Nov. 28, 1933. L. R. CLAPP ET AL 1,936,582

PROCESS OF ROLLING METALS

Filed March 25, 1929 2 Sheets-Sheet 1

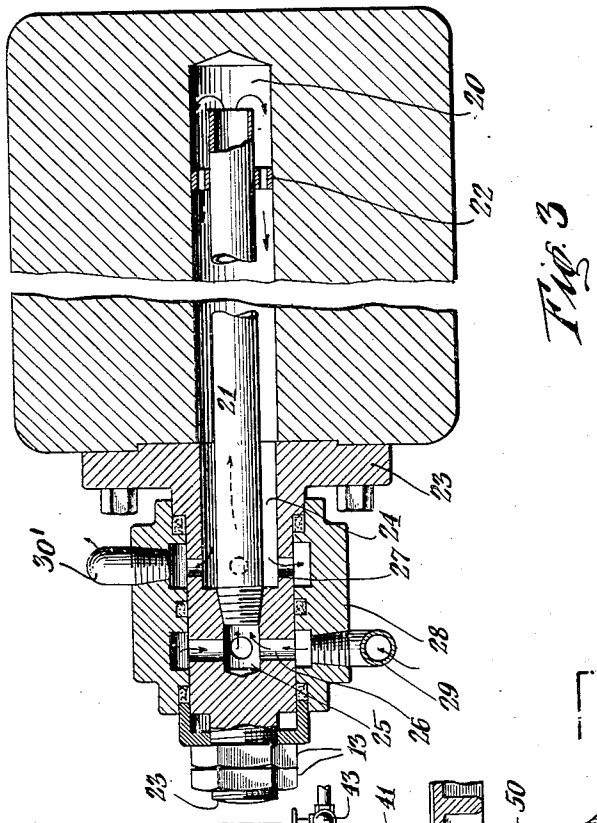

Fig. 3

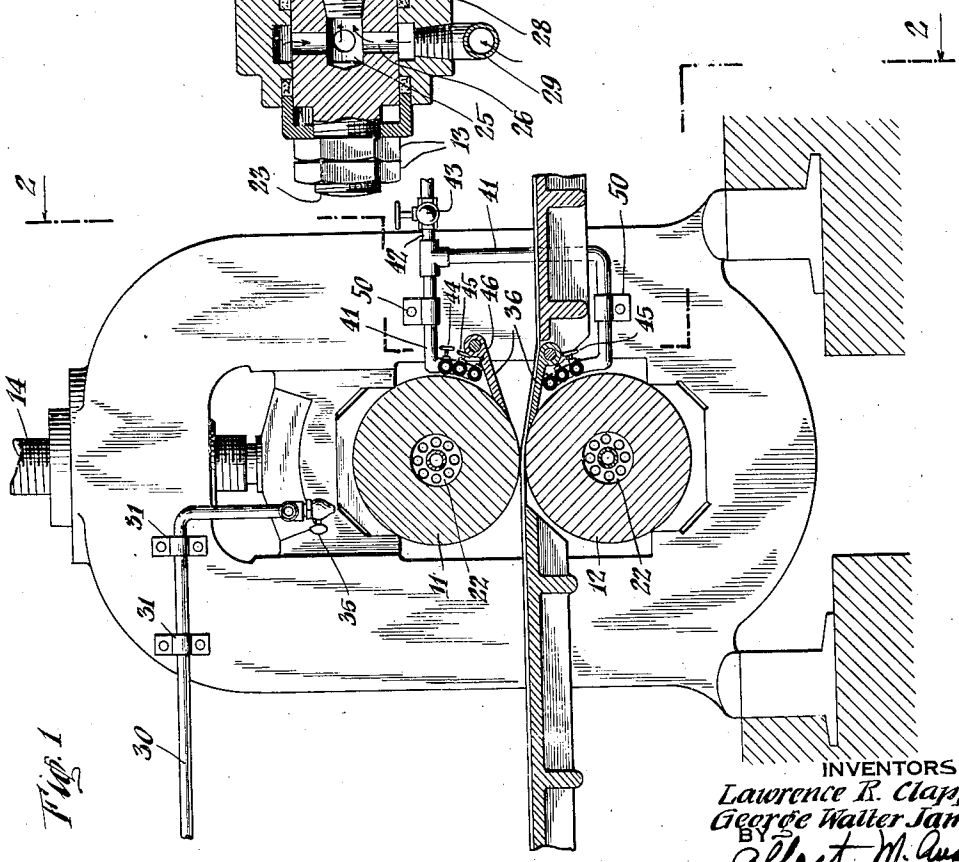

Fig. 1

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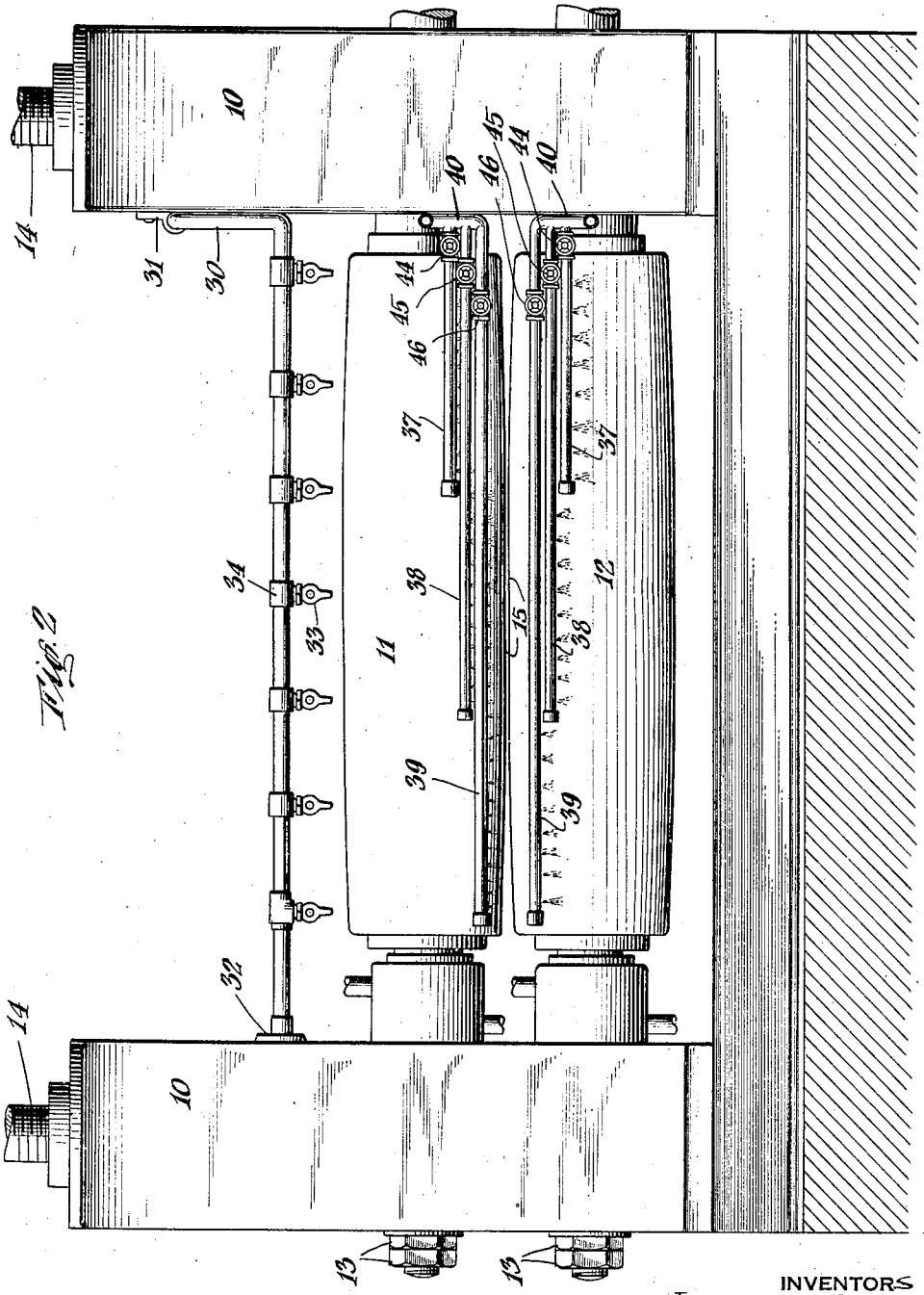

Fig. 2

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UNITED STATES PATENT OFFICE

1,936,582

PROCESS OF ROLLING METALS

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Application March 25, 1929. Serial No. 349,890

13 Claims. (Cl. 80—60)

This invention relates to the production of thin sheets of ductile non-ferrous metals, and more particularly, to the cold rolling of such metals from a slab or plate to produce a thin wide sheet of uniform thickness. The invention relates specifically to the cold rolling of copper plates and provides for a reduction in thickness without intermediate heat treatment in excess of 50%.

In accordance with the present invention the sheets of a width in excess of 22", are cold rolled in a plurality of steps to effect a reduction in thickness in excess of 50% and to produce a sheet in which the variation in thickness is not over 5%.

It has been found that in rolling a sheet of metal the force applied by the rolls may be resolved into horizontal and vertical components. The horizontal component tends to tear the sheet apart and to pull the metal away from the point of rolling, whereas the vertical component represents pure compression. In so rolling the sheet as to reduce the thickness thereof in a single pass by a considerable value, such as 15% to 40%, the horizontal component becomes sufficiently large to tear or otherwise damage the sheet unless the same is of considerable thickness.

The present invention further provides for so controlling the relationship of these components as to prevent tearing of the sheet while obtaining a substantial reduction. For this purpose the slippage between the roll and the rolled sheet is controlled. As the slippage increases the horizontal component is decreased with respect to the vertical component. By suitably controlling the slippage, therefore, the horizontal component may be reduced to a value below that at which the thin sheet would become torn.

It is also necessary to control the heat distribution in the roll in order to prevent uneven expansion thereof and to maintain a comparatively straight and parallel line of contact with the metal. This may be accomplished differentially in a longitudinal direction of the rolls and the total heat must be controlled within given limits.

The present invention further provides for utilizing a single medium for controlling both the heat of the rolls and the slippage. It will be apparent from the specification that a plurality of mediums may be employed if desired in particular instances although the single medium is preferable by reason of the simplicity of operation and the reduction in cost.

In initiating the operation, that is, in making the first pass of metal between the rolls, the plate is comparatively thick, for example ⅛" or more, and a comparatively large horizontal component may be employed. During this operation, therefore, the rolls may be cooled with a medium which will not appreciably affect the slippage thereof, for example, a blast of compressed air. Means is also provided for controlling the application of the cooling medium at various points longitudinally of the rolls whereby the cooling effect may be regulated as necessary to maintain an even flat surface. In subsequent passes, as the thickness of the material is reduced, a cooling medium having lubricating properties may be employed whereby the slippage is increased and the horizontal component correspondingly decreased. For intermediate passes water has been found to be a satisfactory medium and serves to cool the rolls while at the same time permitting a certain amount of slippage. For the final passes, however, as the sheet becomes thin, it is necessary to still further increase the slippage and for this purpose an oil may be employed which will serve as a cooling medium and also to suitably reduce the friction between the roll and the metal and cause the degree of slippage required. During all of these steps a sufficient pressure is employed to maintain the contacting surfaces of the rolls in parallelism as will be more specifically pointed out hereinafter.

The invention further consists in the new and novel features of operation and the new and original arrangements and combinations of steps in the process hereinafter described and more particularly set forth in the claims.

The invention more specifically is carried out in any well known type of mill by the use of rolls between which a plate of metal may be passed. When pressure is applied to the ends of the rolls to produce the necessary compression, a certain bending will take place which would normally tend to form a slight crown on the rolled sheet. The rolls are accordingly crowned in such manner that when pressure is applied the line of contact with the sheet is substantially straight, longitudinally of the roll thereby forming a substantially straight rolling surface. In certain instances a crown in the form of a catenary has been found suitable for this purpose. It is obvious that the amount of crown will depend upon the total pressures to be employed. It is also desirable to use rolls of a comparatively small diameter since the total contacting surface of said

rolls is less than with those of large diameter, and a smaller total force may be used to give the desired pressure per square inch.

The rolling operation produces heat which is absorbed by the rolls and must be removed therefrom. If the temperature of the rolls is permitted to vary an uneven expansion thereof will take place, with a consequent change in the effective shape of the rolling surface. It is accordingly desirable to control the heat longitudinally of the rolls in such manner that the desired rolling surface is maintained throughout the operation. This may be accomplished by circulating a cooling medium internally of the roll or applying a cooling medium externally thereof or both as will be more fully pointed out hereinafter. In starting the operation it may even be necessary to supply heat to certain portions of the rolls, such as the ends, in order to prevent an uneven expansion while they are becoming heated to their operating temperature.

Although the size of roll may vary within limits depending upon the material employed and the width of the sheet being rolled, it has been found that a roll having a diameter less than 16" is preferable in rolling a sheet having a width of 42". This diameter may be decreased, however, as the operation progresses, using a roll having a diameter of some 12" for the final passes.

A plate of ductile non-ferrous metal such as sheet copper having a thickness of approximately ⅛" is first passed between rolls formed as above, preferably while maintaining their outer surfaces dry. This facilitates the rolling operation and eliminates slippage of the roll, so that the horizontal component of the force exerted thereby is maintained as great as possible with respect to the vertical component. For this operation the roll may be cooled internally and/or it may be cooled by a blast of gaseous cooling medium, such as compressed air, which may be blown against the outer surface thereof. This blast is preferably controlled separately at various points longitudinally of the roll so that the heat can be suitably regulated for maintaining the desired rolling surface.

The rolling operation described above is continued by successive passes either between the same set of rolls or between additional sets, and a suitable medium is applied thereto to control the slippage as desired. In intermediate passes it has been found that water may be employed for cooling the rolls and may be applied to the outer surface thereof in place of the compressed air utilized in the initial passes. The water has slight lubricating properties and causes a certain amount of slip to take place between the roll and the rolled sheet, thereby reducing the horizontal component to the desired value. It is to be noted that the water operates both as lubricating medium and a cooling medium, and may be controlled as desired for these purposes. If an additional amount of cooling is required it may be obtained by circulating the cooling medium internally of the roll as above mentioned, by varying the temperature of the water, or by using a combination of water and compressed air.

For the later passes, as the sheet becomes thin, the horizontal component of the force exerted by the rolls must be considerably reduced to avoid tearing. This is accomplished by applying oil to the outer surface of the rolls, the lubricating properties thereof serving to cause slippage to take place. Various types of oil may be employed in accordance with the amount of slippage required. Kerosene has been found suitable for certain passes, while for other or later passes an oil having higher lubricating properties may be required. It is essential in any case to utilize an oil which will not leave a residue on the rolls and thereby tend to corrode the surface of the rolled sheet. While various types of oil may be employed for lubricating purposes it is preferable to utilize an oil which also possesses marked cooling properties. Obviously, a combination of oil and compressed air may be employed if desired. The cooling medium selected will depend on the thickness of the metal being rolled and the total reduction required. A single medium only may be employed if advisable in a particular case.

The novel process hereinabove described may be carried out with a variety of apparatus. In the drawings annexed hereto an apparatus is shown which is suitable for the purposes of the present invention. In the drawings, like numerals refer to similar parts throughout the several views, of which

Fig. 1 is a median transverse vertical section of a two-high rolling mill with associated equipment;

Fig. 2 is a rear elevation of the mill shown in Fig. 1 showing the arrangement of the cooling device; and

Fig. 3 is a detail of a roll with associated cooling apparatus.

Referring more specifically to the drawings, the mechanism shown comprises a two-high mill with the usual standards 10, and having rolls 11, 12 mounted therein in the usual manner. The rolls may be secured in place between the standards by locking nuts, indicated generally at 13. The rolls may be adjusted by the usual means, such as screws 14 mounted in the standards. The rolls 11 and 12 are centrally crowned, as indicated at 15, to permit the proper rolling of the sheets during operation and being convex will not cause the sheets being rolled to be distorted. The crown of the rolls, as shown more particularly in Fig. 2, is shown very marked, but in practice the actual crown formed on the surface of the rolls would amount to a few thousandths of an inch, more or less, depending upon the material to be worked and other design factors. The rolls, as indicated more particularly in Fig. 3, may be internally cooled and for this end are provided with an internal groove or channel 20 into which is fitted an inlet pipe 21, fastened in position within the channel 20 by means of a perforated spacer 22. The shaft 23 is secured to the roll proper in the usual manner, and is itself hollowed out to provide a central channel 24 adapted to register with the channel 20 of the roll. The channel 24 is provided with a reduced extension 25 into which is tapped the end of tube 21. The tube 21 is thus supported between the shaft 23 and the spacer 22. The shaft 23 is apertured, as indicated at 26 and 27, to provide an inlet and outlet for the cooling fluid from the stuffing box 28 which may be provided with inlet and outlet pipes 29, 30'.

The external cooling of the rolls and the supplying of sufficient and proper lubricants and cooling media is accomplished in the following manner: A lubricant feed line 30 is secured to one of the standards by suitable brackets 31 and is thereafter extended across the entire width of the roll, being secured in the opposite standard in any suitable manner, as indicated at 32. A plurality of cocks 33 are tapped into T's 34 and are severally provided with the usual controls 35, permitting individual operation of the several cocks. This ar-

rangement permits the feeding of lubricants onto the forward aspect or face of the rolls during operation and further permits the distribution of the lubricant in any desired spot or spots and in any amount.

To provide for the cooling of the rolls after the lubricant and the roll sheets have been stripped by means of the stripper plates 36, air-cooling means may be provided. This system comprises a plurality of spray pipes 37, 38, 39 extending over the rear faces of the rolls to a desired length, as shown. These pipes are tapped into manifolds 40 having a common supply pipe 41 which is teed onto a main supply pipe 42, the latter being provided with a control valve 43. The several spray or feed pipes 37, 38, 39 are each provided with valves 44, 45, 46. The manifold pipe 41 may be secured to the standard by brackets 50.

The improved apparatus above described may be maintained at a desired uniform temperature, insuring the desired parallelism of the roll surfaces in operation by not only lubricating the material being rolled, but also by applying cooling fluids such as air to the surface of the rolls. By having spray pipe 37, 38, 39 of differential length operatively associated with the rolls, any portion or portions of the roll may be cooled and maintained at the desired operating temperature.

By operating the process as above described a large reduction in cross sectional area may be obtained without the necessity for annealing the sheet. In fact it is possible to obtain a total reduction in cross sectional area of as great as 98%. The reduction is the greatest in the initial passes where the thickest material is being acted upon and may be as high as 40% which varies down to some 15% in the final passes. By suitably selecting the crowning of the rolls with respect to the compressional force employed, the surface of the rolled sheet may be maintained substantially flat throughout the entire operation. A sheet .018" thick and 42" wide has been produced in this manner with a variation in thickness of less than 5%.

The present process is capable of forming a wide flat sheet by uninterrupted cold rolling operations. The sheet may be in excess of 20" in width and has been produced on a commercial scale of a width of 42" and a thickness of .018 from a plate having an original thickness of ⅛". It has heretofore been considered impossible to produce a sheet of this width with a comparatively flat surface without interrupting the rolling operation for intermediate annealing. The tensile strength of the present product is increased progressively with successive rolling operations and in the finished sheet may be in excess of 55,000 lbs. per square inch, a figure which could not be obtained if intermediate annealing operations were resorted to. The process therefore provides for rolling on a commercial scale, sheets having a width and tensile strength greater than that heretofore obtainable and for effecting a greater reduction in cross sectional area without annealing.

Although certain novel features of the invention have been described and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes in the several steps of the process and in its operation and in the form and details of the apparatus illustrated may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. The process of cold rolling sheets of non-ferrous metal which comprises successively passing said sheets through rolls, whereby a given percentage reduction of thickness of said sheet is obtained and controlling the slippage of said rolls in inverse proportion to the thickness of said sheet, whereby tearing of said sheet is avoided and a uniform flat product is obtained.

2. The process of cold rolling sheets of non-ferrous metal which comprises passing said sheets through rolls whereby the thickness thereof is progressively reduced, and progressively increasing the slippage of said rolls with successive passes.

3. The process of cold rolling sheets of non-ferrous metal which comprises passing said sheets between a set of rolls a plurality of times, applying various lubricants in successive roll passes for increasing the slippage of said rolls as the sheets become thinner, and utilizing said lubricants as cooling mediums for regulating the heat of said rolls.

4. The process of cold rolling sheets of non-ferrous metal in a plurality of stages which comprises making a plurality of passes of said sheets between rolls, applying a cooling medium to said rolls during the first passes, applying a second cooling medium having slight lubricating properties to the rolls during intermediate passes and applying a third cooling medium having substantially greater lubricating properties to said rolls during the final passes.

5. A method of cold rolling non-ferrous metals to produce a sheet having a substantially uniform thickness, which comprises successively passing said sheet between a plurality of rolls formed to normally have a convex surface, applying pressure to the ends of said rolls sufficient to form a substantially straight contacting surface, controlling the heat distribution longitudinally of said rolls and variably increasing the slippage of said rolls as the thickness of said sheet is decreased.

6. The process of cold rolling a sheet of ductile metal to effect a substantial reduction in thickness thereof, which comprises successively passing said sheet between squeezing rolls having a crowned surface and applying sufficient pressure to said rolls to produce a substantially straight rolling surface and to make a reduction in thickness in each passage of said sheet in excess of 15% in a single pass, controlling the temperature of said rolls to maintain said substantially straight contacting surface and produce a rolled sheet having substantially parallel surfaces, and controlling the slippage of said rolls whereby the horizontal component of the force supplied thereby decreases as the sheet becomes thinner.

7. The process of cold rolling ductile metal which comprises passing said metal between rolls having a crowned surface, applying sufficient pressure thereto to form a substantially straight contacting surface, cooling said rolls during the initial pass by a blast of compressed air, utilizing water as a cooling medium for said rollers during intermediate passes and utilizing oil as said cooling medium during the final passes, thereby to increase the slippage of the rolls as the metal becomes thinner whereby the horizontal component of the force exerted is reduced and tearing of the sheet is prevented.

8. The process of cold rolling a ductile metal such as copper into thin sheets of a thickness of less than 90 thousandths of an inch and a width exceeding 22 inches, which consists in rolling the sheet between rolls while maintaining

accurate parallelism between the faces thereof, and applying successively lubricants of different viscosities to the rolls during certain successive passes of the sheet.

9. The process of cold rolling a ductile metal such as copper in wide sheets of a uniform thickness throughout, which consists in forming the first passage of the rolls with a reduction which will remove any inequalities of thickness and produce a substantially flat plate, rolling said plate with reductions sufficient normally to heat the rolls unequally in different parts thereof and controlling the temperature of said rolls by successively applying cooling mediums having different heat conductive properties to said rolls as the sheets become thinner thereby to maintain a substantially uniform temperature throughout the length thereof.

10. The process of cold rolling sheets of non-ferrous metal which comprises passing said sheets through rolls whereby the thickness thereof is progressively reduced, and progressively increasing the slippage of said rolls as said sheets become thinner.

11. The process of cold rolling copper into thin sheets having a thickness of less than .009 inches and a width exceeding 22 inches, which consists in passing the sheet between rolls while maintaining accurate parallelism of the faces thereof and applying successively lubricants of increasing viscosities during certain successive passes of the sheet whereby the slippage of the sheet is increased as the metal becomes thinner.

12. The process of cold reduction of a sheet of copper which consists in passing a sheet of said metal rapidly and without intermediate annealing through small accurately crowned rolls with the crown designed to produce a substantially flat sheet on reductions per pass of 15%–40%, removing the large amount of heat generated by these heavy reductions by applying a suitable cooling medium to said rolls and varying the cooling medium and amount of heat removal selectively across the face of the roll to maintain a flat rolling surface.

13. The process of cold reduction of a sheet of copper which consists in passing a sheet of said metal rapidly and without intermediate annealing through small accurately crowned rolls with the crown designed to produce a substantially flat sheet on reductions per pass of 15%–40%, providing adequate means for removing the large amount of heat generated by these heavy reductions and increasing the slippage between the copper and the roll as the former becomes thinner whereby tearing of the sheet is prevented.

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