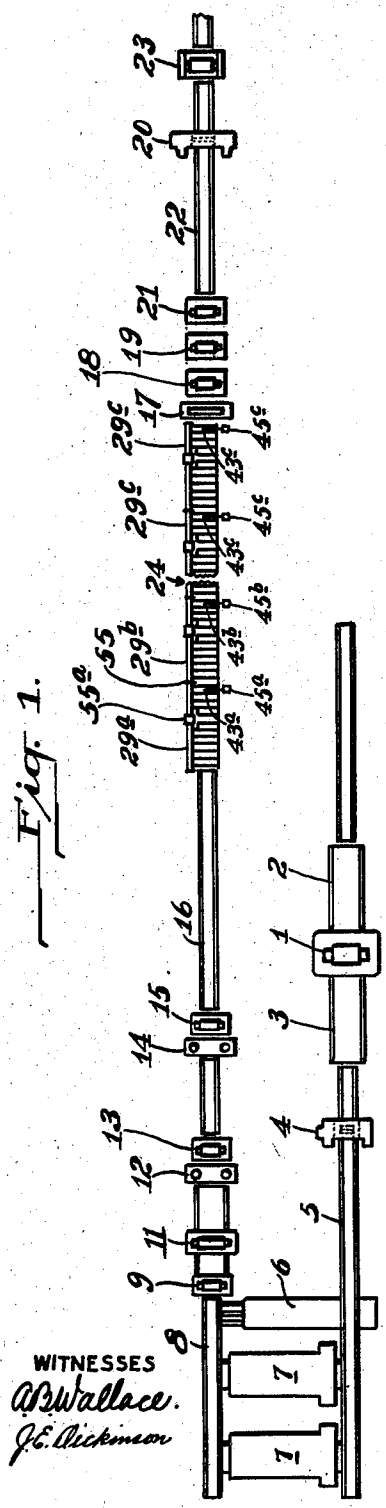
Oct. 12, 1937. F. C. BIGGERT, JR 2,095,430

METHOD AND APPARATUS FOR ROLLING METALLIC STRIP

Filed March 7, 1935 4 Sheets-Sheet 1

Fig. 1.

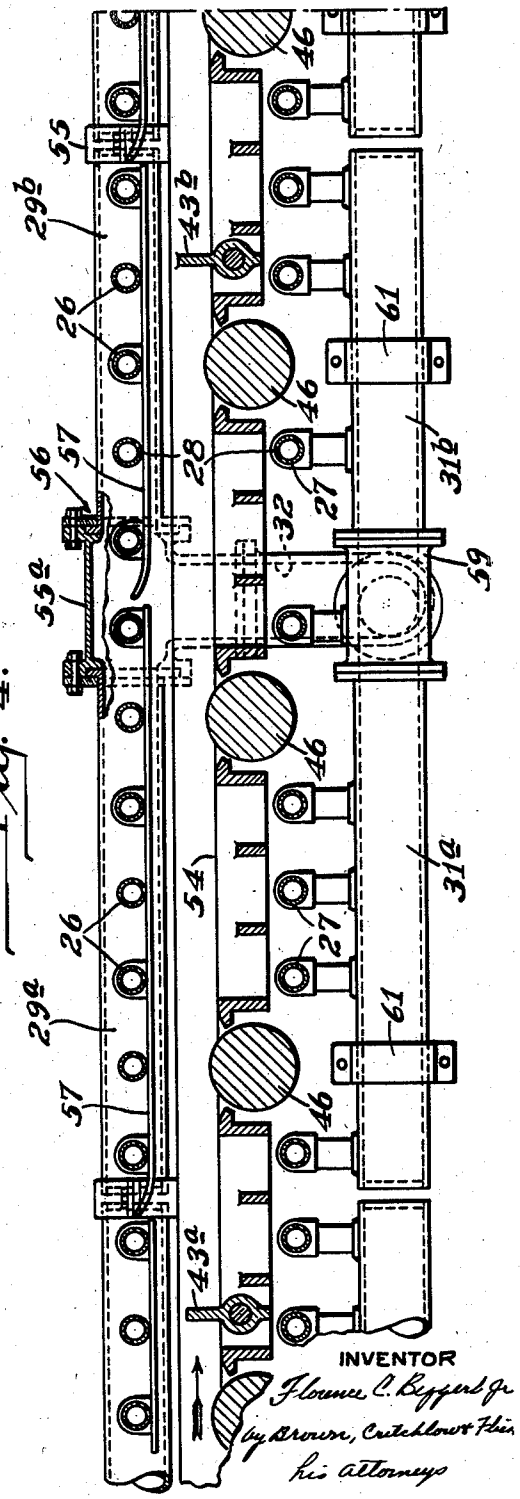


WITNESSES

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Fig. 4.



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METHOD AND APPARATUS FOR ROLLING METALLIC STRIP

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Fig. 2.

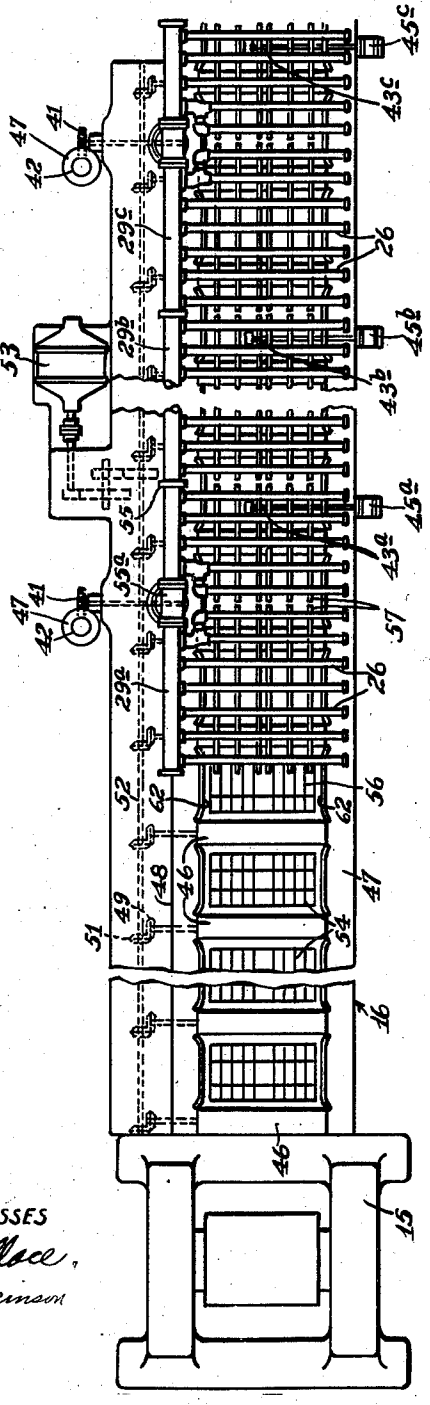


Fig. 10.

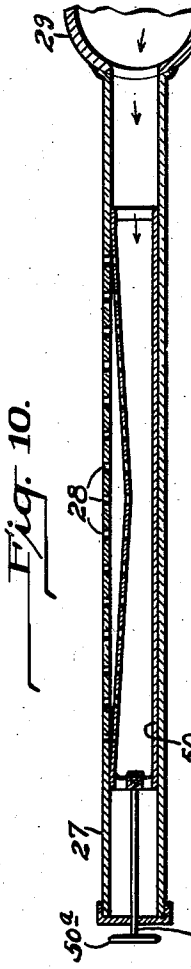


Fig. 9.

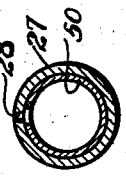
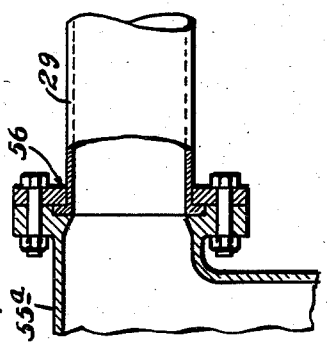


Fig. 8.



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METHOD AND APPARATUS FOR ROLLING METALLIC STRIP

Filed March 7, 1935 4 Sheets-Sheet 3

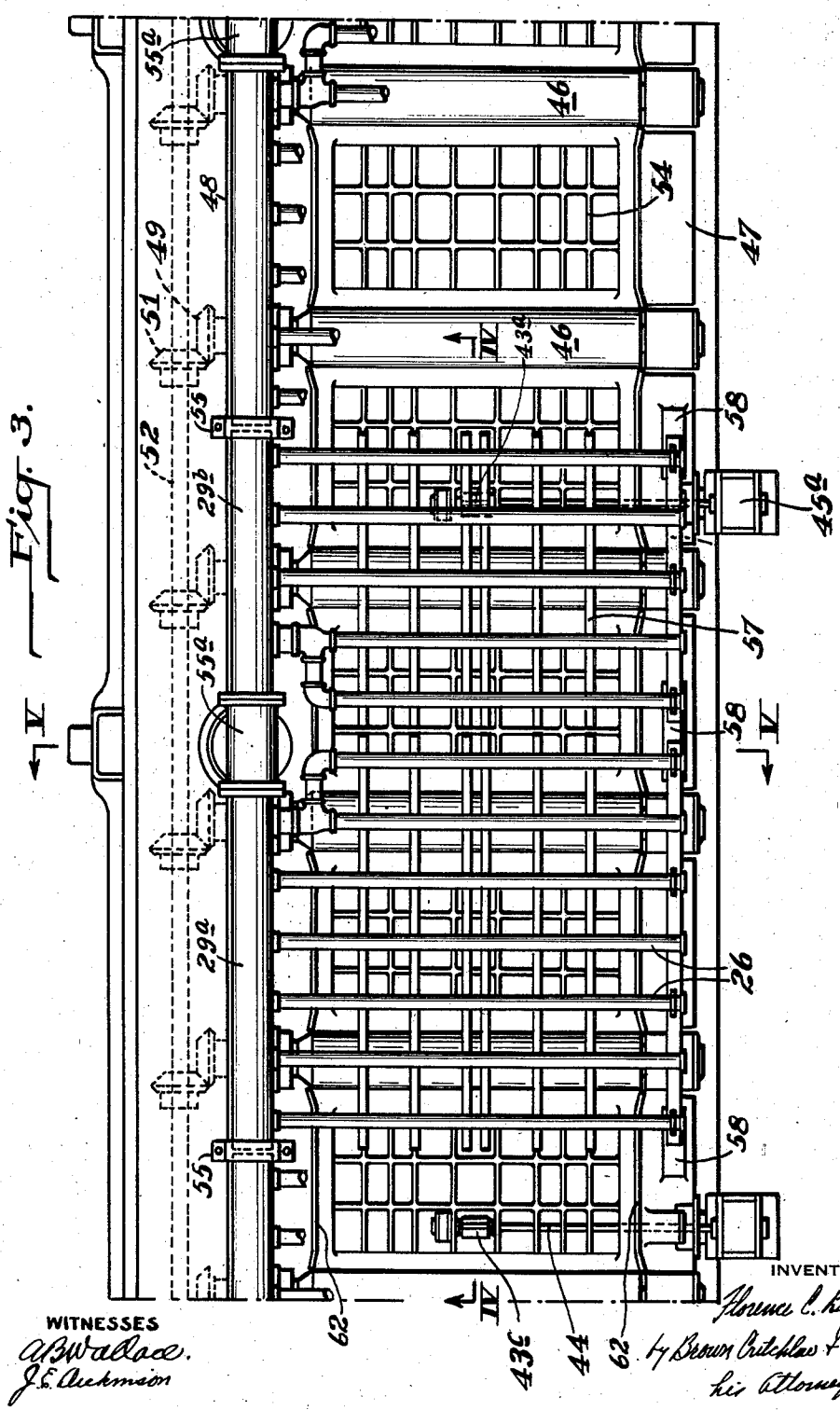


Fig. 3.

Oct. 12, 1937. F. C. BIGGERT, JR 2,095,430

METHOD AND APPARATUS FOR ROLLING METALLIC STRIP

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Fig. 5.

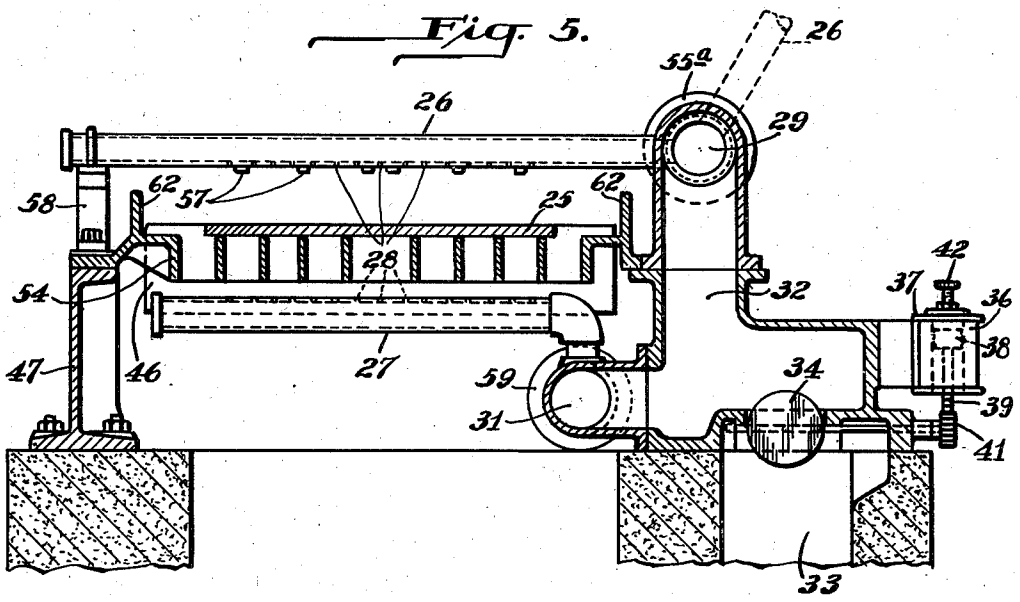


Fig. 6.

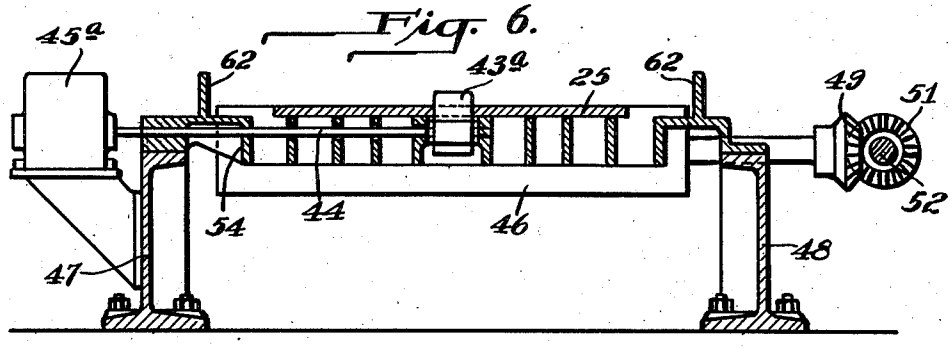
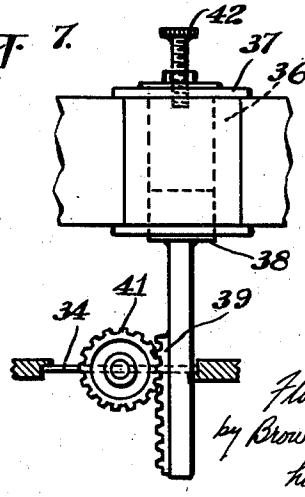


Fig. 7.



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UNITED STATES PATENT OFFICE

2,095,430

METHOD AND APPARATUS FOR ROLLING METALLIC STRIP

Florence C. Biggert, Jr., Crafton, Pa., assignor to United Engineering & Foundry Company, Pittsburgh, Pa., a corporation of Pennsylvania

Application March 7, 1935, Serial No. 9,736

37 Claims. (Cl. 80—60)

This invention pertains to an improvement in method of and apparatus for the rolling of metal strip, and although not necessarily so limited it relates more particularly to an improvement in method and apparatus for the reducing of hot slabs to strip in a series of tandemly arranged roughing and finishing mills.

In the manufacture of strip from hot slabs it has been found to be highly desirable and advantageous to roll the slabs in the roughing stands of a mill at the highest feasible temperature which is in the neighborhood of 2100° F. and to be also desirable and advantageous to have the strip leave the last stand of the finishing mill at a temperature in the neighborhood of 1400° F. By carrying out the roughing operations at the highest feasible temperature it is possible to take very heavy drafts on the slabs and to use the smallest and lightest possible mill stands, drives and motors, all of which make for economy of production as well as reduce the initial cost of the apparatus.

While by completing the hot rolling operations at a temperature in the neighborhood of 1400° F. a product is provided having fine grain structure especially suitable for deep drawing operations, of equal if not more importance, this eliminates or greatly minimizes the subsequent formation of scale on the strip which would take place if the strip were finished at a higher temperature.

To prevent overheating and cracking of the rolls in the roughing mill stands when operating on highly heated slabs, whether such stands are reversing or tandemly arranged, as they may be in accordance with the invention, it is desirable to operate them at a relatively high speed. By so doing, however, the pieces being worked usually leave the roughing stands at a temperature of around 1900° F. Because of this it is necessary, in order to have the resultant strip leave the last finishing pass at or near the critical temperature referred to, that is, at a temperature around 1400° F., to reduce the temperature of the slabs about 300° F. between the time they leave the roughing mill and enter the finishing mill, as the strips usually lose only about 200° F. in the finishing mill. In the past, this heat has been dissipated in various ways, such as by passing the strip back and forth on a table sufficiently large for such purpose located between the roughing and finishing mills, until the strip has been cooled the necessary amount, and also through the use of various other forms of cooling devices or delay tables. These prior methods, however, have greatly held up the production of the mill as a whole, which, for obvious economic reasons, is highly undesirable.

Another difficulty in the prior mills is that, due to the fact that the strip enters the finishing mill at a lower speed than it is passed through the roughing mill, and that its heat is radiated rapidly, it has a progressively lower temperature from its front to its trailing ends as it passes through the finishing mill. This unequal temperature results in the taking of unequal reductions with the further result that the product usually has a progressively increased gauge from its front to its trailing end.

With the foregoing in mind it is an object of this invention to provide for the taking of heavy reductions at high speeds in the roughing stands, in the hot rolling of strip material, while the slab from which the strip is made is at the most suitable rolling temperature, and to provide for so controlling the temperature of the strip preferably by a reduction thereof, between the time it leaves the roughing stands and when it enters the finishing stands that it will have the proper or desired finishing temperature and without delaying the speed of production of the mill.

A further object is to provide for controlling from end to end and edge to edge the temperature of the strip entering the finishing mill so that each constituent part thereof will have such a temperature as it passes through the finishing stands that the finished product will have a substantially uniform desired gauge throughout its length.

A still further object is to provide for accomplishing the aforementioned objectives irrespective of the gauge, width, or initial temperature of the material being rolled.

These and numerous other objects, as well as the various other novel features and advantages of the invention, will be apparent when the following detailed description is read in conjunction with the accompanying drawings of which Fig. 1 is a schematic view of a rolling mill adapted to practice this invention; Fig. 2 a plan view of one form of delivery table and cooling mechanism constructed in accordance with the invention for use between the roughing mill stands and the finishing mill stands; Fig. 3 a plan view to enlarged scale of one of the cooling sections of the delivery table shown in Fig. 2; Fig. 4 a sectional view taken on the line IV—IV of Fig. 3; Fig. 5 a sectional view taken on the line V—V of Fig. 3; Fig. 6 a transverse sectional view of the cooling table illustrating in elevation one of the strip-responsive flags located in the cool-

ing table and its associated limit switch; Fig. 7 an end elevation of one of the magnetically operable actuating units connected to the cooling medium control valves; Fig. 8 a sectional view showing one of the flexible couplings connected in one of the cooling medium supply headers; Fig. 9 a sectional view of one of the cooling medium dispensing headers; and Fig. 10 a perspective view of one of the valve sleeves arranged in the dispensing headers shown in Fig. 9.

Referring in detail to the drawings, and first more particularly to the mill layout illustrated in Fig. 1, the numeral 1 designates a blooming mill utilized to reduce the hot ingots into slab forming billets. For handling the work-pieces in this mill, feeding and run-out tables 2 and 3, respectively, are employed, being adapted to deliver the resultant products to a slab shear 4 where they are cut into slabs for strip rolling. From here the slabs are carried by a conveyor table 5 to either a transfer table 6, a battery of heating furnaces 7, or to a place of storage, not shown. The transfer table 6 is provided to permit the slabs to be passed directly from the slab shear 4 into the roughing mill if this is desired when they retain sufficient heat to permit such operation. Ordinarily, however, they are delivered to one of the heating furnaces and reheated to a desirable and suitable roughing temperature which for the reasons previously stated is preferably around 2100° F.

Opposite the roughing mill side of the heating furnaces 7 there is provided a conveyor table 8 which is disposed to receive the reheated slabs from the heating furnaces and deliver them to the roughing mill. At the delivery end of this table there is arranged a scale breaker 9 which removes the scale from the slabs before they are fed into the first stand 11 of the roughing mill.

The hot roughing mill, although it may consist of one or more reversing stands or any desired number of tandemly arranged stands, is illustrated here as comprising a broadside stand 11, a pair of edging rolls 12, a roughing stand 13, another pair of edges 14, and another roughing stand 15 which are preferably so arranged that a slab is never in more than one roughing stand at a time. This permits them to be run independently of each other so that they can be run at speeds which are not dependent upon the speed of any other stand.

In alignment with these roughing stands there is provided a conveyor table 16 by which the roughed strips are delivered to the finishing mill. Between this table and the latter, however, a scale breaker 17 is provided for removing the secondary scale from the strip before the finishing operations are inaugurated.

As shown as, the finishing mill is arranged in alignment with the roughing mill and comprises a series of tandemly arranged finishing stands 18, 19 and 21. At the delivery end of these a run-out table 22 is provided to either carry the strip away from the mill to a flying shear 20 where it is cut into desired lengths or deliver it to a winding reel 23 where it can be coiled. From here the further working of the strip is optional and comprises no part of this invention.

In accordance with the invention, means, designated by the numeral 24, is provided along the conveyor table 16 disposed between the roughing and finishing stands for treating the strip sufficiently after it leaves the roughing stands and before it enters the finishing stands to provide it from end to end with the proper finishing temperature without interrupting the movement of the strip to the finishing stand.

In the particular embodiment of the invention illustrated, although other means may be used for such purpose, air is utilized as a cooling medium and is projected, by the following described apparatus which also may take other forms, onto the top and bottom surfaces of the strip 25 as it is passed along the conveyor table 16. Referring to Figs. 3, 4, and 5, an upper and lower series of spaced transversely extending secondary headers 26 and 27 which project across the width of the conveyor are employed to blast the air onto the strip. Each of these secondary headers is equipped along its length on the side facing the conveyor with spaced orifices or openings 28 through which the air is discharged and directed onto the strip. This apparatus is preferably arranged at the finishing mill end of the conveyor table 16 so as to control the temperatures of the strip as near the finishing mill as is possible and also to avoid as much as possible injury to such apparatus in the case of a cobble.

As shown in Fig. 5, the upper secondary headers 26 receive their air supply from a primary header 29 and the lower secondary heads 27 from a primary header 31. These latter in turn receive their air supply by way of a common connection 32 from an air tunnel 33 which is supplied with air under pressure from any suitable source not shown. To provide for selectively controlling the cooling of the strip along its engtth, the primary headers 29 and 31 are divided into a series of separate sections 29*a*, 29*b*, 29*c*, etc., and 31*a*, 31*b*, 31*c*, etc., and each of the opposed pairs of these sections connected through a common connection 32 and a separate control valve 34*a*, 34*b*, 34*c*, etc., to the main air supply tunnel 33.

For controlling the operation of the valves 34*a*, 34*b*, 34*c*, etc., they are each provided with a separate actuating unit. In the present embodiment (see Figs. 5 and 7) these units each comprise an electric solenoid 36, mounted in a suitably supported housing 37, and adapted to lift a gravity retrieved plunger 38. This plunger is connected at its lower end to a gear rack 39 meshed with a gear 41 mounted on the supporting shaft of the responsive valve 34 which is illustrated as a butterfly valve. As shown in Fig. 5, each valve 34 is completely open when the plunger 38 is actuated to its upper position and closed when it is in its normal lower position shown in Fig. 7. For varying the opening of each of the valves 34, to thereby vary the air supplied through them to each of the cooling sections, an adjustable stop 42 is mounted in the upper end of each of the solenoid housings 37 and disposed to engage and limit the upward travel of the plunger 38 whereby the degree of rotation of the valve is accordingly controlled.

To further control the operation of the valves 34*a*, 34*b*, 34*c*, etc., a series of flags, 43*a*, 43*b*, 43*c*, etc., is provided, one to each cooling section of the conveyor table. As shown, these are arranged to be operated by the strip as it is passed thereover and counterbalanced so that they are normally held in their inoperative positions. Secured to them by suitably supported shafts 44 is a series of limit switches 45*a*, 45*b*, 45*c*, etc., which are mounted at the side of the conveyor table 16 and electrically connected in the operating current circuits, not shown, for the actuating units coupled to the air supply valves 34*a*, 34*b*, etc. To carry out their intended functions

these switches, although not shown and described in detail because they are so well known as to make this unnecessary, are of the adjustable type and can be set to give any desired period of operation to the valve actuating units once they are themselves actuated by the flags. A further feature of the mounting of these flags and the timing of their associated limit switches is that they are disposed when operated to permit the leading end of the strip to pass out of that particular zone of the table in which they are located before the blast of air controlled by them is applied to the strip, this being done to prevent cooling the ends of the pieces too quickly and thereby causing such ends to mark the rolls of the finishing mill.

The conveyor table **16** as shown, although it may be otherwise constructed, is made up essentially of a series of spaced rollers **46**, suitably journalled in a pair of supporting side frames **47** and **48** and connected at one end by gears **49** and **51** to a drive shaft **52** to which a driving motor **53** is suitably coupled. For supporting the strip between these rollers there is provided a series of stationary table sections **54** which, to permit the application of air to the under side of the strip, are made in the manner of a grid structure through which the cooling air may be readily projected.

As stated hereinbefore, to avoid the possibility of the strip-cooling apparatus being injured by the strip when a cobble occurs, it is located at the finishing mill end of the table. To also provide convenient access to the table the upper primary headers **29** are mounted in such a way that the secondary headers **26** attached to them can be raised or rotated away from the table about the primary headers **29**. As shown, the primary headers **29** are each divided into two sections, both of which are closed at one end and connected at the other to a T coupling **55***a* mounted on the upper end of the associated air supply connection **32**. To permit each of these sections to be conveniently rotated their closed end is pivotally mounted in a supporting sleeve **55** common to the next adjoining section and their supply end connected to the T connections **55***a*, from which they receive their air, by a flexible coupling **56** such as shown in Fig. 8.

As a further feature in the construction of the upper secondary headers **26**, each of the groups thereof connected to the different movable primary headers **29** is bound together by a plurality of spaced straps **57** connected to their under side and extended lengthwise of the table. These, in addition to increasing the rigidity of the groups, function as baffles to prevent the ends of the strip from moving up between the different pipes and also assist in carrying them out of the danger zone if the strip becomes fouled and bumps against them. When in their operative positions the upper secondary heads **26** rest at their outer ends upon a suitable support **58** provided on the side frame **47** of the conveyor table opposite the primary headers **29**.

Like the upper primary headers **29**, the lower primary headers **31** are divided into two sections, one end of each of which is closed and the other connected to the T coupling **59** by means of which they are connected to their associated air supply connections **32**. For supporting them suitable braces **61** are utilized and the secondary headers **27** are connected to them in such a way as to project the air streams issuing from their outlet orifices upwardly through the open spaces in the grid sections of the conveyor table, as shown in Fig. 4.

To also provide for additionally varying the temperature of the strip at its edges, which, due to the thinness thereof as compared to the center of the strip may not require the same cooling treatment as the center of the strip, a valve-like sleeve **50** shown in Figs. 9 and 10 is provided in each header **26** and **27**, and as shown, these sleeves are each equipped with a turning wheel **50***a* which is connected thereto by a shaft **50***b* slidably extended through the outer ends of the headers for turning them to control the opening and closing of the orifices **28**. As will be appreciated from these drawings, as these sleeves are rotated the orifices **28** at the two ends of the headers in which they are located will be shut off or opened depending upon the rotation of the sleeves and the application of the air to the edges of the strip thereby controlled. It will be apparent of course that this control can be also readily modified.

To prevent the strip sliding laterally from the table, its sides are equipped with side rails **62**, and for maintaining the strip centrally between these, adjustable guides, not shown, may be employed if desired.

To operate the above described mill in accordance with this invention an ingot is first rolled in the blooming mill **1**, and the resultant bloom passed through the bloom shear **4** and cut into slabs of the length desired for producing a desired size of strip. These slabs are then delivered to either the heating furnaces **7**, where their temperature is brought up to the proper roughing temperature of preferably around 2100° F., or directly to the roughing mill delivery table **8**. By the latter table **8** onto which the slabs are also delivered from either the transfer table **6** or from the heating furnaces **7** they are fed into the scale breaker **9** located in front of the roughing mill where the scale formed on them is removed. After leaving this scale breaker they are passed, depending on their size and the width of finished strip desired, either endwise or sidewise through the broadside roughing stand **11**. From here they are passed in succession through a series of edging and roughing stands **12**, **13**, **14**, and **15** at a sufficiently high speed to give the best rolling results.

From the last stand **15** of the roughing mill the strip is picked up by the conveyor table **16** connecting the roughing mill with the finishing mill and conveyed to the finishing mill. As previously stated, on leaving the roughing mill the strip usually has a temperature of around 1900° F. which is desirably reduced to about 1600° F. before it enters the finishing mill in order for it to leave the finishing mill at a temperature of around 1400° F., for the reasons previously discussed. To accomplish this without interrupting the delivery speed of the strip the limit switches **45**, valves **34**, and the sleeves **50** are adjusted to so control the amount of air blasted upon the strip while passing over the conveyor **16** that each constituent part of the strip from end to end and edge to edge will have as near as possibly obtainable the desired temperature when entering the first stand **18** of the finishing mill. The adjustment of these switches and valves depends upon the width and over-all gauge of the strip leaving the roughing mill, the temperature thereof, the speed of the delivery table **16**, and the initial temperature of the air, and may be

worked out for each different rolling operation in advance of the rolling.

A feature of the cooling system is that through the selectivity of control which it provides, it is possible to not only reduce the temperature of the strip to the temperature desired for the finishing mill operations, but to also regulate the temperature of the strip along its length in any manner desired. Hence through its use the temperature of the strip may be so regulated along its length that each successive portion thereof will enter the finishing mill at a desired temperature. An important advantage of this is that the rolling operations in the finishing mill may be carried out over the full length of the strip at the same or any variation of temperatures desired. In this way a very accurate control of the gauge from one end of the strip to the other is assured, which is a distinct improvement over the prior methods in which the strip is always being rolled at a progressively decreasing temperature with the result that the gauge of the strip is progressively increased from the leading to the trailing end of each piece rolled. If the strip on leaving the roughing mill is progressively thicker from the front to the trailing end the cooling system may be adjusted to so cool the strip that it will enter the finishing mill at a progressively increasing temperature, the result being that the finishing mill will make a progressive increase in the per cent of reduction in accordance with the progressive increase in the temperature of the strip thereby producing a strip of uniform gauge from end to end.

Before entering the first stand **18** of the finishing mill the strip is preferably passed from the cooling table **16** through the scale breaker **17** where any scale formed after the strip has left the roughing mill is removed. From here it is run through the finishing mill stands **18**, **19**, and **21** at the most suitable speed and then carried by the run-out table **22** to either a further working device not shown or to shear **20** and cut into sections or to a reel **23** and coiled to facilitate its further handling. While not shown, additional cooling apparatus obviously may be associated with the latter run-out table to lower the temperature of the finished product if desired and which may be advantageous to expedite and facilitate the coiling or further handling of the strip.

As a particular example illustrating the invention, for the sake of simplicity, but with the understanding that the conditions referred to may in every instance be varied, assume that a slab 15 feet long and 4 inches thick is delivered to the roughing mill from the heating furnace at a temperature of about 2100° F., and that it is reduced to a thickness of ½ inch in such mill. By reason of such reduction the slab is transformed into a strip having a length of 120 feet and, due to the conditions of rolling, is discharged from the roughing mill at a substantially even temperature from end to end which is normally around 1900° F., it losing about 200° in temperature during the roughing operations. Also assume that the finishing mill is adapted to take the strip at the rate of 120 feet per minute and that there are twelve of the individually controlled cooling sections, each 10 feet in length, arranged along the conveyor between the roughing and finishing mills. This means that a minute elapses between the time the front and rear ends of the strip enter the mill or pass any given point on the conveyor and that the cooling sections must be adjusted so that during this time they reduce the temperature of the strip to the proper temperature for entrance in the finishing mill, which as previously referred to, is preferably around about 1600° F., and also compensate for the normal cooling of the strip, which incidentally takes place much more rapidly at this time than it did when the slab was in the roughing mill due to the increased exposed surface.

To satisfy such requirements the amount of heat normally lost by the strip before it enters the finishing mill, due to radiation and the amount of cooling required to reduce it to the desired finishing temperature, is first ascertained. The valves **50** are then set according to the strip width and the valves **34** and the limit switches **45** adjusted to give the proper period and capacity of operation of each cooling section. For instance the limit switch **45***a* may be adjusted to operate for 60 seconds, the switch **45***b* for 55 seconds and the switch **45***c* for 50 seconds and so on, down to the switch for the last section which may be adjusted to operate for 5 seconds. With such a schedule the first cooling section supplied by the primary headers **29***a* and **31***a* is set in operation as soon as the flag **43***a* for controlling the valve **34***a* connecting such section to the air supply is struck by the leading end of the stock and is operated for 60 seconds, or until the leading end of the strip is processed for entry into the finishing mill. The next section, which is supplied by the headers **29***b* and **31***b*, is set in operation as soon as its flag **43***b* is struck by the stock and is continued in operation for 55 seconds applying cooling fluid to all but the last 10 feet of the strip; the next section likewise treats all but the last 20 feet and so on. When so adjusted all of the limit switches are shut off simultaneously and hence the first 10 feet of the strip, with the exception of a short portion of the leading end thereof, for the reasons previously referred to, are treated for 60 seconds; the next 10 feet for 55 seconds and the next 10 feet for 50 seconds and so on down to the last 10 feet which is treated for approximately 5 seconds. The extreme trailing end however, like the extreme leading end, is subjected only to normal cooling and for the same reason.

In accordance with the foregoing, it may be appreciated that the strip is cooled to a greater extent on its leading end than it is in its successive portions and that its temperature is thereby progressively reduced from end to end. In other words, when the leading end of the strip enters the finishing mill it has a lower temperature than the trailing end at the same instant, but due to radiation of the heat in the latter portions, by the proper operations of the cooling section controls, all portions of the strip enter the finishing mill at approximately the same temperature. It must be understood, however, that the limit switches for the several cooling sections, as well as the control valves therefor, may be varied so as to produce any desired temperature in the strip or any part thereof. For instance, if it is desired that the trailing end have a higher temperature when it arrives between the rolls of the finishing mill than the front end had it may be easily accomplished by the proper setting of the limit switches and valves. It will be also understood that radiation pyrometers may be disposed along the table in a well known manner for actuation by the temperature of the strip to thereby control the op-

eration of the time delay switches if desired. It will be appreciated too that the length of the cooling sections may be greatly varied and made either larger or smaller, and, as will be readily understood by those skilled in the art, the invention may be practiced by means other than the specific embodiment of the invention shown, such as by applying a heat exchanging medium to the strip, the capacity of which varies as the strip passes therethrough, or by applying the medium at a constant rate and varying the speed of the strip, or by a combination of both, or by varying the temperature of the medium.

It will be readily appreciated by those skilled in the art that this invention represents a very desirable improvement in the art both from an economic and quality standpoint and also that the means discussed herein for carrying it into practice may be greatly varied.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention, and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. The method of hot rolling metal strip, which comprises heating a slab to a desired roughing temperature, passing it through a plurality of roughing passes, differentially modifying its temperature simultaneously along its length between the time it leaves the roughing passes and enters a finishing pass so that each successive portion thereof from end to end enters the finishing pass at a substantially preselected temperature, and then passing it through a series of finishing passes.

2. The method of hot rolling metal strip which comprises heating a slab to a desired roughing temperature, passing it through a plurality of roughing passes, differentially modifying its temperature simultaneously along its length between the time it leaves the roughing passes and enters a finishing pass so that each successive portion thereof, from end to end and edge to edge, enters the finishing pass at a substantially preselected temperature and then passing it through a series of finishing passes.

3. The method of hot rolling metal strip which comprises heating a slab to a desired roughing temperature, passing it through a plurality of roughing passes, then through a series of finishing passes and differentially reducing its temperature simultaneously along its length between the time it leaves the roughing passes and enters the finishing passes so that each successive portion thereof enters the finishing passes at a preselected temperature.

4. The method of rolling strip which comprises passing the strip in a heated condition through cooperating reducing rolls but before doing so simultaneously treating it to different extents at different points along its length so that each successive portion thereof has a preselected temperature as it enters the roll pass formed by said rolls.

5. The method of rolling strip varying in temperature from end to end, which comprises passing the strip through cooperating reducing rolls but before doing so modifying its temperature in measured amounts at different points simultaneously along its length in such a way that each successive portion thereof has a preselected temperature as it enters the roll pass.

6. The method of rolling hot strip which comprises passing a slab through a roughing mill at a temperature which results in roughed strip which is too hot to be entered in a finished mill, differentially cooling the strip simultaneously at different points from end to end before it is entered in the finishing mill and in such a way that each successive portion thereof enters the finishing mill at a substantially preselected temperature, then passing it through the finishing mill.

7. The method of rolling a hot slab into a strip which comprises passing the slab through one or more roughing passes, differentially applying a cooling medium to it as it is passed from said roughing passes into one or more finishing passes, and in such a way as to regulate the temperature of said strip so that each successive portion thereof enters the finishing passes at a temperature adapted to provide a selected finishing temperature.

8. The method of rolling a hot slab into a strip which comprises passing the slab through one or more roughing passes, applying a cooling medium to it simultaneously at different points along its length as it is passed from said roughing passes into one or more finishing passes, and in such a way as to so regulate its temperature from end to end and edge to edge that the finishing operations will be performed on each portion of the strip over its full length at a selected temperature.

9. The method of hot rolling metal strip which comprises passing a slab at a relatively high temperature through a plurality of roughing passes, cooling the strip to the desired temperature for entry in the finishing mills as it issues from the roughing passes by passing a considerable length of it in heat exchange relation with a cooling medium, controlling the application of the cooling medium to the strip so as to selectively control the temperature of the strip over its length, and then passing it through a plurality of finishing passes.

10. The method of rolling a hot slab into a strip which comprises heating the slab to a roughing temperature which will result in a roughed strip having too high a temperature for satisfactory working in the finishing passes, passing said slab through one or more roughing passes, then without stopping its movement differentially reducing its temperature from end to end in such a way that each successive portion thereof has a preselected temperature as it is delivered to the finishing mill, and then passing it through a series of finishing passes.

11. The method of rolling a metal slab into a strip which comprises heating the slab to the highest feasible roughing temperature, passing said slab through one or more roughing passes, at such a speed that the strip leaving the roughing passes has too high a temperature to permit satisfactory finishing operation, then without stopping its movement differentially reducing its temperature to a satisfactory finishing temperature by applying a cooling medium to it and then passing it through a series of finishing passes.

12. The method of rolling a hot slab into a strip which comprises passing it at as high a temperature as is feasible through one or more roughing passes, differentially cooling it without interrupting its movement as it issues from said roughing passes sufficiently to give it the proper finishing

temperature and then passing it through one or more finishing passes.

13. The method of rolling a hot slab into a strip which comprises passing it at as high a temperature as is feasible through one or more roughing passes, cooling it as it issues from said roughing passes sufficiently to give it the proper finishing temperature by differentially applying a cooling medium to it just back of its front end and then passing it through one or more finishing passes.

14. The method of rolling strip from a hot slab which comprises passing the slab at the highest feasible temperature through one or more roughing passes, passing it from the roughing passes without interrupting its movement into a series of finishing passes and differentially treating it along its length with a controlled amount of cooling fluid between the time it leaves the roughing passes and when it enters the finishing passes to insure the finishing operations being carried out at a desired temperature.

15. The method of rolling strip from a hot slab which comprises passing the slab at the highest feasible temperature through one or more roughing passes, passing it from the roughing passes without interrupting its movement into a series of finishing passes and differentially treating the upper and lower surfaces thereof along its length with a controlled amount of cooling fluid between the time it leaves the roughing passes and when it enters the finishing passes to insure the finishing operations being carried out at a desired temperature.

16. The method of rolling strip from a hot slab which comprises passing the slab through one or more roughing passes at the highest feasible temperature, differentially applying a cooling medium to the strip at different points simultaneously along the length thereof after it is discharged from said roughing passes, controlling the application of the cooling medium to the strip in such a way as to control the temperature of each successive portion thereof, and then passing it through one or more finishing passes.

17. The method of rolling strip from a hot slab which comprises passing the slab through one or more roughing passes at a high temperature, next passing it in sequence through a series of individually controlled cooling units without interrupting its forward movement, controlling the operation of said cooling units in such a way as to control the temperature of the successive portions of the strip from end to end, and then passing it through one or more finishing passes.

18. The method of hot rolling metal strip which comprises passing a slab at a high temperature through a plurality of roughing passes, differentially cooling the strip to the desired finishing temperature without interrupting its forward movement as it issues from the roughing passes by applying a cooling medium to its surface simultaneously at different points along its length, controlling the application of the cooling medium to the strip so as to selectively control the temperature of the strip from end to end, and then passing it through a plurality of finishing passes.

19. A rolling mill for producing hot rolled strip comprising one or more roughing stands, one or more finishing stands, means for conveying the strip from the roughing stands to the finishing stands, and means for differentially cooling the strip simultaneously at different points along its length as it is conveyed by said conveying means from the roughing stands to the finishing stands.

20. A rolling mill for producing hot rolled strip comprising one or more roughing stands, one or more finishing stands, means for conveying the strip from the roughing stands to the finishing stands, and a plurality of individually controlled tandemly arranged cooling units for differentially cooling the strip from end to end as it is conveyed by said conveying means from the roughing stands to the finishing stands.

21. A rolling mill for the hot rolling of strip comprising one or more roughing stands, one or more finishing stands, a conveyor for carrying the strip being rolled from the roughing stands to the finishing stands, means disposed along the length of said table for applying a cooling medium to the strip as it is fed thereover, and means for controlling the operation of said cooling medium supplying means to thereby differentially regulate the temperature of the strip entering the finishing stands.

22. A rolling mill for the hot rolling of strip comprising one or more roughing stands, one or more finishing stands, a conveyor for carrying the strip being rolled from the roughing stands to the finishing stands, means disposed along the length of said table for applying a cooling medium to the strip as it is fed thereover, and means responsive to the strip for so controlling the operation of said cooling medium supplying means as to thereby selectively regulate the temperature of the successive portions of the strip entering the finishing stands.

23. A rolling mill for the hot rolling of strip comprising one or more roughing stands, one or more finishing stands, a conveyor disposed to carry the strip from the roughing stands to the finishing stands, a plurality of tandemly arranged individually controlled heat exchange units arranged adjacent said conveyor along its length for differentially modifying the temperature of the stock as it is passed along the conveyor.

24. A rolling mill for the hot rolling of strip comprising one or more roughing stands, one or more finishing stands, a conveyor disposed to carry the strip from the roughing stands to the finishing stands, a plurality of tandemly arranged individually controlled heat exchange units arranged above and below said conveyor along its length for modifying the temperature of the stock as it is passed from the roughing stands into the finishing stands.

25. A rolling mill for the hot rolling of metal strip comprising one or more roughing stands, a conveyor for receiving the strip as it issues from said roughing stands, one or more finishing stands disposed to receive the strip from said conveyor, a series of groups of transversely extending pipes equipped with spaced orifices arranged in tandem relation along said conveyor, means for individually furnishing a supply of cooling fluid to said groups of pipes, and means put in operation by the passage of the strip along the conveyor for controlling the supply of cooling fluid furnished to said groups of pipes.

26. A rolling mill for the hot rolling of metal strip comprising one or more roughing stands, a conveyor for receiving the strip as it issues from said roughing stands, one or more finishing stands disposed to receive the strip from said conveyor, selectively operable dispensing means disposed along the length of said conveyor for playing a cooling medium upon the strip as it is passed along the conveyor, means for varying the

amount of cooling medium supplied to said dispensing means, and means for selectively controlling the extent of operation of said dispensing means on each piece of strip.

27. A rolling mill for the hot rolling of metal strip comprising one or more roughing stands, a conveyor for receiving the strip as it issues from said roughing stands, one or more finishing stands disposed to receive the strip from said conveyor, selectively operable dispensing means disposed along the length of said table and adapted to play a cooling medium upon the strip across its width as it moves along the table, means for adjusting the operation of said dispensing means transversely of the strip, and means for selectively controlling the operation of said dispensing means.

28. A rolling mill for the hot rolling of metal strip comprising one or more roughing stands, a conveyor for receiving the strip as it issues from said roughing stands, a plurality of finishing stands disposed to receive the strip from said conveyor, a series of groups of pipes equipped with spaced orifices arranged along the length of said conveyor and extending transversely thereof both above and below the supporting surface of the conveyor, a plurality of headers for supplying a cooling medium to said group of transversely extending pipes, means for supplying a cooling medium to said headers, means for controlling the amount of cooling medium supplied to the headers, and means responsive to the strip as it passes over the conveyor for controlling the operation of said control means.

29. A rolling mill for the hot rolling of metal strip comprising one or more roughing stands, a conveyor for receiving the strip as it issues from said roughing stands, a plurality of finishing stands disposed to receive the strip from said conveyor, a series of groups of pipes equipped with spaced nozzles arranged along the length of said conveyor and extending transversely thereof, a plurality of headers for supplying a cooling medium to said groups of transversely extending pipes, means for supplying a cooling medium to said headers, means for controlling the supply of cooling medium to the headers, and means responsive to the strip as it passes over the conveyor for controlling the operation of said control means.

30. For use in a strip mill between the roughing and finishing stands thereof, a conveyor for carrying the strip from the roughing stands to the finishing stands, a plurality of groups of transversely extending pipes mounted over the top of said conveyor, a plurality of headers for supplying said groups of pipes with a cooling fluid, means in said pipes for directing said fluid onto said conveyor, means connected to the under side of said groups of pipes for binding them together and preventing the strip passing between them, and means in said headers for permitting said groups of pipes to be moved as a unit away from the conveyor.

31. The method of hot rolling metal strip comprising rough rolling a slab, transferring the resulting blank to a finishing mill, and during the transfer thereof differentially modifying its heat at different points simultaneously along its length substantially from end to end thereof thereby presenting all portions of the blank to the finishing mill at a substantially uniform entering temperature.

32. The method of hot rolling metal strip comprising rough rolling a slab, transferring the resulting blank to a finishing mill, and during the transfer thereof differentially cooling the blank substantially from end to end thereof and thereby presenting all portions thereof to the finishing mill at a substantially uniform entering temperature.

33. The method of rolling hot strip which comprises delivering the strip in a heated condition to cooperating reducing rolls and differentially modifying the temperature of the successive portions at different points at the same time except for its leading end before entering it in said rolls.

34. The method of rolling hot strip which comprises delivering the strip in a heated condition to cooperating reducing rolls and differentially modifying the temperature of the successive portions thereof except for its leading and trailing ends before entering it in said rolls.

35. The method of rolling hot strip which comprises delivering the strip in a heated condition to cooperating reducing rolls and differentially modifying the temperature of the successive portions thereof except for its trailing end before entering it in said rolls.

36. The method of rolling hot strip which comprises delivering the strip toward a set of reducing rolls at a temperature in excess of 1000° F. and differentially modifying the temperature of the successive portions thereof at different points along its length at the same time and in such a way that each portion enters the rolls at substantially the same temperature.

37. The method of rolling hot strip which comprises delivering the strip at a temperature in excess of its critical temperature toward a set of cooperating reducing rolls and differentially modifying the temperature of the successive portions thereof at different points along its length at the same time and in such a way that each portion enters the rolls at substantially the same temperature.

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