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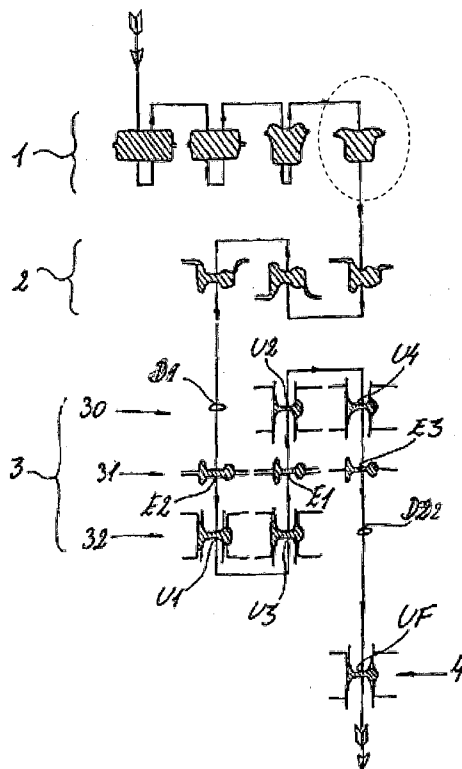


Figure 1

(57) Abstract: This invention relates to a method of rolling steel rails comprising: a method of rolling steel rails comprising: providing a rail blank (5), the blank comprising a foot portion (2), a head portion (3) and a web portion (4) connecting the foot portion to the head portion; finishing the rail blank to form a steel rail (6) in a multi-stand continuous tandem finishing mill comprising at least one horizontal stand (H) and at least five four-roll universal stands (U), wherein each universal stand (U_x) only contains flat vertical rolls for forming the lower foot portion (2a) and the head portion (3a) of the rail, and wherein each universal stand (U_x) contains two shaped horizontal rolls for forming the sides (6a, 6b) of the rail and particularly the web portion (4a, 4b) of the rail, wherein the rail blank is passed only once through said finishing mill, and wherein in at least one combination of two subsequent stands U_i and U_{i+1} the rail is worked on the foot and not on the head using the flat vertical rolls in U_i and wherein the rail is worked on the head and not on the foot using the flat vertical rolls in U_{i+1}; or the rail is worked on the head and not on the foot using the flat vertical rolls in U_i and wherein the rail is worked on the foot and not on the head using the flat vertical rolls in U_{i+1}. The invention also relates to an apparatus for carrying out said method, and to a product produced therewith.



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A METHOD OF ROLLING RAILS, APPARATUS FOR ROLLING RAILS AND RAIL PRODUCED ACCORDING TO SAID METHOD

This invention relates to a method of rolling rails. The invention also
5 relates to an apparatus for carrying out said method, and to a product
produced therewith.

Rails are formed by three general methods of rolling:

- (1) the tongue-and-groove, flat or slab-and-edging method;
- (2) the diagonal or angular method;
- 10 (3) the universal method.

In the first method, the plane of symmetry of the rail coincides with
the pass line or is perpendicular thereto. The diagonal or angular method
differs from the first method in that the shaping of the rail begins with the
first pass in the roughing stand, and instead of first compressing the bloom
15 through a smaller size and then forming the section partly through
compression and partly through spreading, the process is one of
compression from beginning to end. The universal method employs both
horizontal and vertical rolls in one stand to effect shaping of the work piece.
In some cases, a semi-universal stand is used comprising two horizontal
20 rolls and one vertical roll. The universal rolling method allows a greater
degree of hot working of the head and flange of a rail by compression than
can be obtained when horizontal rolls alone are used.

The traditional or conventional style of rolling rails is to use horizontal
rolls either two-high (i.e. two work rolls) or three-high (i.e. three work
25 rolls) typically in a cross country style mill as disclosed in WO2004/009259.
Starting from a bloom or billet, the process comprises the bloom being
deformed into a "top hat" before being turned onto its side. This "top hat"
can be described as a bar having a trapezoidal cross-section. The tail and
head of the bar is subsequently knifed to begin the rolling process where
30 the head portion, web portion and foot portion of the rail are formed. The
consequence of this method is that the deformations of the head and foot
portion are relatively low during some of the passes.

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The conventional universal rolling method also starts by first producing the "top hat", and further using two-high rolls to form the "top hat" pass through knifing into a rail blank shape before completion through universal stands. These universal stands use shaped vertical rolls for the formation of the head and or a combination of open closed grooves of the universal to form the foot. Again the deformations of the head and foot portion are relatively low during some of the passes.

The material may be rolled either in a reversible manner rather than one-way only, depending on the set-up and lay-out of the mill.

The traditional roughing process requires particular techniques to reduce, twist and turn the bar to manipulate the bar into the correct shape and orientation. Up to 12 to 14 passes must be made through the mill, all of which may or may not be through shaped rolls. Usually the number of roughing stands is small, usually two, wherein the work rolls are provided with several pass grooves for subsequent passes and consequently this first stage of the rail rolling process accounts for a considerable time in the mill.

Figure 1 represents a typical example of a cross country style mill. The "top hat" is indicated with the dashed ellipsoid.

Thus the current practice for universal rolling contains a number of steps: universal rolling with two horizontals and two verticals of which the roll which forms the head of the rail is shaped to the particular rail profile being rolled; edger rolling, head rolling and foot rolling within separate stands. The greater part of the reductions of the head and foot are typically performed within the universal stands containing two horizontal rolls and two vertical rolls in a thickness orientation around the profile of the rail section. The breakdown workpiece obtained in this method has a larger section that is substantially similar to the desired rail in shape, as shown in Figures 2 and 3. In order to obtain the breakdown blank shaped like this, the difference in width between the head and foot must be accomplished in the roughing operation as indicated by the pass grooves on the roughing stands as shown in Figures 2 and 3. This calls for providing many roll passes in the roughing mill. As a consequence, the roughing operation is

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the bottleneck in the rail rolling process, and it governs the productivity of the universal rail rolling operation as a whole.

It is an object of this invention to provide a method of rolling rails which allows for increased productivity of the rail rolling operation.

5 It is also an object of this invention to provide a method of rolling rails which allows more mill flexibility by means of an easy convertibility of the rail rolling mill to a section rolling mill.

It is also an object of this invention to provide a method of rolling rails wherein the head and foot portion of the rail have been subjected to a
10 larger total rolling deformation.

It is also an object of this invention to provide a method of rolling rails wherein the drop in temperature of the front end of the rail and of the tail end of the rail is reduced.

One or more of the objects are achieved by a method of rolling steel
15 rails comprising:

- Providing a rail blank (5), the blank comprising a foot portion (2), a head portion (3) and a web portion (4) connecting the foot portion to the head portion;
- Finishing the rail blank to form a steel rail (6) in a multi-stand
20 continuous tandem finishing mill comprising at least one horizontal stand (H) followed by at least five four-roll universal stands (U), wherein each universal stand (U_x) only contains flat vertical rolls for forming the lower foot portion (2a) and the head portion (3a) of the rail, and wherein each universal stand (U_x)
25 contains two shaped horizontal rolls for forming the sides (7a, 7b) of the rail and particularly the web portion (4a, 4b) of the rail, wherein the rail blank is passed only once through said finishing mill, and wherein in at least one combination of two subsequent stands U_i and U_{i+1}
 - 30 o the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_i and wherein

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- the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_{i+1} , or
- o the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_i and wherein the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_{i+1} .

In the rail rolling process in accordance with this invention a rail blank is transferred to the fully continuous multi-stand finishing mill, preferably consisting of at least five stands. Preferably, but not necessarily, the horizontal stand is the first stand and the universal stands are placed downstream of the horizontal stand when seen in the rolling direction. The stands of the finishing mill are operated in tandem, i.e. after threading the product to be rolled is rolled in all stands at the same time. It is noted that this fully-continuous tandem rolling requires careful choice of the rolling schedule and rolling speeds of the respective stands, because the amount of material passing through each stand must be the same at any given time. If not, either necking or rupture of the material may occur in case a later stands rolls faster than its direct predecessor, or a loop of material may form between two stands in case a later stands rolls slower than its direct predecessor. However, the use of a fully-continuous tandem rolling finishing mill through which the material passes only once ensures that the time between start rolling and finish rolling of a rail blank into a finished rail is as short as possible, and then consequently the temperature difference between head and tail of the rail is minimised. Moreover, the faster rolling also results in a higher deformation rate during rolling, and hence in a finer-grained microstructure. The universal rolling process according to the invention is performed such that the flanges of the rail blank corresponding to the foot portion are rolled using flat vertical rolls and shaped horizontal rolls. At least one of the vertical rolls in the universal stands in the finishing mill comprises a vertical roll for working the head portion of the rail. The blank is brought to a suitable rolling temperature prior to rolling. Usually the reheating temperature for steel rails is chosen such that the finishing temperature (i.e. the temperature at which the last deformation is given) is

still in the austenitic range, i.e. above Ar_3 . After finishing the rail, the rail may be cooled in still air (natural cooling) or in a water spray, mist, forced air, or submersion in a coolant (accelerated cooling). These cooling regimes are known.

5 The advantage of the method according to the invention involving the alternation of working of only the lower foot portion by the vertical rolls in one universal stand and then only the head portion by the vertical rolls in the next or preceding universal stand in the at least one combination of two subsequent stands U_i and U_{i+1} is that the head and foot are subjected to
10 larger deformations because of the absence of horizontal mills in between or after universal stands. It should be noted that in the context of this invention a universal stand equipped with two flat vertical rolls which do not work the lower foot portion nor the head of the rail is also considered an horizontal mill stand as these have the same technical effect.

15 It should be noted that the terms vertical and horizontal are used to indicate which rolls are meant. The horizontal rolls have a rotational axis which is about horizontal, and the vertical rolls have a rotational axis which is about perpendicular to the horizontal. All embodiments are described such that the web of the blank is substantially horizontal. It should be
20 pointed out however that the invention could also be performed with the web of the blank in the vertical direction, particularly in the finishing mill.

It is important to apply forging action to the head portion whilst in the universal stands and then apply forming action. In the universal stand where only the foot is worked by the flat vertical rolls, the head is worked
25 using the shaped horizontal rolls. In the universal stand where only the head is worked by the flat vertical rolls, the foot is worked using the shaped horizontal rolls. Only by means of the shaped horizontal rolls the width thickness of the head and foot portion is worked: the web portion and head portion are worked thickness wise as well as the foot, no work is completed
30 heightwise on the rail in these stands or passes: the distance between the head crown and the lower portion of the foot remains unchanged. The forging action within the universal stands provides a direct application of

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pressure on the head portion in the crown area (the surface contacting the wheel of the train when in use), and this prevents the occurrence of rolling imperfections as the rail is reduced to the desired dimensions. The length of the distance between the head crown and the lower portion of the foot is reduced. The foot portion is reduced in the same direction as the head portion as a result of the opposing force exerted by the vertical flat roll which works the foot portion. In typical universal rolling methods the head portion is reduced in two directions i.e. crown and sides. In the process according to the invention there will always be a minimum of five universal stands which the rail will have to pass through to ensure a good product. In conventional methods the head crown is only worked with very slight force applied in the direction as applied by the universal method. The universal method actively forges the head portion in this invention at least 5 times with direct pressure applied to the head crown in three instances with the vertical rolls.

In the known universal rail rolling process, the roll working the head portion in the universal stand arrangement is profiled and shaped to suit each particular section. Using shaped vertical work rolls mean that the rolls are stand specific. Also, wear of the shaped vertical work roll will affect the surface quality of the head portion of the rail. In the process in accordance with this invention both the vertical rolls working the foot and head portion are flat. There is no need for shaped vertical, thereby reducing the need for stand specific rolls. Also, maintenance of the vertical rolls is simplified because there is no need to provide them with a contour during grinding of the roll to remove the worn surface. This allows flexibility between not only products but also between stands. It is also cost-efficient.

By using flat vertical rolls in the universal stands during work-roll change any roll can be chosen for any stand. Also as part of the universal process with flat verticals it may not be necessary to change stands for rolling similar products, whereas with shaped verticals the profile of the crown will change and thus a stand change may be required. The flat vertical work rolls would simply require a change to the schedule settings.

This flexibility in using work rolls for various rolling schedules and in different rolling stands saves both time and money. Also better dimensional tolerances of the rails are obtainable.

Also, the number of replacement sets of rolls may be reduced.

5 An advantage of the process according to the invention is that surface defects within the head portion are prevented as a result of the increased working of the head in comparison to the known process. As the head undergoes more direct work in the crown area, any potential surface defects caused by rolling are rolled out and hence do not occur in the
10 finished product.

In an embodiment of the invention in at least two combinations of two subsequent stands U_i and U_{i+1} and U_j and U_{j+1} with i smaller or equal to $(j-2)$

- 15 ○ the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_i and U_j and wherein the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_{i+1} and U_{j+1} ; or
- 20 ○ the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_i and U_j and wherein the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_{i+1} and U_{j+1} ; or
- 25 ○ the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_i and U_{j+1} and wherein the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_{i+1} and U_j ; or
- the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_{i+1} and U_j and wherein the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_i and U_{j+1} .

30 This embodiment allows to subject the head and foot to an even higher degree of deformation and thus any defects are effectively removed by this method. Preferably the two combinations are placed in immediate

succession to each other, i.e. $i=j-2$. In principle, there can also be more than two combinations (e.g. 3 or 4) provided there are enough rolling stands in the finishing mill. However, the inventors found that two combinations proved to be particularly efficient in producing a high quality rail as a result of a stable thermomechanical process. When using more
5 stands, the temperature control of the material to be rolled becomes more difficult, potentially leading to too low rolling temperatures or potentially necessitating in-line heating equipment.

In an embodiment the finishing mill comprises one horizontal stand
10 and six universal stands. It was found that this configuration allows maximum flexibility and throughput.

In an embodiment the finishing mill consists of one horizontal stand (H1) and six universal stands (U2 to U7), preferably in the configuration H1-U2-U3-U4-U5-U6-U7. Preferably, there are two combinations of two
15 subsequent stands U_i and U_{i+1} and U_j and U_{j+1} with i smaller or equal to $(j-2)$ where U2 and U3 is one combination and U4 and U5 is the other.

In an embodiment the rail blank is provided by casting a cast steel rail blank. By providing the rail blank from an alternative source, either in addition to rolled rail blanks, or instead of rolled rail blanks, the
20 dependence on the roughing mills to provide the rail blanks is reduced. The productivity of the finishing mill can hereby be significantly increased. By choosing a suitable layout of the rolling and casting operations the rail blank may be hot charged into a reheating furnace prior to rolling thereby obtaining a potential energy saving. The cast rail blank may be
25 asymmetrical or symmetrical with respect to the centreline of the web portion of the rail blank.

In an embodiment of the invention the rail blank is provided by:

- breakdown rolling a bloom in a roughing mill, preferably having a square or rectangular cross-section, to a blank with a substantially
30 rectangular cross-section, or by
- casting a blank with a substantially rectangular cross-section.

In the context of this invention the roughing mill should be understood to comprise a breakdown mill for converting a bloom into a blank with a substantially rectangular cross-section and an intermediate mill for converting the blank into a rail blank.

5 Preferably the blank has a substantially square cross-section

In order to obtain a rail blank, the cast shape or rectangular or square-shaped blank is taken from the breakdown mill and passed to the intermediate mill where the head and foot will be given different widths and thicknesses formed in the intermediate reversing operation according to the
10 roll-pass design. Accordingly, the rail blank from the intermediate mill resembles the rail to be manufactured in shape, but is larger in dimensions than the finished rail product.

Since the head and foot of a rail are of an almost equal cross sectional area, the required rectangular or square-shaped blank from the breakdown
15 mill or caster can feed the intermediate mill to produce a rail blank.

Again, by choosing a suitable layout of the rolling and casting operations the square-shaped cast blank may be hot charged into a reheating furnace prior to rolling thereby obtaining a potential energy saving.

20 This process is comparable to the known method for producing rail, albeit that the bloom is not converted into a "top-hat"-configuration but into a substantially square-shaped blank. The use of the rectangular or square-shaped blanks as the initial stock or material, rather than passing through the "top-hat" stage, greatly reduces the amount of time spent at
25 the reversing mills during the breakdown operation. The blank may also be in a cast form. By providing the rectangular or square-shaped blanks from an alternative source, either in addition to rolled rectangular or square-shaped blanks, or instead of rolled rectangular or square-shaped blanks, the dependence on the breakdown mill to provide the blanks is reduced.
30 The productivity of the finishing mill can hereby be significantly increased.

The method does not require any increase in the number of roughing or intermediate passes and, therefore, requires no additional stands.

The use of rectangular or square-shaped blanks with a simple cross section makes it possible to use the roughing operation with only a single
5 roughing stand and a single intermediate stand thus removing any potentially difficult twist or turn operations as in the "top-hat" method.

In an embodiment of the invention the roughing mill is a reversing mill.

In order to ensure that the head, base and web of a rail are elongated
10 at the same rate through each pass, no more than one pass should be allowed in each pocket. This permits rolling rails from simple rectangular or square-shaped blanks, streamlining the roughing process which in the conventional method accounts for approximately 70 percent of the total rail rolling time, and yet at the same time using the same starting material that
15 is used for the manufacture of H-sections and I beams.

In an embodiment the intermediate mill forms the rectangular blank into a rail blank which is asymmetrical with respect to the centreline of the web portion of the rail blank. The advantage of an asymmetrical rail blank is to ensure good delivery from each finishing mill stand allowing a smooth
20 transition from one stand to the next without the risk of cobbling in the mill.

In an embodiment the rolled bloom and blank remain substantially symmetrical with respect to the eventual centreline of the web portion of the rail blank throughout the entire rolling process of bloom to finished rail.
25 The advantage of this symmetrical process is that the top and bottom rolls are identical.

In an embodiment of the invention the last universal stand of the finishing mill is a semi-universal stand consisting of two shaped horizontal rolls for working the head portion and the web portion, one flat vertical roll
30 for working the lower foot portion and one flat vertical dummy roll opposite

the flat vertical roll for working the lower foot portion. The dummy roll does not work the head crown of the rail.

The final stand is semi-universal and part of the continuous rolling train. The final universal stand rolls the section to the final dimensions as required by the customer. The use of a semi universal stand in the final
5 stand allows the finished products to have excellent tolerance and surface quality around the head and foot of the rail.

In an embodiment all universal rolling stands U_x can be replaced by semi-universal stands if only the head crown or the lower foot portion is
10 worked. In figure 4, each of the universal stands U_3 to U_7 may be replaced by semi-universal stands if so desired. However, it is preferable that all universal stands are full universal stands from a control and power point of view.

According to a second aspect of the invention a rolling mill for rolling
15 rail in accordance with the method described above is provided wherein the rolling mill comprises a multi-stand continuous tandem finishing mill comprising at least one horizontal stand (H) and at least five four-roll universal stands (U), wherein each universal stand (U_x) only contains flat vertical rolls for forming the lower foot portion (2a) and the head portion
20 (3a) of the rail, and wherein each universal stand (U_x) contains two shaped horizontal rolls for forming the sides (6a, 6b) of the rail and particularly the web portion (4a, 4b) of the rail.

It is possible to roll both rails and sections using the same breakdown mill. The substantially rectangular or square shaped cast or rolled blank
25 can be rolled into an H-section or I-section using the same finishing mill not only from the same blank as used for rolling rails but also using the same flat vertical rolls in the four roll universal configuration. When the mill is converted from rail rolling to section rolling, the shaped horizontal rolls in the universal stands are exchanged for flat horizontal rolls which perform
30 the forming action of the web of the I-section or H-section. This exchange can be done much more quickly, thus reducing the downtime of the mill.

Costs for rolls are also reduced, because the vertical rolls are the same. The mill also has become more flexible.

According to a third aspect a rail is provided, produced according to the method described above. As a result of the more extensive working of the head in comparison to the known methods, the final microstructure of the head in the finished rail is finer and the likelihood of defects is further reduced.

The invention will now be further explained by means of the following, non-limiting drawings.

Figure 1 represents a typical example of a cross country style mill. The "top hat" is indicated with the dashed ellipsoid. Shaped vertical rolls are used for the shaping of the head portion of the rail in U1-U4 and UF. Three edger stands are used in the configuration E2-U1-U3-E1-U2-U4-E3-UF.

Figure 2 represents a typical example of a mill using grooves and involving turning actions. The "top hat" is indicated with the dashed ellipsoid.

Figure 3 is a schematic representation of the evolution of a blank 1 into a rail. The blank in figure 3a comprises a foot portion 2, a head portion 3 and a web portion 4 connecting the foot portion 2 to the head portion 3. The blank has a symmetrical cross-section with respect to the centreline (dot-dashed line) of the web portion 4. The blank must not necessarily be symmetrical with respect to the line perpendicular to the centreline, although in this case it is.

In Figure 3b, the shape of the rail is drawn in conjunction with the blank from which it is made. It is obvious that the ratio of the cross-sectional area of the head and the foot of the blank are about the same as the ratio of the head and the foot of the rail, because otherwise the mass-flow of the steel through the roll gap causes warping of the rail between the stands and upon leaving the last stand.

In figure 3c the lower foot portion of the rail 6 is indicated with 2a. This lower foot portion is the part of the rail which rests on the sleeper or

the rail bed. The head crown, i.e. the part which eventually comes into contact with the wheels of a train, is indicated with 3a. The edges of the web part are indicated with 4a and 4b, whereas 7a and 7b represent the entire side curvature starting at the head crown, and ending at the lower portion of the foot. 7a and 7b are the parts formed by the horizontal rolls. 4a is therefore a part of 7a. 2a and 3a are the parts formed by the vertical rolls.

Figure 4 is a schematic representation of a process according to the invention. In Figure 4c the finishing mill is represented which, starting from a rail blank produces a finished rail in a 7-stands continuous tandem mill of a H1-U2-U3-U4-U5-U6-U7, wherein all vertical rolls are flat rolls. The combination of U3 and U4 and the combination of U5 and U6 are the combinations wherein in U3 and U5 only the foot is worked by the flat vertical roll and wherein in U4 and U6 only the head is worked by the flat vertical roll. In all universal stands and the horizontal stand the web of the rail is worked.

Figure 4b represents the evolution of a square-shaped blank into a rail blank in an intermediate mill, and Figure 4a represents the evolution of a bloom into an square-shaped blank in a breakdown mill. The breakdown mill and the intermediate mill jointly form the roughing mill.

The process schematically indicated in Figure 4b and 4c can also be started with a cast square-shaped blank or cast rail blank respectively.

It should be noted that the orientations mentioned hereinabove of the rails and stands in terms of horizontal and vertical are those used in normal practice. However, it will be clear that the invention is also applicable to mills where the orientation of rails and rolls is rotated 90°, or indeed a rotation of any magnitude, with respect to the longitudinal axis of the rail to be rolled.

CLAIMS

1. A method of rolling steel rails comprising:
- Providing a rail blank (5), the blank comprising a foot portion (2), a head portion (3) and a web portion (4) connecting the foot portion to the head portion;
 - Finishing the rail blank to form a steel rail (6) in a multi-stand continuous tandem finishing mill comprising at least one horizontal stand (H) and at least five four-roll universal stands (U), wherein each universal stand (U_x) only contains flat vertical rolls for forming the lower foot portion (2a) and the head portion (3a) of the rail, and wherein each universal stand (U_x) contains two shaped horizontal rolls for forming the sides (6a, 6b) of the rail and particularly the web portion (4a, 4b) of the rail, wherein the rail blank is passed only once through said finishing mill, and wherein in at least one combination of two subsequent stands U_i and U_{i+1}
 - o the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_i and wherein the rail is worked on the head and not on the foot using the flat vertical rolls in U_{i+1} ; or
 - o the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_i and wherein the rail is worked on the foot and not on the head using the flat vertical rolls in U_{i+1} .
2. Method according to claim 1 wherein in at least two combinations of two subsequent stands U_i and U_{i+1} and U_j and U_{j+1} with i smaller or equal to $(j-2)$
- o the rail is worked on the lower foot portion (2a) and not on the head (3a) using the flat vertical rolls in U_i and U_j and wherein the rail is worked on the head and not on the foot using the flat vertical rolls in U_{i+1} and U_{j+1} ; or

- the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_i and U_j and wherein the rail is worked on the foot and not on the head using the flat vertical rolls in U_{i+1} and U_{j+1} ; or
 - 5 ○ the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_i and U_{j+1} and wherein the rail is worked on the foot and not on the head using the flat vertical rolls in U_{i+1} and U_j ; or
 - 10 ○ the rail is worked on the head (3a) and not on the lower foot portion (2a) using the flat vertical rolls in U_{i+1} and U_j and wherein the rail is worked on the foot and not on the head using the flat vertical rolls in U_i and U_{j+1} .
3. Method according to claim 1 or 2 wherein the finishing mill comprises
- 15 one horizontal stand and six universal stands.
4. Method according to any one of the preceding claims wherein the finishing mill consists of one horizontal stand (H1) and six universal stands (U2 to U7), preferably in the configuration H1-U2-U3-U4-U5-
- 20 U6-U7.
5. Method according to any one of the preceding claims wherein the rail blank is a cast steel rail blank or a rolled steel rail blank.
- 25 6. Method according to any one of claims 1 to 5 wherein the rail blank (1) is provided by:
- breakdown rolling a bloom (8) in a roughing mill, preferably having a substantially rectangular cross-section, to a substantially rectangular shaped blank, followed by forming the rail blank (1)
 - 30 from the rectangular blank in an intermediate mill, or by
 - casting a substantially rectangular cast blank, followed by forming the rail blank (1) from the cast blank in an intermediate mill.

7. Method according to claim 6 wherein the roughing mill is a reversing mill.
- 5 8. Method according to any one of claims 6 or 7 wherein the intermediate mill forms the rectangular blank into a rail blank which is asymmetrical with respect to the centreline of the web portion of the rail blank.
- 10 9. Method according to any one of claims 1 to 7 wherein the rolled bloom and blank remain substantially symmetrical with respect to the eventual centreline of the web portion of the rail blank throughout the entire rolling process of bloom to finished rail.
- 15 10. Rolling mill for rolling rail from a rail blank in accordance with the method claimed in 1 to 9 wherein the rolling mill comprises a multi-stand continuous tandem finishing mill comprising at least one horizontal stand (H) and at least five four-roll universal stands (U), wherein each universal stand (U_x) only contains flat vertical rolls for forming the lower foot portion (2a) and the head portion (3a) of the rail, and wherein each universal stand (U_x) contains two shaped
20 horizontal rolls for forming the sides (6a, 6b) of the rail and particularly the web portion (4a, 4b) of the rail.
- 25 11. Rolling mill according to claim 10 which is convertible into a rolling mill for rolling H-beam sections by replacing the shaped horizontal rolls in all universal stands by flat horizontal rolls.
12. Rail produced using the method of any one of claims 1 to 9.

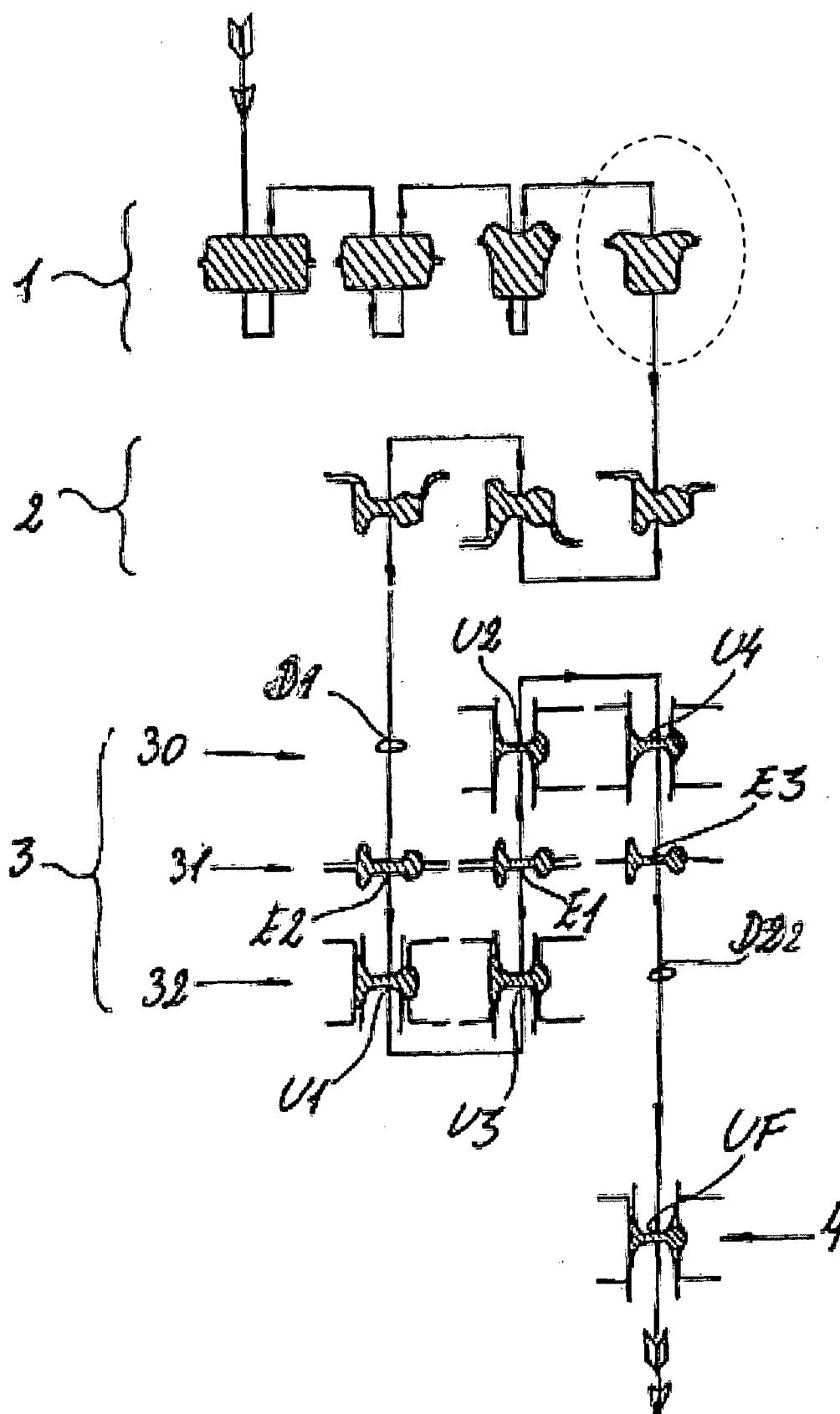


Figure 1

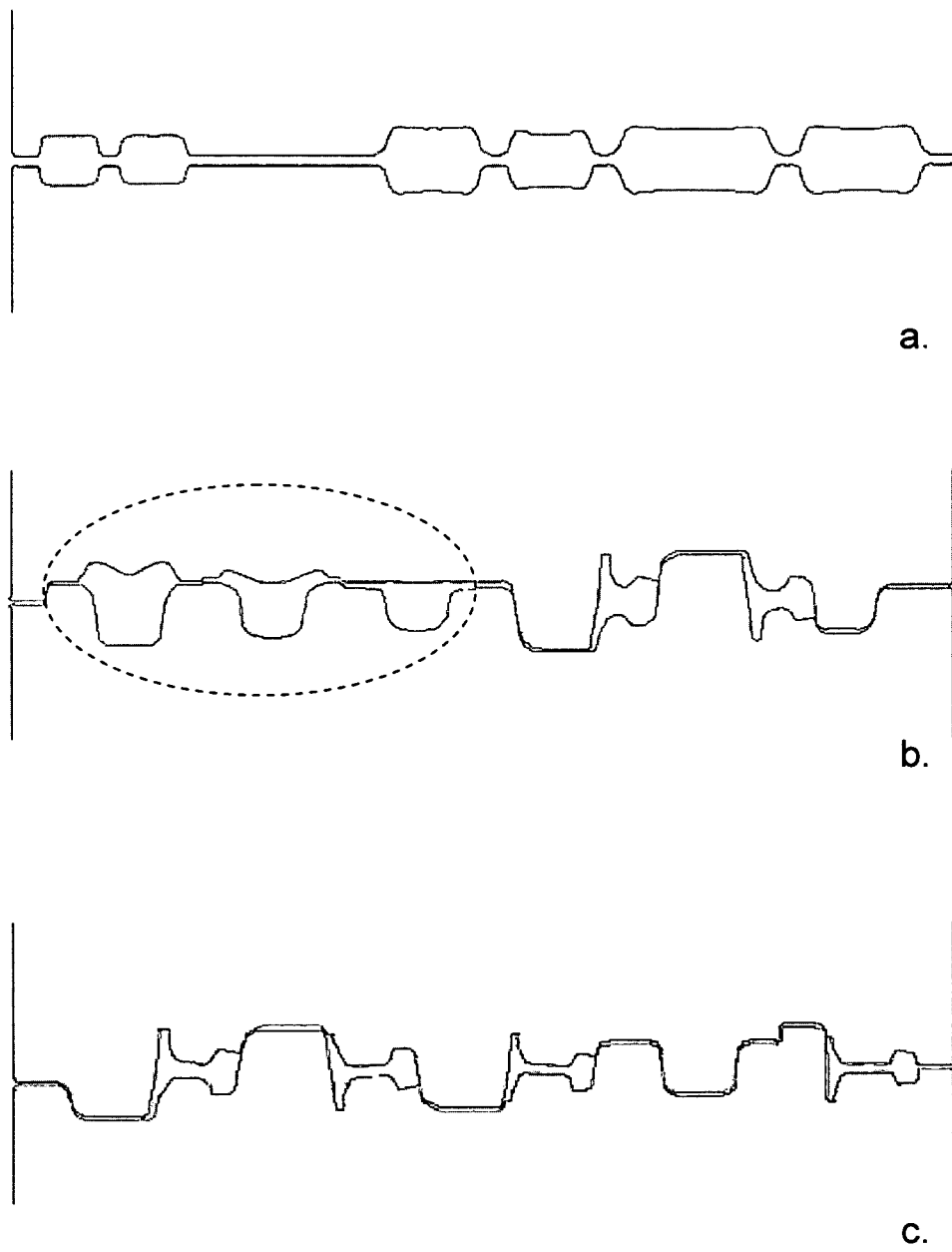


Figure 2

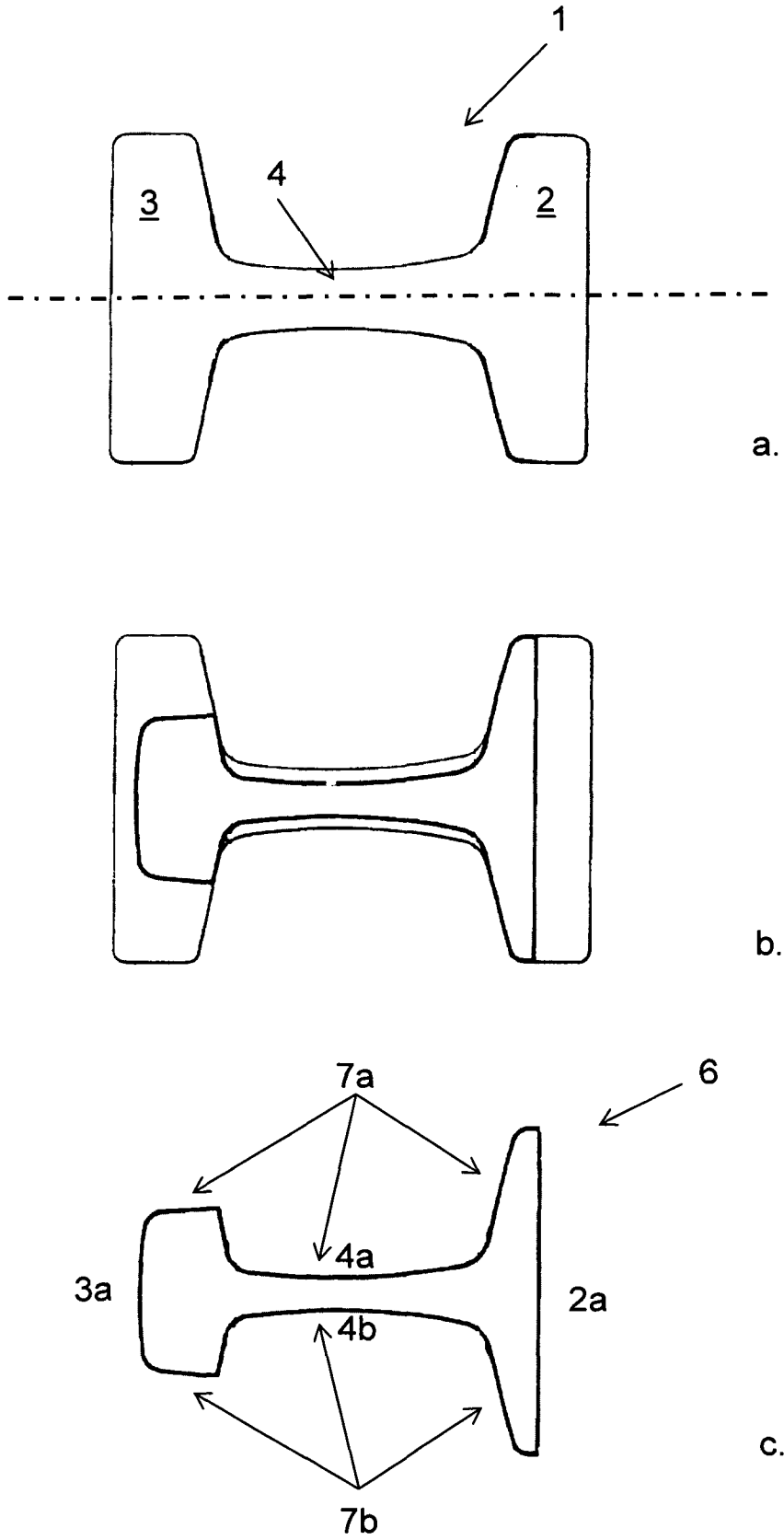


Figure 3

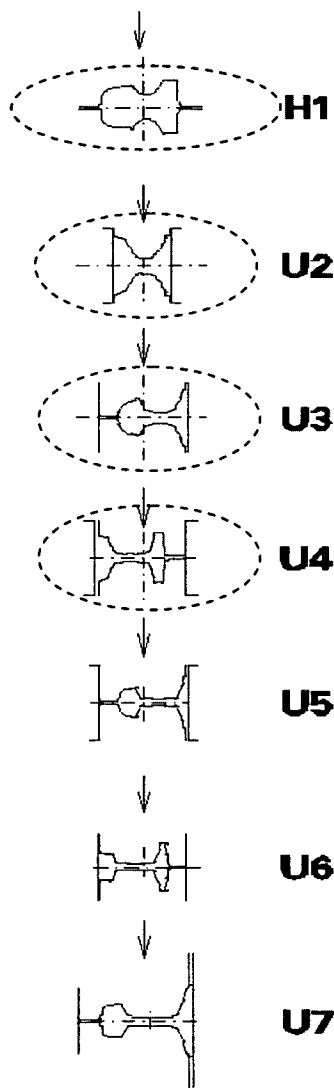
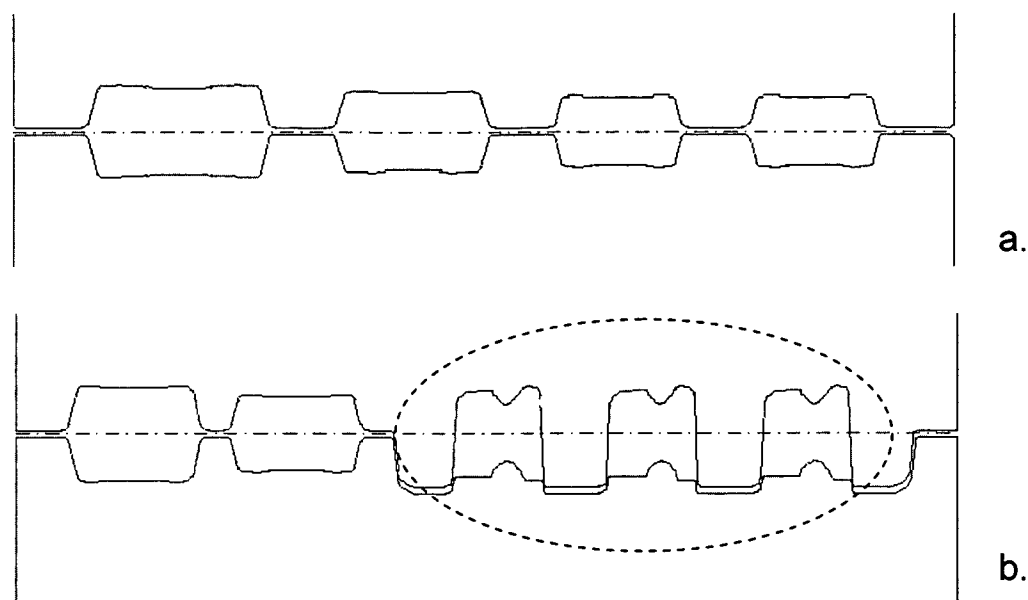


Figure 4

c.