

Feb. 6, 1934.

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1,946,240

HOT ROLLING STEEL STRIPS

Filed Aug. 20, 1930

2 Sheets-Sheet 1

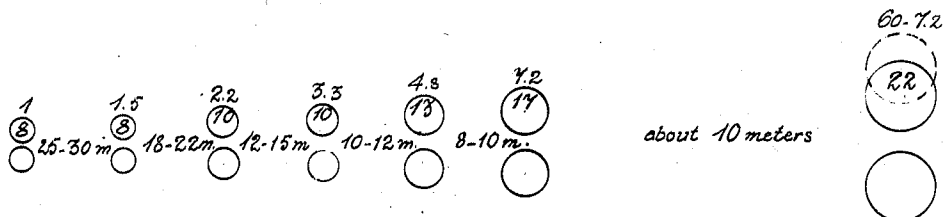


Fig. 1 (Old form)

Figures in the Circles - Diameters of Rolls in Inches 1:40
 Figures above the Circles - Thickness of Material in Millimeters 1:4
 Figures between Pairs of Rolls - Distances in Meters

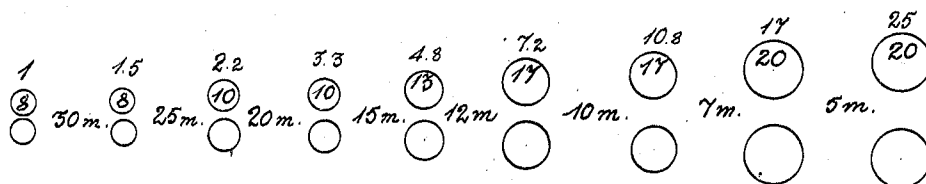


Fig. 2 (Old form)

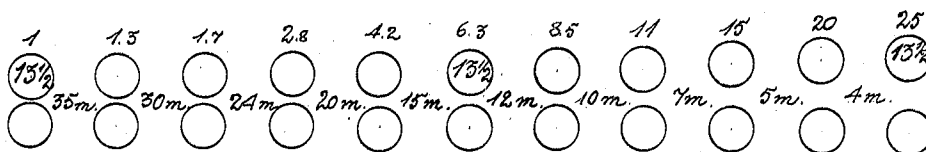


Fig. 3 (Old form)

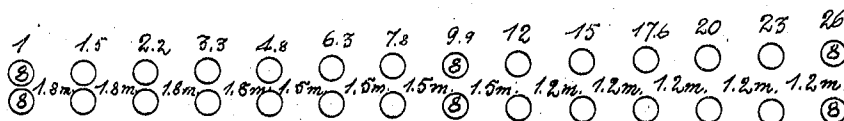


Fig. 4

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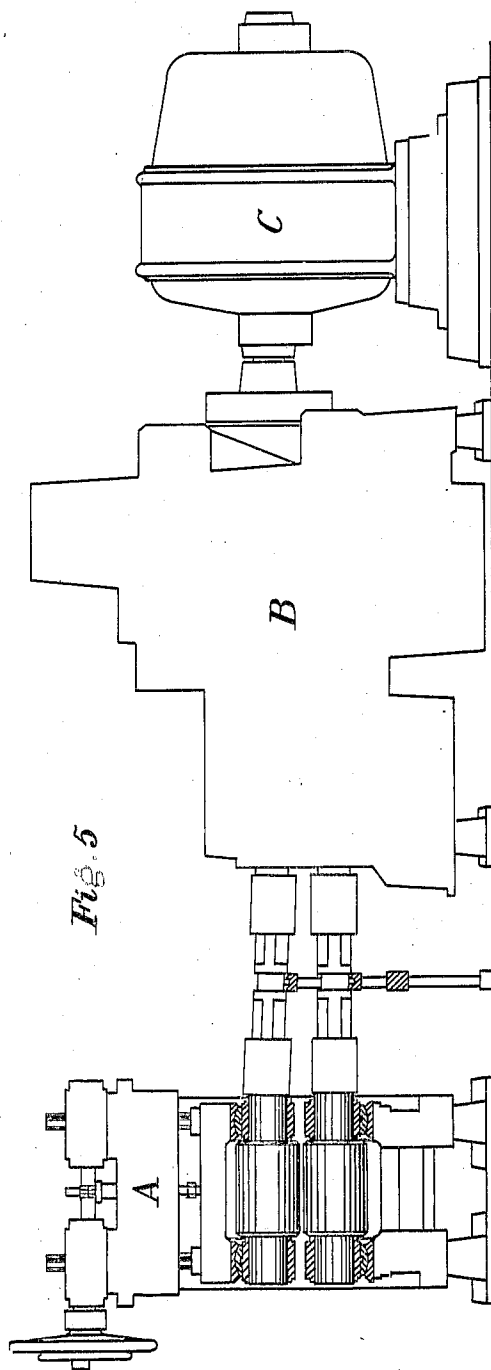
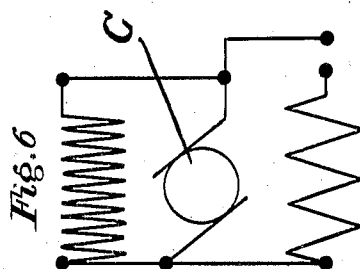
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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HOT ROLLING STEEL STRIPS

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5 Claims. (Cl. 80—60)

My invention relates to the rolling of bands or strips from ingots, billets or bars and provides a continuous method of hot rolling and a continuous hot strip mill by which such operations
5 can be carried out more efficiently at lower costs, for construction and operation, than heretofore.

In the rolling mills hitherto in use serving for continuously rolling bands of different width only a few rolling stations, each comprising a
10 pair of rolls, in most cases 3-5 are mounted one directly behind the other and when the blank to be rolled is passing through these few rolling stations it is allowed to run through altogether. The further rolling stations required to finish
15 the rolling operation are as a rule not disposed one behind the other but aside from the other and the blank is rolled out in these latter stations with the formation of loops. In other cases there follow behind the first group of 3-5 roll-
20 ing stations one or two other groups of 3-5 stations, the space between the different groups being so large as to allow the material being rolled to come entirely out of contact with the rolls. Obviously the passing through of the whole blank
25 through the first stations as also the running of the blank in loops or through the intervening spaces causes the blank or band under operation to cool down considerably, which is very unsatisfactory. Following this design it was only
30 possible to reduce the material from an initial thickness to a final thickness at a ratio of not more than 1:10 or 1:12.

The rate of reduction in the single passes is so chosen that in each rolling station the per-
35 centage of reduction of thickness is such that the material to be rolled out can just stand it, it being desired to obtain the greatest possible reduction with the least possible number of rolling stations, in consequence thereof in the first
40 rolling stations of a continuous band rolling mill rolls of large diameters are provided. The diameter of the rolls decreases from one station to the next following one until the blank under operation passes through between rolls, the
45 diameter of which is small as compared with the diameter of the rolls in the first stations. This reduction of diameters is due to two circumstances: If an equal percentage reduction of the thickness of the blanks to be rolled out is desired, there is adopted for an ingot or billet
50 initially 50 mm. thick a reduction of 15 mm. in the first pass and of 10 mm. in the second pass, so that the blank is reduced first to 35 and thereafter to 25 mm. But when the blank has
55 been reduced to 10 mm. there is only a further

reduction of 3 mm. In consequence thereof the substantially tapered portion of the blank which connects the portion of the blank about to enter between the rolls with that portion which has
60 already passed through between the rolls will be considerably longer during the first passes than during the last ones, so that in the first stations higher rolling pressures and in consequence thereof also stronger rolls are required. Furthermore the grip of the rolls on the blank
65 depends upon the angle enclosed between the entering portion of the blank and the inclined portion connecting same with the portion leaving the rolls, so that in the first passes, in order to obtain a secure gripping of the blank, the rolls
70 must have a larger diameter, in order that this angle be kept sufficiently small. If for instance the blank to be rolled out has an initial thickness of 50 mm., it is first passed through be-
75 tween rolls having a diameter of 420 mm. After the thickness has been reduced to 20 mm. the blank is passed through between rolls of 310 mm., and after the thickness of the blank has been reduced to 3 mm. it is passed through between
80 rolls of 250 mm. in diameter.

Obviously rolling mills constructed on this principle involve the disadvantage of requiring a great number of pairs of rolls of different diameters, the largest one commanding a very high price, more especially if ingots of great thickness
85 are rolled.

In contradistinction thereto the new rolling mill according to the present invention is provided in most or all of the rolling stations with rolls having the same diameter. I prefer choos-
90 ing the diameter of the rolls in such manner that it is especially suited as far as the mechanical and metallurgical properties of the raw material are concerned for the smallest thickness of the blank leaving the rolls.
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Obviously in a rolling mill of this kind it will not be possible to attain in each rolling station the highest reduction admissible for the material under treatment, but it will be necessary to roll
100 it out in a greater number of single passes, in order to reduce it from a predetermined initial thickness down to a predetermined final thickness.

If it is desired to roll a billet with an initial thickness of 50 mm. down to a final thickness of
105 1 or 0.8 mm., the blank should first be reduced in succession to 42-35-29-24 mm., so that instead of the two passes mentioned above four passes must be used in this case. However in the further
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treatment of the blank the same number of passes as hitherto used will suffice.

On the basis of 250 mm. for a final pass of 3 mm. referred to above as a common practice and even for a final pass of 1 to 1.5 mm. assumed to be best suited to the final reduction, the ratio of the roll diameter to the pass is somewhat less than 250 to 1. Assuming such a ratio for the present example, the rolls for the final pass would have a diameter less than 250 mm. All roll diameters being substantially equal, the ratio of the roll diameter in the first stand to the initial thickness would be somewhat less than 5 to 1; generally between 5 to 1 and 3 to 1.

The invention is illustrated in the annexed diagrammatic drawings in which the size and number of the rolls in the usual mills and in a mill according to the present invention are shown by way of comparison.

Fig. 1 indicates the usual arrangement of a mill in which the billets are first stepwise reduced in a reversing mill provided with rolls having a diameter, for instance, of 22 inches by gradually narrowing the gap between the rolls. Thereafter the plates are passed, for instance, through two pairs of rolls having 17 inches and 13 inches in diameter respectively, then, as the case may be, through two pairs having 10 inches and two other pairs having 8 inches in diameter. The next progress in developing the rolling mills involved the use of two continuous pairs of rolls with fixed gauge having a diameter of 20 inches only, as shown in Fig. 2.

When going over from these usual mills to mills having rolls of uniform diameter it would be obvious at first sight to employ rolls having a diameter corresponding to the average diameter of the rolls shown in Figs. 1 and 2. Thus, for instance, diameters of about 16 inches would be adopted. When employing such rolls about 11 pairs of rolls would be needed instead of 9 as shown in Fig. 2.

The rolls of the mill shown in Fig. 3 are accommodated to the rolling work in the middle of the mill and do there the optimum rolling work. For the first sets they are a little too small considering the fact that the reduction should be as high as possible in each set. For the last sets they are too large and therefore do not permit a reduction of thickness that would be sustained by the material under treatment per se, and they consume more power than smaller rolls. Moreover, the rolls for the last stands have an excessive price owing to their size.

Now according to the present invention the work is done as shown in Fig. 4, that is to say the rolls are of uniform diameter corresponding to the diameter of the smallest rolls shown in Figs. 1 and 2, viz. 8 inches in the present example. It is true that the number of sets must be further increased over that shown in Fig. 3. The rolls are now so selected that in the last sets a strong reduction in thickness is obtainable, that the consumption of power amounts to a minimum, that the rolls in the last sets are accommodated to that rolling pressure which is produced in the last sets with the greatest admissible reduction in cross-section. In this case the percentile reduction in cross-section in the first sets must be smaller than in rolling mills according to Figs. 1 and 2, as the small rolls would not grip, that is to say draw in the material by friction into the gap between the rolls, and as with decreasing diameter of the rolls the pressure to which these

rolls may be exposed diminishes. Consequently the number of stands must be increased.

Calculation shows that in spite of the greater number of rolling stations required the total cost of construction of a rolling mill according to the present invention is lower than that of a rolling mill with a less number of stations, the first of which are provided with particularly large sized rolls.

The invention further offers the advantage that the rolls of all stations can be exchanged so that only a comparatively small number of reserved rolls need be kept in stock.

I obtain the still further advantage that the rolls of the last stations, after having been worn down, can still be used in a preceding station, through which a thicker blank is passing, so that a far better utilization of the single pairs of rolls is obtained than if each station or group of stations were provided with rolls of different diameters.

Furthermore all reserve housings and other reserved parts only a single type is required to be kept in stock. If the rolls of the last passes are worn down they need not be removed from their housing, but the housing and the rolls can simply be shifted onto a preceding station.

The rolls are preferably driven by electric motors, one for each station, compound wound so as to have a characteristic lying between that of a shunt motor and that of a series motor with such a ratio of the shunt windings to the series windings that the speed of each motor will be adjusted to occasional variations in the load on its stand of rolls and will avoid the looping or straining of the strip between the rolls.

The speed of each roll is automatically maintained in such relation to the reduction to be made in the thickness of the strip as to exercise on the strip only such a moderate pull as will prevent looping and straining between successive stands, notwithstanding variations of the load which may occur at any stand. For example, in a mill installed in accordance with the invention, if the load on any stand of rolls is increased or reduced 100 per cent (by variations in the thickness of the strip entering the rolls), there will be a drop or an increase in the revolutions per minute of the motor which is more than half as large as the percentage reduction (in thickness of the strip) to be effected by the rolls of the stand in question, under normal conditions.

For a reduction of 18 per cent in thickness of the strip, the speed of the motor tends to drop about 10 per cent. For a reduction of 35 per cent in thickness of the strip, the speed of the motor tends to drop about 20 per cent. Thus, if of adjacent motors the first one has practically no reduction to effect on the strip, its speed would be increased, but, because no elongation by reduction of the thickness takes place, the strip is fed more slowly to the second one. Here the reduction required, may be double the normal. The speed of the rolls will be reduced because of the increased load, and the relative speeds of both motors adapt themselves to each other. The double reduction in thickness of the strip will cause an increase of its exit speed sufficient to compensate for the reduction of speed of the two stands and to restore the normal rate for the following stands. Such conditions may occur from time to time along the entire series of rolls so that their average rate will be that required, and the minimum rate will in no case be sufficient to permit the formation of loops be-

tween the stands. Each motor is independent of direct control from the others and is, in fact, controlled by the load on it within limits which maintain the desired condition. No automatic switches nor relays need to be used for the speed control. The whole control of speeds, torques and loads of each motor is effected by its winding under the influence of its own load. When the load on it is reduced to practically nothing, its speed will be increased to that which is sufficient to take up the strip. When its load is increased, such increase is limited to 100 per cent by the slowing down of the motor so that no one motor will get more than double its normal load. Each motor effects a rolling speed which adapts itself automatically to the speed of the preceding and succeeding stands without looping or straining of the strip.

Where a reduction of 20 to 1, or greater is to be carried out in a continuous mill of this type, including a comparatively large number of single stands, each having rollers of diameters which are smaller than usual, it is very important that the stands should be as close together as possible to prevent the strip from cooling too much. The motors described facilitate the reduction of the space between the stands. With this arrangement a far greater number of stands can be disposed in line without substantial gaps between them than in accordance with the previous practice. This permits the passing of the strip through a greater number of stations in one heat, which involves a great saving of time, floor space and heat.

For this reason, the strip can be passed out of the last stand at a comparatively high temperature so that the total consumption of power will be smaller than usual. It is the last stations which consume the greatest percentage of the total power of such an assembly of rolls. By operating them upon a hotter blank, considerable power is saved.

In cases where it is desired to obtain a product with predetermined properties which require that it leave the rolls at a comparatively low temperature, as is for instance the case with knife blades, the large number and close spacing of the roll stands permits the entry of the billet into the first stand at a lower temperature than usual, because the loss of heat during rolling is comparatively low. The use of a billet of comparatively low temperature also involves less waste by scaling. A better worked and less overheated metal structure is also obtained, which is a great desideratum in the case of knife blade steel.

Inasmuch as the drop in the number of revolutions per minute of the motor depends on the reduction to be effected in the thickness of the strip, the motor characteristics cannot be illustrated in such a way as to apply to all cases. Fig. 5, however, is a side elevation of a pair of rolls in a stand A driven through a gear box B from a compound wound motor C; which is separately illustrated in Fig. 6 with its two different windings.

In this manner it is not only possible to obtain a stretching of the material to be rolled in a proportion from 1:10 to 1:12 within a single group of rolling stations, as was hitherto the case, but it is even possible to obtain a stretching of the blank of 1:30 and even 1:50 with one group of rolling stations, which are only slightly spaced from each other and without any intermediate discharge spaces or spaces for forming loops.

Various changes may be made in the details disclosed in the foregoing specification without de-

parting from the invention or sacrificing the advantages thereof.

In the claims affixed to this specification no selection of any particular modification of the invention is intended to the exclusion of other modifications thereof and the right to subsequently make claim to any modification not covered by these claims is expressly reserved.

I claim:—

1. The method of rolling a steel strip from a hot billet or the like which includes passing the blank continuously without re-heating through a comparatively large number of successive stands of rolls in alinement and close together so as to conserve the heat in the blank, maintaining wholly or chiefly by the rolls the necessary tension to prevent looping between stands, using rolls which are of the same comparatively small diameter best suited to the permissible reduction at the temperature of the blank in the last pass, effecting in each of the first passes a much less reduction than is permissible at the temperature of the blank and compensating for the slight reduction per pass by an increased number of passes.

2. The method of rolling a steel strip from a hot billet or the like which includes passing the blank continuously without re-heating through a comparatively large number of successive stands of rolls in alinement and close together so as to conserve the heat in the blank producing and, maintaining wholly or chiefly by the rolls the necessary tension to prevent looping between stands, using rolls throughout the mill which are of the same comparatively small diameter best suited to the permissible reduction at the temperature of the blank in the last pass, effecting in each of the first passes a much less reduction than is permissible at the temperature of the blank and compensating for the slight reduction per pass in the first stands by an increased number of passes, driving each pair of rolls by an independent motor and automatically controlling the speed of each motor by variations in its own load only and within limits which prevent looping or excessive tensioning of the blank.

3. The method of rolling a steel strip from a hot billet or the like which includes passing the blank continuously without re-heating through a comparatively large number of successive stands of rolls in alinement and close together so as to conserve the heat in the blank producing and, maintaining wholly or chiefly by the rolls the necessary tension to prevent looping between stands, reducing the thickness in the last pass to less than one-twelfth of the initial thickness of the billet, using rolls throughout the mill which are of the same comparatively small diameter best suited to the permissible reduction at the temperature of the blank in the last pass, effecting in each of the first passes a much less percentile reduction than is permissible at the temperature of the blank and compensating for the slight reduction per pass in the first stands by an increased number of passes.

4. The method of claim 3 using a ratio of roll diameter to the last pass which is less than 250 to 1 and a ratio of roll diameter to the first pass which is less than 5 to 1.

5. The method of rolling a steel strip from a hot billet or the like which includes passing the blank continuously without re-heating through a comparatively large number of successive stands of rolls of the two-high self-supporting type in alinement and close together so as to

conserve the heat in the blank producing and, maintaining wholly or chiefly by the rolls the necessary tension to prevent looping between stands, reducing the thickness in the last pass 5 to less than one-twelfth of the thickness of the billet, using rolls throughout the mill which are of the same comparatively small diameter best suited to the permissible reduction at the tem- perature of the blank in the last pass, effecting in each of the first passes a much less reduction than is permissible at the temperature of the blank and compensating for the slight reduction per pass in the first stands by an increased num- ber of passes. 8

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