Jan. 12, 1937. W. TRINKS 2,067,514

METHOD OF AND APPARATUS FOR COLD ROLLING STRIP MATERIAL

Filed July 22, 1933 2 Sheets-Sheet 1

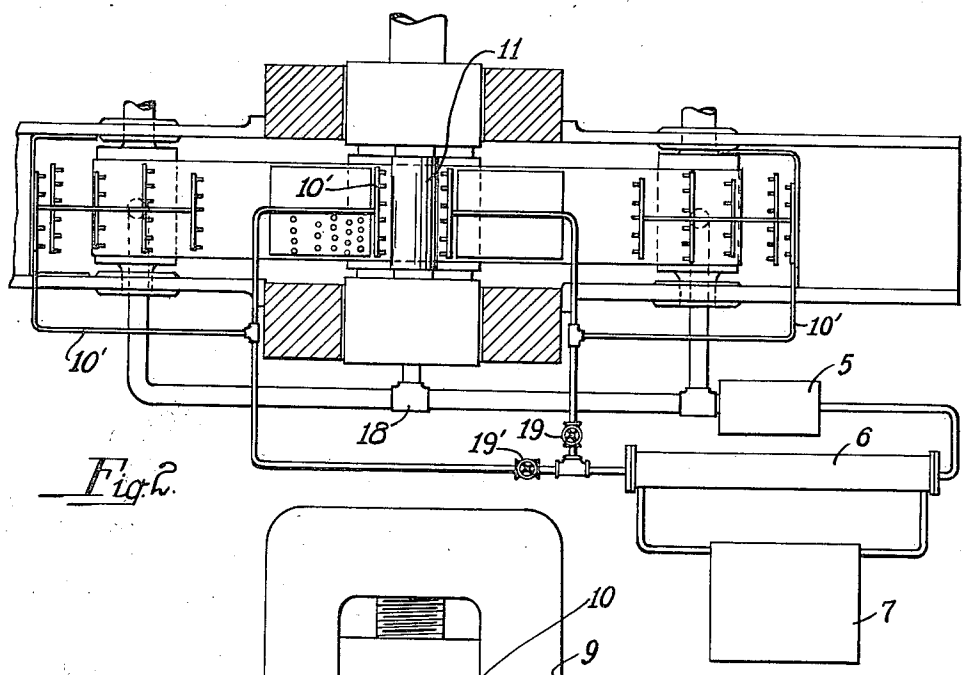


Fig. 2.

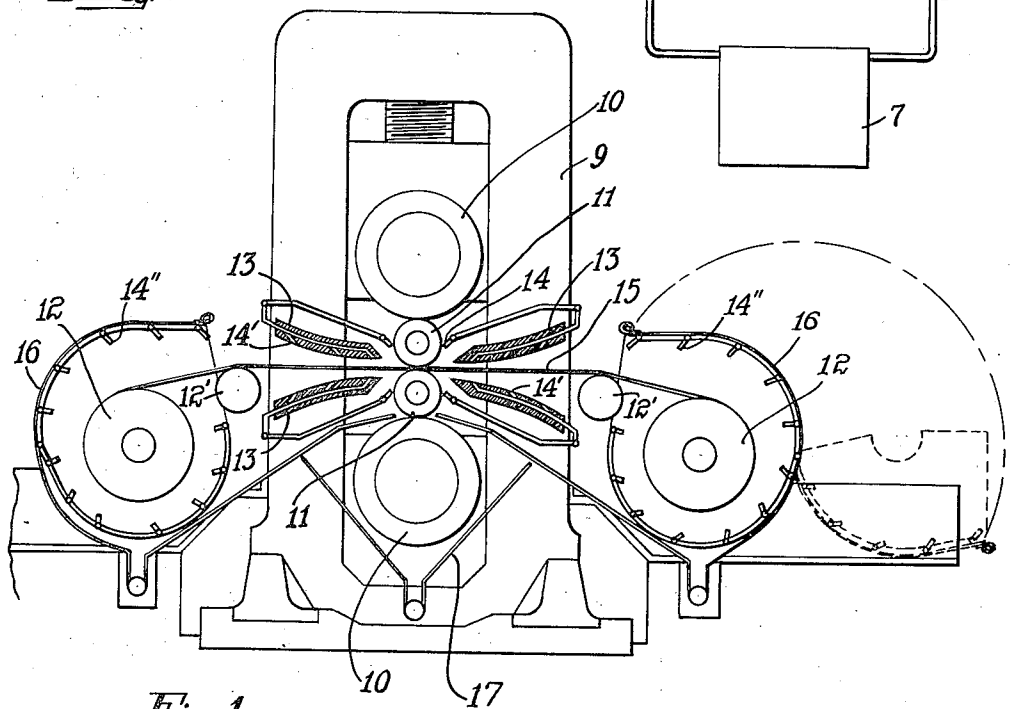


Fig. 1.

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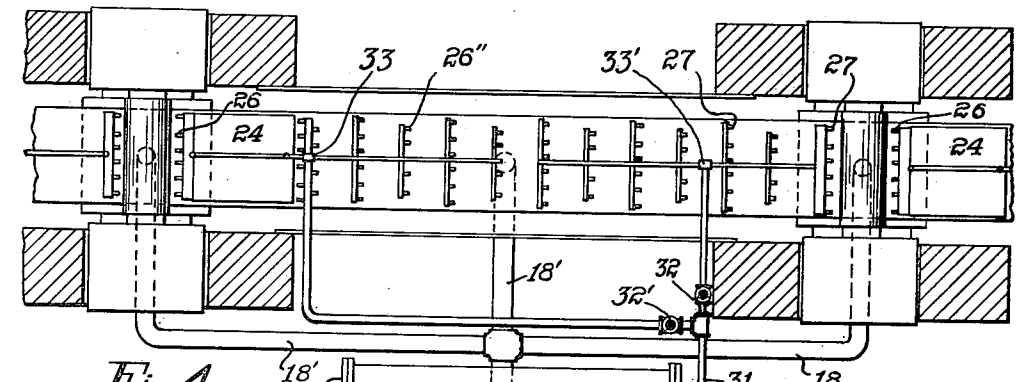


Fig. 4.

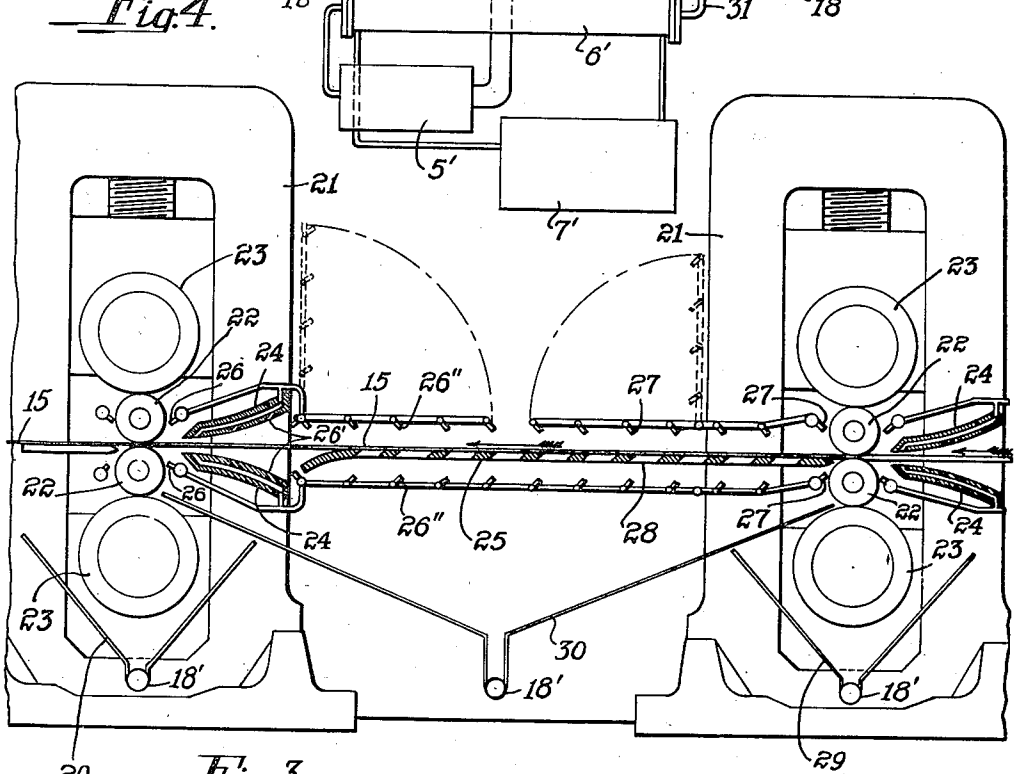


Fig. 3.

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UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR COLD ROLLING STRIP MATERIAL

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Application July 22, 1933, Serial No. 681,693

24 Claims. (Cl. 80—60)

This invention relates generally to cold rolling, but more particularly to the cold rolling of strip material. In employing the term "strip" or "strip material" I make no distinction between strips and sheets, since I may employ my improved procedure in the cold rolling of any strip material independently of its width and final thickness.

In all cold rolling operations, and particularly where ferrous metals are involved, considerable heat is developed, due to the internal deformation of the metal rolled and to the slippage of the deforming rolls on the metal as well as to plastic deformations in the rolls themselves. This has long been recognized and various expedients have been employed for overcoming the detrimental effects occasioned thereby. In the past, cold rolling operations have been limited to low speeds or to small reductions, primarily because of the temperature conditions encountered. While the amount of heat developed per cubic inch of steel, for a given reduction, is about the same whether the steel is rolled rapidly or slowly, the slow rolling operation provides more time for abstracting or dissipating the mechanically generated heat than a fast rolling operation. Where heat is developed by the rolling operation more rapidly than it is abstracted or dissipated, numerous detrimental effects are encountered, such as loss of hardness of the roll surface, surface spalling and change of roll contour, due to uneven thermal expansion. This not only decreases the effective life of the rolls, but also injuriously affects the rolling operation and the spalling detrimentally affects the surface of the sheets or strips rolled. Where slow speed rolling is employed, the time element may be sufficient to minimize these and other difficulties, particularly if some ordinary expedients are employed for carrying away at least some of the mechanically generated heat, and it has therefore been the practice to either externally or internally cool the rolls by a flow of cooling liquid.

I have, however, discovered that rolling friction or skin friction is responsible for a large part of the mechanically generated heat. By the term "rolling friction" I refer to the friction occasioned by the relative slipping between the roll surfaces and the material being rolled. It is, of course, apparent that this rolling friction contributes to roll wear and also has some effect in roughening the roll surfaces. In my opinion, it also occasions surface hardening of the strip material rolled and increases the directional difference of physical properties of the rolled material, such, for example, as ductility. The most serious effect of roll friction is encountered in rolling thin material, such as sheets or strips, since it may actually increase the resistance of the metal to compression strains to such an extent that the thin material may traverse the roll pass without responding to the rolling pressures encountered or without being reduced to an extent commensurate with the pressures employed.

From the foregoing it is apparent that it is not only essential to dissipate the mechanically generated heat in order to obtain the best results in a rolling operation, but it is also at least highly desirable to minimize rolling friction or skin friction, and thus to some extent minimize the cause for the detrimental effects encountered.

In the past, water has been used as a coolant in rolling operations and it is excellent for that purpose, but it has very little effect as a lubricant especially under the pressures encountered in cold rolling operations. Oil, on the other hand, as heretofore employed in cold rolling operations, has the desired effect as a lubricant, but it is ineffective as a coolant.

In order to obtain the desired cooling effect and at the same time minimize rolling friction, I employ a cooling fluid having a high lubricating characteristic and also having the capacity for absorbing heat at a relatively rapid rate and such a fluid is referred to throughout this application by the term "cooling lubricant". The use of an emulsion of oil in water is old and is not claimed as part of the present invention.

The temperature of the strip attained in any given roll pass is directly related to the temperature of the sheet material entering the pass, the degree of deformation of the material in the pass, and rolling or skin friction. From the foregoing it is apparent that the temperature of the material entering the pass contributes to the temperature of the material leaving the pass, with the result that under ordinary conditions of rolling, the heating effect is cumulative, since ordinary means of cooling, such as heretofore employed, are not alone sufficient to extract the heat from the rolls with sufficient rapidity to keep them at a reasonably low temperature, if the material entering the rolls during successive passes enters at progressively higher temperatures.

It is, of course, apparent that the length of

time between successive passes will have some effect on the ultimate temperature of the strip material being rolled, but where maximum production per unit of equipment is the ultimate aim, the time between passes must be minimized and this is true whether a continuous or a reversing mill is employed. In a continuous mill, the period between passes is necessarily dependent upon the speed of rolling and the distance between the stands, but in all mills there is necessarily a limitation to stand spacing and in any event, ordinary variations in stand spacing will not vary the time interval between passes sufficiently to make a material difference in the amount of heat dissipated or removed from the material by atmospheric absorption.

From the foregoing it will be apparent that where fast rolling is employed, the surface temperatures of the rolls rise excessively and, in a continuous mill, vary greatly from pass to pass even where the ordinary expedients for abstracting heat are employed. The resulting expansion of the rolls not only varies from the middle toward the ends of the rolls, but also varies from time to time and from pass to pass and thus makes it extremely difficult to maintain constancy of gauge or thickness of the material rolled. Then too, as I have stated, these excessive temperature changes produce excessive stresses in the rolls themselves, which result in cracking or spalling of the roll surfaces, as well as in drawing the temper and reducing the hardness of the surfaces. These detrimental effects are likewise encountered in a reversing mill, and particularly where a high output per mill is sought and the strip material is reeled between passes, because the reeling operation in itself conserves the heat within the material and the intervals between passes are necessarily not much longer than the intervals between passes in a continuous mill or, in any event, are not long enough to prevent the cumulative heating effect in both the material and the rolls. It is, therefore, highly desirable to maintain the strip material at as low a temperature as possible during the cold rolling operation whether a continuous or a reversing mill is employed, and to present the material to each pass at as nearly as possible the temperature of its presentation to the preceding pass in order to avoid this objectionable cumulative effect of the mechanically generated heat.

In carrying out the procedure constituting my improved method of rolling, I may employ either a continuous mill or a reversing mill, and I also employ means for, in effect, cooling the strip material by turbulent streams of cooling lubricant moving rapidly relative to the strip and under such conditions that the heat mechanically generated within the material, as it traverses each pass, is largely abstracted and dissipated before the material is subjected to the deforming and heating effect of a subsequent pass. For best results, the cooling lubricant must have a temperature only slightly above the freezing point of water.

The primary object of my invention is to produce a method of cold rolling and apparatus for carrying out that method, such as will overcome difficulties usually encountered in connection with rapid rolling under normal commercial conditions.

Figure 1 is a diagrammatic view of apparatus embodying my invention shown in connection with a side elevation of a reversing mill and adapted to carry out the process herein defined in connection with a reversing mill;

Fig. 2 is a plan view of the apparatus shown in Fig. 1, the reversing mill there illustrated being shown in section for convenience of illustration;

Fig. 3 is a diagrammatic illustration of adjacent stands of a continuous mill and illustrates apparatus for carrying out my improved process as applied to such stands; the apparatus being shown in section for convenience of illustration; and

Fig. 4 is a plan view of the apparatus shown in Fig. 3, and in which the stands of the adjacent mill are shown in section for convenience of illustration.

In the illustrated embodiments of my invention, I employ means for spraying a refrigerated cooling lubricant onto the strip material as it leaves the working rolls and also onto the working rolls. Where the invention is carried forward in connection with a reversing mill, the means above referred to are so located and arranged that the material issuing from either side of the mill is subjected to the spray of refrigerated cooling lubricant.

In carrying out my invention, I preferably employ a cooling lubricant, for the double purpose of minimizing rolling friction and also absorbing heat from the rolls and from the strip material being rolled. In order to render the lubricant effective as a cooling medium, I reduce its temperature, by suitable refrigeration, far below any temperature heretofore employed, and I deliver the thus refrigerated lubricant at a sufficiently high velocity, with relation to the surfaces to be cooled, and in sufficient quantities to abstract the greater part, if not substantially all of the heat mechanically generated by the passage of the material through each roll pass. The lubricant thus refrigerated is, as previously stated, herein referred to as "cooling lubricant."

The apparatus employed includes a source of cooling lubricant under pressure, herein diagrammatically disclosed as a pump 5; a cooler 6, through which the lubricant from the source of pressure is delivered, and a series of spray nozzles so arranged that the cooling lubricant is delivered in the form of pressure jets to the material rolled, and also to the surfaces of the working rolls. I preferably divide the nozzles into groups so arranged that the cooling lubricant is delivered to both sides of the strip at substantially the zone of contact between the rolls and the strip and also along the strip as it leaves the rolls so that the material is, in effect submerged by a rapid flow of cooling lubricant for a sufficient period to insure adequate cooling. In order to assure the abstraction of substantially all of the heat generated, I also employ a refrigerator or refrigerating machine 7, which, as diagrammatically illustrated, is so arranged that it refrigerates the cooling medium delivered to the cooler 6. It will, of course, be understood that this cooling medium may be any non-freezing liquid, such as brine or liquefied ammonia, since my purpose is to cool the lubricant, i. e., the cooling lubricant employed, to a temperature of about 32° F.

While it is possible during the winter months to use cold water from rivers or lakes as a cooling medium to remove heat from the cooling lubricant, and thus, to dispense with the refrigerating machine, from an economic standpoint this is not in most cases feasible, because the

water cannot ordinarily have a temperature below 32 degrees Fahrenheit. In endeavoring to cool a lubricant to nearly the same temperature, the temperature gradient will be very small, and the heat-exchange apparatus required will be so excessively bulky and expensive as to be commercially impracticable. Furthermore, such apparatus can only be used during the few months of the year when water is available near a freezing temperature; and, since it is desired to roll material throughout the year, a refrigerating machine will be required to, in most cases, permit operation during the other months.

In Fig. 1 I have diagrammatically illustrated a reversing mill, including a frame 9, top and bottom backing rolls 10, and top and bottom working rolls 11. It will be understood that the mill is provided with the usual bearings, screw downs and other accessories, and that while a four-high is illustrated, the invention may be carried forward with any type of mill suitable for the rolling conditions encountered. As illustrated, the mill is equipped with coiling reels 12, located on opposite sides of the frame portion thereof, and is also provided with suitable guide rolls 12'. It will, of course, be understood that some means is provided for driving the rolls, or at least the reducing rolls 11 of the mill, and that means are also employed for so actuating the reels 12 that the material being rolled will be drawn off of one reel and wound onto the other. The mill is also provided with the usual entering guides 13.

In order to abstract the mechanically generated heat from the material being rolled, and also from the rolls themselves, I provide a series of nozzles on each side of the mill which, for convenience of description, may be said to be divided into three groups, viz., the nozzles 14 which are arranged to spray refrigerated lubricant onto the face of the rolls 11 and consequently onto the material 15 being rolled at a point adjacent to the zone of contact between the rolls and the material. In the illustrated embodiment, the guides 13 are hollow and are provided with apertures which constitute nozzles 14', arranged to deliver the refrigerated lubricant onto the material as it leaves the pass. A third group of nozzles 14'' are located within and are spaced around the casing 16 for each reel 12. A reference to Figure 2 discloses that the nozzles 14 are located in spaced relation along the rolls 11 and that the spacing is such that the jets of liquid issuing therefrom will spread sufficiently to, in effect, submerge the entire length of each roll 11 by a rapidly moving film of lubricant which, because of the force of the jets, is impelled onto the material 15 being rolled. The apertures constituting the nozzles 14' are similarly spaced transversely of the strip material 15, and are so spaced along that material as to provide a copious flow of cooling lubricant on both the upper and the lower surfaces thereof. A similar transverse spacing of the nozzles 14'' is employed, and these nozzles are also located around substantially the entire periphery of the associated reel 12 so that the material is continuously subjected to a flow of cooling lubricant from the time it leaves the pass until the coiling operation is completed.

From the foregoing it will be apparent that all of the nozzles 14, 14' and 14'' are included as a part of a pressure system, which also includes the pump 5 and the cooler 6.

In order to avoid waste of cooling lubricant, I employ catch basins so arranged as to collect the lubricant as it drops from the rolls, the material being rolled and the material being coiled, and these basins form a source of cooling lubricant supply for the pump 5. As shown, one such basin 17 is located below the bottom backing roll 10 and a similar basin may be located below each reel or may form a part of the casing 16 of each reel. Each of these basins is provided with a submerged outlet port which communicates through suitable piping 18 with the inlet to the pump 5. With this arrangement the cooling lubricant delivered to the rolls 11 and the material 15 is collected in the several basins, is returned to the pump 5 and is forced under pressure through the cooler 6 and back to the nozzles.

In order to provide access to the reels, the casings 16 are provided with a hinged portion which is capable of being moved to the dotted line position shown in the right hand portion of Fig. 1. This necessitates a joint in the piping to such of the nozzles 14'' as are supported by the hinged cover.

In order that the mill of Figures 1 and 2 may be operated as a reversing mill, the cooling facilities above described are located on both sides thereof, and it will be apparent that by properly setting the valves 19, 19', the flow of cooling lubricant can be so controlled that only the nozzles on the delivery side of the mill are effective. It will, however, be apparent that under some conditions of operation it may be desirable to deliver the cooling lubricant to both sides of the mill in order to insure the desired cooling of the material prior to entering the pass, and I also call attention to the fact that the nozzle arrangement is such that the material being cooled is not only subjected to the flow of cooling lubricant during the coiling operation, but that this flow may be continued after the coiling operation is completed and under such conditions that the entire coil is, in effect, submerged by a relatively rapid flow of cooling lubricant.

In Figures 3 and 4 I have shown an arrangement of apparatus adapted for carrying out my invention in connection with a continuous mill. In those views I have illustrated but two stands of the continuous mill, but it will be understood that the invention may be applied to each of the several stands of such a mill. As there illustrated, each stand comprises a frame 21, working rolls 22, backing rolls 23 and such auxiliary devices and accessories as are ordinarily employed in such mills. Each stand is also provided with entering guides 24 and a table 25 is located between the stands and forms a means of support for the material 15 being rolled and passing between the two adjacent stands. As described in connection with Figures 1 and 2, the cooling system includes separate groups of nozzles so arranged that the strip material 15 is, in effect, subjected to a submerging flow of cooling lubricant throughout the entire rolling operation, the lubricant moving at high velocity relative to the material.

As shown, each roll stand is provided with four groups of nozzles, viz., nozzles 26, which deliver cooling lubricant onto the rolls 22 in such a way that the surface of the rolls and the entire width of strip material entering the pass are both submerged by the flow; nozzles 26' are formed in the hollow guides 24, as described in connection with Figures 1 and 2;

these nozzles are supplemented by a series of nozzles 26''; and each roll stand is provided with nozzles 27 located on the delivery side thereof and which cooperate with the nozzles 26, 26' and 26'' associated with the adjacent stand, in insuring that the entire length of strip material from one stand to another is in effect submerged by the flow of cooling lubricant. It will be apparent from the drawings that the nozzles referred to are located both above and below the strip material being rolled, and for this reason, the table 25 is provided with adequate apertures 28, through which the cooling lubricant is sprayed directly onto the surface of the material passing over the table. It will be understood from Figure 4 that the nozzles are spaced transversely of the rolls and of the strip material with which they are associated, and that the nozzles form a part of a pressure system which includes the pump 5', a cooler 6' and a refrigerator 7', all diagrammatically shown in substantially the same relationship as in Figure 2.

In order to avoid waste of the cooling lubricant, I also provide basins 29 and 30, each of which is provided with a submerged outlet port which, in effect, forms a source of supply for the pump 5'. These outlet ports communicate with the inlet of the pump 5' through conduits 18' and the nozzles above described are included in a piping system, including the pipes 31, valves 32 and 32' and branch pipes, as shown.

In order to provide access to the portion of the strip located between stands or traversing the table 25, I preferably so arrange the nozzles constituting the group 26' and a portion of the group 27 that they may be elevated to the dotted line position as shown in Figure 1. This, of course, refers only to the nozzles located above the table 25 and is accomplished by providing a swivel joint in the piping as shown at 32, 32' in Figure 4.

It will, of course, be apparent that a reel may be associated with the first and last stands of the continuous mill, and that under some conditions of operation it may be desirable to surround the coiling reel with nozzles for delivering cooling lubricant, such as the nozzles 14'' of Figure 1. It will also be apparent that various changes in the positioning and the arrangement of the nozzles may be employed and that, while I have disclosed some of the nozzles associated with entering guides, wherein the guides are hollow so as to provide cooling lubricant delivery passages therein, such an arrangement may be varied and that the apertures of the guides may be replaced by properly located, separately formed nozzles. The apparatus illustrated may be supplemented by any convenient arrangement of shields for preventing loss of cooling lubricant and of guiding the same into such catch basins as are provided. It will also be apparent that the nozzles 14 of Figure 1 and the nozzles 26 and 27 of Figure 2, may be replaced by other expedients for cooling the working rolls, but that the broad intent of the invention is to provide an arrangement such that the mechanically produced heat is dissipated substantially as rapidly as it is generated so that the material enters the successive passes, whether in a reversing mill or a continuous mill, at substantially the same temperature for each pass.

This is in general accomplished by subjecting the material being rolled to a heat dissipating influence substantially at and immediately following the time of subjecting it to deforming strains, and in so controlling the cooling effect and the duration of the cooling influence as to abstract the greater part of the mechanically generated heat from the strip material before the material is subjected to a subsequent rolling pass. In addition to the above, such heat as may be generated in or may be absorbed by the surfaces of the deforming rolls is also dissipated, or largely offset, by rapidly carrying away the heat at the surface of the roll, and thus maintaining a more or less uniform temperature distribution throughout the body of the roll.

While I prefer to refrigerate the cooling lubricant to temperatures approximating the freezing temperature of water, the delivery temperature of the cooling lubricant, will depend on the rate of lubricant flow, the speed of rolling, the amount of reduction per pass and the period intervening between passes. That is to say, under some exceptional conditions of operation, the desired result may be accomplished by water cooling the cooler 6, particularly where an adequate flow of low temperature water is available, e. g., from the rivers or lakes during the winter months of the year.

In the claims, the word "copious" as applied to the flow of a cooling lubricant, is to be understood to mean a sufficiently large quantity to substantially cover the sheet with a liquid film flowing rapidly with respect to the surface. Thus, in effect, the material is maintained submerged during the feeding, transferring, rolling, coiling and uncoiling operations. Also in the claims, the words "artificially cooled" mean cooled by a refrigerating machine or other means suitable for producing a temperature considerably below that of the atmosphere.

From the foregoing it will be apparent that various changes, both in the procedure described and in the apparatus contemplated for carrying out that procedure, may be made without departing from the spirit and scope of my invention as defined by the appended claims.

What I claim is:

1. A method of cold rolling which includes subjecting the material rolled to successive rolling passes in opposite directions, coiling the material as it issues from each pass and subjecting the material to a copious-high-velocity flow of cooling lubricant substantially as defined in the specification as it issues from each pass, as it moves toward the coiler and during the coiling operation, said lubricant being artificially cooled to a sub-atmospheric temperature.

2. A method of cold rolling which includes, subjecting strip material to successive rolling passes in opposite directions, coiling the material as it issues from each pass and spraying the material as it issues from each pass as it moves toward the coiler and as it is being coiled with a copious supply of cooling lubricant artificially cooled to substantially 32° F. and moving at high velocity relative to the material.

3. In combination with a rolling mill, a coiler, a plurality of liquid spray nozzles located above and below the path of travel of material issuing from said mill and passing to said coiler, spray nozzles surrounding said coiler, a casing partially enveloping said coiler and having a liquid delivery port formed therein, a pump for delivering liquid under pressure to said spray nozzles and means for delivering liquid from said delivery port to the inlet of said pump.

4. In combination with a rolling mill, a coiler

a plurality of spray nozzles spaced between said mill and said coiler and surrounding said coiler, a basin located below said mill and having a delivery port formed therein, a basin located below said coiler and having a delivery port formed therein, a pump for delivering liquid to said nozzles, a cooler intervening between said pump and said nozzles, and piping between said delivery ports and the inlet port to said pump.

5. In combination with a rolling mill, a coiler, spray nozzles located between said mill and said coiler and around said coiler, basins for collecting liquid issuing from said nozzles, a pump for delivering liquid to said nozzles, a cooler intervening between said pump and said nozzles, means for refrigerating the cooling medium delivered to said cooler and means for delivering liquid collected in said basins to the inlet of said pump.

6. In combination with a continuous mill comprising a plurality of stands, a guide table between adjacent stands having liquid delivery openings formed therein, spray nozzles located in spaced relation between said stands and above and below said table, a basin located below said table, a pump for receiving lubricating liquid from said basins and delivering liquid to said nozzles and a cooler intervening between said pump and said nozzles.

7. In combination with a continuous mill comprising a plurality of roll stands, hollow delivery guides associated with each such stand and having liquid delivery apertures formed therein, spray nozzles located in spaced relation between said stands and above and below the path of travel of material traversing said mill, means for collecting liquid issuing from said apertures and said nozzles, a pump communicating with said means for delivering liquid to said nozzles and said hollow guides, a cooler intervening between said pump and said nozzles and means for refrigerating the cooling medium delivered to said cooler.

8. In combination with a continuous mill comprising a plurality of roll stands, guide tables located between adjacent stands and having liquid delivery openings provided therein, hollow entrance delivery guides associated with each of said stands and provided with liquid delivery apertures, a series of nozzles located in spaced relation between said stands and movable toward and away from said table, a pump for delivering liquid to said nozzles and to said guides, means for collecting liquid issuing from said nozzles and for delivering liquid so collected to said pump, a cooler intervening between said pump and said nozzles and means for refrigerating the cooling medium delivered to said cooler.

9. The combination with a reversing mill, a coiler located on each side of said mill, a casing for each coiler having a hinged cover, spray nozzles located in spaced relation between said mill and each of said coilers, spray nozzles associated with said casings and movable with said cover, a pump for delivering liquid to all of said spray nozzles, a cooler intervening between said nozzles and said pump, means for receiving liquid delivered from said spray nozzles and delivering such liquid to said pump.

10. In combination with a reversing mill, hollow entrance guides located on each side thereof and having liquid delivery apertures formed therein, a coiler located on each side of said mill, a casing for each coiler having a movable cover, spray nozzles located in spaced relation above and below the path of travel from said mill to each coiler, spray nozzles associated with each casing and cover and surrounding said coiler, a pump for delivering liquid under pressure to said spray nozzles and to said hollow guides, a cooler intervening between said pump and said nozzles, a basin located below said mill for receiving liquid delivered by said nozzles and having a liquid delivery port communicating with the inlet port of said pump.

11. A method of cold rolling suitable material such as strips and sheets which includes, artificially cooling a lubricant to a low temperature, subjecting the material to a succession of rolling passes, coiling the material after subjecting it to each rolling pass, directing the cooled lubricant upon the material while moving the material to and from a coiled position and while coiling and uncoiling the material, and directing the cooled lubricant upon the rolls in such a manner that the material will be reduced to its initial temperature before entering each successive rolling pass.

12. The method of cold rolling suitable material such as strips and sheets which includes, subjecting the material to successive passes between rolls under pressure in a reversing mill, coiling the material as it comes from a pass, and later uncoiling it as it enters the next pass, cooling the strip to substantially a predetermined fixed temperature by artificial cooling means as it comes from the pass and while coiling and uncoiling it, said temperature being substantially the same for all passes, and subjecting the material to a succeeding pass immediately after it has moved through a preceding pass.

13. A method of cold rolling strip metal which includes incrementally roll reducing a work piece from initial to final gauge and in projecting against the reducing rolls and the top and bottom surfaces of the work piece high velocity jets of liquid lubricant having a temperature of about 32° F. and in sufficient quantities to cool the rolls and envelop the work piece with a rapidly moving stream of cooling liquid.

14. A method of cold rolling strip metal which includes passing a work piece through reducing rolls and in projecting liquid lubricant having a temperature of about 32° F. and in the form of jets against said rolls and against the top and bottom surfaces of the work piece on the entering and exit sides of said rolls and in quantities sufficient to flood the entire work piece with rapidly moving cooling liquid.

15. A method of cold working strip metal which includes incrementally roll reducing a work piece from initial to final gauge and simultaneously with such reductions in projecting jets of liquid lubricant against the reducing rolls and against the top and bottom surfaces of the work piece in such quantities as to deluge all portions of the work piece adjacent such jets with rapidly moving cooling liquid having a temperature of about 32° F.

16. A method of cold working strip metal which includes incrementally roll reducing a work piece from initial to final gauge and continuously projecting high velocity jets of liquid lubricant maintained at a temperature of about 32° F. against the reducing rolls and the top and bottom surfaces of the work piece; the volume of lubricant so projected being sufficient to provide a rapidly moving envelope capable of lowering the temperature of the work piece

to substantially its initial temperature after each such reduction.

17. A method of cold rolling strip material which includes subjecting a work piece to successive roll reductions and during and between such reductions in enveloping all portions of the work piece with a flood of rapidly moving liquid lubricant having a temperature of about 32° F.; said flood being formed by high velocity jets directed against the upper and lower surfaces of the work piece.

18. A method of cold rolling strip material which includes subjecting a work piece to successive roll reductions and throughout the periods intervening between such reductions in deluging the work piece with rapidly moving liquid lubricant formed by projecting against the entire upper and lower surfaces of the same jets of liquid lubricant having a temperature of about 32° F.

19. A method of cold rolling strip material which includes subjecting a work piece to successive roll reductions and a continuous temperature reducing procedure which consists in contacting its entire upper and lower surfaces with a rapidly moving deluge of liquid lubricant by projecting jets of liquid lubricant cooled to about 32° F. against such surfaces and against the reducing rolls whereby the temperature of the work piece after each reduction is lowered to substantially its initial temperature.

20. In combination with the rolls of a reversing mill for cold reducing strip material, nozzles located at both sides of said mill above and below the path of travel of material traversing the mill and arranged to project high velocity jets of liquid lubricant along the upper and lower surfaces of such material, a lubricant collector located below the path of travel of the material, a pump for receiving liquid from said collector and for delivering the same to said nozzles and a lubricant cooler located between said pump and said nozzles.

21. The combination with the reducing rolls of a mill for cold reducing strip metal, of upper and lower hollow delivery guides adjacent said rolls and provided with jet apertures for projecting liquid lubricant along the upper and lower surfaces of material entering and leaving the mill, means for collecting liquid flowing from the material being rolled, a pump communicating with said means and arranged to project liquid through said jet apertures, a cooler intervening between said pump and said jet apertures and means for refrigerating the cooling medium delivered to said cooler to a temperature such that the liquid lubricant is projected onto the material being rolled at a temperature of about 32° F.

22. The combination with the reducing rolls of a reversing mill for cold reducing strip metal, of liquid delivery nozzles located on opposite sides of said mill and arranged to direct liquid lubricant onto and along the top and bottom surfaces of the material traversing the mill, a pump for forcibly projecting sufficient liquid lubricant through said nozzles and onto the material being rolled to completely envelop the same, means for collecting liquid delivered by said nozzles and flowing from said material, a cooler intervening between said pump and said nozzles, and means for refrigerating the cooling medium delivered to said cooler whereby the liquid lubricant is delivered by said nozzles at a temperature of about 32° F.

23. A method of cold reducing strip metal which includes subjecting the material to be reduced to successive roll reductions in a reversing mill, coiling the material between reductions and during its travel to and from the mill in projecting onto and along its upper and lower surfaces high velocity jets of liquid lubricant discharged at a temperature of about 32° F. and during coiling in also projecting high velocity jets of such lubricant against the outer surface of the material.

24. A method of cold rolling which includes subjecting strip material to successive reducing passes through which the material alternately moves in opposite directions, coiling the material between passes and projecting onto the material as it issues from each pass, as it moves toward the coiler and during coiling high pressure jets of liquid lubricant cooled to substantially 32° F. and moving at a high velocity relative to the material.

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