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

(11) Publication number: **0 178 695 B1**

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **20.06.90**

(51) Int. Cl.^{5}: **B 22 D 11/10**, B 22 D 11/12

(21) Application number: **85201268.1**

(22) Date of filing: **06.08.85**

(54) Continuous casting line with multiple-function stirrers and improved cooling system.

(30) Priority: **17.09.84 IT 8341684**

(43) Date of publication of application:
23.04.86 Bulletin 86/17

(45) Publication of the grant of the patent:
20.06.90 Bulletin 90/25

(84) Designated Contracting States:
AT BE CH DE FR GB LI LU NL SE

(56) References cited:
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EP-A-0 036 611
EP-A-0 096 077
CH-A- 403 172
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PATENT ABSTRACTS OF JAPAN, vol. 7, no. 41 (M-194) 1186r, 18th February 1983; & JP - A - 57 190 756 (NIPPON KOKAN K.K.) 24-11-1982

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Courier Press, Leamington Spa, England.

EP 0 178 695 B1

Description

This invention concerns a continuous casting line with an inclined ingot mould, multiple-function stirrers and an improved cooling system.

The invention can therefore be applied to horizontal, almost horizontal, vertical or almost vertical casting. In the following description, while disclosing an application to an almost horizontal casting, it is to be understood that the subject of the invention can be applied to any continuous casting.

The known art has attempted to provide embodiments intended to reduce the overall bulk of continuous casting lines. As is known, traditional continuous casting lines include a vertical or substantially vertical ingot mould and a casting line which curves progressively until it takes up a substantially horizontal development in correspondence with an extracting and straightening unit.

In such embodiments, as the curvature of the casting line may necessarily not be increased beyond a given limit, the casting line, including the ingot mould, has a considerable vertical bulk.

In order to reduce such considerable vertical bulk many solutions have been proposed which are intended to arrange the casting line with a substantially oblique development.

For instance, document CH—A—403172 discloses a device for the continuous casting of metals by means of an ingot mould shaped as an arc of a circle and of a curved guide for bars located downstream and an extraction means, the device being characterized by an arrangement of the ingot mould below a horizontal plane passing through the centre of curvature of the ingot mould; in this case a plane running through such centre of curvature and through the upper edge of the inner wall of the curved ingot mould forms together with the above horizontal plane an angle ranging from 20° to 89°.

Said document also claims the application of an electromagnetic device exerting, when energized, a certain influence on the direction of the casting.

This proposal, however, is limited in what concerns the practical realization of the device and the inability of the electromagnetic device to exert an active influence on the casting stream without leading to anomalies within such casting.

All known electromagnetic devices in general involve this kind of shortcomings.

The main problem arising with such solutions is the lack of uniformity in the cooling of the molten metal introduced into the ingot mould.

Such lack of uniformity can lead to cracks and flaws within the material and in any event may make the casting and extraction of the bars difficult besides lowering the quality of the material.

Moreover, the inclination of the free surface of the casting in relation to the walls of the ingot mould entails difficulties regarding the departure of any gases trapped within the molten metal. Such gases therefore stay within the ingot mould and remain enclosed in the bar when the metal solidifies.

Thus the castings which can be obtained in this way are not free of flaws and it is extremely hard, if not actually impossible, to produce a material having optimum properties.

In the cited document the attempt to save space in the overall bulk of the ingot mould and casting line in a vertical direction is nullified by the very great overall vertical bulk of the casting line/stirrer means assemblage.

Various applications of electromagnetic devices to continuous casting processes are known in the art.

Document US—A—3,153,820 discloses electromagnetic stirrers arranged circumferentially in a ring about the metal casting. Such electromagnets can be supplied with alternating or direct current and can be operated continuously and/or in succession and at various frequencies and/or phase relationships so as to develop agitation forces of differing intensities.

Document JP—A—56190756 discloses a couple of permanent magnets secured to a table rotating about the cast metal and, in particular, about the continuous casting mould. Stirring of the metal is performed in a circumferential direction.

Document EP—A—0036611 discloses a stirrer located near the casting line and suspended on an articulated quadrilateral and operated by cam means.

Document GB—A—2,103,131 discloses the stirring of molten metal in a continuous casting mould by means of permanent rotating magnets in an embodiment analogous to that of said JP—A—57190756.

Document EP—A—0009803 discloses the application of electrical stirrers alongside a continuous casting line.

Document GB—A—2,013,542 discloses a continuous casting line provided with electromagnetic stirrers positioned in a lengthwise arrangement. This invention has the purpose, in particular, of producing an action which does not reach the centre line of the mass of molten metal being cooled. The magnet members are supplied with three-phase current and produce a variable magnetic field.

Document DE—A—3.218.288 discloses electromagnetic stirrers arranged near a preferred position of the continuous casting billet and acting crosswise thereto.

Document EP—A—0096077 discloses the application of stirrers near a continuous casting ingot mould so as to cause a circulating crosswise flow of the molten metal.

It is a purpose of the present invention to overcome the drawbacks linked to the known art by providing a continuous casting line which meets the necessary requirements of a minimum bulk and also offers excellent conditions for cooling the molten material inside the ingot mould.

This is achieved by a continuous casting line having the features disclosed in claim 1.

It is also a purpose of this invention to obtain an optimum drawing-stirring effect in line with the requirements of a perfect casting and solidification of the cast material.

According to the invention an electromagnetic source having one or more sections is provided and cooperates with the inclined ingot mould and the secondary cooling line (the segment downstream of the ingot mould).

Such electromagnetic source exerts a pendular action which is electrically obtained.

According to a form of embodiment an electrical device induces with a required progression the succession of the actuation of the various sections forming the electromagnetic source, which in this case remains stationary.

According to the invention the electromagnetic source can act in the same direction as the direction of movement of the molten metal but can act also in the opposite direction.

Thus, for example, it may act with the maximum possible intensity in the direction of movement of the molten metal whereas in the opposite direction it may act with a lesser intensity able to maintain a given turbulence in the opposite direction (inversion of polarity).

Again, according to another form of embodiment of the invention, the electromagnetic action can be varied in intensity in the zone where the liquid-solid conversion of the casting takes place, and can therefore be adapted to the actual capability of the casting to accept such action.

According to another form of embodiment of the invention the electromagnetic action can undergo one or more inversions of polarity in localized zones or along the path of the casting.

Since the electromagnetic source is stationary and is actuated electrically or electronically, it can be immersed in a cooling chamber.

Such cooling chamber can be independent or be a part of the cooling chamber of the ingot mould.

In such an embodiment the cooling fluid is introduced into a rear annular chamber near the outlet of the bar and passes into a cavity outside the ingot mould.

According to an essential feature of the invention, the section of said cavity is different on the various sides of the ingot mould. That means that the distance between the wall of the ingot mould and a portion wall defining the chamber is not constant.

In this way different flows are obtained on the various sides, a subsequent differentiated cooling accompanying the electromagnetic action.

According to another embodiment the cavity may comprise several chambers. For instance, two chambers may be provided, a lower and an upper chamber, otherwise four separate chambers may be provided, one on each side.

Any of said embodiments of the invention, as said earlier, makes possible a controlled, differentiated cooling of the various walls of the inclined ingot mould.

It is therefore possible to determine such cooling so as to obtain an auxiliary action compensating the electromagnetic action, thus obtaining a bar having the required properties.

By means of the invention it is possible to obtain the required homogeneity of the product; elimination of any non-metallic inclusions and gas is facilitated.

We shall describe hereinafter some preferred embodiments of the invention, as non-limiting examples, with the help of the attached Figures, in which:—

Fig. 1 shows a casting line according to the invention;

Fig. 2 shows a side view of an ingot mould according to the invention;

Fig. 3 shows possible forms of the cooling interspace;

Fig. 4 shows a form of embodiment of the electromagnetic source.

In the embodiment of Fig. 1 a casting line 10 comprises an inclined ingot mould 11 shown at the left and positioned obliquely.

A roller conveyor 12, which is also curved, is located immediately downstream of the inclined ingot mould 11 together with cooling sprayers 13.

The end segment of the roller conveyor 12 leads to an extraction and straightener unit 14.

A tundish 15 with a nozzle 16 having an oblique outlet axis is shown above the ingot mould 11.

The inclined ingot mould 11 is supported on a fork-shaped support 18, which in its turn is solidly fixed to a rocker lever 19, which is conformed with an elbow and is pivoted at 119.

The shape of the rocker lever 19 is such that it does not protrude substantially above the level determined by its pivot 119.

In this way the overall height of the casting line 10 is considerably less than the overall height of the prior art casting lines and in particular is lower than the level at which the tundish 15 lies.

Thus the casting line may be disposed within sheds which are not particularly high; furthermore, it can be transported already complete and pre-assembled to its installation site.

A crank 20 is pivoted at the end of the rocker lever 19 and is driven by a cam 21, which in turn gets its motion through a transmission of a known type from motor means 22, which in this case comprise an electric motor. Such motor means are positioned in such a way that they do not protrude above the level cited above.

The whole assemblage of the rocker lever 19 and motor means 22 is supported by a supporting structure 23 having the form of a framework.

As we said earlier, such structure 23 can be supplied already assembled with all the parts fitted to it, such as the ingot mould 11 on its support 18, the rocker lever 19 already fitted rotatably at 119 and the motor 22 with the crank 20.

Likewise the curved roller conveyor 12 to extract the bars can already be assembled on the supporting structure 23 in the factory.

In view of its modest overall size, the whole can be transported as it is to its installation site.

Fig. 2 shows a detail of the ingot mould 11, which is illustrated cutaway in a side view.

According to this embodiment the ingot mould comprises a cooling system providing a differentiated refrigeration to the various sides of the ingot mould itself.

A lower chamber 31 surrounds the lower opening of the ingot mould 11. The cooling liquid is delivered to this chamber 31 by means of conduits 33 for the introduction of liquid.

Such liquid flows from the chamber 31 into a cavity 30 located between a wall 24 of the ingot mould 11 and an intermediate wall 29.

The cooling liquid thus enters the cavity 30 on the outside of the ingot mould 11.

According to the invention the cavity 30 can be conformed in various manners so as to provide a differentiated refrigeration of the ingot mould 11.

Fig. 3a shows an embodiment in which the cavity 30 has a differentiated section.

In this way a differentiated distribution of the flow of cooling liquid is obtained along the upper wall, lower wall and side walls respectively of the ingot mould 11.

Fig. 3b shows an embodiment in which the cavity 30 is formed with an upper chamber 130 and lower chamber 230 respectively. Such chambers 130—230 may have the same section or different sections.

When their section is the same, the feed of liquid may be divided; for instance, it is possible to divide the chamber 31 (see Fig. 1) into two portions, of which one communicates with the cavity 130 and the other with the cavity 230.

Correspondingly there will be separate feeds of liquid to the two parts of the chamber 31.

Fig. 3c shows an embodiment with four independent cavities, namely an upper 130, a lower 230 and side cavities 330. One or more of such cavities may have an independent feed of liquid.

The cavities 130—230—330 may have different sections according to the speeds of liquid which are to be obtained and according to the pre-set flow rates.

An outer chamber 32 (Fig. 2) is located outside the intermediate wall 29; within said outer chamber 32 electromagnetic stirrer means 25 are mounted, coils 125 of which are shown diagrammatically. In this case five coils 125 are provided on one side and five coils 225 on the other side of the ingot mould 11.

The number of coils 125—225 can be varied in accordance to various requirements, but experiments have shown that three will be the minimum number, whereas the maximum number will depend on factors of functioning and economical working.

The orientation of the coils 125—225 can be pre-set so as to create a magnetic flux of the desired orientation within the ingot mould in order to obtain the required currents of flow within the fluid metal.

Thus the coils 125—225 may assume an annular or toroidal shape which enfolds the ingot mould, or they may take up an L-shaped or C-shaped form so as to enfold at least two or three sides of the ingot mould 11.

In the example of Fig. 2 the coils 125—225 are located next to each other; each of them acts on one side of the ingot mould, while the whole assemblage of them covers two to four sides of the ingot mould 11.

In the example of Fig. 2 the coils 125—225 may have their axis parallel or normal to the ingot mould 11.

The electromagnetic source 25 may also act on a part or on the whole of the zone downstream from the ingot mould 11 to the extractor of the starter bar or even to the shears.

A suitable position for the electromagnetic source 25 downstream of the ingot mould is shown in dashed lines in Fig. 1.

In this variant the electromagnetic source 25 can work also in the segment downstream of the ingot mould 11 or only in the segment downstream of the ingot mould 11.

In Fig. 4 the electromagnetic source 25 includes a plurality of coils 125 arranged near the casting line 12. The coils 125 can be energized in a programmed sequence or a sequence which can be programmed to obtain a certain required effect.

Therefore, the variants and embodiments provided by the invention for the application of the source 25 to the ingot mould 11 can also be extended to the case where the electromagnetic source 25 acts only in the area downstream of the ingot mould 11 or acts on the area downstream of the ingot mould 11 and on the ingot mould 11.

The electromagnetic source 25, as said earlier, is applied in order to make uniform the structure of the departing ingot.

In the case where the electromagnetic source 25 cooperates with the ingot mould 11, this situation can take place according to an embodiment identical or similar to that of Fig. 2. In such a case the cooling liquid reaches the chamber 32 after having passed through the cavity 30.

In this way the cooling liquid cools also the electromagnetic source 25.

Lastly, the cooling liquid leaves the chamber 32 through outlets 34.

The special cooling system employed obtains a predetermined cooling of the ingot mould 11; this feature cannot be obtained by means of prior art embodiments.

The reference number 26 indicates an upper plate where there is located an inlet 126 for the ingot mould 11 through which the casting of molten metal is poured.

The lower chamber 31 is shut at its rear by a rear closure 27 consisting of a plate of a substantially circular shape.

It should be noted that according to the invention the application of electromagnetic stirrer means 25 does not increase the overall bulk since such means 25 are located together with the relative coils 125—225 within the chamber 32 without creating any further external bulk.

The disclosed embodiments, therefore, enable a great uniformity of material leaving the ingot mould 11 to be obtained, this being impossible to obtain with known casting lines.

Instead, in this case the advantage of a particularly modest overall bulk is obtained by means of the invention.

A second advantage arising from the application of electromagnetic stirrer means within the chamber 32 in combination with the special cooling system employed consists in the uniformity of the cast bar, whereas such uniformity cannot be obtained with the prior art casting lines.

In this way the stirring and the creation of flow currents within the molten metal cause the molten metal to be made homogeneous before becoming solidified and also facilitate the elimination of any inclusions.

In Fig. 2 the components 125 and/or 225 of the electromagnetic source 25 are sequentially actuated by electrical or electronic actuating means.

In the case where the coils are actuated according to a sequence direction which is reverse in respect of the direction of the running molten metal, this actuation can be carried out in the same way as in the case where the coils are actuated in a sequence corresponding to the direction of the running molten metal; the actuation may also be carried out by means of a prior inversion of the current polarity, or by reducing or anyway varying the intensity of the generated field.

The shapes and proportions of the individual parts can be changed and it is possible to provide oscillation means 17 conformed otherwise than as shown or employing motor means 22 different from that shown.

It is also possible to provide coils 125—225—325 having any required orientation to suit the effect desired and being of a desired number and size.

These and other variants are all possible without departing thereby from the scope of this invention, which can be applied to vertical, almost vertical, horizontal or almost horizontal casting lines.

Claims

1. Continuous casting line (10), comprising an inclined ingot mould (11) defined by at least one wall (24) and located under a tundish (15), a mechanism (17—21) operated by motor means (22) for imparting to the ingot mould (11) an oscillating movement, a roller conveyor (12) disposed downstream of said inclined ingot mould (11), and including at least one curved area, said inclined ingot mould (11), mechanism (17—21), motor means (22) and roller conveyor (12) being disposed under the plane on which said tundish (15) lies, said casting line (10) further comprising one electromagnetic stirrer means (25) including electrically or electronically actuated coils (125, 225) in order to create a variable magnetic flux of a predetermined orientation which varies according to a pendular action, electrically obtained, within said ingot mould (11) and/or roller conveyor (12), whereby the molten metal is induced to flow along predetermined paths within said ingot mould (11) and/or roller conveyor (12), said casting line (10) further comprising at least one cooling chamber (32) in which said coils (125, 225) are located and in which a cooling liquid flows, said chamber (32) comprising means (30) providing, around said at least one wall (24) of the inclined ingot mould (11), a cavity having different cross sections and/or independent feeds of cooling liquid for differentiated sections.

2. Casting line (10) according to claim 1, wherein the variable magnetic flux of a predetermined orientation varies according to a constant pendular action.

3. Casting line (10) according to claim 1, wherein the variable magnetic flux of a predetermined orientation varies according to a variable pendular action.

4. Casting line (10) according to claim 1, wherein the coils (125, 135) are sequentially energized.

5. Casting line (10) according to any one of claims 1 to 4, wherein the means (30) for providing zones of different refrigeration include at least one cavity (30, 130, 230, 330) defined by a partition wall (29) contained in at least one chamber (32), said cavity at least partially surrounding at least one wall (24) of the ingot mould (11).

6. Casting line (10) according to claim 5, wherein the distance between at least one wall (24) of the ingot mould and the partition wall (29) is not constant.

7. Casting line (10) according to any one of the preceding claims, wherein the mechanism (17—21) comprise means (18) for supporting the ingot mould (11) which are pivotably connected to a rocker lever means (19) conformed with an elbow (119).

Patentansprüche

1. Stranggießstrecke (10) mit einer geneigten Kokille (11), die zumindest durch eine Wand (24) bestimmt ist und unter einer Gießwanne (15) gelegen ist, einem Mechanismus (17—21), der durch Motormittel (22) zum Erteilen einer Pendelbewegung der Kokille (11) betrieben wird, einem

Rollenförderer (12), der stromab von der geneigten Kokille (11) gelegen ist und zumindest eine gekrümmte Fläche aufweist, wobei die geneigte Kokille (11), der Mechanismus (17—21), die Motormittel (22) und der Rollenförderer (12) unter der Ebene gelegen sind, in welcher die Gießwanne (15) leigt, die Gießstrecke (10) ferner ein elektromagnetisches Umrührmittel (25) mit elektrisch oder elektronisch betriebenen Spulen (125, 225) aufweist, um einen veränderlichen magnetischen Fluß einer vorbestimmten Richtung zu erzeugen, der sich gemäß einer pendelnden Wirkung ändert, die elektrisch innerhalb der Kokille (11) und/oder des Rollenförderers (12) erhalten wird, wodurch das geschmolzene Metall zum Fließen entlang vorbestimmter Pfade innerhalb der Kokille (11) und/oder des Rollenförderers (12) bewegt wird, wobei die Gießstrecke (10) ferner zumindest eine Kühlkammer (32) aufweist, in welcher die Spulen (125, 225) gelegen sind und in welcher eine Kühlfüssigkeit fließt, die Kammer (32) Mittel (30) aufweist, die um zumindest eine Wand (24) der geneigten Kokille (11) einen Hohlraum mit verschiedenen Querschnitten und/oder unabhängigen Zuführungen von Kühlflüssigkeit für unterschiedene Abschnitte ergeben.

2. Gießstrecke (10) nach Anspruch 1, bei welcher sich der veränderliche magnetische Fluß einer vorbestimmten Richtung gemäß einer konstanten pendelnden Wirkung ändert.

3. Gießstrecke (10) nach Anspruch 1, bei welcher sich der veränderliche magnetische Fluß einer vorbestimmten Richtung gemäß einer veränderlichen pendelnden Wirkung ändert.

4. Gießstrecke (10) nach Anspruch 1, bei welcher die Spulen (125, 135) sequentiell erregt werden.

5. Gießstrecke (10) nach irgendeinem der Ansprüche 1 bis 4, bei welcher die Mittel (30) zum Bilden von Zonen verschiedener Abkühlung zumindest einen Hohlraum (30, 130, 230, 330) aufweisen, der durch eine Trennwand (29) bestimmt ist, die zumindest in einer Kammer (32) enthalten ist, wobei der Hohlraum zumindest teilweise zumindest eine Wand (24) der Kokille (11) umgibt.

6. Gießstrecke (10) nach Anspruch 5, bei welcher der Abstand zwischen zumindest einer Wand (24) der Kokille und der Trennwand (29) nicht konstant ist.

7. Gießstrecke (10) nach irgendeinem der vorgehenden Ansprüche, bei welcher der Mechanismus (17—21) Mittel (18) zum Tragen der Kokille (11) aufweist, die schwenkbar mit einem Kipphebelmittel (19) verbunden sind, das mit einem Knie (119) ausgebildet ist.

Revendications

1. Ligne de coulée continue (10), comprenant une lingotière inclinée (11) définie par au moins une paroi (24) et située sous un distributeur (15), un mécanisme (17—21) actionné par un dispositif moteur (22) pour communiquer à la lingotière (11) un mouvement oscillant, un transporteur à rouleaux (12) disposé en aval de la dite lingotière (11) et comportant au moins une surface courbe, la dite lingotière inclinée (11), le mécanisme (17—21), le dispositif moteur (22) et le transporteur à rouleaux (12) étant disposés sous le plan sur lequel se trouve le distributeur (15), la dite ligne de coulée (10) comportant de plus un dispositif agitateur électromagnétique (25) comprenant des bobines (125, 225) activées électriquement ou électroniquement pour créer un flux magnétique variable d'orientation prédéterminée qui varie selon une action pendulaire obtenue électriquement dans la dite lingotière (11) et/ou le transporteur à rouleaux (12), le métal fondu étant incité à s'écouler le long de chemins prédéterminés dans la dite lingotière (11) et/ou le transporteur à rouleaux (12), la dite ligne de coulée (10) comprenant de plus au moins une chambre de refroidissement (32) dans laquelle les dites bobines (125, 225) se trouvent et dans laquelle circule un liquide de refroidissement, la dite chambre (32) comportant un moyen (30) fournissant, autour d'au moins une paroi (24) de la lingotière inclinée (11), une cavité ayant différentes sections transversales et/ou des alimentations en liquide de refroidissement differentes pour les sections differenciées.

2. Ligne de coulée (10) selon la revendication 1, dans laquelle le flux magnétique variable d'orientation prédéterminée varie selon une action pendulaire constante.

3. Ligne de coulée (10) selon la revendication 1, dans laquelle le flux magnétique variable d'orientation prédéterminée varie selon une action pendulaire variable.

4. Ligne de coulée (10) selon la revendication 1, dans laquelle les bobines (125, 135) sont excitées séquentiellement.

5. Ligne de coulée (10) selon l'une des revendications 1 ou 4, dans laquelle le moyen (30) pour fournir des zones de réfrigération différente comporte au moins une cavité (30, 130, 230, 330) définie par une cloison de séparation (29) contenue dans au moins une chambre (32), la dite cavité entourant au moins partiellement au moins une paroi (24) de la lingotière (11).

6. Ligne de coulée (10) selon la revendication 5, dans laquelle la distance entre au moins une paroi (24) de la lingotière et la paroi de séparation (29) n'est pas constante.

7. Ligne de coulée (10) selon l'une des revendications précédentes, dans laquelle le mécanisme (17—21) comporte un moyen (18) pour supporter la lingotière (11) qui est relié de façon pivotante à un dispositif de levier oscillant (19) formé avec un coude (119).

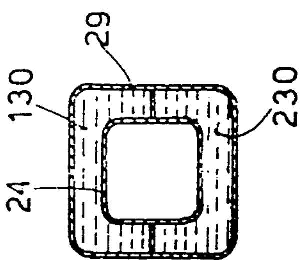

fig.3 b

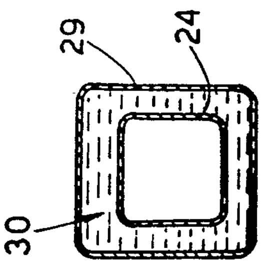

fig.3a

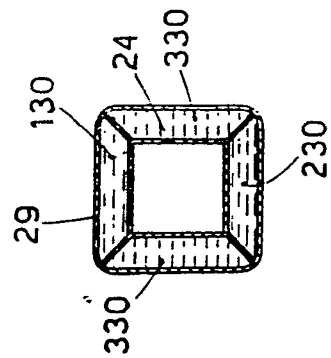

fig. 3c

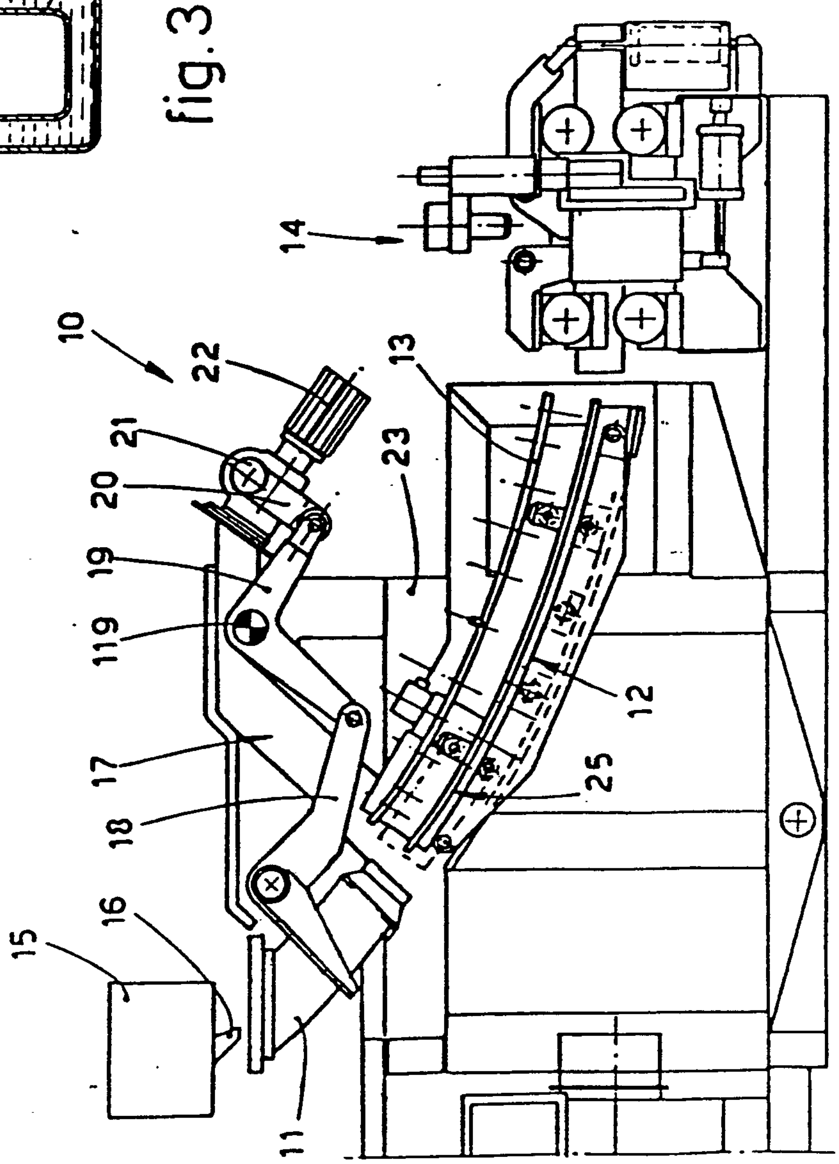

fig.1

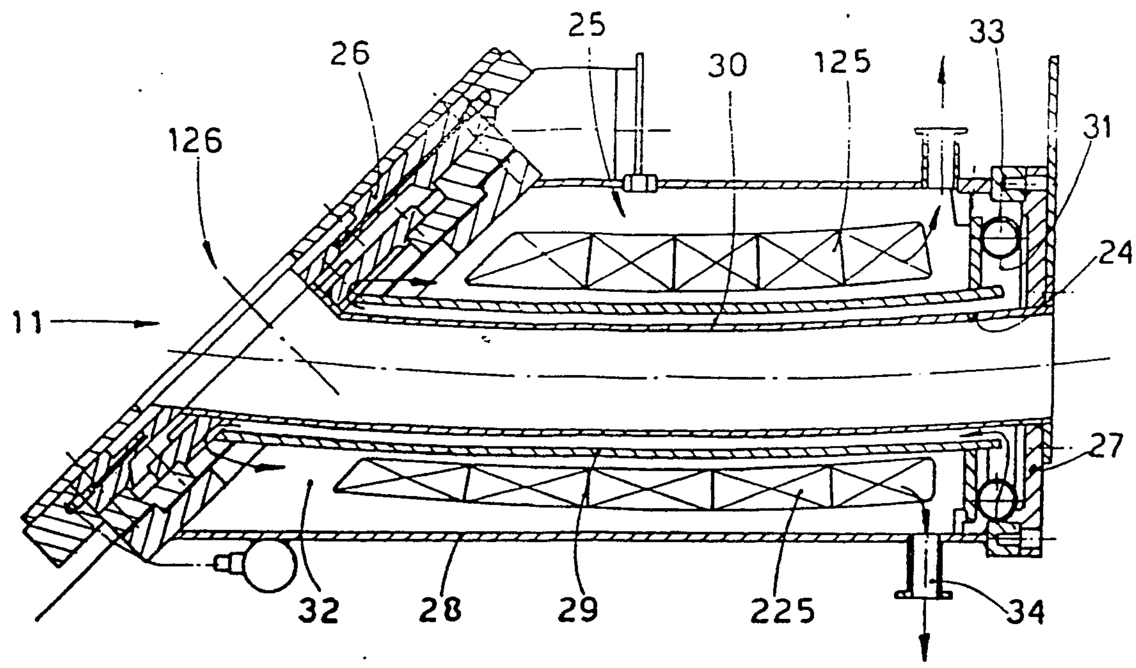

fig. 2

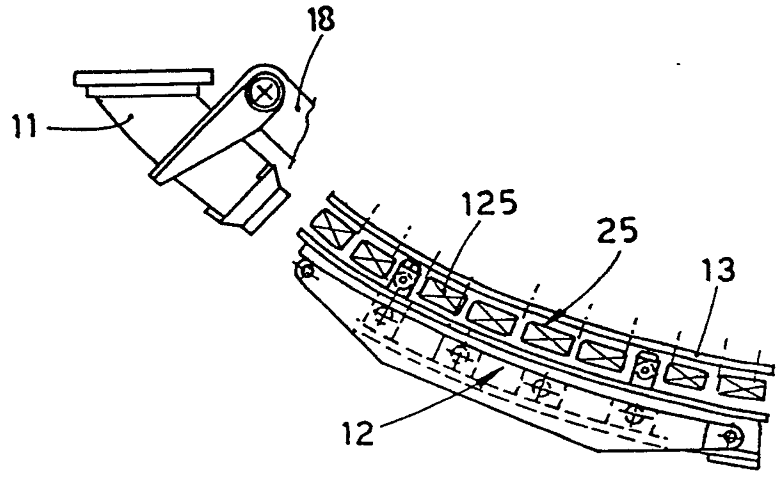

fig. 4