molten plating metal is adhered as a plating film to the surface of the strip.

Such a plating method may carry out the plating, not using the molten metal bath at all, and feeds a solid plating metal material to the steel strip to be plated, and melt it just before the strip surface by a required plating amount and adheres to the steel strip, whereby the plating adhesion amount may be controlled at a feeding speed of the solid plating metal material, and the plating amount may be secured at a high precision.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs.1 and 2 are explanatory views showing basic embodiments of the inventive method;

Fig.3 is a perspectve view showing another embodiment of the inventive method;

Fig.4 is an explanatory view showing another embodiment of the inventive method;

Fig.5 is a perspectve view showing another embodiment of the inventive method;

Fig.6 is an explanatory view showing another embodiment of the inventive method;

Fig.7 is a perspectve view showing another embodiment of the inventive method;

Figs.8 and 9 show other embodiments of the inventive method, and Fig.8 is a perspective view and Fig.9 is a perspective view showing a concrete structural example for moving the device in the width of teh steel strip;

Fig.10 is an explanatory view showing another embodiment of the present invention, plating on one side of the steel strip;

Fig.11 is an explanatory view showing another embodiment of the present invention, plating on one side of the steel strip;

Fig.12 is an explanatory view showing another embodiment of the present invention, plating on one side of the steel strip;

Fig.13 is an explanatory view showing another embodiment of the present invention, plating on one side of the steel strip;

Fig.14 is an explanatory view showing another embodiment of the present invention, plating on one side of the steel strip;

Fig.15 is an explanatory view showing another embodiment of the inventive method, plating on one side of the steel strip; and

Fig.16 is an explanatory view showing another embodiment of the inventive method, plating on one side of the steel strip;

DETAILED DESCRIPTION OF THE INVENTION

Fig.1 shows one of the embodiments that the inventive method is applied to a continuous plating treatment of the steel strip in which 1 designates a running steel strip, 2 is a plating metal material of a solid state to be continuously fed toward the surface of the steel strip, and 3 is a melting device of the plating metal material facing to the strip.

The plating metal material 2 to be fed to the strip surface is preheated by a preheater 4 and molten at its end in succession, and a molten meta 18 is adhered to the strip surface 1 so that a plated film 5 is formed.

The melting device 3 comprises a cylindrical body having a heating means 6 (heater, etc.) and is formed with a nozzle 7 at its one end, whose outlet 71 is near the surface of the passing strip. The plating metal material 2 is charged within the device 4 at an opening of the other end, and is molten at its end in succession, and the molten metal 8 thereby is applied to the steel surface from the nozzle 7 to form the plated film 5.

The melting device 3 to be used in the inventive method is not limited to the above exemplified ones, but as far as it is a practice having a nozzle near the steel surface, any heating system and any structure will be sufficient.

In such a plating method, assuming that the running speed of the steel strip 1 is U, the supplying speed of the plating metal material 2 is V, and the thickness of the plating metal material 2 in the strip running direction is W, a plated film thickness H is given with an under mentioned formula.

$$H = W\left(\frac{V}{U}\right)$$

A determined plated film thickness H may be therefore formed by making determined the supplying speed V of the plating metal matreial 2.

When a zinc plating of a plated adhesion amount of 60 g/m^2 (one side) is carried out according to the inventive method, and if W = 20 mm, the plating is carried out under the conditions of around U = 120 m/min and V = 0.857 m/sec.

In the inventive method, the steel strip 1 may be plated at room temperatures, but a preferable performance is the plating on a preheated steel strip so as to prevent occurrences of a bad shaping of the strip by rapid solidification of the molten metal. Preheating temperatures are not limited, but those above a melting point of the plating metal material 2 are especially preferable.

The plated film 5 formed as said above is often caused with differences in the adhesion amount by vibrations of the steel strip, and these differences may be uniformed by a surface adjusting device 10. As the surface adjusting device 10, for example, a device with a supersonic vibration system (so-called supersonic trowel) having a supersonic vibrator is used. This device is supported by a cylinder device (not shown) having a buffer mechanism, and its vibration plate is slightly contacted to the strip surface formed with the plated film, and the film thickness of the plated metal is uniformed by adding the supersonic vibration to the plated film.

For preventing the differences in the plating adhesion caused by the vibrations of the strip in the above mentioned plating treatment, the strip 1 may be pinched by pinch rolls 9 at an unflow side than a contacting part of the plating metal meterial as shown in Fig.2. In such a manner, the differences in plating by the vibration of the strip may be avoided, and collisions thereby between the strip 1 and the plating metal material 2 may be also avoided.

The pinching of the strip by the pinch rolls 9 is better in a near position to the contacting part of the plating metal material 2, in general preferably within 2000 mm (more preferably within 500 mm) in the length of the strip from the above contacting part.

As a preventing means of the adhesion differences (a pinching means), not only said pinch rolls but also appropriate means such as an air cushion or an electromagnetic force system may be sufficient.

Further, it is preferable to perform the plating treatment by the inventive method in a non-oxidizing atmosphere (e.g., a mixed gas of H_2: 20 to 25% and N_2: 80 to 75 %) for securing a plating wettability and adhesion. The surface of the steel strip should be cleansed off before the plating also in the inventive method.

The inventive method has various preferable embodiments and modifications as mentioned under for the performance thereof.

Figs.1 and 2 show one side platings of the steel strips. In these platings, there often occur dispersions in the plating amounts by the vibrations of the steel strip.

A space exist, as seen in Fig.1, between the nozzle 7 and the strip 1, and for stably providing the thickness of the plated film 5, it is necessary to keep this space at a determined distance. However, the passing strip 1 vibrates vertically and the strip displaces in a direction of the space, and subsequently the amount of plating adhesion is changed.

This problem may be removed by supporting the rear side of the strip to be plated by means of a supporting means. The vibration at the part to be plated is checked by the supporting means and a uniformly plated adhesion may be secured.

Most general supporting means is rolls, and the other appropriate ones may be employed, for example, a gas cushion device of getting a high pressure gas to the strip surface.

Fig.3 shows an embodiment of this invention, using the support means.

The plating metal material 2 is continuously charged into the plating metal supply device 11 having the melting device facing to the steel passing line, and the front end of the plating metal material 2 is molten by the melting device and the molten metal is continuously adhered as the plated film to one surface of the passing strip 1.

The present example uses a roll 12 as the supporting means of a non-plated surface, and the roll 12 supports the rear surface of a part A of the strip to be plated.

The numeral 13 designates feed rolls of the plating metal material 2.

Fig.4 shows another embodiment of using the supporting means which is a gas cushion device 14. The gas cushion device 14 is provided with a gas cushion header 15. The gas cushion header 15 blows the gas to the strip surface from a nozzle 16 of the header so as to support the strip 1 by this gas.

The supporting means are not limited to the above mentioned ones and those of suitable structures may be employed.

Although depending upon the above mentioned practice, the adhesion amount is often effected with small differences in the plated film, and these differences may be uniformed by the surface adjusting device 10 as shown in Fig.1. For more effectively preventing the differences caused by the vibrations of the strip, the strip 1 may be pinched by pinch rolls 9 at an upflow side than the the plating treatment part as shown in Fig.2.

In Figs.1 and 2, the plating metal material 2 is supplied only to one side of the strip 1. For plating both sides thereof, the plating metal material 2 are of course placed at the both sides of the steel strip for practising the plating on each side. In this case, it is not necessary to carry out the platings on the both sides at the same positions in the passing line.

Also in performing the platings on the both sides, there is the problem about non-uniform in the plating amount caused by the strip vibrations. This problem is removed by carrying out the respective platings at different positions in the line and supporting the rear side of each of the plating treatment parts.

Similarly to the one side plating as stated above, the most generally available supporting means is the roll, and other suitable means, for example, the gas cushion device as said above may be available. In particular, since this gas cushion device supports the strip by non-contacting, and when the plating of one side is performed while the plating of the other side is done at the downflow side, this device is useful as the supporting means for the plated rear side.

Although depending upon this method, the differences in the adhesion amount of the plated metal also more or less occur and may be uniformed by the surface adjusting device 10 as shown in Fig.1 (for example, the supersonic vibration system as stated above).

Thus the steel strip may be supported while uniforming the adhesion amount of the plated surface by using the supporting means having the plated surface adjusting function, especially having the plated surface adjusting function by the supersonic vibration system as the supporting means of the plated part at said downflow side.

Fig.5 shows one of the examples of platings on the both surfaces.

Plating metal supply devices 11a,11b are disposed at different positions in the strip passing line, and the platings are performed respectively. With respect to plate treating parts A,B, the strip 1 is supported by the supporting means at the rear side thereof.

The present embodiment uses a roll 12 as the supporting means of the plate treating part A at the upflow side, and a surface adjusting device 10x of the supersonic vibration system (supersonic vibration trowel) as the supporting means of the plate treating part B at the downflow side. The surface adjusting device 10x is provided as above said with a supersonic vibrator 17 which may uniform the plating adhesion amount by slightly pressing on the strip surface. The strip surface to be supported by the supporting means at the plate treating part B of the downflow side is a plated surface. If a distance between the plate treating parts A and B is small, said plating surface is non-solidified, and the roll cannot be used as the supporting means because the surface property is worsened. This embodiment uses therefore the surface adjusting device 10x as the supporting means which may directly contact the plated surface, so that it may simultaneously practise the surface adjustment of the plated side (uniforming the plated adhesion amount) and the supporting of the plate treating part.

In this case, the surface adjustment (treatment by e.g., said supersonic vibration trowel), by the surface adjusting device, on the film formed at the plate treating part B of the downflow side is performed at a further downflow side.

Fig.6 shows another embodiment which uses the gas cushion device 14 as the supporting device of the plate treating part B at the downflow side. The gas cushion device 14 is, as said above, provided with a gas cushion header 15 directing to the steel strip, and the gas is blown to the strip surface from the nozzle 16 of the header so that the strip 1 is supported by this gas. In this example, the plating adhesion amount is uniformed by the surface adjusting devices 10 after platings on the both surfaces.

The supporting means at the plate treating parts may employ various embodiments (structures) and combinations. For example, if the plating at the downflow side is carried out after solidification of the plated surface at the upflow side, the supporting means at the plate treating part B of the downflow side may also use the rolls.

In the above mentioned plating method of the both sides, for exactly preventing differences in the plating amounts by the strip vibrations, the steel strip 1 may be, as seen in Fig.2, pinched by the pinch rolls 9 at the upflow side than contacting the plating metal material.

One of the problems in practising the inventive plating method is in response to changings in the width of the steel strip to be plated. That is, in the plating method of this invention, since the solid plating metal material supplied in succession is molten immediately before the strip to be plated, the plating metal material should have almost the same width as the steel strip.

The plating metal material must be therefore changed in response to the width of the strip, for which a changing device of a large scale is required, and it takes much time for changing the plating metal material in response to the width of the strip, resulting in decreasing a production efficiency.

Fig.7 shows one of the embodiments which may solve such problems where the plating metal support device 11 is charged with the plating metal material 2 which is divided plurally in the width, and feeds to the strip surface the optional ones of the divided plating metal material in accordance with the width of the strip to be plated.

In this example, the plating metal material 2 is composed of a center divided material $2a_0$ and both side divided materials $2a_1$,$2a_2$. To a steel strip of a small width, the divided material $2a_0$ is used, while the materials $2a_0$,$2a_1$,$2a_2$ are used to a strip of a large width. The divided plating metal materials $2a_0$ to $2a_2$ are charged into the plating metal supply device 11, and the optional ones of the divided materials are molten and fed to the steel strip in accordance with the widths of the strip to be plated. For enabling to separately feed each of the divided materials, feed rolls 13, pre-heating devices 4 and melting devices 3 are divided as b_0 to b_2, d_0 to d_2, and e_0 to e_2, respectively in accordance with the width of the divided materials $2a_0$ to $2a_2$.

For example, to the strip of a small width, only the divided material $2a_0$ is molten, and the other materials $2a_1$,$2a_2$ are not molten by the melting devices e_1 and e_2 but awaited within the supply device 11. On the other hand, to the strip of a large width, the melting devices e_0,e_1,e_2 are all mobilized to melt the divided materials $2a_0$,$2a_1$,$2a_2$.

Also in this example, the plated surface 5 is uniformed by the surface adjusting device 10x of the supersonic vibration system.

Fig.8 shows another embodiment (device) which may change the plating width in accordance with the strip width.

In this device, a plurality of plating metal supply devices are arranged along the strip passing line, and each of the devices may be moved in the width of the steel strip.

According to this device, the plurality of plating metal supply devices are moved in the strip width to adjust positionings, and the plating is performed under covering the whole width of the strip with said plurality of supply devices.

The device shown in Fig.8 is provided with the two plating metal supply devices 11A,11B for melting the charged plating metal materials, back and forth in the strip passing line.

These two plating metal supply devices 11A,11B are disposed so that one of them plates one side in the strip width, and the other does the other side thereof. The both devices 11A,11B are movable for adjusting the positions in the strip width.

Fig.9 shows a concrete structural example for moving the plating metal supply device 11, where melting devices 3, preheaters 4 and feed rolls 13 are attached to a frame 18, which are movable or slidably held on guide rails (not shown) furnished in the strip width via rollers or shoes.

In addition, the frames 18 are provided with pairs of brackets having screwed holes into which screw shafts 21 rotatably supported at fixtures 20 outside of the device are fitted, so that each of the devices 11 is moved in the strip width by rotating the screw shaft 21 by a motor 22.

There is disposed the surface adjusting device 10x of the supersonic vibrating system at the downflow side than the plating metal supply device 11B.

In the above stated device, the plating metal supply devices 11A,11B are adjusted in positionings in accordance with the strip width for plating as covering the full width of the steel strip.

For example, for zinc-plating the steel strip, if the strip width is 630 to 1260 mm and a zinc sheet as the plating metal material is 30 mm thickness x 630 mm width, it is possible to perform the plating on the strip by arranging the devices 11A,11B as shown in Fig.8 and allowing to move around maximum 315 mm.

The plating metal supply device 11 of optional number may be disposed as required in the strip passing line.

One of the problems in carrying out the inventive methods is non-uniform in the adhering amount of the plating metal. In the above mentioned plating method which does not employ the hot dip plating bath, the non-uniformities are easily caused by the strip vibrations. In the plating method by the molten metal, the adhesion amount of the plating metal is adjusted by means of an air squeezing or others after plating, but conventional adjusting devices could not display a sufficient adjusting function on such parts of the plating adhesion less than an objective amount. Said method supplies therefore the plating metal more than the objective amount, and an excessive metal is removed.

However since the excessive plating metal is molten, it flows to the upfolw side than the adjusting device of the plate adhesion amount and a part thereof drops and splashes to cause troubles by striking the plated surface of the strip.

According to methods shown in Figs.10 to 16, it is possible to exactly adjust the plating adhesion amount without causing troubles as splashing of the excessive plating.

Fig.10 shows one of these examples.

There is provided a gas squeezing nozzle 23 for adjusting the plating adhesion amount at the downflow side than the plate treating part of the passing strip (the upper side in this example) and the excessive plating metal of the plated film 5 is blown off by the gas blown from this nozzle so as to adjust the plated adhesion amount. The removed metal flows downward, that is, the upflow side of the pass line of the strip.

In this example, a sensor 26 such as a range finder successively measures the thickness of the plated metal 25 of a drop part by the excessive plating metal at the upflow side than an amount adjusting part 24 of the plating metal adhesion by the gas squeezing nozzle 23. In accordance with measured values by the sensor 26, the supply amount of the plating metal at the plate treating part, i.e., that of the plating metal material 2 in this example, is controlled. Actually, an optimum range of the thickness of a plated metal 25 is predetermined, and a feed control (ON-OFF control or a feed amount control) of the plating metal material 2 is carried out, so that the meaured values are set therein. For example, when the value measured by the sensor 26 reaches an upper limit, the supply of the plating metal 2 is stopped, and when the thickness decreases and reaches a certain determined value (lower limit), the plating metal material 2 is fed again at a constant speed.

Thus the plating adhesion amount may be exactly adjusted without generating extremely excessive plating metal.

Fig.11 shows an example using a supersonic system as the adhesion amount adjuster (the same as the surface adjuster shown in Fig.5), and the same controlling is made here.

Fig.12 shows another system where sensors 26a,26b detect a drop end 27 of the excessive metal from the adhesion amount adjusting part 24 so as to control the feed of the plating metal material 2 in accordance with said detection.

Actually, the drop end 27 of the excessive metal is detected by the sensors 26a,26b such as the range finder and the feed control of the plating metal material 2 (ON-OFF control or the feed amount control) is carried out so that said end falls within a range (X) between the sensors 26a and 26b. For example, the feed of the plating metal material 2 is stopped at the time of detecting the drop end 27 by the sensor 26a, and then when the excessive plating metal amount decreases and the drop end 27 is detected by the sensor 26b, the control is made so as to feed again the plating metal material 2 at a determined speed.

In the above stated method, the controlling of the adhesion amount of the plating metal material is not limited, and appropriate practices other than the gas squeezing or the supersonic vibration systems may be employed.

In addition to said control of the feed amount of the plating metal, the thickness of the plated metal is measured at the downflow side of the line direction than the adjusting part of the metal adhesion amount, it is possible to control the film thickness at the adjusting part of the adhesion amount in accordance with the measured values. According to such a system, in addition to said system, the film thickness is also measured at the downflow side than the adjusting part of the adhesion amount. The control may be made at a higher precision.

Figs.13 to 15 show that thicknesses of the plated films are successively measured by the sensors 28 at the downflow side than the adjusting part 24 of the adhesion amount, and the film thicknesses are controlled in accordance with the measured values. That is, a feed gas pressure is controlled in a case of the gas squeezing nozzle 23, and a pressure of a vibration plate 29 is controlled in a case of the supersonic vibration system, so that the measured values fall into allowable ranges.

Since other subjects are the same as Figs.10 to 12, explanations will be omitted.

The inventive plating methods are applicable to various metal or alloy platings, for example, it is possible to perform the platings on the steel strips such as not only Zn plating, Al-Zn alloy plating, but also Co-Cr-Zn alloy plating (e.g., 1%Co-1%Cr-Zn alloy plating), Al-Mg-Zn alloy plating (e.g., 5%Al-0.6%Mg-Zn alloy plating). Al-Si-Zn alloy plating (e.g., 55%Al-1.6%Si-Zn alloy plating), Si-Al alloy plating (e.g., 10%Si-Al alloy plating), Sn-Pb alloy plating (e.g., 10%Sn-Pb alloy plating).

The present invention is especially suited to productions of Zn-Ni alloy plated steel sheets and Zn-Fe alloy plated steel sheets which have been used widely as rust resistance for automobiles, and Zn-Mn alloy plated sheets, which are seen hopeful as rust resistance for automobiles in a coming age.

Needs have recently become more demanded for rust resistant steel sheets having high corrosion resistability, mainly laying stresses on automobiles. In the zinc plated steel sheets, the high corrosion resistance may be secured by increasing the plating amount, but too much amount deteriorates processability (powdering resistance) and weldability, and a problem about scrap treatment occurs. In view of these circumstances, developments have been made on alloy electroplated steel sheets having excellent resistability. Among them, since Zn-Fe alloy plated steel sheet and Zn-Ni alloy plated steel sheets are excellent in faculties such as paint adhesion, corrosion resistance and others, those have widely been used as the rust resistant steel sheets for the automobiles. Since Zn-Mn alloy plated steel sheets are also excellent in the paint adhesion and corrosion resistance, it is promised as the rust resistant steel sheets of the automobiles in the coming age.

However, these alloy plated steel sheets have such defects that electrolyzing efficiency is relatively low, and production costs are high. For satisfying the needs of the high corrosion resistance which has become recently higher, those alloy platings must secure plated amounts of a certain extent, and plated steel sheets securing the plated amount are very expensive.

With respect to the Fe-Zn alloy plated steel strip, alloyed hot dip zinc plated steel strips have conventionally been produced which were subjected to an alloying heat treatment immediately after the hot dip zinc plating, and have been widely used as the rust proof steel sheets for the automobiles. However, in this kind of plated steel sheet, when the plating adhesion amount is more than 60 g/m^2, a Γ phase is made thick and the processability is extremely lowered.

On the other hand, according to the inventive method, it is possible to produce each of the above mentioned alloy plated steel sheets without bringing about the problems as said.

The melting points of Zn-Fe alloy, Zn-Ni alloy and Zn-Mn alloy are higher than that of zinc, and it is almost impossible in view of melting corrosions of the rolls in the plating bath to operate such alloy platings in the practice having the molten pot. Rare cases have made studies on faculties of the above alloy plated steel sheets.

The inventors have developed the present inventive method which may industrially practise the platings by the molten metals with respect to alloys of high melting points, and it has been possible to produce each of the above mentioned alloy plated steel sheets. Following facts have been proved in their studies on the properties of their plated steel sheets.

Zn-Fe ALLOY PLATED STEEL SHEET:

This plated steel sheet has corrosion resistance of higher degree after plating in comparison with the electrodeposited steel sheets and the alloyed hot dip plated steel sheets which have the same plating adhesion amounts and Fe contents, and further it has more excellent processability than the alloyed hot dip plated steel sheet. Reasons therefor are not always apparent, but such assumptions may be taken that with respect to the corrosion resistance after the plating, in the plated sheet of the invention, a part of zinc in the surface layer evaporates in a process after the plating and an Fe enriched film is formed, so that Fe thereby improves the property of a phosphate film formed by the pre-treatment of the coating, and with respect to the processability, the alloyed hot dip zinc plating has a mixed structure of ζ phase, δ_1 phase and Γ phase, and on the other hand, the inventive plated steel has the same uniformed structure as the electrodeposited Zn-Fe plating.

Zn-Ni ALLOY PLATED STEEL SHEET:

This plated steel sheet has the corrosion resistances of higher degree (bare corrosion resistance and corrosion resistance after the coating) in comparison with the electrodeposited steel sheet which has the same plating adhesion amount and Ni content. The reasons therefor are not always apparent, but such assumptions may be taken that a part of zinc in the surface layer evaporates in a cooling process after the plating and a Ni enriched layer is formed, and this layer effectively acts on the corrosion resistance.

Zn-Mn ALLOY PLATED STEEL SHEET:

This plated steel sheet has the corrosion resistances of higher degree (bare corrosion resistance and corrosion resistance after the coating) in comparison with the electrodeposited steel sheet which has the same plating adhesion amount and Mn content. The reasons therefor are not always apparent, but such assumptions may be taken that a thermally non-equilibrium phase is formed in the plated film of the electrodeposited Zn-Mn alloy plating, while a thermally equilibrium phase is formed in a plated film of the molten Zn-Mn alloy plating, and this phase will effectively act on the corrosion resistance.

According to the present invention, each of the alloy plated steel sheets is produced by supplying, as the plating metal materials, Zn-Fe alloy material, Zn-Ni alloy material and Zn-Mn alloy material to the steel strips 1 as shown in Fig.1 and the followings.

In the above mentioned plating treatments, plating metal materials are used where alloying element contents are specified as follows.

Zn-Fe alloy plating:
Zn-Fe alloy material of Fe being not more than 60 wt%
Zn-Ni alloy plating:
Zn-Ni alloy material of Ni being not more than 30 wt%
Ni-Mn alloy plating:
Zn-Mn alloy material of Mn being not more than 60 wt%.

Accordingly, the alloy plated steel sheets to be produced are formed with plated films almost corresponding to the above alloying ratios.

In the Zn-Fe alloy plating, if Fe content is more than 60 wt%, the melting point of the alloyed material is made too high, and it is difficult to provide an appropriate melting condition, and a victim corrosion resisting action to a steel sheet is deteriorated. It is preferable to set the lower limit of Fe content to be 3 wt% for securing the corrosion resistance after the coating.

In the Zn-Ni alloy plating, if Ni content is more than 30 wt%, the melting point of the alloyed material is made too high, and it is difficult to provide an appropriate melting condition. Although the Ni content exceeds 30 wt%, it is scarecely effective to the corrosion resistance, and not only it is disadvantageous in view of the cost, but also the victim corrosion to the steel sheet is lowered, resulting in easily causing red rusts. It is preferable to set the lower limit of Ni content to be 5 wt% for securing a determined corrosion resistance.

In the Zn-Mn alloy plating, if Mn content is more than 60 wt%, the melting point of the alloyed material is made too high, and it is difficult to provide an appropriate melting condition. Although the M content exceeds 60 wt%, it is scarecely effective to the corrosion resistance, and it is disadvantegeous in view of the cost. It is preferable to set the lower limit of Mn content to be 10 wt% for securing the desired corrosion resistance.

In addition to advantages of the functions as said above, the steel sheets of the invention may be produced at very low costs in comaprison with the electrodeposition.

Further, in the present invention, multi-layered platings are possible by contacting the plating metal materials of homogeneous or heterogeneous sorts to the steel strip back and forth in the strip passing direction.

Various kind of new plated steel sheets have recently been demanded, and one of them is an ultra thick plated sheet, or a multi-layered steel sheet by the heterogeneous sort (including alloys, and the same in the following).

As the methods of forming the plated films on the steel strips, there have conventionally been the hot dip plating where the steel sheet is immersed into the molten metal bath, and the electroplating. If the plated steel sheets as said above are produced in dependence upon the prior art, following problems will occur.

In the hot dip plating method, since a balance limit exists between a viscosity that the plating metal in the bath is upheaved and a gravity that the plating metal drops, the plating adhesion amount is limited accordingly. If the adhesion amount is exceedingly made much, the plated surface is drop and the outer appearance of the steel sheet will be deteriorated. The plated thickness obtained by the ordinary hot dip plating method has a certain limit. There is a method of practising more than twice of the hot dip platings (multi-layered plating) for providing the ultra thick plating or the plated film of the heterogeneous sort. If the multi-layered plating is performed in the hot dip plating method, the facility is made large scaled and the cost thereof is too high. Among the plural layered platings composed of the heterogeneous plating metals, there are some kinds impossible to be produced. In the multi-layered platings that the melting point of the lower plated layer is lower than that of the upper plated layer, the plated film of the lower layer is molten when the upper layer is plated. The plating of such a combination is impossible.

On the other hand, the ultra thick plated steel sheet by the electroplating has a demerit of high production cost. Furthermore, in the production of the multi-layered sheet composed of the heterogeneous plated metal films, a water-washing facility is required for preventing the plating composition from going into the other plating bath, so that a facility cost is made high. In addition, there are technical and economical restraints in the kinds of plating available metals and embodiments.

According to the present invention, the multi-layered platings are possible in dependence upon the molten metal without inviting the above mentioned problems.

Fig.16 shows one example of the multi-layered platings of this invnetion, in which a first layer is formed at a plating part A, and a plated film 5a thereby is solidified by a cooling device 30, and the same plating treatment is done at another plating part B to form a plated film 5b of a second layer.

The inventive method may realize, without problems, the multi-layered platings of such a combination that the melting point of the melting metal at the second layer is higher than that at the first layer, and of the plating metals of the same kinds. As an example of the former, the multi-layered steel strip is produced, having the first layer of Fe (15 to 20%)-Zn alloy plated film excellent in a victim corrosion resistance and the second layer of Fe (60 to 80%)Zn alloy plated film suitable to a substrate to be coated. The strip of the ultra thick plating may be produced by the multi-layered platings with the plating metal of the same kind as the latter.

In the inventive method, the plating metal material 2 to be charged into the plating metal supply device 11 is generally shaped in plate, but it may be sufficient with, for example, powders.

Further, in the inventive method, the steel strip 1 may run other than horizontally, for example, vertically. In a vertical line, the strip may run irrespective of the up and down directions.

Furthermore, when plating the both surfaces of the strip according to the invention, it is possible to easily practise the platings of the heterogeneous sorts on the respective surfaces of the strip by positioning the plating metal materials of the different compositions at the both sides of the strip. For example, as a blank sheet of an outer panel for the home electric appliances, Fe-Zn alloy plated film is formed on one side (for coating side) and Zn plated film is formed on the other side (bare side).

By the present invention, it is possible to form the plated film continuously on the metal sheet, not using the hot dip plating bath, and the under mentioned merits are brought about in compariosn with the prior art using the plating bath.

1) The plating metal is not lost other than adhering to the steel strip, since no dross is generated as using the plating bath.

2) The outer appearance is kept beautiful without staining drosses or impurities to the strip surface.

3) The same component as the plating metal material is plated because the plating metal

material is directly deposited, and the component in the plated film is uniform and is easily controlled accordingly.

4) Any mechanical parts are not immersed in the bath, so that the operation is not stopped for exchanging or repairing the corroded mechanical parts.

5) Any rolls are not used in the bath, and the roll grooves are not translated to the outer plated surface of the strip.

6) It is not necessary to exhaust the bottom and top drosses, initially pass the strip into the bath, and repair the rolls in the bath, whereby the burden on the operators is considerably reduced.

7) For practising the alloy platings, it is sufficient to only exchange the plating metal material to be supplied to the steel strip, and the large operations are not required as changing the bath or moving the pot, and the platings of various kinds are available.

8) It is possible to easily operate the one-side plating, the multi-layered platings, the thickness differet platings of the both sides, and the heterogeneous platings of the both sides by selecting and changing the positionings of the plating metal material and the supplying embodiment and speed of the plating metal material.

In addition to these merits, since the solid plating metal is fed toward the steel strip to be plated, and molten by a required plating amount at the strip surface, the plating adhesion amount may be controlled by the feeding speed of the solid plating metal material, and therefore the adhesion amount at the high precision may be secured.

INDUSTRIAL APPLICABILITY

The present invention may be widely utilized as a substitution for the conventional continuous hot dip zinc plating method, and employed to the continuous plating for various kinds of metals and alloys other than zinc, especially the invention may easily produce Zn-Fe, Zn-Ni and Zn-Mn alloy plated steel sheets which have been impossile in the prior art using the melting pot.

Claims

1. A method of continuously plating metal sheets, comprising continuously feeding a plating metal material toward a surface of a running metal strip, melting said plating metal material at its end by means of a melting device facing the running strip, and continuously adhering the molten plating metal as a plating film to the surface of the steel strip.

2. A method as claimed in claim 1, characterized by performing more than one of following steps (i) and (ii) for forming a plated film of a uniform thickness;

   (i) carrying out, after forming the plated film, a uniforming treatment of an adhering amount of the plated film, and

   (ii) pinching the metal sheet by pinching means of a contact type or a non-contact type at an upflow side than a contacting part of the plating metal so as to prevent vibrations of the passing metal sheet.

3. A method as claimed in claim 1, characterized by supporting a rear side of the metal strip to which the plating metal material contacts, thereby to cntinuously plate one side of the strip.

4. A method as claimed in claim 3, characterized by performing more than one of following steps (i) and (ii) for forming a plated film of a uniform thickness;

   (i) carrying out, after forming the plated film, a uniforming treatment of an adhering amount of the plated film, and

   (ii) pinching the metal sheet by pinching means of a contact type or a non-contact type at an upflow side than a contacting part of the plating metal so as to prevent vibrations of the passing metal sheet.

5. A method of continuously plating metal sheets, for continuously plating the metal sheet on the both sides thereof according to the method of claim 1, characterized by carrying out the plating treatments to the metal sheet on the respective parts thereof with the plating metal materials at different positions in the sheet passing line, and supporting the metal sheet on its rear sides at the respective plate treating parrts by means of a supporting means.

6. A method as claimed in claim 5, characterized in that the supporting means in the plate treating part at the down flow side of the sheet passing line, has the surface adjusting function.

7. A method as claimed in claim 5, characterized by performing more than one of following steps (i) and (ii) for forming a plated film of a uniform thickness;

   (i) carrying out, after forming the plated film, a uniforming treatment of an adhering amount of the plated film, and

   (ii) pinching the metal sheet by pinching means of a contact type or a non-contact type at an upflow side than a contacting part of the plating metal so as to prevent vibrations of the passing metal sheet.

8. A method as claimed in claim 1, characterizing by charging plating metal materials plurally divided in width into a device for supplying the plating metal material and melting the optional ones of the divided plating metal materials in accordance with the width of the metal sheet to be plated, and supplying to the surface of the metal sheet.

9. A method as claimed in claim 8, characterized by performing more than one of following steps (i) and (ii) for forming a plated film of a uniform thickness;
   (i) carrying out, after forming the plated film, a uniforming treatment of an adhering amount of the plated film, and
   (ii) pinching the metal sheet by pinching means of a contact type or a non-contact type at an upflow side than a contacting part of the plating metal so as to prevent vibrations of the passing metal sheet.

10. A method as claimed in claim 1, characterized by providing, in the strip passing line, a plurality of plating metal supply devices which feed the plating metal materials toward the metal strip, melt the plating metal materials at ends thereof in succession around the strip, and adher the molten plating metal as plated films to the strip, making these devices movable in the width direction of the metal strip, and selecting positions of said devices in the width of the metal strip, thereby to supply the molten plating metals to the full width of the metal strip.

11. A method as claimed in claim 1, characterized by adjusting the plate adhesion amount after having formed the plated film, measuring, at the upflow side in the line than the adjusting part of the plated adhesion amount, the thickness of the plated metal including an excess plated metal brought from said adjusting part of the plate adhesion amount, and controlling the supplying amount of the plating metal at the plate treating parts in accordance with said measured value.

12. A method as claimed in claim 1, characterized by adjusting the plate adhesion amount after having formed the platd film, detecting an end of a drop part of the excess plated metal brought from said adjusting part of the plate adhesion amount at the upflow side of the line than the adjusting part of the plate adhesion amount, and controlling the supplying amount of the plating metal at the plate treating parts in accordance with said adhesion.

13. A method as claimed in claim 1, characterized by adjusting the plate adhesion amount after having formed the plated film, measuring, at the upflow side in the line than the adjusting part of the plated adhesion amount, the thickness of the plated metal including an excess plated metal brought from said adjusting part of the plate adhesion amount, and controlling the supplying amount of the plating metal at the plate treating parts in accordance with said measured value, and measuring the plated thickness at the downflow side of the line than the adjusting part of the plate adhesion amount, and controlling the film thickness at the adjusting part of the plate adhesion amount in accordance with said measured value.

14. A method as claimed in claim 1, characterized by adjusting the plate adhesion amount after having formed the platd film, detecting an end of a drop part of the excess plated metal brought from said adjusting part of the plate adhesion amount at the upflow side of the line than the adjusting part of the plate adhesion amount, and controlling the supplying amount of the plating metal at the plate treating parts in accordance with said adhesion, measuring the plated thickness at the downflow side of the line than the adjusting part of the plate adhesion amount, and controlling the film thickness at the adjusting part of the plate adhesion amount in accordance with said measured value.

15. A method as claimed in claim 1, characterized by using, as a plating metal material, a Zn-Fe alloy material of Fe content being not more than 60 wt%, thereby to form Zn-Fe alloy plated film of Fe content being not more than 60 wt% on the surface of the steel strip.

16. A method as claimed in claim 1, characterized by using, as a plating metal material, a Zn-Ni alloy material of Ni content being not more than 30 wt%, thereby to form Zn-Ni alloy plated film of Ni content being not more than 30 wt% on the surface of the steel strip.

17. A method as claimed in claim 1, characterized by using, as a plating metal material, a Zn-Mn alloy material of Mn content being not more than 60 wt%, thereby to form Zn-Mn alloy plated film of Mn content being not more than

60 wt% on the surface of the steel strip.

18. A method of continuously plating metal sheets, characterized by repeatedly practising the plate treating process as claimed in claim 1 in the metal sheets passing line while solidifying the plated film between the respective processes, thereby to form multi-layered plated film composed of homogeneous or heterogeneous kinds of the plated metals on the metal sheet.

Fig. 1

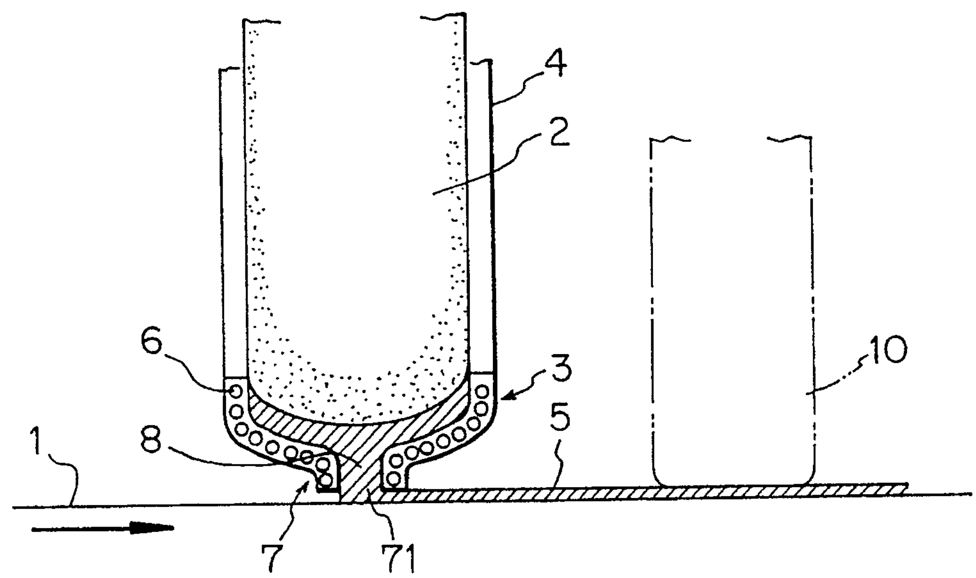


Fig. 2

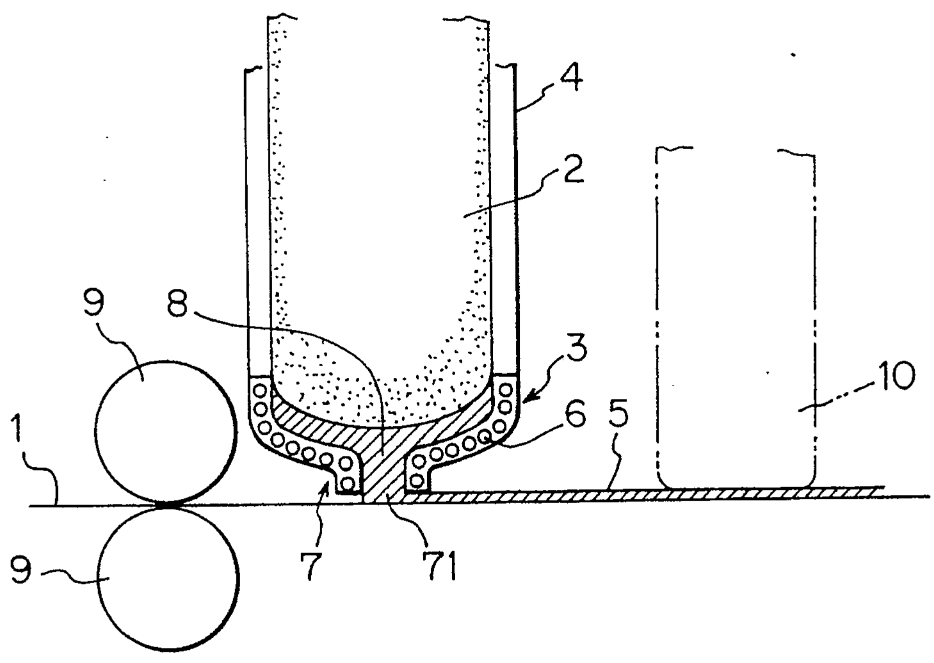


Fig_3

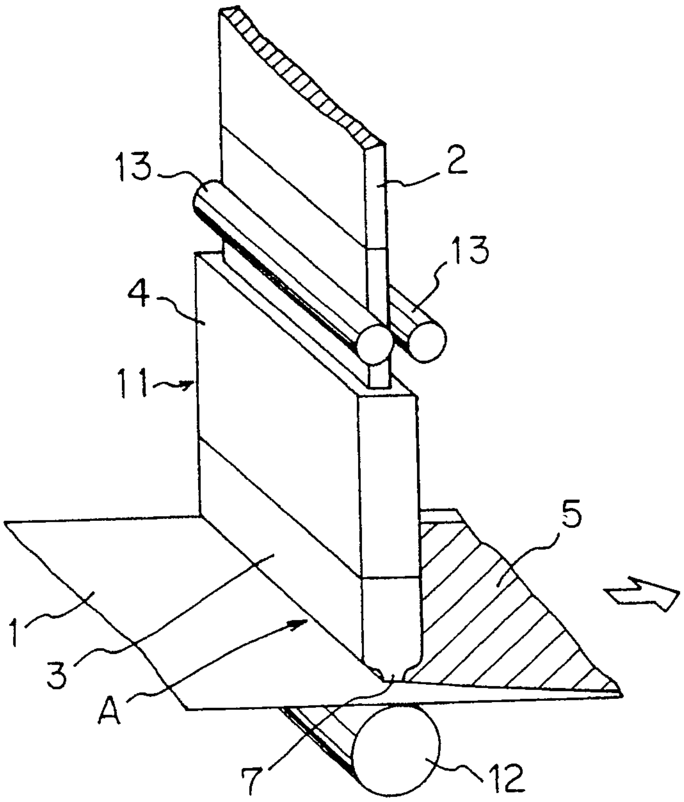


Fig_4

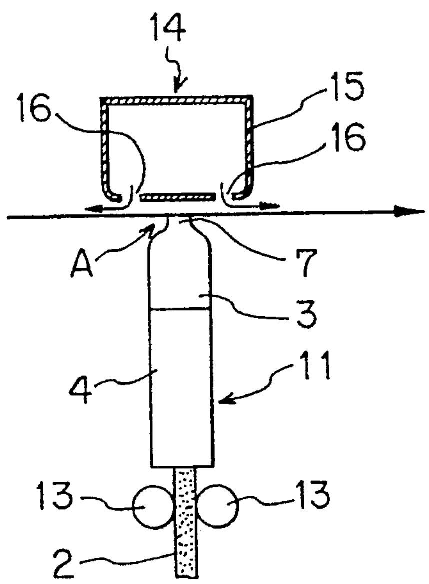


Fig. 5

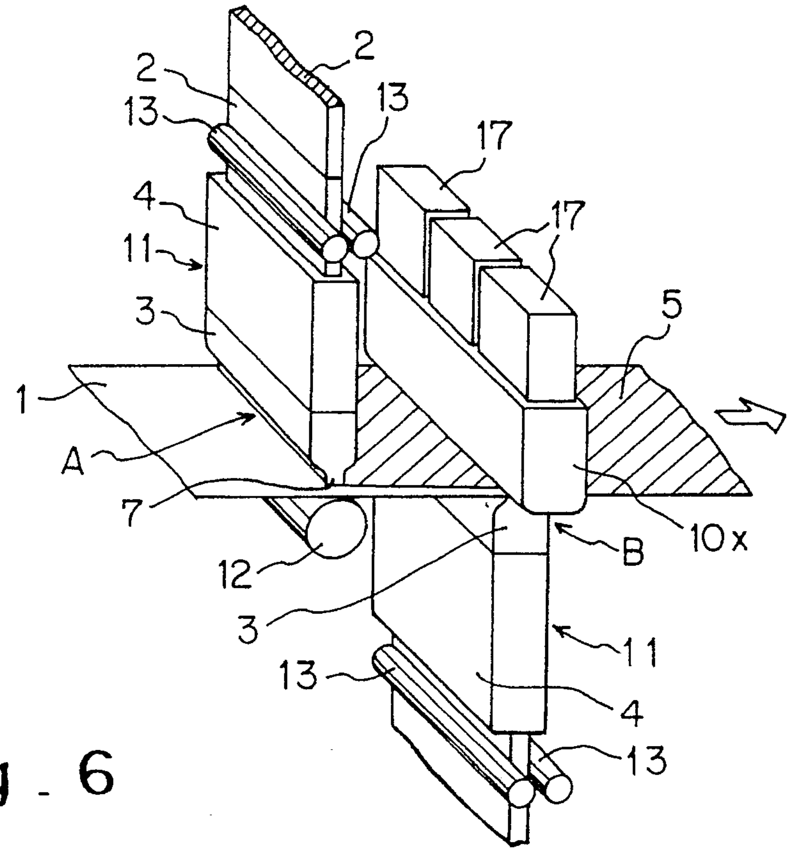

2
2
13
13
17
17
17
4
11
3
5
1
A
7
10x
12
B
3
11
13
4
13

Fig. 6

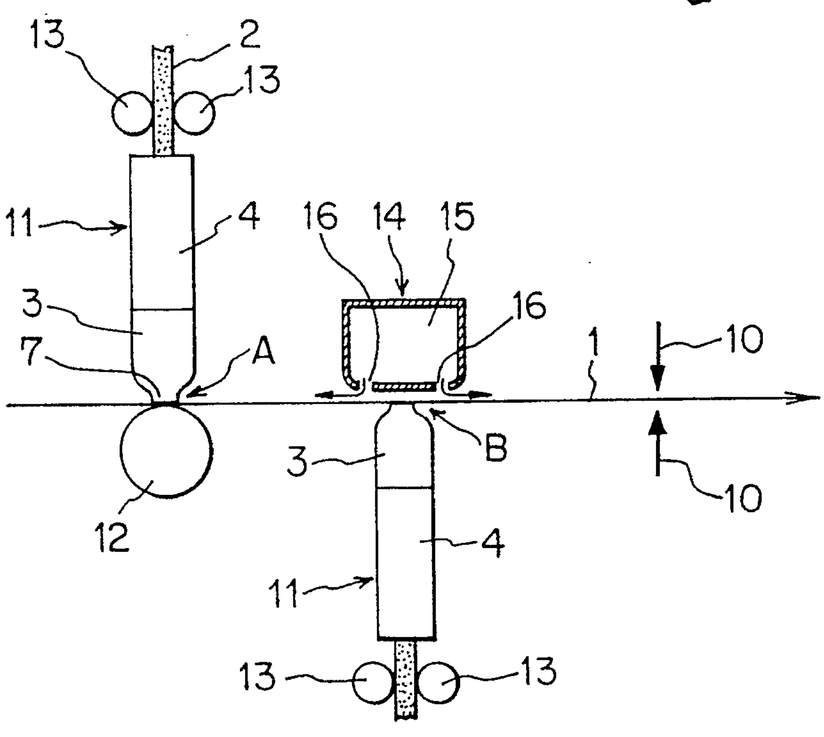

13
2
13
11
4
16
14
15
16
3
7
A
1
10
B
3
10
12
4
11
13
13

Fig. 7

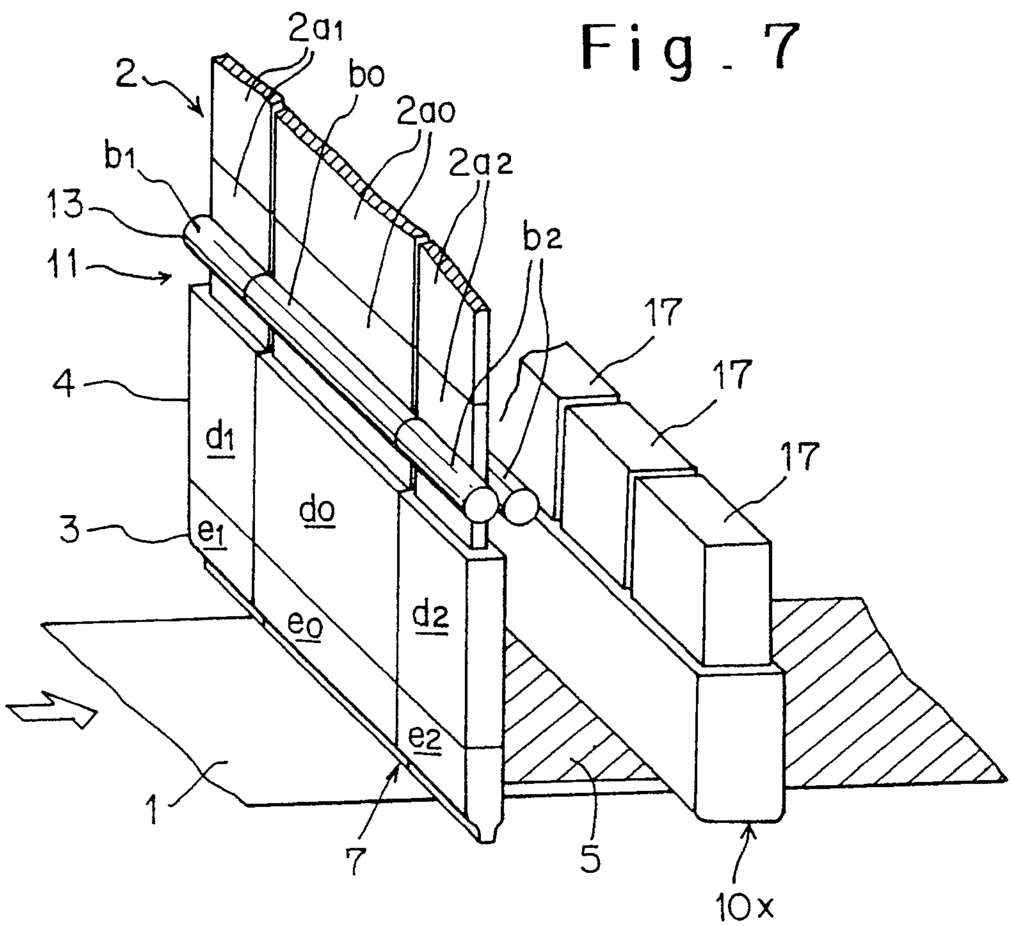

2
2a1
bo
2ao
2a2
b1
13
11
b2
17
17
17
4
d1
do
3
e1
d2
eo
e2
1
7
5
10x

Fig. 8

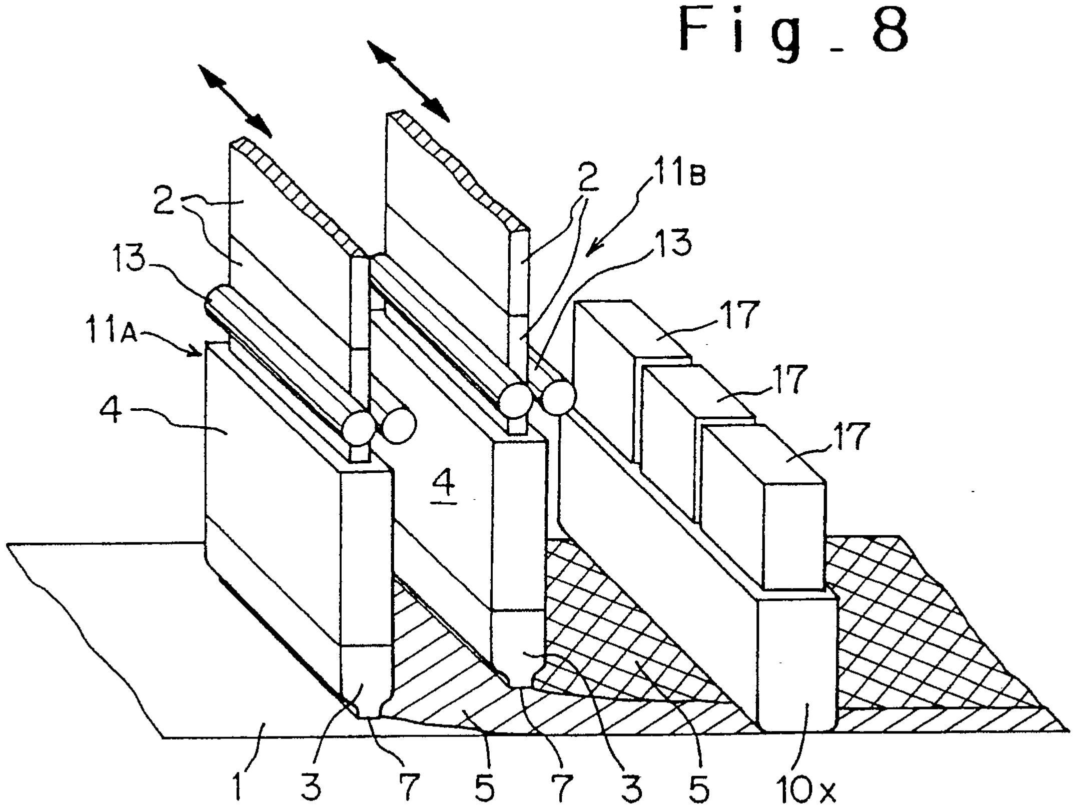

2
11B
13
13
11A
17
17
17
4
4
1
3
7
5
7
3
5
10x

Fig. 9

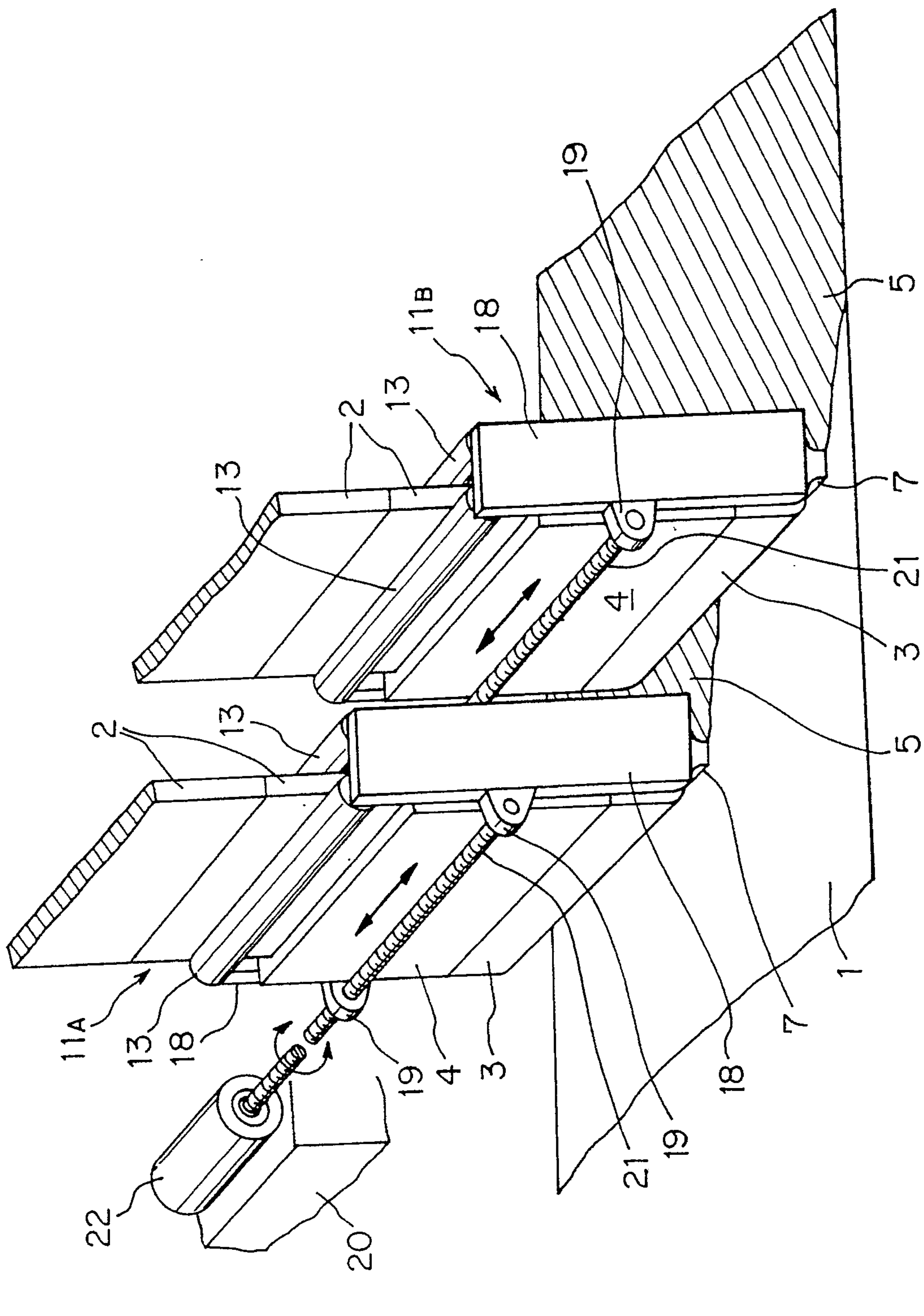


Fig. 10

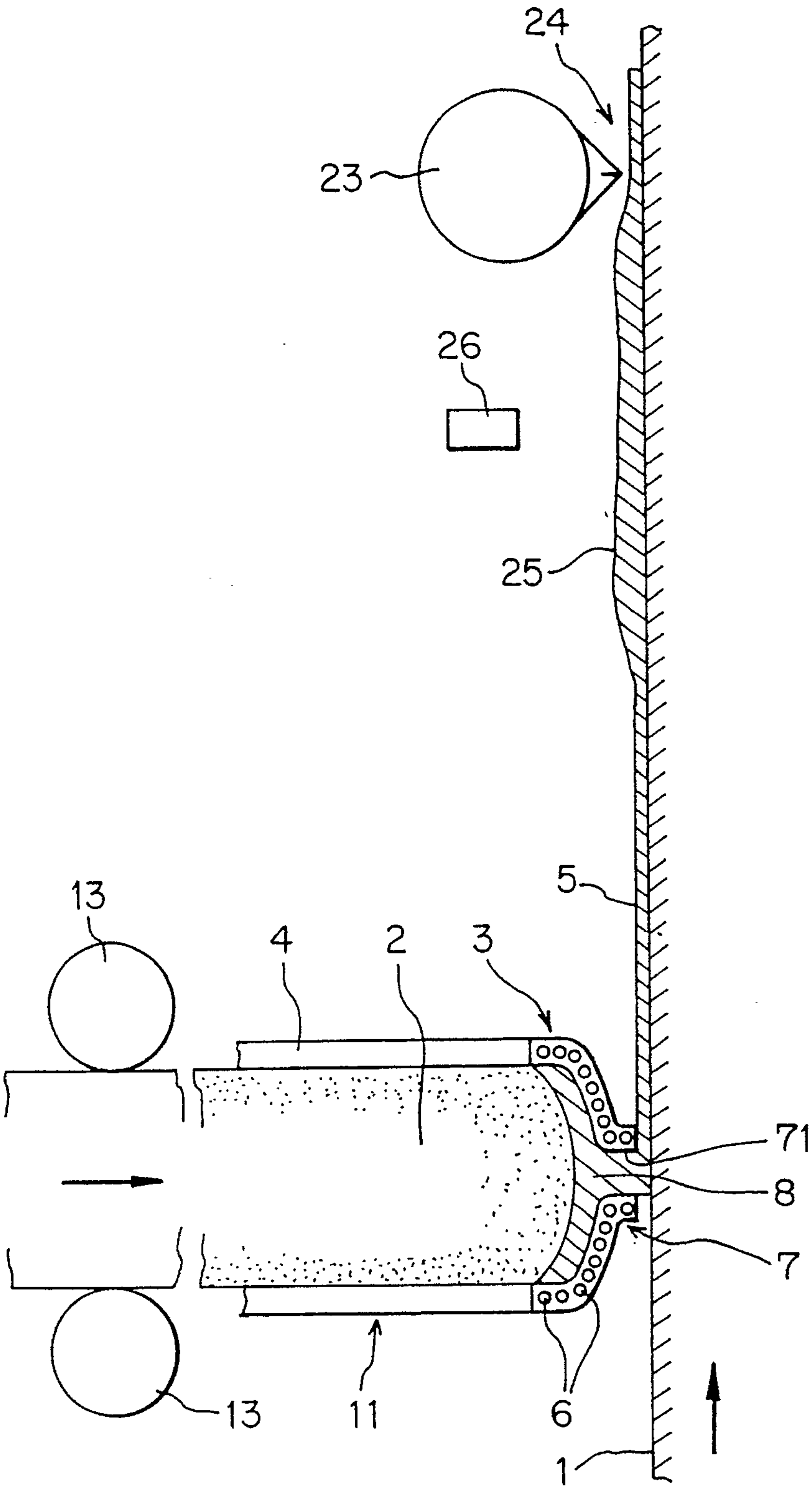


Fig.11

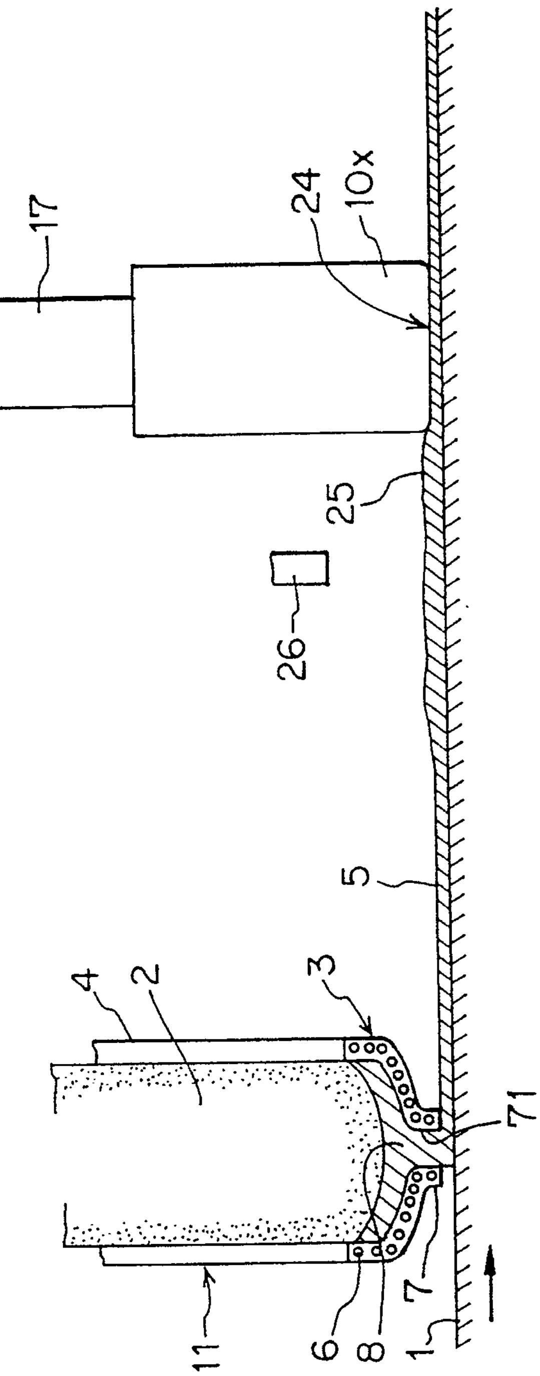


Fig.14

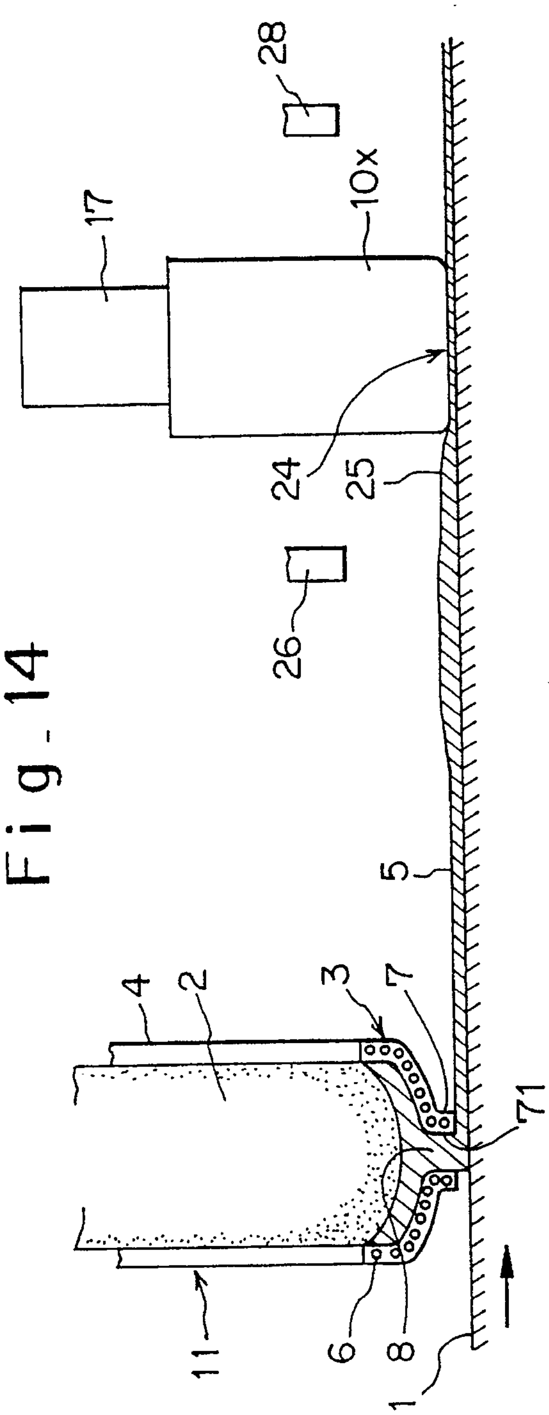


Fig. 12

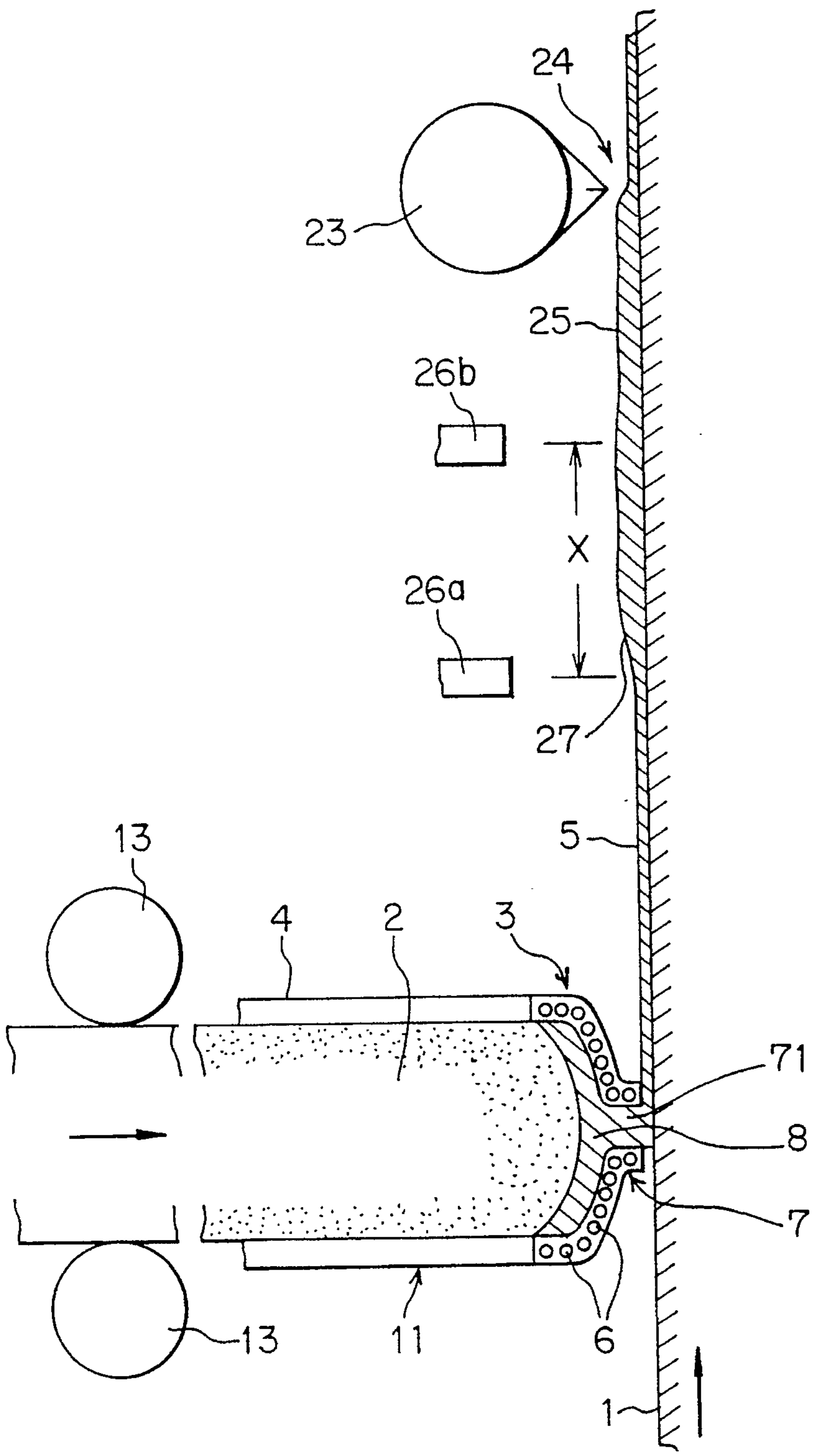


Fig. 13

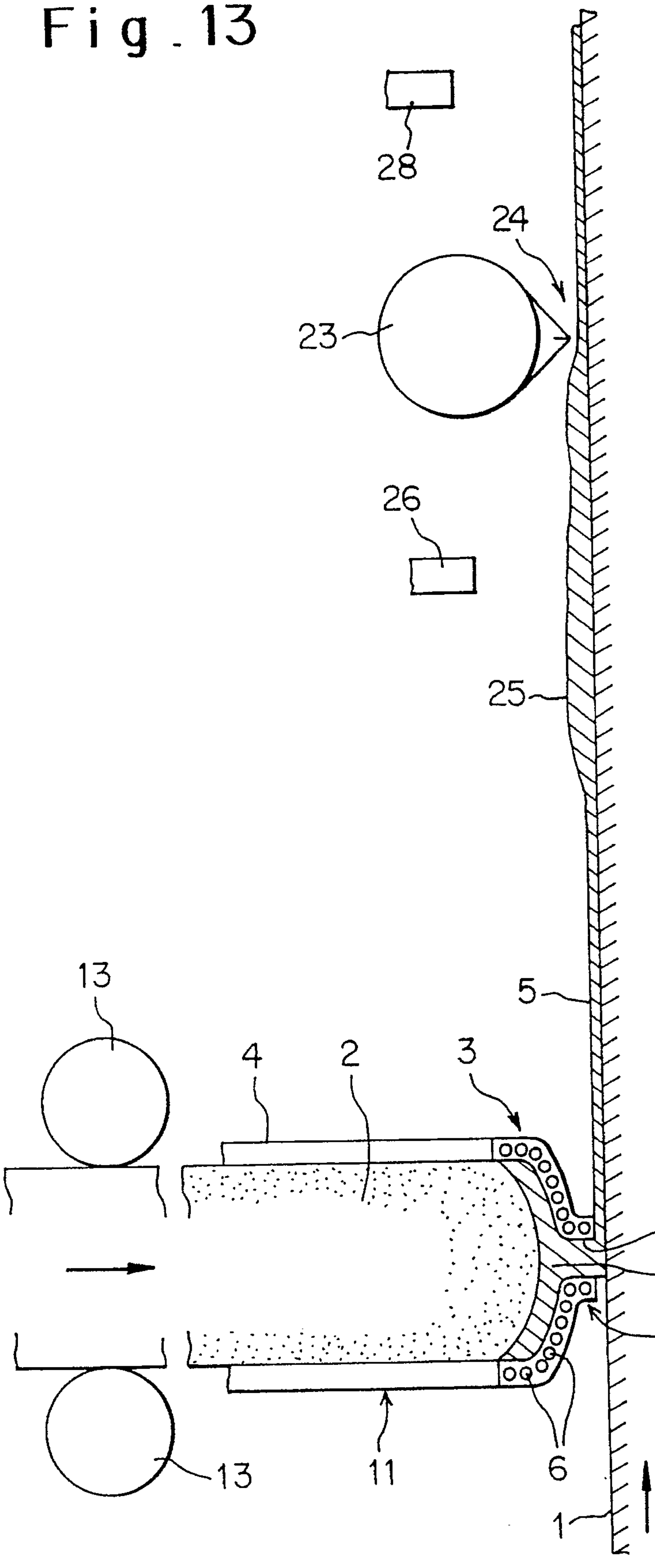


Fig. 15

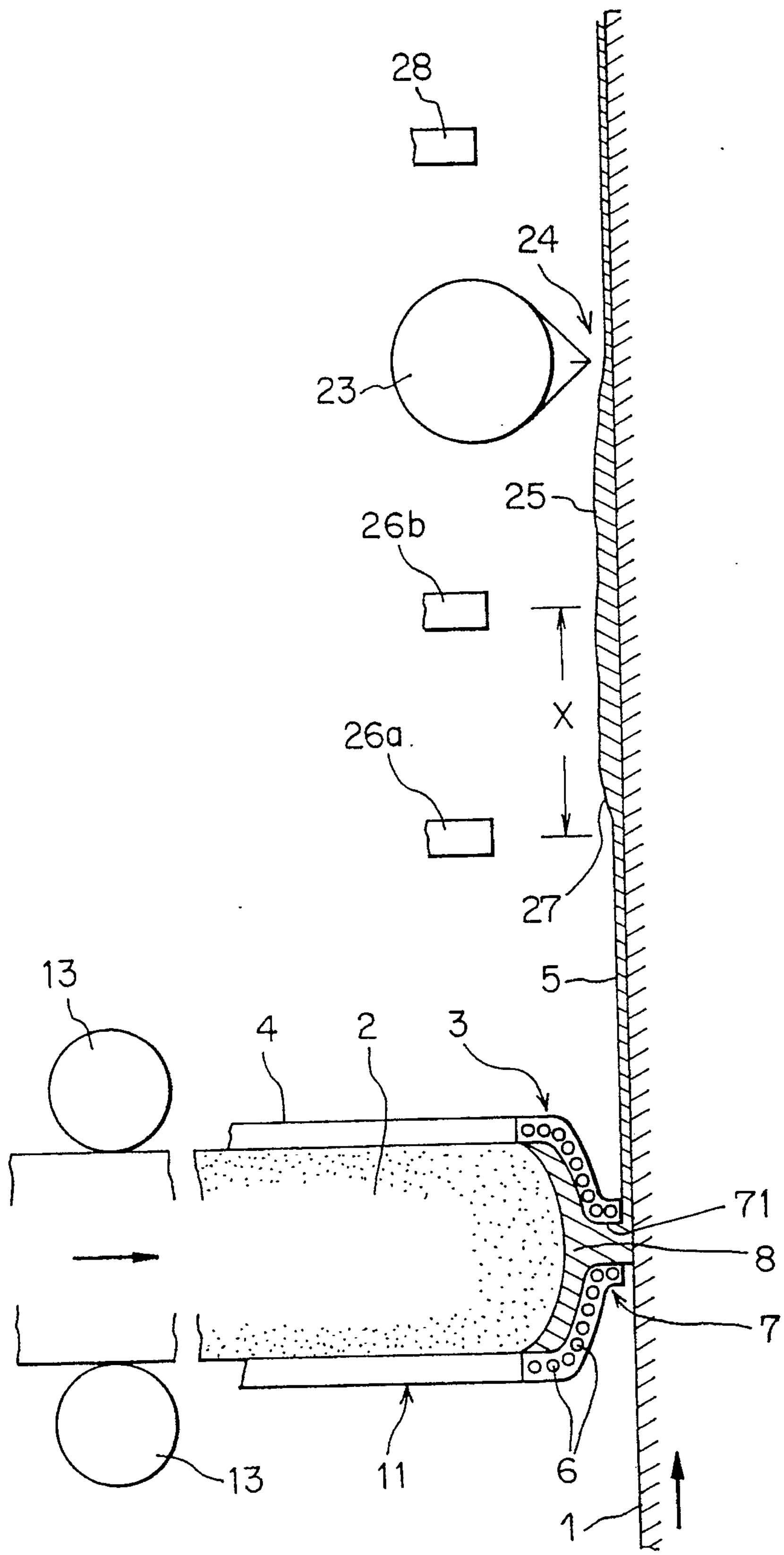
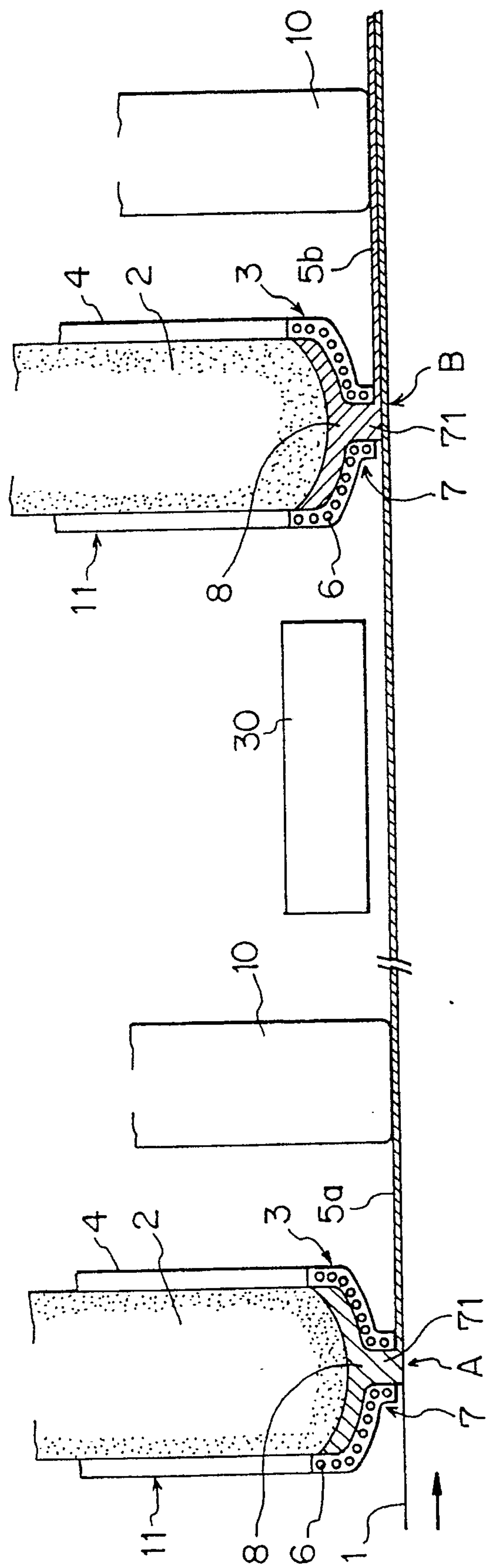


Fig. 16



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP89/01095

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5] C23C2/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	C23C2/00 - 2/40, C23C26/02, B05C5/04

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1926 - 1989
Kokai Jitsuyo Shinan Koho	1971 - 1989

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
E	JP, A, 64-73062 (Nippon Steel Corporation), 17 March 1989 (17. 03. 89), Page 1, left column, lines 4 to 9, page 5, left column, line 13 to page 5, right column, line 3 and Fig. 1, (Family: none)	1 - 4
Y	JP, B1, 46-29601 (New Nippon Electric Co., Ltd.), 28 August 1971 (28. 08. 71), Page 1, column 2, line 13 to page 2, column 3, line 5 and Figs. 1 to 2, (Family: none)	1 - 18

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
January 8, 1990 (08. 01. 90)	January 22, 1990 (22. 01. 90)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	