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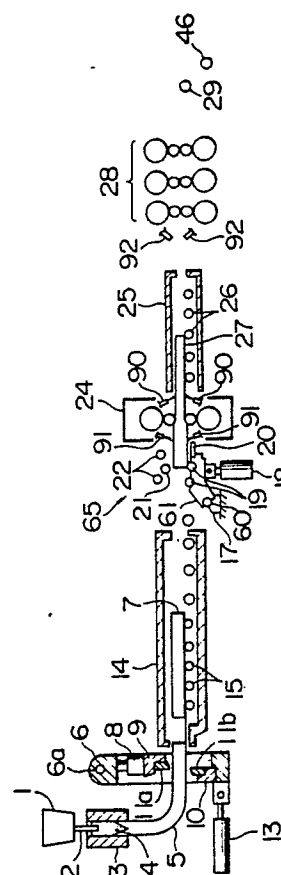
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(54) **Apparatus and method for hot-rolling slab into sheets.**

(57) A hot rolling apparatus having a rough rolling mill (24, 35, 36) and a finish rolling mill (28, 37) disposed downstream of the rough rolling mill (24, 35, 36) so as to successively roll a slab material (7) to reduce the thickness of the material thereby to produce a sheet product (32). The rough rolling mill (24, 35, 36) comprises a reversible rolling mill capable of performing forward and backward passes. A take-up device (65, 71) capable of coiling and uncoiling the material under rolling is provided on the upstream side of the rough rolling mill (24, 35, 36). This arrangement eliminates necessity for a huge table system which is used for supporting the long rolled material after a backward rough rolling pass immediately before the last forward rough pass, so that the size and investment cost of the apparatus can be remarkably reduced.

FIG. 1



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APPARATUS AND METHOD FOR HOT-ROLLING SLAB INTO SHEETS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to apparatus and method for effecting hot-rolling of a slab into a sheet or thin web. More particularly, the present invention is concerned with hot rolling apparatus and method capable of producing a sheet or thin web at a reduced investment on the apparatus.

DESCRIPTION OF THE PRIOR ART

A typical conventional hot rolling apparatus for rolling a slab into a thin web includes a rougher or roughing mill composed of a few or several roughing mill stands for effecting rough rolling of the slab and six to seven finisher or finishing mill stands connected to the rough rolling mill. This type of rolling apparatus is suitable for production of sheets in a huge quantity, but enormous investment and cost are incurred for building up and running such an apparatus.

On the other hand, there is an increasing demand for small-scale hot-rolling apparatus so-called mini-mill which can be flexibly adapted to a variety of demands and which can avoid undesirable effect of business fluctuation.

A typical example of such mini-mills is disclosed in Japanese Patent Unexamined Publication No. 58-202906. This mini-mill has a rough rolling mill composed of a single reversible rolling stand, a finish rolling mill which is composed of a pair of rolling stands, and take-up or winding devices disposed upstream and downstream of these two finish rolling stands. In finish-rolling operation, the material rolled through the rough-rolling mill is passed through these two finish rolling stands while being wound and unwound from one and another take-up devices so as to be rolled down to the sheet product of the final thickness. The number of rolling stands employed in this mini-mill is as small as 1.3 to 1.4 of that in the conventional rolling mill, so that the mini-mill is economical as compared with conventional rolling apparatus.

The mini-mill, however, suffers from the following disadvantage. Namely, this rolling apparatus should have a long table system which supports the material under rolling, and therefore the temperature of the rolled material is seriously lowered due to radiation of heat during long stay of the material on the table system.

The mini-mill, particularly the mini-mill disclosed in Japanese Patent Unexamined Publication No. 58-202906 mentioned above, also involves the following problems.

In general, low-carbon steels are the materials which are rolled most frequently in hot rolling mills. Such steels have to be maintained at high temperature of 900°C or above during the rolling so that oxide scales tend to be formed on the material surface during the rolling. It is assumed here that the hot-rolling apparatus of the type disclosed in Japanese Patent Unexamined Publication No. 58-202906 mentioned above is used for rolling a low-carbon steel. Usually, the material under finish rolling has a length of about 300 to 900 meters and the finish rolling speed generally ranges between about 300 and 600 m/minute, so that the rolling time per one pass effected by winding and unwinding into and from each take-up device is as long as 60 to 90 seconds. Thus, formation of oxide scale is unavoidable also in the finish rolling which is conducted by winding and unwinding the material. If the rolling is continued without removing the scale, the scale is forced into the matrix metal, so that the state of the surface of the web or sheet is degraded to seriously impair the quality of the web as the product.

In order to obviate this problem, it is necessary to conduct an operation called "de-scaling" in which cooling water of a high pressure, e.g., 150 kg/cm², is jetted onto the surface of the strip so as to crush and blow off the scale. However, since the sheet under finish rolling has a very small thickness which is usually not greater than several millimeters, the descaling operation effected in each finish rolling pass causes the temperature of the strip to be lowered to a level which is much lower than the temperature normally required in rolling a low-carbon steel material, with the result that the expected quality of the product is often failed.

This is because carbon steels usually exhibit phase transition or transformation from austenite phase to α -phase at a temperature below A_{r3} transformation point which is about 900°C though it varies depending on the carbon content. Once the transformation occurs, finish rolling can no more be effected smoothly so that the quality of the final rolled product is undesirably impaired.

Thus, the conventional rolling methods have two major problems.

The causes of these problems will be described in more detail with reference to a case where a typical thin web product having a thickness of about 2.5 mm is produced by rolling. The thickness of the slab material as an original ma-

material to be processed in a mini-mill usually ranges between 80 and 220 mm. In practical operation of the mini-mill, slabs of various thicknesses within the above-mentioned range are selected at various factories or iron works. However, regardless of the initial thickness of the slab, the last 3 passes of rough rolling in this rolling mill are executed substantially as follows by the rough rolling mill.

Namely, when the slab has an initial thickness of, for example, 220 mm, rolling is initially conducted so that the thickness of the material is reduced by about 30 mm per pass. The magnitude of reduction in thickness is gradually reduced at the last few or several rolling passes. For instance, in the forward pass which is second to the final pass, the rolling is effected to reduce the thickness from 80 mm to 52 mm. In the subsequent backward pass which is immediately before the final pass, the thickness is reduced from 52 mm to 25 mm. In the final pass which is a forward pass, the thickness is reduced from 25 mm to 12 mm. The slab roughly rolled is then fed to the finish rolling mill or finishing mill.

In general, the rolling operation of the type described requires that the weight of the product per unit width of 1 mm is usually about 15 kg/mm. Thus, in the forward pass which is second to the final pass in which the slab thickness is reduced to 52 mm, the rolled material is elongated to 36.7 m as a result of the rolling. In the next pass in which the thickness is reduced to 25 mm, the slab is elongated to 76.4 m. In the final pass in which the thickness is reduced to 12 mm, the length of the material is increased to 159 m.

In the forward pass which is second to the final pass, the problem caused by temperature drop is not so serious because the thickness of the material is still large (52 mm) and the length of the material is not so large. In the subsequent pass which is a backward pass, however, the material thickness is as small as 25 mm and the length of the material is as large as 76.4 m. This pass, therefore, requires a large supporting table system which is capable of supporting the material of 76.4 m. In addition, a large quantity of heat is radiated from such long material while the material stays on this table system during the backward pass and the subsequent final forward pass. Partly because of this heat radiation and partly because of higher cooling rate due to the reduced thickness of the material which is as small as 25 mm, the temperature of the material under rolling is lowered seriously.

In the subsequent finish rolling, the thickness is reduced from the initial thickness of 12 mm to 6 mm after the rolled material or sheet leaves the second finish roll stand, and the strip is then taken-up by the take-up device of the outlet side.

In a subsequent pass, the strip is unwound from the take-up device of the outlet side and is made to pass through the finish roll stands backwardly while being taken-up by the take-up device of the inlet side. The thickness of the strip is reduced to about 3.8 mm through this backward pass. In the final rolling, the material is unwound from the takeup device of the inlet side so that rolling is conducted forwardly through two finish roll stands, whereby the final product having a thickness of 2.5 mm or less is obtained.

As explained before, a considerably long time, e.g., 60 to 180 seconds, is required for the strip to be finish-rolled while being unwound and wound by the respective take-up devices, so that oxide scale is unavoidably formed on the surface of the strip. It is therefore necessary to conduct de-scaling operation by jetting cooling water of high pressure each time the strip is unwound and rolled. The de-scaling operation may, however, tend to lower the temperature of the strip to 900°C or below, with the result that products of desired quality cannot be produced.

The sheet or material to be rolled is exposed to the atmosphere only for a short time during travelling between two roll stands of the tandem finish rolling mill and, therefore, only a very thin oxide scale is formed. It is therefore not necessary to conduct de-scaling operation during rolling through two roll stands of the finish rolling mill.

A rolling mill called "hot tandem mill" is also known. The simplest form of this type of rolling mill employs a single rough rolling mill and 6 to 7 sets of tandem finish rolling mills arranged on the downstream side of the rough rolling mill. In operation, a slab or material to be rolled is reciprocatingly rolled through the single rough rolling mill so as to reduce its thickness from 220 mm down to 30 mm and is then rolled into the final thickness through the series of tandem rolling mills.

De-scaling operation is conducted also in this rolling mill, between successive passes of the rough rolling and at the inlet side of the finish tandem mill. The de-scaling operation, however, does not cause substantial temperature drop because the slab still has large thicknesses in these stages. At positions between adjacent finish rolling stands in which the thicknesses of the material have been reduced, the rolled material is exposed to the atmosphere only for a short time when it moved from one to the next finish roll stand so that de-scaling is unnecessary. It is therefore possible to roll the strip into the final thickness before the strip temperature is lowered.

In this rolling mill, if the rough rolling is to be conducted to reduce the material thickness to a small value, the slab which has just rolled by the backward pass immediately before the final forward

coarse rolling pass has to have a very large length so that a huge table system has to be installed on the inlet side of the coarse rolling mill. In order to avoid this problem, the rough rolling is executed such that the material thickness after the forward final rough rolling pass is as large as 30 mm in the hot tandem mill. Since the finish rolling is commenced with such a large initial thickness, a large number of finish roll stands are required uneconomically.

SUMMARY OF THE INVENTION

In view of the above-described problems encountered with prior art, an object of the present invention is to provide a hot rolling apparatus which eliminates necessity for huge table system for supporting the material rolled in the backward pass immediately before the forward final rough rolling pass so as to realize a compact construction, as well as a hot rolling method which can conduct hot rolling at a reduced investment or cost.

To this end, according to one aspect of the present invention, there is provided a hot rolling apparatus having a rough rolling mill and a finish rolling mill disposed downstream of the rough rolling mill so as to successively roll a slab material to reduce the thickness of the material thereby to produce a thin web-like or sheet product, wherein the rough rolling mill comprises a reversible rolling mill capable of performing forward and backward passes, and wherein take-up means capable of winding and unwinding or coiling and uncoiling the material under rolling is provided on the upstream side of the rough rolling mill.

According to another aspect of the present invention, there is provided a hot rolling method for hot-rolling a slab material into a thin web-like or sheet product comprising the steps of: feeding the material into a reversible rough rolling mill so as to effect at least one forward pass and at least one backward pass through the rough rolling mill; taking up and coiling the material immediately after a backward pass by means of a take-up device provided on the upstream side of the rough rolling mill; subjecting the material to the last forward rough rolling pass while uncoiling the material from the take-up device; and directly feeding the slab from the rough rolling mill into a finish rolling mill so as to roll the material into the final thin web-like product.

Another object of the present invention is to provide a compact hot rolling apparatus which can prevent the temperature of the rolled material from coming down below an optimum temperature and a hot rolling method which can be carried out at a reduced investment cost.

To this end, the present invention provides a hot rolling apparatus in which the finish rolling mill is composed of a plurality of finish roll stands arranged in a tandem manner so as to finish-roll the material in one pass, as well as a hot rolling method which makes use of this hot rolling apparatus. Preferably, the finish rolling mill is a tandem rolling mill composed of, for example, two to four rolling stands arranged on the outlet side of the rough rolling mill.

The advantage of the present invention is enhanced by the provision of a take-up means also on the outlet side of the rough rolling mill.

The take-up means capable of winding and unwinding the material under rolling may have a temperature-preserving means capable of suppressing drop of temperature of the coiled material. The temperature-preserving means may be composed of a heat-insulation cover capable of suppressing heat radiation from the coil or a suitable heating device capable of supplying heat to the coil.

When a slab material is hot-rolled by the hot-rolling method which makes use of the hot rolling apparatus of the present invention, the slab is first rolled to a predetermined thickness without operating the take-up device. For instance, when a slab of an ordinary thickness, e.g., 220 mm, is rolled, forward and backward passes are executed a few or several times so as to reduce the thickness down below 30 mm. Then, subsequent rolling passes are executed while winding and unwinding the slab onto and from the take-up device which is disposed on the inlet side or on both sides of the rough rolling mill. When the take-up device is provided only on the inlet side of the rolling apparatus, the material under rolling is wound on the take-up device only after the backward rough rolling pass immediately before the forward final rough rolling pass. Thus, the forward final rough rolling pass is executed while unwinding the material from the take-up device, in such a manner that the material coming out of the coarse rolling mill is fed directly towards the finish rolling mill.

It will be seen that the huge table system for supporting long rolled material is dispensed with because the material after rolling in the last backward rough rolling pass is taken-up by the take-up device. In addition, the rolled material taken-up in the form of a coil experiences only a small heat radiation so that the temperature drop of the rolled material is suppressed advantageously. The temperature-preserving effect will be further enhanced if the take-up device has a suitable temperature-preserving means such as a heat-insulation cover as mentioned above.

In the rough rolling in which the material is rolled through repeated forward and backward

passes, oxide scale is unavoidably formed on the surface of the material under rolling so that de-scaling is essentially conducted. In order to avoid excessive temperature drop of the rolled material, there is a practical lower limit in the reduction of the thickness in the rough rolling. Thus, the rough rolling effected by the reversible rough rolling mill is conducted such that the thickness of the rolled material which is taken up by the take-up device on the inlet side of the rough rolling mill after the backward rough rolling pass immediately before the forward final rough rolling pass is not smaller than about 6 mm.

After completion of the last backward rough rolling pass, the forward last rough rolling pass is executed and the material from this pass is directly fed to the finish rolling which is executed by two to four finish roll stands which are arranged in a tandem manner on the outlet side of the rough rolling mill.

The finish rolling is conducted at a speed which is as high as that in ordinary tandem mills, so that it is not necessary to conduct de-scaling of the material between adjacent finish roll stands. Thus, in this rolling apparatus, there is little risk for excessive temperature drop of the rolled material because the descaling operation, which unavoidably causes the material temperature to drop, is unnecessary in the region where the material thickness has been reduced to such an extent as to cause a excessive temperature drop of the material.

As has been described, the hot rolling apparatus of the present invention employs take-up means provided on the inlet side of the rough rolling mill or on each of the inlet and outlet sides of the rough rolling mill so as to roughly roll the material to a thickness which is smaller than that obtained with rough rolling mill in the conventional apparatus, while effectively suppressing temperature drop of the material during the rough rolling. Therefore, the number of the finishing roll stands can be reduced to about half or below of that in the conventional hot tandem rolling mill.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of a hot rolling apparatus of a first preferred embodiment of the present invention illustrative of a forward pass of rolling;

Fig. 2 is a sectional view of the apparatus shown in Fig. 1 illustrative of a backward pass of rolling;

Fig. 3 is a sectional view of the apparatus shown in Fig. 1 illustrative of the last forward pass of rolling;

Fig. 4 is a sectional view of a hot rolling apparatus of another preferred embodiment of the present invention which employs two rough rolling mills illustrative of the rolling operation;

Fig. 5 is a sectional view of a hot rolling apparatus of still another preferred embodiment of the present invention which employs a take-up device on each of the inlet and outlet sides of the rough rolling mill; and

Fig. 6 is a sectional view of a hot rolling apparatus of a further embodiment of the present invention in which finish rolling is conducted by a reversible rolling mill.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will be described with reference to Figs. 1 to 3.

Referring to Fig. 1, an original material or a billet of, for example, a low-carbon steel is prepared by a continuous casting machine.

A melt of the steel is poured from a tundish 1 into a continuous mold 3 so as to be cooled and solidified into a continuous billet 5. Various sizes of billet 5 are obtainable but the following description will be given on an assumption that a billet of a typical size, e.g., 80 mm thick and 700 to 1300 mm wide is cast at a speed of 2 to 5 m/min.

The continuous billet 5 is then cut at a predetermined length by a shearing machine 6. In case of a product having a weight per unit width of 15 kg/mm, the billet is cut at a length of 20 to 30 m.

The shearing machine 6 has upper and lower blades 11a and 11b provided on blade bases 9 and 10. The upper blade 11a is capable of being driven downward by the force produced by a cylinder 8 so as to shear the billet 5, whereby slabs 7 are obtained. During the cutting or shearing, the shearing machine 6 is fed by a cylinder 13 about a fulcrum pin 6a in the direction of movement of the billet in synchronization with the speed of movement of the billet 5 so that the shearing is effected without fail.

The slab 7 thus obtained is conveyed by a table roller 15 in a furnace or oven 14. The oven 14 is capable of preventing radiation of heat from the slab 7. The oven 14 also may be designed so as to provide heat energy as required thereby to heat the slab 7.

The slab 7 is then fed to a reversible rough rolling mill i.e. rougher or roughing mill 24 so as to be rolled through forward and backward passes. In the illustrated embodiment, a four-high mill composed of a pair of work rolls and a pair of back-up rolls is used as the reversible rough rolling mill.

This, however, is only illustrative and the reversible rough rolling mill may be composed of other types of rolling mill such as a mill having a pair of work rolls without back-up roll or a six-high mill.

In the illustrated embodiment, a bending roller device composed of two lower bending rollers 19 and a single upper bending roller 21 and a take-up device 65 as take-up means having coil support rollers 22 are provided on the inlet side of the reversible rough rolling mill 24.

The bending roller 19 together with a frame 61 supporting the roller 19 and the guide plate 20 is swingable about a fulcrum 60 on the bracket 17 by means of a cylinder 18. During the first forward pass performed by the reversible rough rolling mill 24, the bending roller 19 is swung to a lower standby position shown in Fig. 1 so as to allow the passage of the rolled material 27.

In order to prevent cooling of the rolled material during the first forward pass, a heat-radiation prevention oven 25 is disposed on the outlet side of the rough rolling mill 24. A table roller 26 also is disposed in the oven 25 so as to feed the material 27. The material 27 is rolled down to a thickness of about 52 mm through the first forward pass. During execution of the first forward rolling pass, de-scaling is conducted by jetting water at a high pressure of about 150 kg/cm² onto upper and lower sides of the material 27 from a set of nozzles 91 and 90 which are arranged on the upper and lower sides of the path of the rolled material at the inlet side and outlet side of the rough rolling mill 24 as viewed in the direction of forward feed of the material, thereby to remove scale formed on the surfaces of the material.

After completion of the first forward pass, a backward pass is executed in a manner shown in Fig. 2. The thickness of the rolled material is reduced from 52 mm down to 25 mm through this backward pass. When this backward pass is executed, the lower bending rollers 19 and the guide plate 20 are swung upward by the cylinder 18 to a position for taking up the material 27 in the form of a coil as shown in Fig. 2. As this backward pass proceeds, the material 27 backwardly fed through the rough rolling mill 24 is guided by the lower bending rollers 19 and the upper bending roller 21 so as to be arcuately bent into the form of a coil and is further fed as indicated by an arrow B thereby forming a coil 23. The coil is supported by the coil support roller 22. De-scaling by nozzles 90 and 91 is executed also during execution of the backward pass.

After completion of the backward pass, the final forward rough rolling pass is executed in a manner shown in Fig. 3.

During the execution of the forward pass, the coil 23 is unwound from the take-up device 65 into

the rough rolling mill 24, and the material which has been rolled down to a small thickness, now denoted by numeral 31, is directly fed into a finish rolling mill, i.e. finisher or finishing mill 28 for finish rolling, whereby a hot-rolled thin web-like product 32 is obtained. The sheet product 32 is fed in the direction of the arrow C while being guided by a guide roller 29 so as to be wound on a take-up drum 46, whereby a coil of the product is formed. During execution of the finish rolling, de-scaling is executed not only by the nozzles 90 and 91 but also by a nozzle 92 which also jets water at a high pressure. However, de-scaling is not necessary for the material moving through regions between adjacent ones of three finish rolling stands of the finish rolling mill 28, because the material can pass these regions within a very short time.

In the hot rolling apparatus of the present invention, the de-scaling operation is conducted while the thickness of the material under rolling is still large, so that undesired excessive temperature drop of the material is substantially suppressed as compared with the case where the rolling apparatus of the type disclosed in Japanese Patent Unexamined Publication No. 58-202906 is used.

Though the embodiment shown in Fig. 3 employs three finish roll stands, this number of finish roll stands is not exclusive but may be varied in accordance with, for example, the thickness of the product. Three finish roll stands are adequate when the material 31 rolled through the last forward pass of the rough rolling mill 24 is about 12 mm and the final product 32 obtained through the finish rolling mill 24 has a typical thickness of 2.5 mm.

The rolling speeds in the rough rolling mill and the final finish roll stand are about 75 m/min and about 360 m/min, respectively, in the illustrated embodiment.

In the described embodiment, a blank slab having a thickness of 80 mm is rough-rolled through three passes in the reversible course rolling mill 24. This also is illustrative and the arrangement may be such that a slab 7 having a thickness greater than 80 mm is rough-rolled through a number of passes greater than 3.

For instance, when a slab of 120 mm thick is rolled, the slab may be rolled down to 100 mm in the first forward pass and then down to 80 mm in the first backward pass. In such a case, the material is not taken up by the take-up device during the first backward pass in which the material is rolled from 100 mm to 80 mm, because the material in this state still has a large thickness and a short length so that the heat radiation from the material is negligible. It is to be understood rolling is conducted such that the weight per unit width of the material is substantially unchanged regardless of the slab thickness because the slab length is

selected shorter when the slab thickness is selected larger.

When the slab 7 has a greater thickness, thickness-reducing rolling is conducted through repeating forward and backward passes without conducting take-up of the material until the material thickness is reduced to about 30 mm. When the rough rolling has proceeded to reduce the slab thickness to 30 mm or below, the take-up device 65 on the inlet side of the roughing mill 24 is put into operation and then the rough rolling and finish rolling are executed in a manner explained before.

Although in the described embodiment the take-up device 65 provided on the inlet side of the coarse rolling mill 24 is an up-coiler type which upwardly takes up and coils the material, other types of take-up device such as a drum-type take-up device and a device capable of downwardly taking up and coiling the material, known as "Steleco" (registered trademark) can be used as well.

Fig. 4 shows another embodiment suitable for use in the case where the slab 7 to be rolled has a thickness greater than 80 mm, e.g., 110 to 220 mm. This embodiment employs two reversible rough rolling stands 35, 36, though three or more stands may be used. The material to be rolled is fed forward, backward and then forward, thus undergoing six rolling passes in total, whereby a large rolling reduction is effected by the roughing mill 35, 36. When the initial slab thickness is about 120 mm, the slab can be rolled down to a thickness of 6 to 10 mm through the six passes. After the last forward pass, the material is sent for the finish rolling by the mill 28, whereby a product having a thickness of 1.7 to 2.5 mm is obtained.

In the embodiment shown in Fig. 4, the coil 23 of the rolled material on the take-up device 65 is covered by a heat-keeping box 70 as the heat-keeping or preserving means so that radiation of heat from the coil 23 is substantially suppressed. Though a mechanism for lifting and lowering the lower bending roller 19 is not shown in Fig. 4, it is to be understood that a lifting mechanism similar to that shown in Fig. 1 is used also in the embodiment shown in Fig. 4.

Fig. 5 shows still another preferred embodiment of the hot rolling apparatus in accordance with the present invention. The apparatus shown in Fig. 5 has take-up devices 71 and 72 capable of coiling and uncoiling the material on the inlet and outlet sides of the rough rolling mill 35. During execution of a forward pass in the rough rolling mill 35, the take-up device 72 operates in a coiling mode so as to take-up and coil the material thereby suppressing radiation of heat from the slab after this forward pass. The material rough-rolled into a predetermined thickness after additional passes is

then fed to a finish rolling mill 38 so as to be rolled into the final product in one pass as shown by one-dot-and-dash line.

In this embodiment, the rough rolling can be conducted to produce a smaller thickness of the material than in the preceding embodiments, by virtue of provision of the take-up devices 71 and 72 on both sides of the rough rolling mill 35. A practical example of such rolling process will now be described.

A slab 7 having a large initial thickness is repeatedly rolled by the rough rolling mill 35. When the material thickness has been reduced to 30 mm or so, the take-up device 71 on the inlet side of the rough rolling mill 35 is put into operation so as to take-up and coil the material. In a subsequent forward pass, the material is rolled down to a thickness of about 17 mm and then taken up by the take-up device 72 on the outlet side of the rough rolling mill 35. After the subsequent backward pass, the material is rolled down to a thickness of 9 mm and is taken up by the take-up device 71 on the inlet side of the rough rolling mill 35. The material is then uncoiled from the take-up device 71 so as to be rolled down to a thickness of about 6.5 mm through the last forward pass. In this state, the finish rolling mill 28 is operatively coupled with the rough rolling mill 35 so that the material after the last forward rough rolling pass is directly fed to the finish rolling mill 28 so as to be finish-rolled into the final product having a thickness of about 2.0 mm.

In this embodiment, the rough rolling mill 35 and the finish rolling mill 28 are arranged in the close proximity of each other so as to minimize radiation of heat from the material travelling through the zone between these rolling mills 35, 28.

When rough rolling is executed without the operation of the take-up device 72, the material under rough rolling may enter a zone of the finish rolling mill 28 during execution of a forward pass. However, the forward rough rolling pass can be executed without any interference because in such a case the gaps between the upper and lower work rolls of the finish roll stands are increased by suitable means so as to allow the material to freely come into and out of the zone of the finish rolling mill 28. Thus, the overall length of the hot rolling apparatus can be further decreased.

Fig. 6 shows a hot rolling apparatus including another example of the finish rolling mill. In this case, the finish rolling mill 37 is composed of a single roll stand which is reversible, though two or more reversible finish rolling stands may be employed.

Reversible take-up devices 80 and 81 capable of coiling and uncoiling the material under rolling

are disposed on the inlet and outlet sides of the finish rolling mill 37. The material 27 after the rough rolling is fed into the finish rolling mill 37, undergoes a forward pass through the mill 37 and is taken-up by pinch rollers 42 so as to be wound on a take-up drum 45 to form a coil 44. During the subsequent backward pass, the material is taken-up by pinch rollers 41 onto a drum 40 so as to form a coil 39. Finish rolling is thus conducted repeatedly until a predetermined thickness is obtained. Then, the final finish rolling is executed through the final forward pass and the material is fed towards the guide roller 29 as shown by one-dot-and-dash line, so as to be wound on the drum 46 in the form of the coil 30.

The coils 39 and 44 formed on the inlet and outlet sides of the finish rolling mill 37 are covered by boxes 38 and 43 which effectively suppress heat dissipation from these coils 39, 44.

The present invention can offer the following advantages by the provision of a take-up device capable of coiling and uncoiling a material under rolling on the inlet (i.e. upstream side in the forward pass) of the rough rolling mill.

1. The material fed back at a backward pass through the rough rolling mill is taken-up by the take-up device, so that a huge table system which hitherto has been necessary for supporting the long material at the inlet side of the rough rolling mill can be substantially eliminated, thus contributing to a reduction in the space and installation cost.

2. In the conventional rolling apparatus, the material under rolling is cooled due to heat radiation therefrom at the inlet side of the rough rolling mill during execution of a backward pass and a subsequent forward pass.

According to the invention, however, the heat radiation from the rolled material at the inlet side of the rough rolling mill is suppressed by virtue of the fact that the material is coiled at the inlet side of the rough rolling mill, so that the material experiences a reduced temperature reduction. In the conventional case, the rolled material laid on a support table on the inlet side of the rough rolling mill is usually cooled at a rate of, 2 degrees (in unit of °C) per second. Since it takes about 60 seconds for the rough rolling mill to conduct a backward pass and a subsequent forward pass, the temperature is lowered by about 120° C. In operating the conventional rolling apparatus, therefore, it is necessary to elevate the initial slab temperature to compensate for this temperature drop.

In contrast, the hot rolling apparatus of the present invention only allows a small temperature drop of about 0.2 degree or so per second, by virtue of the fact that the material under rolling is taken-up as a coil at the inlet side of the rough

rolling mill, so that the temperature of the rolled material is preserved for a long time, thus remarkably saving energy.

3. In the embodiment in which the take-up device is provided on each of the roughing mill can be rough-rolled to a smaller thickness than in the case where the take-up device is provided only on the inlet side of the rough rolling device, so that the number of the finish roll stands disposed downstream from the rough rolling mill can be reduced to a half or less compared with that in the conventional rolling apparatus.

As has been described, according to the present invention, a take-up device is provided at least on the inlet side of the rough rolling mill, so that the length of the table to be installed on the inlet side of the rough rolling mill can be decreased and the undesirable cooling of the material under rolling can be substantially suppressed. This also enables the number of the finish roll stands arranged in the tandem manner on the outlet or downstream side of the rough rolling mill to be decreased and yet the necessity of de-scaling for the material moving through the zones between adjacent finish roll stands is eliminated to prevent excessive temperature drop of the thin material rolled through these finish roll stands, thus ensuring an excellent quality of the surface of the final rolled product.

Claims

1. A hot rolling apparatus having a rough rolling mill (24, 35, 36) and a finish rolling mill (28, 37) disposed downstream of said rough rolling mill (24, 35, 36) so as to successively roll a slab material (7) to reduce a thickness of the material thereby to produce a sheet product (32), wherein said rough rolling mill (24, 35, 36) comprises a reversible rolling mill (24, 35, 36) capable of performing forward and backward passes, and wherein take-up means (65, 71) capable of coiling and uncoiling the material under rolling is provided on an upstream side of said rough rolling mill (25, 35, 36).

2. A hot rolling apparatus according to Claim 1, wherein said finish rolling mill (28, 37) includes a plurality of finish roll stands arranged in a tandem manner so as to conduct finish rolling in one pass.

3. A hot rolling apparatus according to Claim 2, further comprising heat-keeping means (70) provided around said take-up device (65, 71) so as to suppress a temperature drop of the material coiled on said take-up device (65, 71).

4. A hot rolling apparatus having a rough rolling mill (24, 35, 36) and a finish rolling mill (28, 37) disposed downstream of said rough rolling mill (24,

35, 36) so as to successively roll a slab material (2) of carbon steel to reduce a thickness of the material thereby to produce a sheet product (32), wherein said rough rolling mill (24, 35, 36) comprises a reversible rolling mill (24, 35, 36) capable of performing forward and backward passes, and wherein take-up means (65, 71) capable of coiling and uncoiling the material under rolling is provided on an upstream side of said rough rolling mill (24, 35, 36), said finish rolling mill (28, 37) including a plurality of finish roll stands arranged in a tandem manner so as to conduct finish rolling in one pass.

5. A hot rolling apparatus according to Claim 4, further comprising take-up means (72) disposed downstream of said rough rolling mill so as to coil the material after a forward pass through said rough rolling mill (24, 35, 36) and uncoil the material to feed said material into said rough rolling mill (35) in a backward pass.

6. A hot rolling apparatus having a rough rolling mill (24, 35, 36) and a finish rolling mill (28, 37) disposed downstream of said rough rolling mill (24, 35, 36) so as to successively roll a slab material (7) to reduce a thickness of the material thereby to produce a sheet product (32), wherein said rough rolling mill (24, 35, 36) comprises a reversible rolling mill (24, 35, 36) capable of performing forward and backward passes, and wherein take-up means (65, 71, 72) capable of coiling and uncoiling the material under rolling is provided on each of upstream and downstream sides of said rough rolling mill (24, 35, 36).

7. A hot rolling apparatus according to Claim 6, wherein said finish rolling mill (28, 37) includes a plurality of finish roll stands arranged in a tandem manner so as to conduct finish rolling in one pass.

8. A hot rolling apparatus according to Claim 6, further comprising heat-keeping means (70) provided around at least one of said take-up devices so as to suppress a temperature drop of the material coiled on said take-up device (65, 71, 72).

9. A hot rolling apparatus according to Claim 6, further comprising de-scaling means (90, 91) provided on the upstream and downstream sides of said rough rolling mill so as to remove scale from the material fed into and out of said rough rolling mill (24, 35, 36).

10. A hot rolling method for hot-rolling a slab material (7) into a sheet product (32) comprising the steps of: feeding the material into a reversible rough rolling mill (24, 35, 36) so as to effect at least one forward pass and at least one backward pass through said rough rolling mill (24, 35, 36); taking up and coiling material immediately after said at least one backward pass by means of a take-up device (65, 71) provided on an upstream side of said rough rolling mill (24, 35, 36); subjecting the material to the last forward rough rolling

pass while uncoiling the material from said take-up device (65, 71); and directly feeding the material from said last forward pass of said rough rolling mill (24, 35, 36) into a finish rolling (28, 37) mill so as to roll the material into the final sheet product (32).

11. A hot rolling method according to Claim 10, wherein, after a plurality of forward and backward rough rolling passes under said rough rolling mill (24, 35, 36), the material rolled through the last backward pass is taken-up and coiled by said take-up device (65, 71) disposed on the upstream side of said rough rolling mill (24, 35, 36).

12. A hot rolling method for hot-rolling a slab material (7) of carbon steel into a sheet product (32) comprising the steps of: feeding the material into a reversible rough rolling mill (24, 35, 36) so as to effect at least one forward pass and at least one backward pass through said rough rolling mill (24, 35, 36); taking up and coiling the material immediately after said at least one backward pass by means of a take-up device (65, 71) provided on an upstream side of said rough rolling mill (24, 35, 36); subjecting the material to the last forward rough rolling pass while uncoiling the material from said take-up device (65, 71); and directly feeding the material from said last forward pass of said rough rolling mill (24, 35, 36) into a finish rolling mill (28, 37) so as to roll the material into the final sheet product (32).

13. A hot rolling method for hot-rolling a slab material (7) into a sheet product (32) comprising the steps of: feeding the material into a reversible rough rolling mill (24, 35, 36) so as to effect at least one forward pass and at least one backward pass through said rough rolling mill (24, 35, 36); taking up and coiling the material immediately after said at least one forward pass by means of a take-up device (72) provided on a downstream side of said rough rolling mill; subsequently conducting a backward rough rolling pass while uncoiling the material from said take-up device (72) and taking-up and coiling the material by means of another take-up device (65, 71) provided on an upstream side of said rough rolling mill (24, 35, 36); subjecting the material to the last forward rough rolling pass while uncoiling the material from said another take-up device (65, 71); and directly feeding the material from said last forward pass of said rough rolling mill (24, 35, 36) into a finish rolling mill (28, 37) so as to roll the material into the final sheet product (32).

FIG. 1

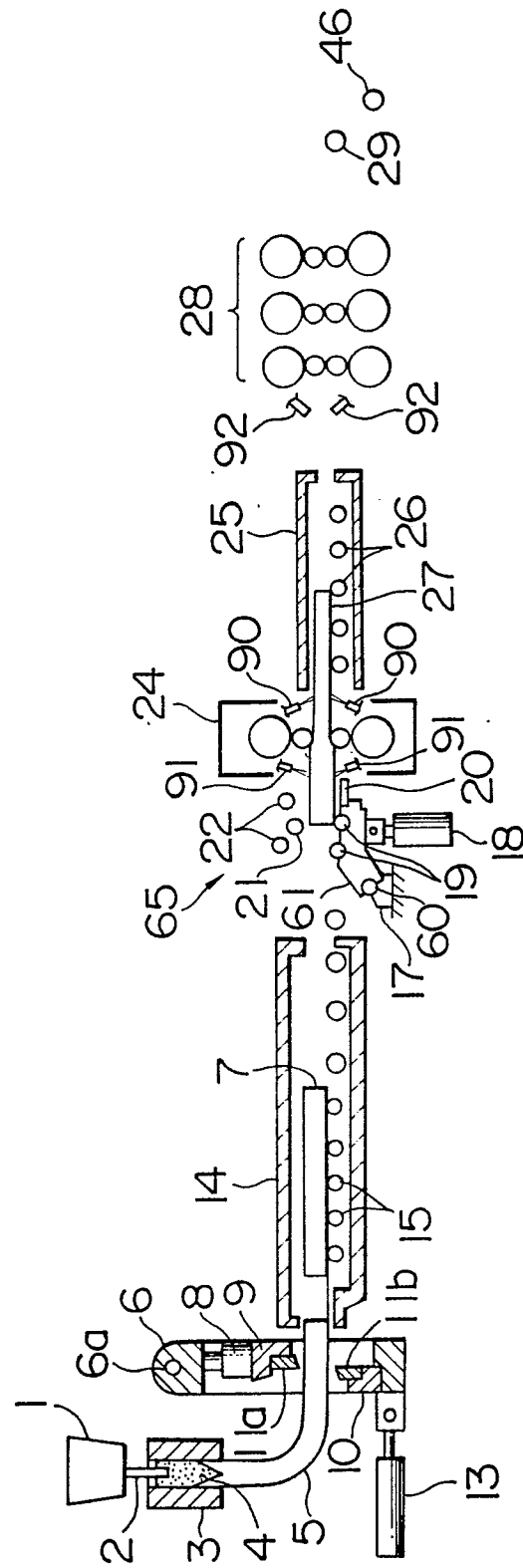


FIG. 2

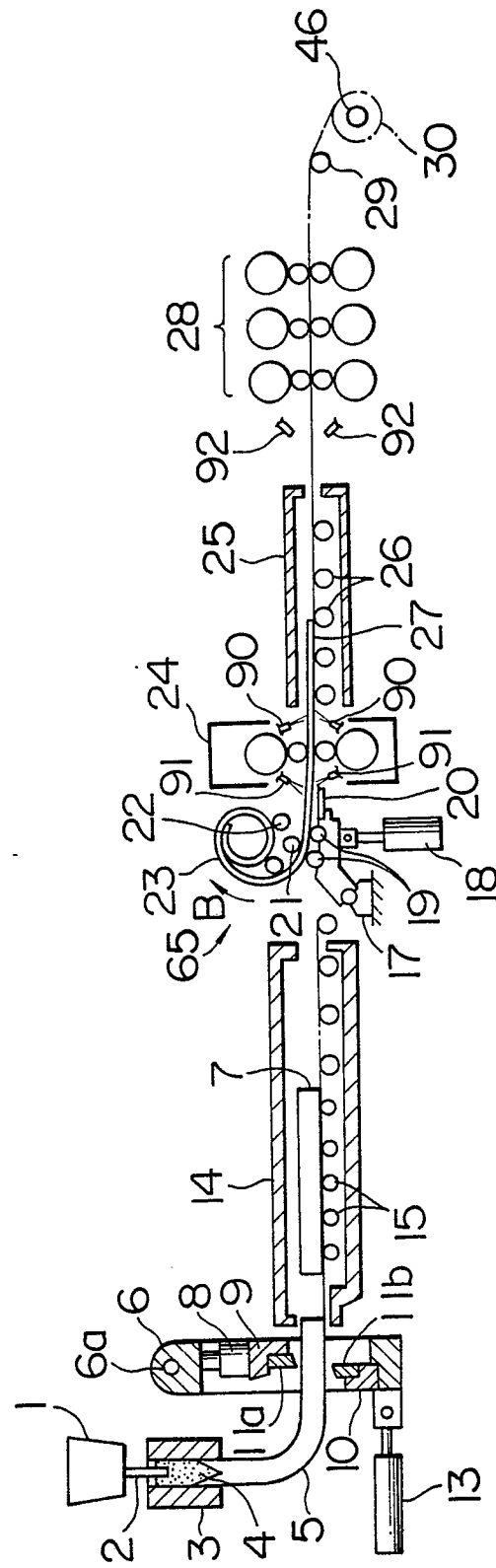
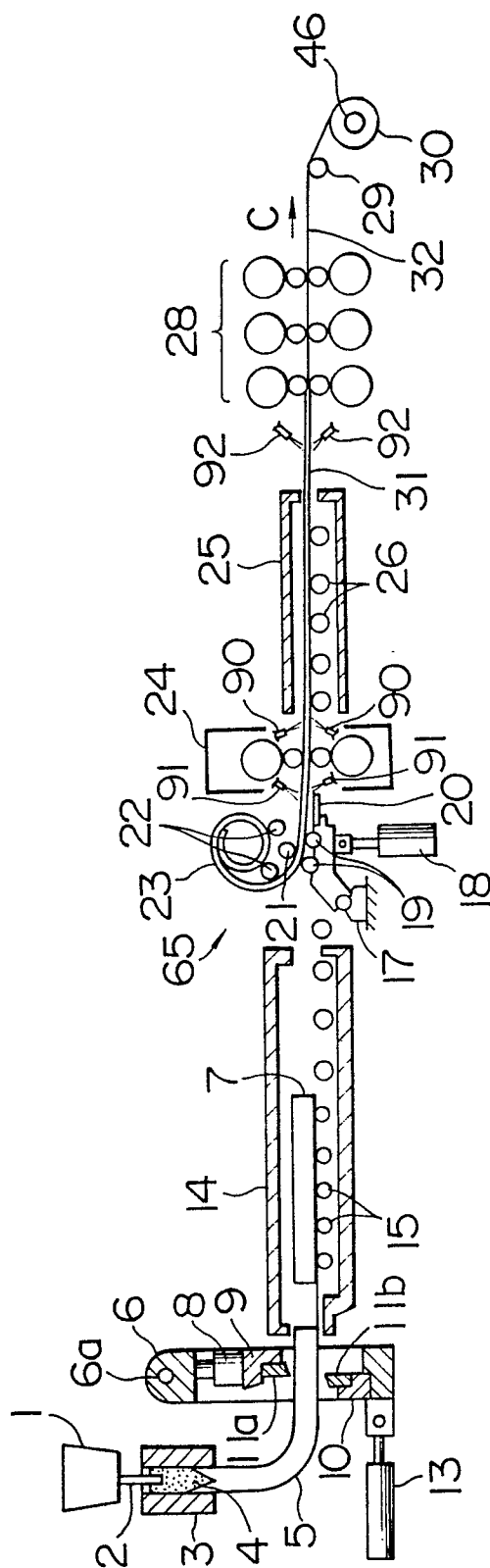




FIG. 3



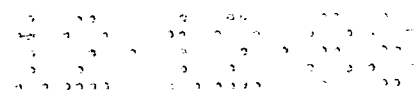


FIG. 4

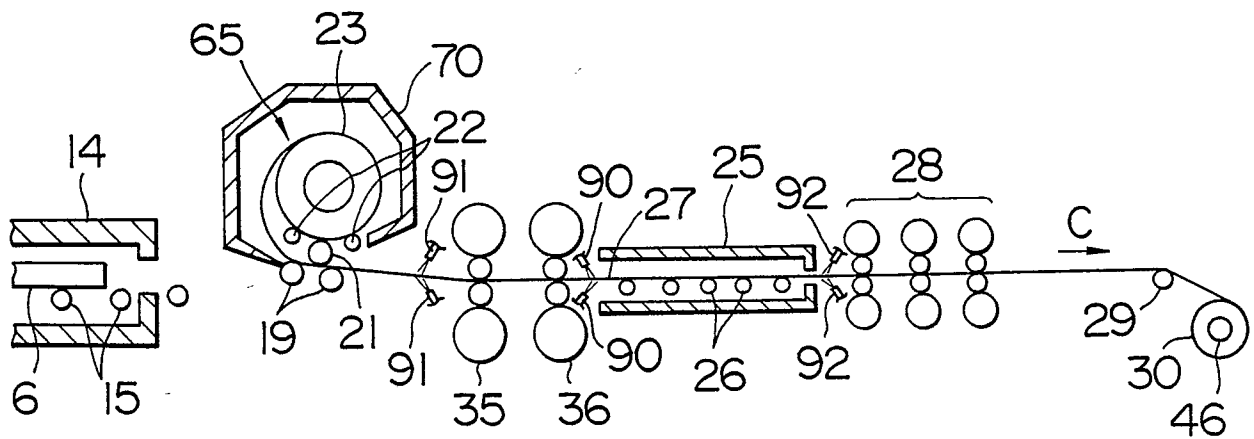


FIG. 5

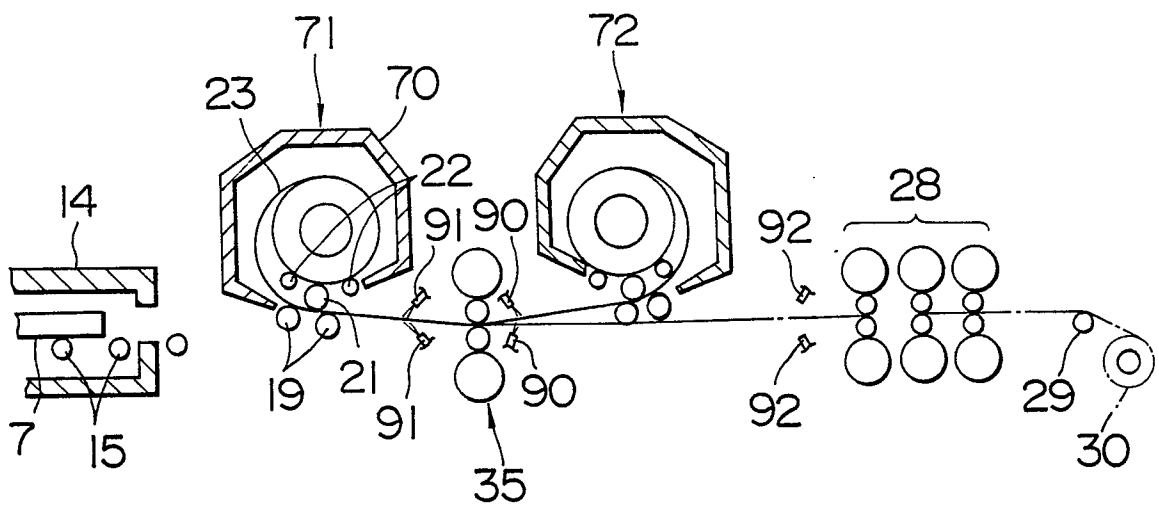
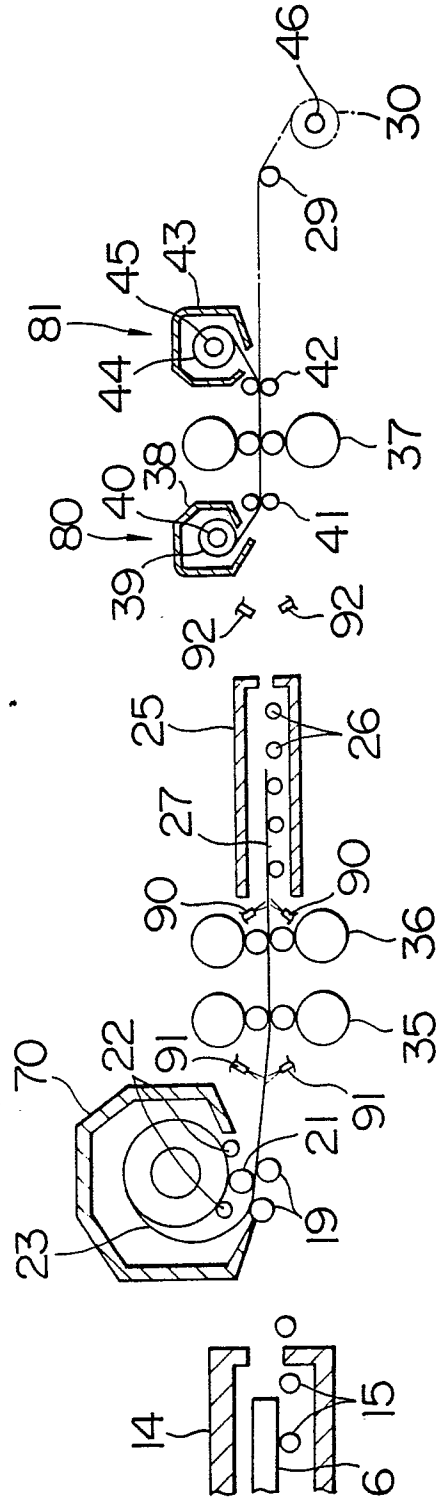


FIG. 6





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A- 652 772 (BRASSET) * Figure 1, references 11,12,5,15,34,35; figures 2-6; page 1, lines 57-59,82-89; page 2, lines 24-31,77-112; page 3, lines 39-59; page 4, lines 2-9 *	1-3,6-9	B 21 B 1/06 B 21 B 1/26
Y	---	4,5,10-13	
X	DE-C-1 162 796 (MOELLER & NEUMANN) * Column 1, lines 1-10,44-45; column 2, line 43 - column 3, line 2; column 3, lines 10-14 *	1,6,10-13	
Y	---	4,5,10-13	
X	US-E- 31 344 (EIBE) * Abstract; lines 1-12; column 1, line 56 - column 2, line 9; column 6, line 50 - column 7, line 17 *	1,2,6,7	
X	US-A-4 019 359 (SMITH) * Abstract; column 2, lines 48-51 *	1,6	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	GB-A-2 030 491 (TIPPINS) * Page 1, lines 54-64 *	1,6,8	B 21 B
A	EP-A-0 183 187 (TIPPINS) * Page 3, lines 19-27 *	1,6,8	
A	EP-A-0 177 187 (TIPPINS) * Column 1, line 36 - column 2, line 29 * --- -/-	1,6	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 03-03-1989	Examiner VERMEESCH, P.J.C.C.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	DE-B-1 158 024 (MOELLER & NEUMANN) * Whole document * ---	1-13	
A	EP-A-0 088 745 (VOEST) * Figures 1-3 * & JP ³ A-58 202 906 (Cat.D) -----	1-13	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 03-03-1989	Examiner VERMEESCH, P. J. C. C.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			