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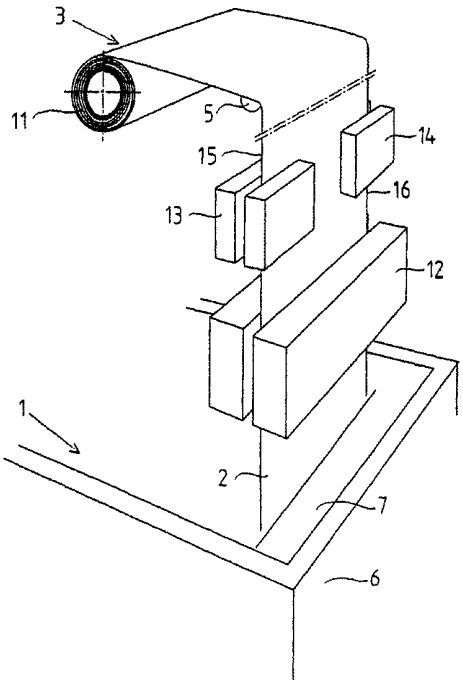
(54) Title: A METHOD AND A DEVICE FOR APPLYING A COATING ONTO AN ELONGATED OBJECT



(57) Abstract: The invention refers to a method and a device for applying a coating onto an elongated object (2). The object is semi-continuously or continuously transported along a transportation direction from an arrangement (1) for depositing a coating comprising a molten metal onto the object (2) to an arrangement (3) for receiving the coated object (2). Means are provided to wipe off excessive coating in a longitudinal direction of the object substantially opposite to the transportation direction. A first moving electromagnetic field, generating a force acting on the molten metal coating towards a first lateral edge (15) of the coated object (2), is applied to the object (2). A second moving electromagnetic field, generating a force acting on the molten metal coating towards a second lateral edge (16) of the coated object (2) opposite to the first lateral edge, is applied to the object.

WO 00/77272 A1

A METHOD AND A DEVICE FOR APPLYING A COATING ONTO AN ELONGATED OBJECT

BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention relates to a method of applying a coating onto an elongated object, said object being continuously transported along a transportation direction from an arrangement for depositing a coating comprising a molten metal onto the object to an arrangement for receiving the coated object, wherein excessive coating is wiped off in a longitudinal direction of the object substantially opposite to the transportation direction. The invention also relates to a device for applying a coating onto an elongated object, comprising an arrangement for depositing a molten metal onto the object, an arrangement for receiving the coated object, means for continuously transporting said object along a transportation direction from the depositing arrangement to the receiving arrangement, and means for wiping off excessive coating from the object in a longitudinal direction substantially opposite to the transportation direction.

As such methods and devices are particularly advantageous in the case of continuous galvanising of steel strips, the invention will hereinafter be described with reference to such an application. However, it should be realised that the invention is also applicable to other, similar applications, such as when somewhat thicker coatings are applied by continuously casting a metallic coating onto an object, such as a metal strip.

During continuous galvanising of a steel strip the steel strip is continuously passed through a bath containing molten metal, normally zinc. In the bath, it normally passes under a

submerged roll and then moves upwards through stabilising and correcting rolls. It emerges from the bath and travels through a set of gas knives which blow the excess zinc off the strip and back down towards the bath, thus controlling the coating thickness. The gas in the knives can be air, nitrogen, steam, or an inert gas, but air and nitrogen are most commonly used. The strip then continues unsupported until the coating has had time to cool and solidify. The coated steel strip is then linked or directed via a roll to an arrangement for cutting the strip into separate strip elements or winding the strip onto a roll. Normally, the strip moves in a vertical direction from the submerged roll through the correcting and stabilising rolls and the gas knives to the roll, the top roll, via which it is further directed.

By galvanisation of steel strips, the coating thickness should be even and thin. The coating mass is normally measured after the strip has passed around the top roll, and this reading is used to control the gas knives and hence regulate the coating thickness. However, due to the geometry of the steel strip, the distance it has to run unsupported, its speed, and the blowing action of the gas knives, the steel strip will move or vibrate in a direction generally perpendicularly to its forwarding direction. Certain measures, such as the use of the correcting and stabilising rolls, a very precise control of the gas flow from the gas knives, and an adjustment of the steel strip speed and/or the adjustment of the distance over which the strip has to run unsupported may be taken in order to reduce these transverse movements. If not reduced, these transverse movements will significantly disturb the precise wiping of the gas knives, resulting in an uneven coating thickness.

A high strip speed as well as an accurate and precise wiping of excessive coating material is required. However, the gas pressure from the knives has to be increased as the speed of the strip is increased. Such a pressure increase will result in

sputtering of the molten coating and air turbulence problems at the edges of the strip.

Therefore, it has been proposed to combine or even replace the gas knives with a magnetic wiping device. The magnetic wiping device generates an alternating magnetic (AC) field which is used to wipe off excessive coating from the strip. Thereby, the gas pressure from the gas knives might be lowered while, at the same time, the same or an even better wiping effect is accomplished. The use of the magnetic wiping device helps to make it possible to increase the strip speed while maintaining an accurate and exact wiping off of excessive coating.

Preferably, the alternating magnetic field is a magnetic field which moves in a direction opposite to the transportation direction of the elongated object. Thereby, excessive coating is wiped off in a longitudinal direction opposite to the transportation direction of the elongated object. However, in the regions near or at the opposite lateral edges of the strip the current induced in the coating cannot reach the very edge for physical reasons. Hence, the coating covering said regions will not be properly wiped off, resulting in an uneven coating thickness across the width of the strip. Until now, there has not been any satisfying proposal of how to accomplish a supplementary wiping off of the remaining excessive coating at said lateral edge regions of the strip.

FR-A-2 754 545 discloses a device for wiping off excessive coating from a metal strip. The device includes centrally provided air knives arranged to wipe off excessive coating in a longitudinal direction substantially opposite to the transportation direction of the metal strip. Furthermore, this document discloses electromagnetic actuators provided at the respective lateral edges of the metal strip. The actuators produce an alternating magnetic force at a frequency between 500 KHz and 1 MHz. The actuators are arranged to produce magnetic fields

providing forces to the excessive coating in a direction inwardly towards the centre of the metal strip.

SUMMARY OF THE INVENTION

One object of the present invention is to provide a method that makes it possible to obtain a coating having a thickness as even as possible across the width of the elongated object onto which said coating is applied. It should also make it possible to precisely control the thickness of the coating in the regions of one or both of the opposite lateral edges of the elongated object. The method should also be easily incorporated into an industrial process for manufacturing coated, elongated objects, in particular steel strips coated with an anti-corrosive metal, e.g. zinc.

This objective is fulfilled by means of a method as initially defined, characterised in that a first moving electromagnetic field, generating a force acting on the molten metal coating towards a first lateral edge of the coated object, is applied to at least a region adjacent to said first lateral edge of the coated object, and a second moving electromagnetic field, generating a force acting on the molten metal coating towards a second opposite lateral edge of the coated object, is applied to the object in a region adjacent to the second lateral edge of the coated object. Hence, the method proposes to wipe off excessive coating in a lateral direction of the elongated object. This is done as a supplement to wiping off excessive coating in a longitudinal direction opposite to the transportation direction of the object. Even though it is particularly advantageous when combined with a longitudinal wiping off by means of an electromagnetic field, the inventive method is also advantageous when combined with other techniques for wiping off the excessive coating in the longitudinal direction, e.g. by means of gas knives. The force acting in a direction generally towards a lateral edge of the coated object is preferably

substantially perpendicular to the longitudinal direction of the object, but could nevertheless be almost of any main direction having at least a substantial component in the direction perpendicular to the longitudinal direction of the object. Such a main direction could be within $\pm 45^{O}$ from the lateral direction. The inventive method is perfectly suited for the production of coated objects, both lateral edges of which should have a precisely controlled coating thickness. The electromagnetic field, generating a force acting on the molten metal coating in a direction opposite to the transportation direction of the object, is preferably used to wipe off the excessive coating across a major part of the width of the elongated object, including the middle of the object. Hence, the electromagnetic fields generating the forces in the lateral directions could be used as a perfect supplement to the electromagnetic field generating the force in the direction opposite to the transportation direction of the object in order to accomplish a supplementary wiping off of excessive coating in the lateral direction of the object.

According to a further definition, the object has the shape of a continuous strip or web. Thereby, the electromagnetic fields generated extend through the thickness direction of the strip or web, thus generating said forces on the coating on the opposite sides of the strip or web, resulting in the excessive coating being wiped off on both sides of the strip or web.

Another object of the invention is to provide a device which makes it possible to obtain a coating having a thickness as even as possible across the width of an object coated by means of a device as initially defined. The device should be such that it also makes it possible to precisely control the coating thickness in one or both regions adjacent to or at the lateral edges of the coated object. It should also promote a cost effective and reliable industrial manufacture of coated, elongated objects, such as zinc coated steel strips.

This object is obtained by means of a device as initially defined, characterised in that it comprises first means for applying a first moving electromagnetic field generating a force acting on the molten metal coating towards a first lateral edge of the object, and second means for applying a second moving electromagnetic field generating a force acting on the molten metal coating towards a second, opposite lateral edge of said object. Such forces will wipe off excessive coating from the object if generated in regions adjacent to the lateral edges and moving towards said edge. The direction of the forces are such that at least a substantial component thereof is directed towards the respective lateral edge of the object. Preferably, the forces are directed substantially perpendicularly to the longitudinal direction of the object. The electromagnetic fields extend over a predetermined length in the longitudinal direction of the object, defining a wave movement towards the edge of the object. The current induced in the coating mainly extends in the longitudinal direction of the object, except from the end regions of the field.

According to another embodiment, the first and second means are located in the region adjacent to a corresponding edge in order to apply an electromagnetic field moving towards the respective lateral edge. A location in the region adjacent to the corresponding edge promotes a precise control of the electromagnetic field generating said force on the coating. Moreover, the supplementary means for wiping off excessive coating in the longitudinal direction of the object might be arranged in order to wipe of excessive coating between the regions covered by the first and second means. Such a solution will find a good industrial applicability, while being both cost effective and reliable.

According to another embodiment, the means for wiping off excessive coating in a longitudinal direction is arranged to apply an electromagnetic field generating a force acting on the molten metal coating in a direction opposite to the transportation

direction of the object, and the first and second means adapted to wipe off excessive coating in a lateral direction that, for technical reasons, cannot be wiped off in the longitudinal direction by the means for wiping off excessive coating in the longitudinal direction. This provision does not exclude that the means for applying the lateral forces do wipe off also molten coating that could be wiped off by the magnetic field generating the longitudinally directed force. However, in the crosswise direction of the object, i.e. the width direction, the different regions covered by the different electromagnetic fields should be in the proximity to each other, while covering the total width of the object but, preferably, without or only slightly overlapping each other. Thereby, an even coating thickness across the width of the coated object is promoted.

According to a further embodiment, the object has the shape of a continuous strip or web. The inventive device is particularly advantageous when used for covering such an object with a metal coating.

The invention also refers to the use of the inventive method for applying a coating onto an elongated strip, and the use of the inventive device for applying a coating onto an elongated strip.

Further features and advantages of the inventive method and device will appear from the rest of the description and the rest of the patent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described, by means of example, with reference to the annexed drawings, in which

fig. 1 is a schematic perspective view of a device according to the invention,

fig. 2 is a schematic, partly cut front view of the inventive device,

fig. 3 is a cross-sectional view from above of the inventive device along A-A in fig. 2, and

fig. 4 is a schematic side view of the inventive device.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A preferred embodiment of the inventive device is shown in figs. 1-4. It should be stated that the device is only shown schematically and by way of example.

The device comprises an arrangement 1 for depositing a coating of molten metal onto an object 2. It also comprises an arrangement 3 for receiving the coated object 2 and means 4, 5 for continuously or semi-continuously transporting or feeding said object 2 from the depositing arrangement 1 to the receiving arrangement 3. A transporting means 4, 5 could, for example, comprise a driven roll or the like, via which the object 2 is directed along a given path.

The object 2 is elongated and has a cross-sectional area substantially smaller than its length. It can be a strip or a web or the like. Preferably, it is made of metal, such as steel or any other metal suitable for coating processes of the kind suggested by the invention. The coating and the object may have the same or different chemical compositions.

The arrangement for depositing a molten metal onto the object 2 comprises a tank 6 containing a bath 7 of molten metal. The object 2 is fed or directed into the bath 7 and redirected by means of a redirection member arranged in the bath 7. Here, the redirection member is a roll arranged in the tank 6 and identical with the transporting means 4. The roll 4 is submerged in the bath. Also submerged in the bath 7 is a set of correcting and stabilising rolls 8, 9, arranged downstream the redirection

member/transporting means 4, as seen in the transportation direction of the object 2. From the surface 10 of the bath 7, the object 2 runs generally unsupported all the way to the receiving arrangement 3 where a redirecting member 5 comes into contact with the object 2 and is directed to a member 11 for storing the coated object 2. Such a member 11 for storing the coated object 2 could be a roll onto which the object 2 is wound. The redirecting member 5 is a roll which also might be driven in order to feed the object 2 forward in its transportation direction towards the storing member. However, there may also be separate feeding members (not shown), for example rolls, for feeding the object 2 forward.

As the object 2 leaves the bath 7 it is draped with a coating of molten metal from the bath. The device is arranged such that the path of the object 2 runs generally vertically from the region of the surface 10 to the arrangement 3 for receiving the object 2. The object 2 runs generally unsupported from said region to the receiving arrangement 3. At a predetermined distance from said surface, a means 12 for wiping off excessive coating in a direction opposite to the transportation direction of the object 2 is arranged. The means 12 may comprise a device that uses gas for said wiping operation, a device that generates an alternating magnetic field for said wiping operation or a combination thereof. Here, the means 12 comprise two sets of coils arranged on opposite sides of the object 2 in order to apply a moving electromagnetic field through the object 2, said field inducing current paths I in the coating, schematically shown in fig. 2, and accordingly, a force acting upon the coating in a direction opposite to the transportation direction of the object 2. The means 12 operates in accordance with the principles for a linear motor or an electromagnetic stirrer in order to accomplish the moving electromagnetic field. Thereby, excessive coating is wiped off in a longitudinal direction by the means 12.

As can be seen in fig. 2, the current I induced in the coating by the means 12 does not extend all the way to the opposite lateral edges 15, 16 of the object 2. This effect has physical reasons and must be accepted. Accordingly, the excessive coating in the regions adjacent to the opposite lateral edges 15, 16 of the object 2 will not be properly wiped off by the means 12. Thus, an unevenness in the thickness of the coating is likely to appear. Given that the means only would comprise gas knives, there would still be thickness problems due to air turbulence at the edges of the object 2.

Therefore, downstream the means 12, there are provided first and second means 13, 14 for applying two separate electromagnetic fields located adjacent to or at the opposite first and second lateral edges 15, 16 of the object 2. Each of the first and second means 13, 14 include two sets of coils arranged at and overlapping opposite sides of the object 2. The first and second means 13, 14 operate in accordance with the principles of a linear motor or an electromagnetic stirrer, such that the generated electromagnetic field moves towards the lateral edge 15, 16 adjacent to which the means 13, 14 are arranged. Each of the means 13, 14 operates in a way similar to the means 12, but with the moving direction of their electromagnetic fields turned 90^{O} with respect to the moving direction of the electromagnetic field generated by the means 12. Thereby, the first and second means 13, 14 generate forces F', F'' upon the coating directed to the adjacent lateral edge 15, 16 of each means 13, 14, such that excessive coating is wiped off laterally through the action of said first and second means 13, 14. The task of the means 13, 14 is to wipe off excessive coating that cannot be wiped off by the means 12 for physical reasons, as mentioned above. Thereby, the thickness of the coating of the regions adjacent to the opposite lateral edges 15, 16 of the object 2 can be precisely controlled, such that an even coating thickness across the width of the object 2 is obtained. The currents I induced by the means 13, 14 in the coating are

schematically indicated in fig. 2. They mainly extend in the longitudinal direction of the object 2.

In the preferred embodiment described, the object 2 is a continuous strip or web, preferably made of steel, and the coating mainly comprises zinc. This galvanised steel strip is preferably used for chassi parts of motor vehicles. However, all kinds of applications may come in question.

Preferably, the object 2 is transported with a speed of approximately 90-300 m/min. For a steel strip with a thickness of approximately 0.5-1.5 mm and a final coating thickness of approximately 5-30 μm moving with such a speed, the strength of the magnetic fields generated by the means 13, 14 should be approximately 0.5-1.5 T. A moving electromagnetic field requires a low feeding frequency in order to accomplish a lateral force like the one aimed at. In this case, the feeding AC-frequency should be 1-1000 Hz, preferably 10-500 Hz, and more preferably 30-150 Hz. Too high a frequency will lead to an excessive heating of the strip.

It is to be understood that the means 12, 13, 14 for generating said magnetic fields may comprise one or more magnets or coils that generate said field and that these magnets or coils may be arranged such that the magnetic fields are divided into a plurality of sub-fields of equal or unequal strength and/or direction through the object. However, the field or fields should be applied to the coating where the latter is still in a molten state.

The inventive device could also include or be combined with means for cooling the coated object downstream the means 12, 13, 14 for applying the electromagnetic fields in order to speed up the solidification of the coating and making it possible to shorten the distance between the depositing arrangement 1 and the arrangement 3 for receiving the coated object.

Of course, a plurality of alternative embodiments of the invention will be obvious for a man skilled in the art without going beyond the scope of the invention as defined in the annexed claims supported by the description and the annexed drawings.

For example, the receiving arrangement 3 does not need to be exactly of the kind described here, but could be described as being comprised by the first element or elements by which the coated object 2 is supported downwards from the depositing arrangement 1 as seen in the transportation direction of the object 2.

Moreover, the means 12 for applying a magnetic field generating a force acting on the coating in a direction opposite to the transportation direction of the object 2 could be any such means for wiping off excessive coating in the longitudinal direction of the object 2, such as gas knives. However, the means 12 as described above are preferred.

Claims

1. A method of applying a coating onto an elongated object (2), said object (2) being semi-continuously or continuously transported along a transportation direction from an arrangement (1) for depositing a coating comprising a molten metal onto the object (2) to an arrangement (3) for receiving the coated object (2), wherein excessive coating is wiped off in a longitudinal direction of the object (2) substantially opposite to the transportation direction, characterised in that a first moving electromagnetic field, generating a force (F') acting on the molten metal coating towards a first lateral edge (15) of the coated object (2), is applied to at least a region adjacent to said first lateral edge (15) of the coated object (2), and a second moving electromagnetic field, generating a force (F'') acting on the molten metal coating towards a second opposite lateral edge (16) of the coated object (2), is applied to the object (2) in the region adjacent to the second lateral edge (16) of the coated object (2).

2. A method according to claim 1, characterised in that each moving electromagnetic field is moved towards said lateral edge (15, 16).

3. A method according to any one of claims 1 and 2, characterised in that each moving electromagnetic field is an AC-field.

4. A method according to any one of claims 1-3, characterised in that said wiping off in the longitudinal direction is provided by applying an electromagnetic field generating a force acting on the molten metal coating in the longitudinal direction of said object (2).

5. A method according to any one of the preceding claims, characterised in that the electromagnetic fields generating the

lateral forces (F', F'') are used to wipe off excessive coating from the regions adjacent to the lateral edges (15, 16) of the object (2).

6. A method according to any one of the preceding claims, characterised in that the electromagnetic field generating the force in the direction opposite to the transportation direction is applied upstream the fields generating the lateral forces as seen in the transportation direction of the object (2).

7. A method according to any one of claims 1-6, characterised in that the object (2) has the shape of a continuous strip or web.

8. A device for applying a coating onto an elongated object (2), comprising an arrangement (1) for depositing a molten metal coating onto the object (2), an arrangement (3) for receiving the coated object (2), means (4, 5) for continuously or semi-continuously transporting said object (2) along a transportation direction from the depositing arrangement (1) to the receiving arrangement (3), and means for wiping off excessive coating from the object (2) in a longitudinal direction substantially opposite to the transportation direction, characterised in that it comprises first means (13) for applying a first moving electromagnetic field generating a force (F') acting on the molten metal coating towards a first lateral edge (15) of the object (2), and a second means (14) for applying a second moving electromagnetic field generating a force (F'') acting on the molten metal coating towards a second opposite lateral edge (16) of said object (2).

9. A device according to claim 8, characterised in that the first and second means (13, 14) are located in the region adjacent to a corresponding edge (15, 16) in order to apply an electromagnetic field moving towards the respective lateral edge (15, 16).

10. A device according to any one of claims 8-9, characterised in that the means (12) for wiping off excessive coating in a longitudinal direction is arranged to apply an electromagnetic field generating a force acting on the molten metal coating in a direction opposite to the transportation direction of the object (2).

11. A device according to any one of claims 8-10, characterised in that each of the first and second means (13, 14) comprises coils arranged at opposite sides of the object (2).

12. A device according to any one of claims 8-11, characterised in that the first and second means (13, 14) are adapted to wipe off excessive coating in a lateral direction that, for technical reasons, cannot be wiped off in the longitudinal direction by the means (12) for wiping off excessive coating in the longitudinal direction.

13. A device according to any one of claims 8-12, characterised in that the means (12) for wiping off excessive coating in the longitudinal direction are arranged upstream the first and second means (13, 14).

14. A device according to any one of claims 8-13, characterised in that the object (2) has the shape of a continuous strip or web.

15. Use of the method according to any one of claims 1-7 for applying a coating onto an elongated strip (2).

16. Use of the device according to any one of claims 8-14 for applying a coating onto an elongated strip (2).

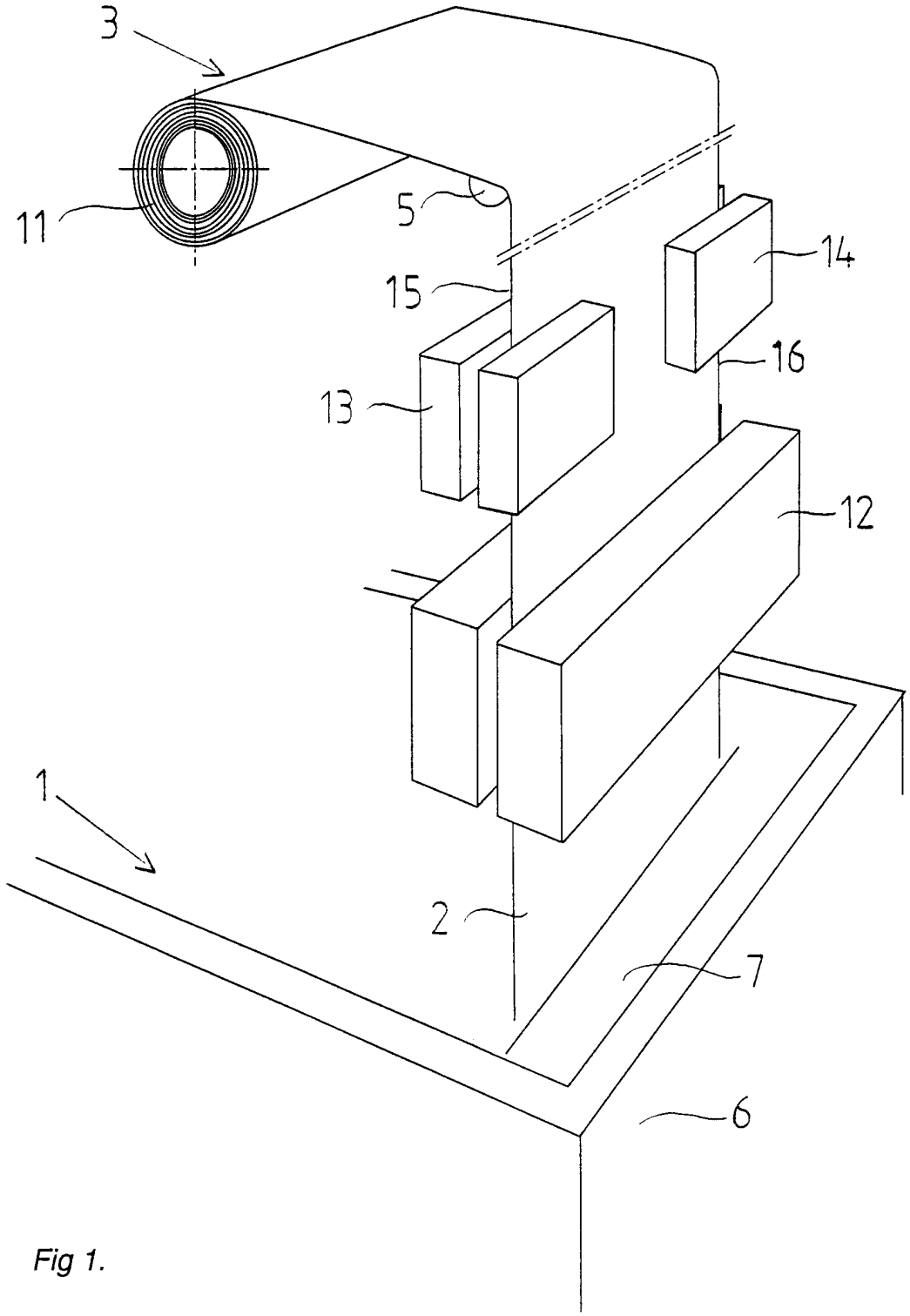


Fig 1.

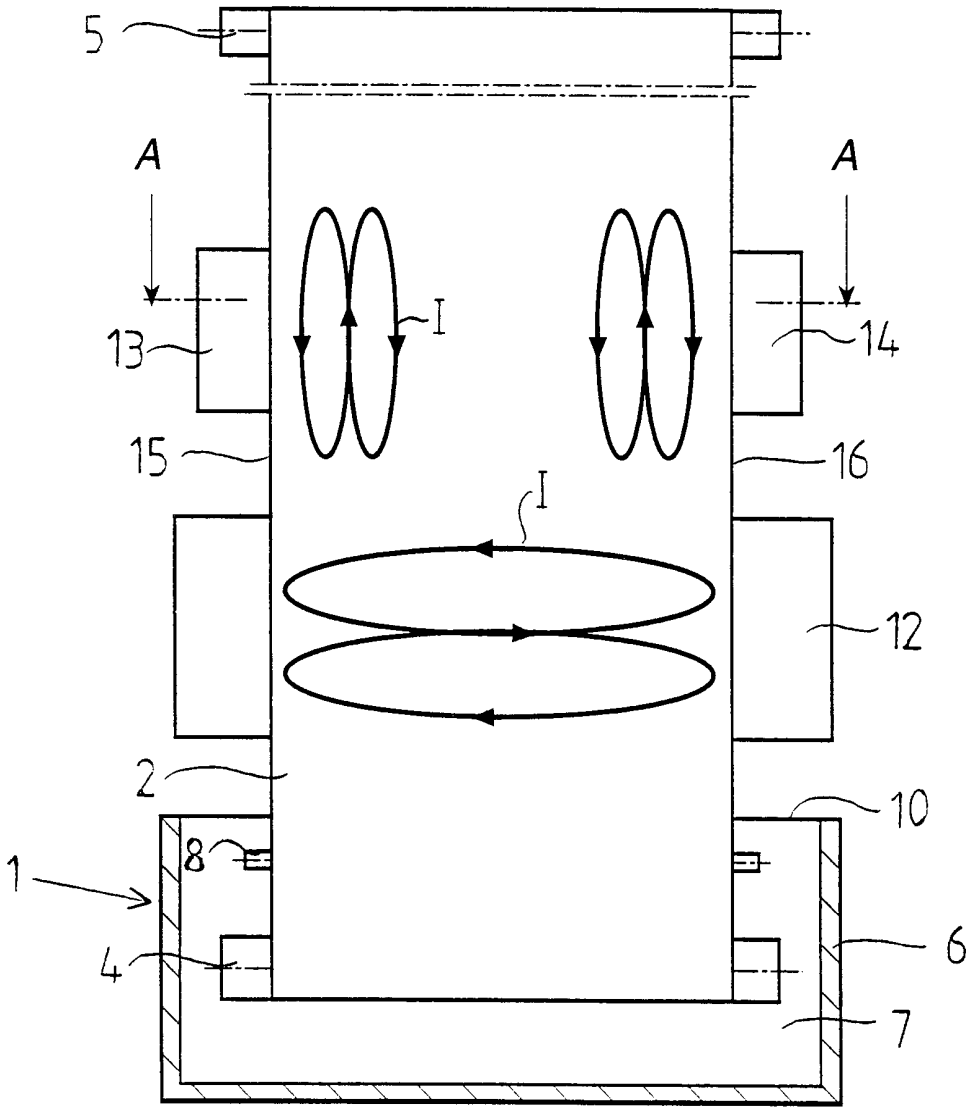


Fig 2.

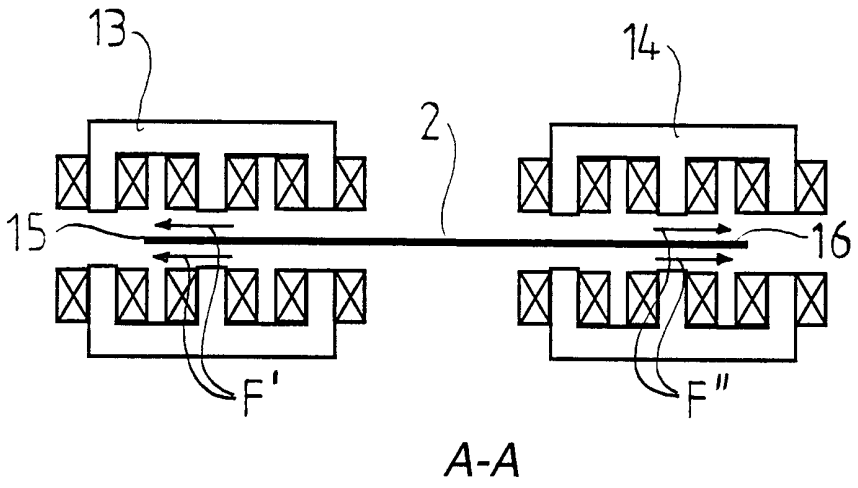


Fig 3.

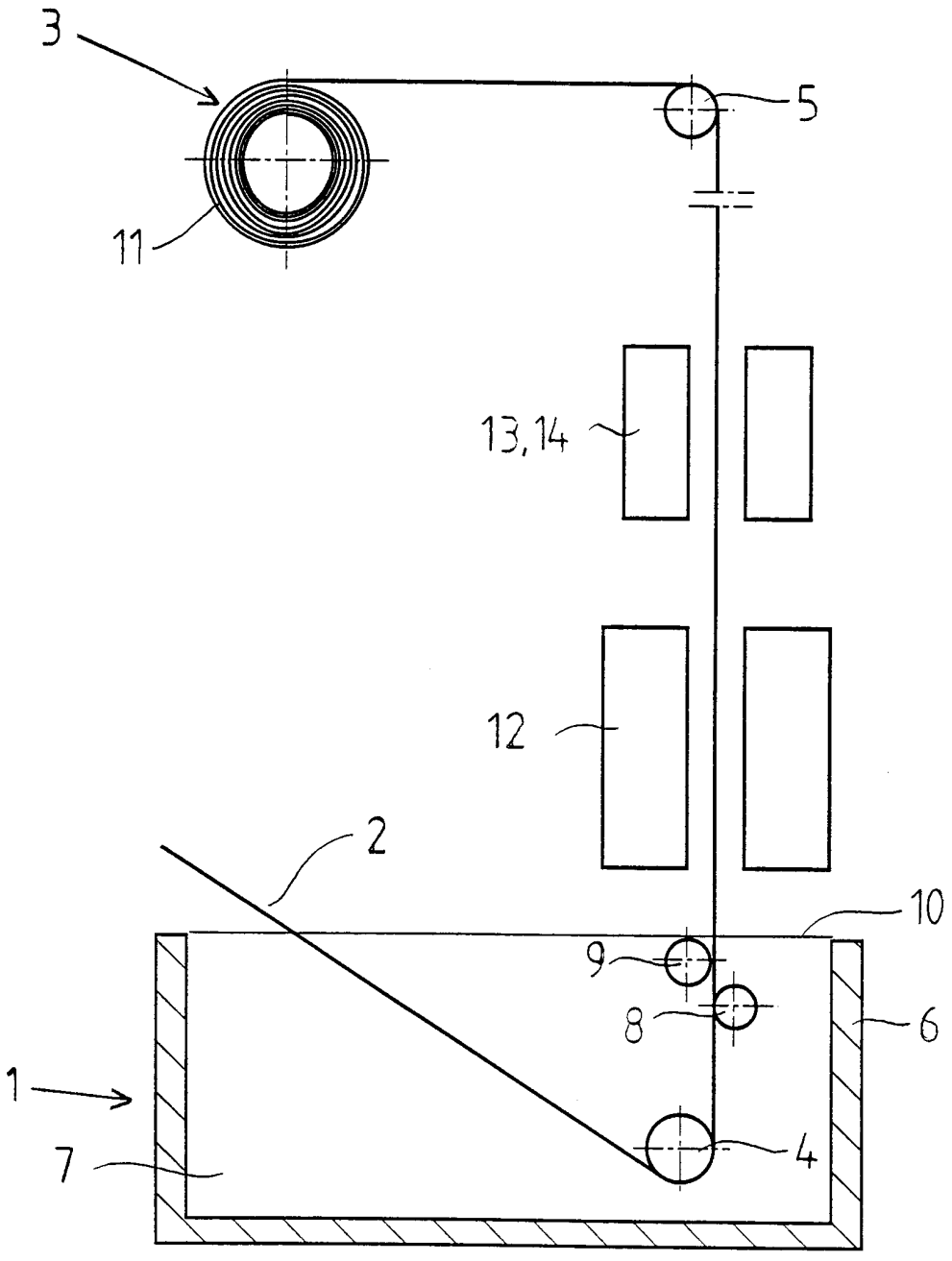


Fig 4.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01168

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C23C 2/38, C23C 2/40, C23C 2/24, C23C 6/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPIL, EDOC, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2754545 A1 (FABRIQUE DE FER DE MAUBEUGE SOCIETE ANONYME), 17 April 1998 (17.04.98), page 1, line 1 - page 3, line 17; page 4, line 11 - page 5, line 25, figures 1-3, abstract ---	1-16
X	JP 8053742 A (NIPPON STEEL CORP) 1996-02-27 (abstract) World Patents Index (online. London, U.K.: Derwent Publications, Ltd. (retrieved on 2000-01-25). Retrieved from: EPO WPI Database. DW199618, Accession No. 1996-1975894; & JP 8053742 (NIPPON STEEL CORP) 1996-06-28 (abstract) (online) (retrieved on 2000-01-25). Retrieved from: EPO PAJ Database; & JP 8-53742 A (NIPPON STEEL CORP) 27 February 1996 ---	1-16

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 August 2000	15 -09- 2000
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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01168

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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