United States Patent

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[73] Assignee **Nippon Steel Corporation Tokyo, Japan**

[32] Priority **Jan. 16, 1968**
[33] **Japan**
[31] **43/2,213**

[54] **METHOD AND APPARATUS FOR ROLLING STEEL MATERIAL AND RAILS OR SIMILARLY SHAPED PRODUCTS**
4 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **72/225**
[51] **Int. Cl.** **B21b 13/10**
[50] **Field of Search** 72/224, 225, 221, 226, 234

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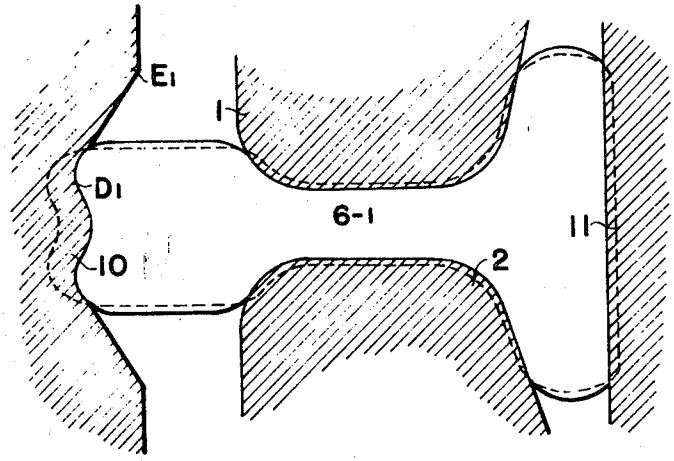
ABSTRACT: A method and apparatus for rolling steel material into steel products having flanges such as rails and H-shaped products by use of a universal rolling mill wherein the cross section along the direction of axis of the vertical roll of the universal rolling mill has a convex shape. Therefore, the rolling by such vertical roll gives a reduction of nearly V-shaped concentration to the part of the steel material contacting said vertical roll and to be made into a flange.



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4 Sheets-Sheet 1

FIG. 1 PRIOR ART

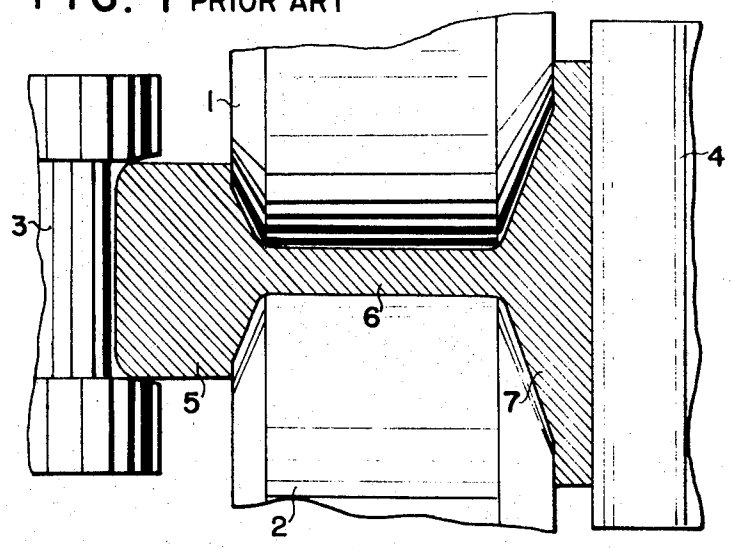

FIG. 2 PRIOR ART

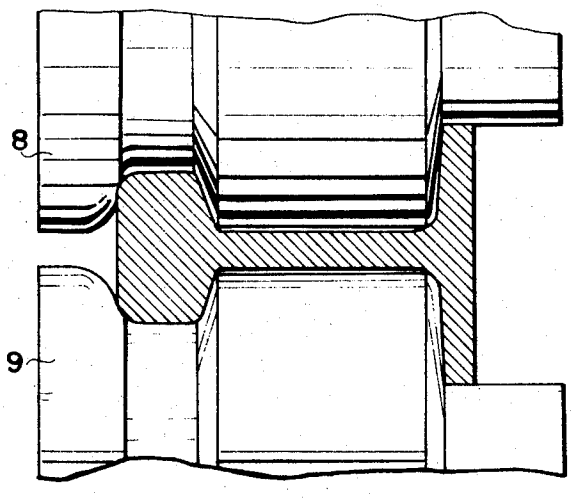

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FIG. 3A PRIOR ART

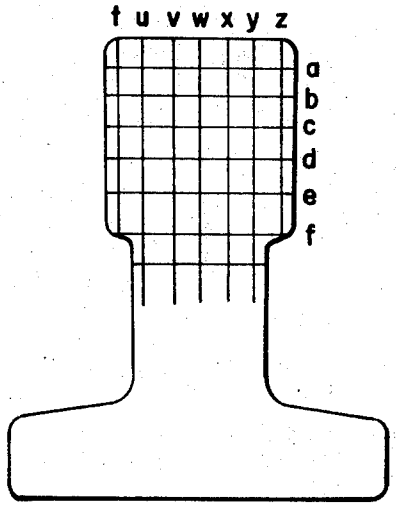

FIG. 3B PRIOR ART

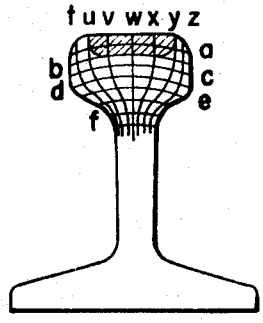

FIG. 4A

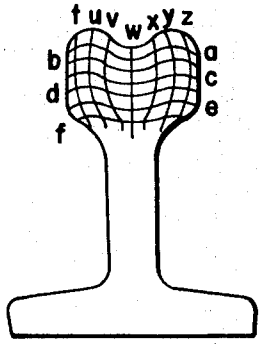

FIG. 4B

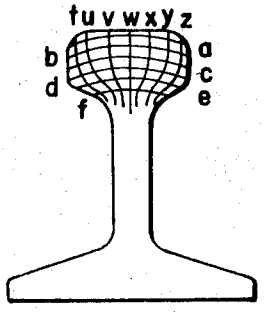

FIG. 5

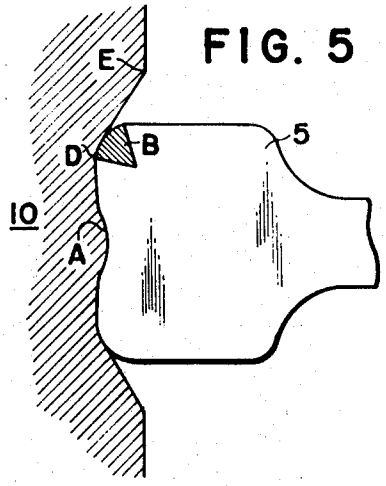

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FIG. 6

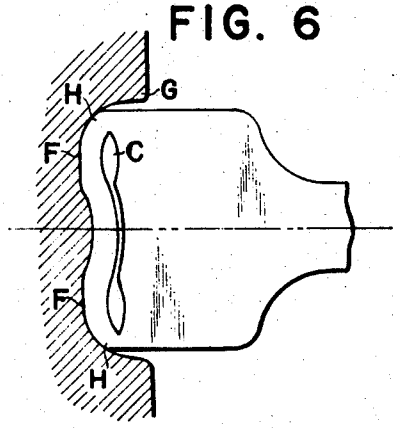

FIG. 7

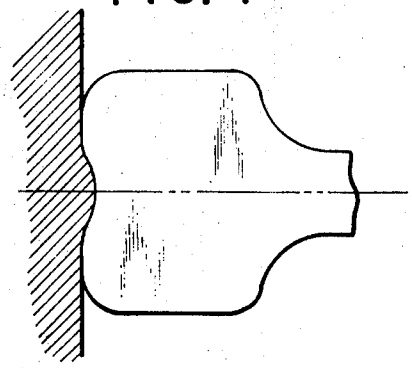

FIG. 8

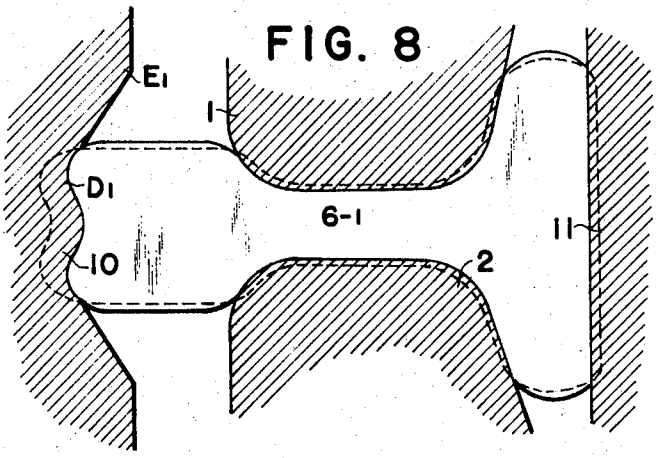

FIG. 9

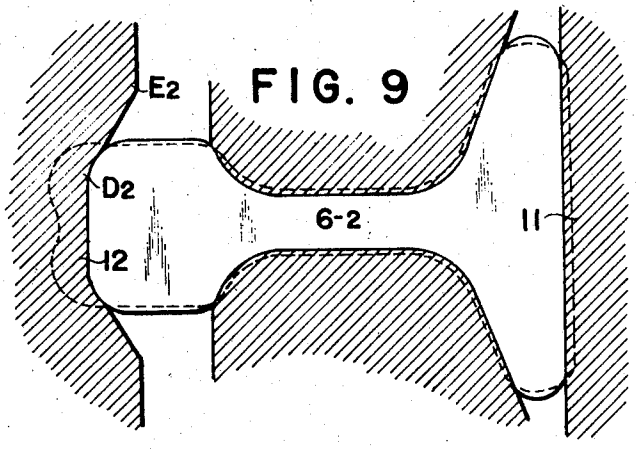

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FIG. 10

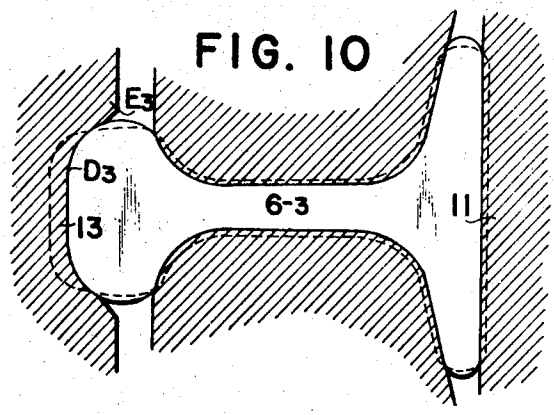
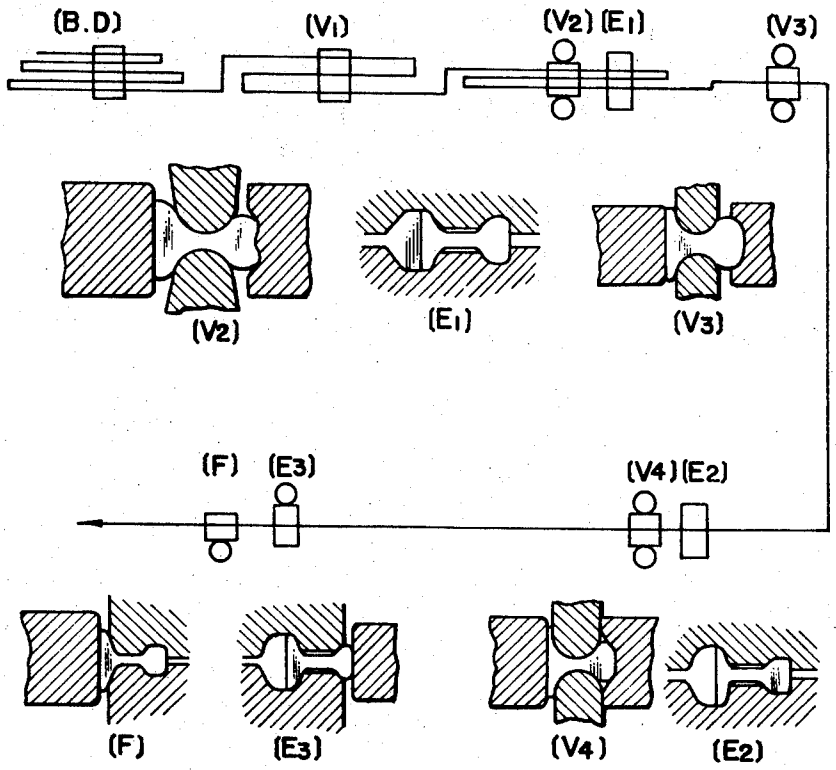


FIG. 11



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METHOD AND APPARATUS FOR ROLLING STEEL MATERIAL AND RAILS OR SIMILARLY SHAPED PRODUCTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and apparatus for rolling a steel material into rail or similarly shaped product such an H-shaped steel product or an I-shaped steel product by the universal rolling mill.

2. Description of the Prior Art

It is widely known that the rolling of steel material into products having flanges such as rails, H-shaped steel products, I-shaped steel products and T-shaped steel products by the conventional pass rolling methods, becomes more difficult as the cross section of such products becomes larger.

In order to overcome difficulties arising from the size of the rolled products, particularly when large as mentioned above, the conventional methods have been superceded by a rolling method using the universal rolling mill having vertical rolls as well as horizontal rolls.

The rolling by such universal rolling mill has the merit of forming the head, particularly of a rail which requires forging to a great degree, concentrically by the vertical rolls. That is, the surface of the head of the rail which contacts wheels, is required to meet the most severe conditions, compared with the other parts, and therefore, the concentrated forging of the surface of the head of rail is an important factor for the prolongation of the life of the rail as well as for the prevention of breakage which might cause accidents.

Also, concerning H-shaped steel products and I-shaped steel products of the ordinary type, increased forging of flanges is required the in view of the demand for increased strength as construction material. Though, as mentioned above, the universal rolling mill can concentrically forge the head of rail, even such concentrated forging leaves certain parts unforged (hereafter referred to as the "unforged zone"). This causes poor quality of product and the resulting complications, which constitutes an unavoidable problem in making rails and similarly shaped products by the universal rolling mill.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and apparatus for rolling a steel material into steel products having flanges such as rails, H-shaped steel products and I-shpaed steel products by the universal rolling mill, without the formation of the unforged zone on the flanges of the products, such as the head of the rail.

The special characteristic of the present invention lies in the improvement of the method for rolling steel material into a shaped steel product having flanges such as a rail or an H-shaped steel product by the universal rolling mill and also the improvement of the universal rolling mill per se, whereby the cross section along the direction of the axis of the vertical roll of said universal rolling mill has a convex shape, Therefore, the rolling by said vertical roll gives a reduction of V-shaped concentration to the central part of the steel material contacting said vertical roll.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates the rolling of a rail according to the conventional method using the universal rolling mill; FIG. 2 illustrates the operation of edger rolls set before and behind the universal rolling mill of FIG. 1; FIG. 3A and B illustrate metal flow during the rolling of a rail according to the conventional rolling methods of FIGS. 1 and 2: FIG. 3A shows metal flow while rolling a roughly preformed steel piece and FIG. 3B the condition of the metal after the rolling of the method of FIG. 1 is finished; FIG. 4A and B show metal flow during the rolling of a rail according to the present invention; FIG. 4A illustrating metal flow while rolling a roughly preformed steel piece of the same source as the piece of FIG. 3A, and FIG. 4B the condition of the metal after the rolling is finished; FIG. 5 illustrates the operation of the vertical rolls of the universal rolling mill on the head of rail according to the present invention; FIG. 6 illustrates the rolling according to the rolling method of FIG. 1; FIG. 7 exemplifies the modification of the rolling according to the present invention, showing the distribution of the same pressure when the vertical roll has only one convex part; FIG. 8 to FIG. 10 illustrates the rolling by the universal rolling mill according to the present invention, of which FIG. 8 shows that at first stage, FIG. 9 that at the middle stage and FIG. 10 that at the last stage; and FIG. 11 is a sketch of the overall process according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The following is the description of the preferred embodiment of the present invention using as an example of the rolling on a rail according to the present invention, compared with the conventional method.

FIGS. 1 and 2 illustrate the rolling of a rail using the universal rolling mill, as carried out conventionally.

By passing through a predetermined space between a pair of the horizontal rolls 1 and 2 and a space between the vertical roll 3 having the rolling pass shaped similarly to the head of the rail and the vertical roll 4 rolling the material from the direction of the part of the material to be made into the foot of the rail, the to-be-rolled material is reduced in the thickness of the head 5, of the web 6 and of the foot 7. In next step, as shown in FIG. 2, the material passes through a predetermined space between the horizontal rolls 8 and 9 (the so-called "edger rolls"); which passage is for the formation of the widths of the head and of the foot; the combination of the above rollings being carried out repeatedly until the desired sizes of the final product are obtained.

However, the rolling carried out by the conventional method, as mentioned above, is found to cause certain complications resulting in a poor quality product, which complications arise from the formation of an unforged zone in the surface of the head. This is due to the clinging of the object rolled by the hot rolling mill. The unforged zone does not contribute to extension or deformation of the material, even though a great reduction overall is obtained by such method.

FIGS. 3A illustrate the formation of the unforged zone, presenting the observation of metal flow of product when rolled by the rolling method of FIGS. 1 and 2, using an assumed network on the cross section of the roughly preformed steel piece. By this observation it is found that, compared with the central part, the surface part has some squares the height of which remain as high as before rolling, proving that the surface part was scarcely extended. Such zone is shown with oblique lines in FIG. 3B though it does not exist actually with such a distinct boundary. The area of the oblique lines varies according to ratios of the thickness and the width of the material, reductions, etc.

The presence of such unforged zone causes complications during rolling operations, resulting in poor quality or breakage of product, as follows:

1. The presence of such unforged zone necessitates a great reduction in load. More in detail, when comparing the reductions H of thickness H of the material with and without the presence of the unforged zone having a thickness I, the reduction rate of the latter case is represented by $\Delta H/H$, and that of the former by $\Delta H/H - I$. Such comparison makes it clear that in order to obtain a reduction of ΔH, the former case required a greater reduction rate, and a correspondingly greater reduction load than the latter case.
2. Distortion of the to-be-rolled material may occur due to the difference in extension rate between the surface part containing the unforged zone and other parts.
3. Defects may be produced.

4. As it is impossible to quantitatively determine the influence of the presence of the unforged zone on the extension rates of the head, web and foot, it is difficult to balance reductions among them.
5. As the extension rate of the surface part is small, uneven deformation tends to occur from one place to another of the same cross section, producing residual stress.
6. Also due to the above-mentioned uneven deformation, shearing stress is produced on the boundary line, causing such difficulties as crack and breakage of the product by impact while in use.

The present invention is based on the finding that the modification of the shape of the rolling pass of the vertical roll can eliminate the unforged zone.

FIG. **5** shows the head of rail deformed by the vertical roll of the universal rolling mill according to the present invention, the part A of the vertical roll **10** corresponding to the central part of the head of rail **5** having a convex shape.

Thus, the unforged zone produced in the head of the rail is subjected to concentrated reduction by said convex part of the vertical roll, resulting in enforced rolling of the unforged zone.

This operation condition is clearly illustrated in FIG. **4A** and B. In this case was used a roughly preformed steel piece of the same source as that used in the rolling of FIG. **3A**. FIG. **4A** shows metal flow while rolling said steel piece into the head of a rail while subjected to concentrated reduction by the vertical rolls each having a convex shape according to the present invention; and FIG. **4B** shows the so rolled finished product. When comparing metal flow shown in FIG. **4A** with that of the rolled product of the conventional method shown in FIG. **3** B, the product of the present invention contains a much smaller unforged zone, by which it can be seen that the present invention provides an improved effective rolling method. If a rail having a very broad head is to be made, the vertical roll may be provided with two or more convex parts, so as to eliminate the unforged zone more effectively.

However, for complete elimination of the unforged zone as shown in FIG. **4B**, restriction in the direction of width of the rail must be considered, as well as the provision of one or more convex parts.

In the rolling of a rail by the universal rolling mill, particularly for the strong forging of the corner part B of the head of the rail FIG. **5**, it is reportedly important that the vertical roll of the universal rolling mill and the edger rolls set before and behind it should maintain contact with said corner part B during the entire rolling operation. This, of course, causes the extension of the material in the direction of the width to be restricted.

However, it has been found that the restriction of extension in the direction of the width during rolling by the universal rolling mill is contradictory to the above mentioned elimination of the unforged zone. Since the extension in the direction of the width is restricted during such rolling, even if a concentrated reduction with the convex part of the vertical roll is given to the head of the rail, the unforged zone is not completely eliminated, but part moves toward the corner part B as shown by C in FIG. **6**. That is, as the curved part FG of the vertical roll of the conventional type contacting the corner part B is usually so sharp as to effect forging of the corner part B, the extension in the direction of the width is restricted particularly by the part H.

On the contrary, as shown in FIG. **7**, a vertical roll having a convex shape in the center but without any device to restrict extension in the direction of the width may be used. This method is effective for the elimination of the unforged zone, but there may occur from time to time misalignment of the convex part of the vertical roll with the central part of the head of the rail when the extension in the direction of the width is not restricted. This is caused by the action of the lower horizontal roll of the universal rolling mill which is generally positioned above the surface of the roll table, and pushes up against the tip of the to-be-rolled material as carried over by the roll table and charged into the rolling mill.

Therefore, in order to avoid such misalignment taking place when the rolls contact the material, a restriction to some degree of extension in the direction of the width is required. More in detail, the rolling pass of the vertical roll **10** includes the concave parts D on both sides of the convex part A, and the curve DE (or taper DE) of the concave part is made sharper than the curve of the corner part B of the final product. Thus, the extension of the corner part (B) of the rail is partly restricted, but care must be taken not to give excessive restriction to the extension of the material in the direction of the width.

According to the present invention, it is desirable to provide such universal rolling mill at as early stage of the process as possible, since the rolling pass used at the middle stage should take a profile as nearly resembling the shape of the final product as possible. This is true since the formation of a concave part in the central part of the head anew at this stage constitutes an additional process, which addition is not effective; since rolling has progressed to a considerable extent, making it impossible to provide a convex part large enough to eliminate the unforged zone.

Another reason, other than that above-mentioned is, that wrinkles may be produced from time to time at the next stage for making up the concave part provided to eliminate the unforged zone. FIGS. **8** to **10** illustrate the rolling into of a rail at each stage: FIG. **8** shows that at the early stage, FIG. **9** shows that at the middle stage, and FIG. **10** shows that at the final stage.

According to the present invention, there are provided edger rolls of the ordinary type before and behind the universal rolling mill, as illustrated in FIG. **11**.

The vertical roll **10** of the universal rolling mill used at the early stage of rolling has the rolling pass shaped like the letter "W," which concentrically reduces the whole of the part of the to-be-rolled material **6—1** to be made into the head. At the same time, the thickness of the part to be made into the web and of the part to be made into the foot are reduced respectively by a pair of the horizontal rolls **1** and **2** and the vertical roll (**11**).

At the middle stage, the material which has passed through the previous stage, is subjected to reduction on the part to be made into the head by the vertical roll **12** having a rolling pass for smoothing said part.

An important thing regarding the rolling at this stage is that the part of the material to be made into the head has been subjected to the reduction of V-shaped concentration but since has been sufficiently forged, and the tip D, of the concave part corresponding to the corner part of the head of the final product forms a sharp angle against its skirts, forging is achieved at the same time as the smoothing operation.

As a result, it becomes unnecessary to keep the vertical roll and the edger rolls of the universal rolling mill in contact with the corner part of the head, as mentioned above. But the taper $\overline{DE}$ of the vertical roll is made relatively greater and more like the shape of the final product toward the end of the rolling operation, that is, at the middle stage (FIG. **9**) and the final stage (FIG. **10**), by gradually making greater the above-mentioned restriction of extension in the direction of the width; for example, if the taper for $\overline{D_1E_1}$ is 1/2, that for $\overline{D_2E_2}$ is made 1/2—1/1.5 and that for $\overline{D_3E_3}$ 1/1.

FIG. **11** shows one example of the overall rolling apparatus according to the present invention. [B.D.] indicates the breakdown equipment for making a roughly preformed steel piece from a lump of steel, which is subjected to several passes and charged into the rough rolling mill [V_1]. Then, rolling of the material is carried out by the universal rolling mill [V_2] and the edger rolls [E_1], which stage constitutes the above-mentioned early stage of rolling.

Having been discharged from the edger roll, the material is charged into the universal rolling mill [V_3], the rolling which constitutes the middle stage. After one pass by [V_3], the material is contacted by the edger roll [E_2] and the universal rolling mill [V_4], such rolling constituting the final stage, and

then for rolling the part to be made into the head, the material is charged into the edger roll [E_3] having the vertical roll and finished by the finishing roll [F].

The processes of rolling by respective rolls are shown in FIG. 11.

As mentioned above, the present invention makes possible stable rolling operations for making such shaped steel products as rails by adjusting the profile of the rolling pass of the vertical roll, thereby overcoming such difficulties as mentioned above in connection with rolling operations, and giving strong forging to the part of the material to be made into the head, particularly of a rail which is required to meet severe operating conditions.

I claim:

1. In a method for rolling by the universal rolling mill steel material into shaped steel products having flanges such as rails and H-shaped articles, the improvement comprising subjecting the part of said material to be made into a flange to a first rolling operation by a first vertical roll concentration of reduction force to the center of said part while preventing substantial restriction of extension of said part in the width direction thereof, thereby preventing the formation of an unforged zone of said part; subjecting said part to a second rolling operation by a second vertical roll of said universal rolling mill including imparting a smoothing reduction force to said part while increasing the restriction of extension of said part in the width direction thereof; and subjecting said part to a third rolling operation by a third vertical roll of said universal rolling mill

including imparting a further smoothing reduction force to said part while further increasing the restriction of extension of said part in the width direction thereof.

2. In a universal rolling mill for rolling steel material into shaped steel products having flanges such as rails and H-shaped articles, the improvement comprising a first vertical roll adapted to contact that part of said material to be made into a flange, said first vertical roll having a convex portion around the periphery thereof adapted to impart a concentrated V-shaped reduction force to the center of said part, and concave portions on either side of said convex portion, the outward extensions of said concave portions forming curves having a lower rate of curvature than the corners of said part when finished, said curves adapted to prevent substantial restriction of extension of said part in the direction of the width thereof.

3. In a universal rolling mill as claimed in claim 2 the further improvement comprising a second vertical roll adapted to contact said part, said second vertical roll having curves similar to but having a higher rate of curvature than said curves of said first vertical roll.

4. In a universal rolling mill as claimed in claim 3, the further improvement comprising a third vertical roll adapted to contact said part, said third vertical roll having curves similar to but having a higher rate of curvature than said curves of said second vertical roll.