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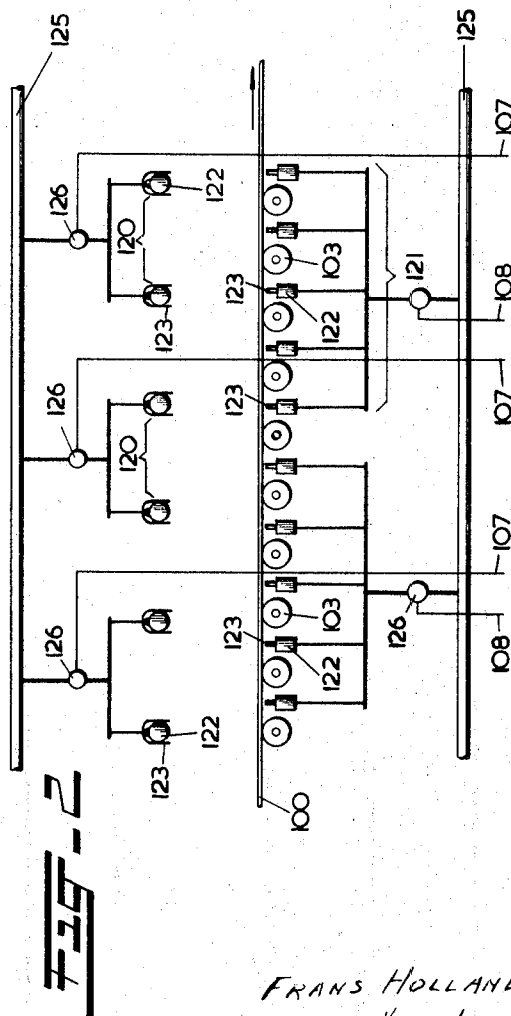
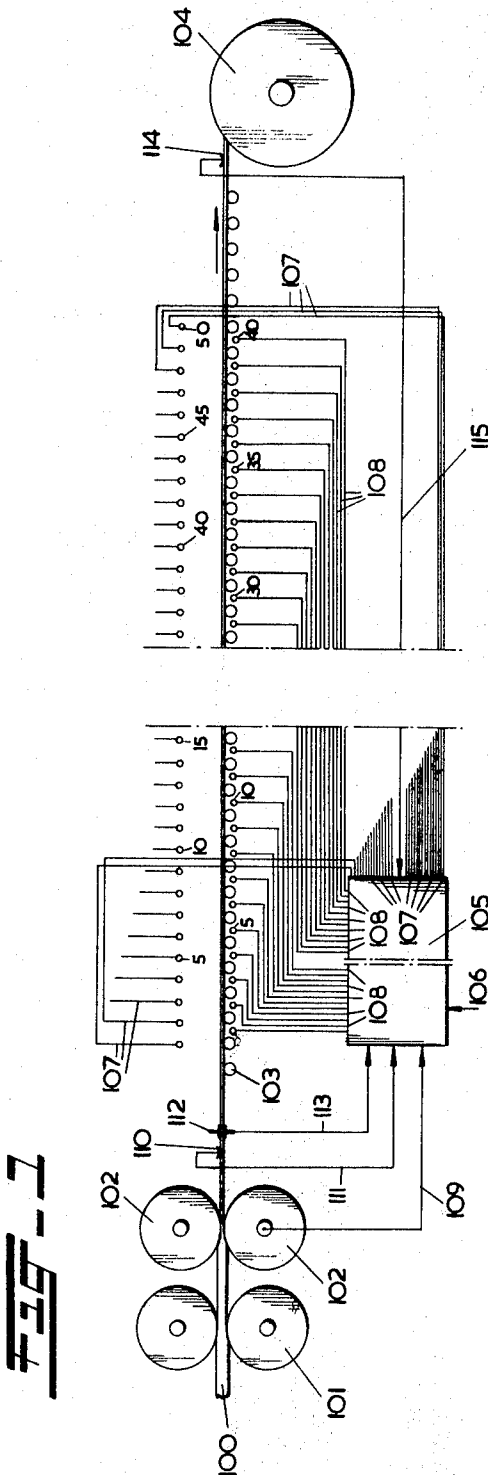
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3,533,261

METHOD AND A DEVICE FOR COOLING HOT-ROLLED METAL STRIP
ON A RUN-OUT TABLE AFTER BEING ROLLED

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2 Sheets-Sheet 1



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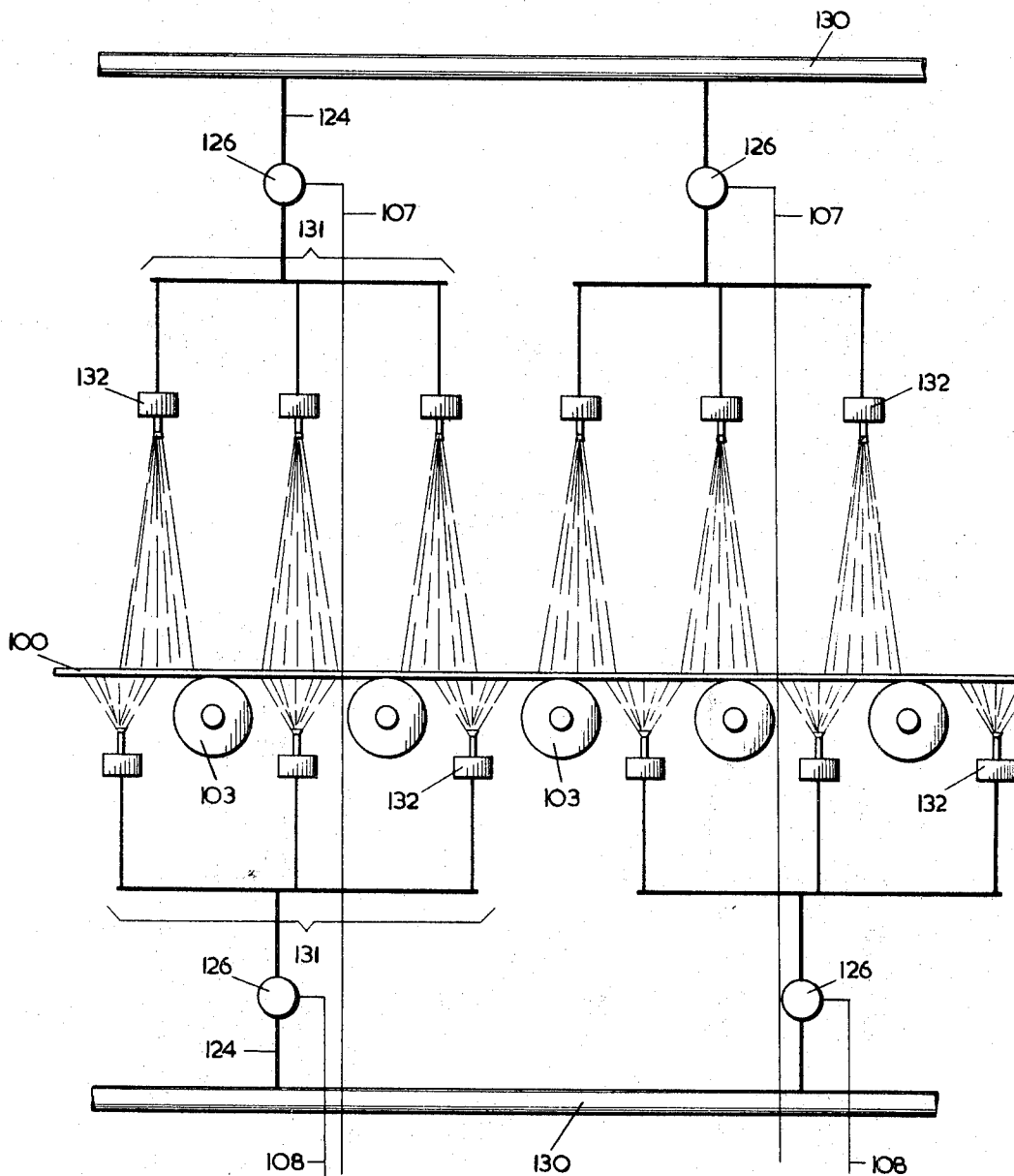
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2 Sheets-Sheet 2

FIG. 3



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METHOD AND A DEVICE FOR COOLING HOT-ROLLED METAL STRIP ON A RUN-OUT TABLE AFTER BEING ROLLED

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ABSTRACT OF THE DISCLOSURE

A method and a device for cooling hot-rolled metal strip on a run-out table after rolling, with a large number of cooling sections along the run-out table, of which those sections are put in operation which cool the strip so as to give a prescribed cooling speed for each part of the strip, independent upon the moving speed of the strip, with cooling sections not in operation present between at least part of the cooling sections in operation.

The device includes adjusting and control means for putting the right cooling sections into and out of operation also when the moving speed of the strip varies, and these means may include a computer to calculate the correct cooling sections to be operated in each particular case.

This invention relates to a method and a device for cooling hot-rolled metal strip on a run-out table, over which the strip moves after being rolled, with cooling means consisting of a number of cooling sections dispensing water into contact with the strip and provided in a large number along and usually both above and below the length of the strip.

In manufacturing hot-rolled steel strip it is usually started from slabs coming from a slabbing mill or from a continuous casting machine, which slabs should be at a temperature, which e.g. for low carbon steel is about 1200° to 1300° C. at the beginning of the rolling thereof into strip. If desired the slabs are brought or maintained at this temperature in a so-called slab-reheating furnace. Thereafter the slab is rolled to strip in a number of steps divided into roughing and finishing rolling steps, the oxide layer on the metal being removed at several positions by high pressure water sprays.

By radiation, conduction and convection of air and by said water sprays the temperature of the slab and of the strip made therefrom will decrease. On the other hand heat is generated in the slab and in the strip by the rolling.

After this rolling the strip reaches a run-out table, usually with rollers supporting the strip, along which table the strip is cooled by water to the temperature desired at the end of process, e.g. where the strip is wound on a coiler.

The temperature immediately after the last finishing reduction (the so-called finishing temperature) is for steel with a low carbon content e.g. about 900° C. and the final temperature after cooling, e.g. the coiling temperature, is usually between 400° and 800° C.

It is known to measure both said temperatures continuously or at regular intervals of time.

The length of the run-out table varies in practice usually from 40 to 100 m. for small and medium rolling mills to 140 to 200 m. for large rolling mills.

The slabs usually have a length of 2.5 to 12 m., the rolled strip has a length of from 100 m. to at present even 1.5 km. Therewith the thickness is reduced from e.g. 10–25 cm. at the slab to a few millimeters or even somewhat more than 1 millimetre. The width of slab and strip could vary from e.g. .6 m. to 2.5 m.

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Essential for the hot-rolling method of steel with not too high carbon content is that all reductions in thickness take place in the austenitic phase of the steel.

On the run-out table the temperature of the strip decreases such that first a transition temperature is passed in which ferrite begins to segregate, the remaining austenite becoming enriched in carbon. With a higher carbon content the transition temperature decreases. For steel with low carbon content (lower than .1%) the transition temperature is about 890° C. The measurement of the final rolling temperature is a check for the presence of the correct structure also during the coldest final part of the rolling process. On further cooling, when passing a lower transition temperature, the remaining austenite is transferred into perlite. When cooling takes place more rapidly the ferrite crystals become smaller and the cementite in the perlite becomes more finely distributed. The cooling speed thus is of considerable influence on the mechanical characteristics.

It is known to choose and vary the cooling along the run-out table in such a way that the final temperature of the strip after cooling always reaches a desired value. This means that with a higher strip speed there will be more intensive cooling along the same stretch because the strip will remain in the cooling zone during a shorter time period. The cooling speed of each part of the strip will in such a process not be the same, but may be higher for higher speeds of the strip.

The present invention aims at giving an improvement in this respect and obtaining also with a difference in strip speed always the desired structure and mechanical characteristics of the cooled strip.

According to the invention this is obtained by putting into operation only part of all cooling sections in a number and in places along the length of the cooling zone chosen such as to obtain approximately a desired relation between the temperature of the strip and the time for each part of the strip, the cooling sections put into operation being at least in part separated by cooling sections not in operation.

This could be realized with the aid of an adjusting and control device, including e.g. a computer, with an input, by which it is possible to program or adjust it in such a way that the outputs to valves or the like governing the water supply to the several cooling sections put those valves into open position which will cause the desired cooling speed to be obtained for each part of the strip.

The speed with which the slab and the strip rolled therefrom move through the rolling mill is usually chosen as high as possible in order to obtain a high capacity of the plant and in order to prevent too much cooling of the strip, which would occur if it remained during a too long period upon the so-called delay table in front of the finishing train. Of course such speed is limited by the structure of the apparatus, by the drives, by safety considerations and by the necessity to discharge the rolled strip in a correct manner, e.g. in having it caught correctly and safely by a coiler, on which the rolled strip should be coiled at the end of the plant.

In this respect it is known to heat the tail end of the slabs to a higher temperature than the head end and/or to cool the head end of the strip before it reaches the finishing rolls more than the tail end of the strip, because the tail end will, before it reaches the finishing rolls, be subjected to cooling during a longer period than the head end. In this way it is possible to prevent differences in thickness by differences in temperature during rolling. It is usual to roll the strip in the finishing rolls with a constant speed. In modern rolling mills it is moreover known to choose at first a low rolling speed, after which at a certain moment the rolling speed is increased. There-

by it is possible to guide the beginning of the strip correctly and safely through the mill and to pick it up correctly after cooling, e.g. by a coiler, and moreover the time of cooling for the tail end of the strip will in this way be shorter than without such acceleration.

Also in case the speed of the same strip changes during rolling, the present invention provides a method and means to allow the desired mechanical properties to be obtained over the entire length of the strip uniformly and evenly, namely by putting into operation additional cooling sections downstream of the cooling sections being in operation at the lower speed when the speed of the strip increases, with cooling sections not in operation positioned between at least part of such additional cooling sections. It is also possible, particularly if the desired cooling speed for each part of the strip is not a constant in the entire temperature field through which the strip has to pass, to realize the invention in such a way that with an increase in the speed of the strip during rolling of a same strip one or more cooling sections are closed down and a larger number of in part other cooling sections are put into operation, in total covering a greater length of cooling zone. Whether with varying speed one or more cooling sections will be closed down in this way or not will depend on the question whether the desired cooling speed is a constant during the cooling time or whether the temperature should follow a more intricate predetermined course in relation to time. In the latter case this closing down should be applied together with the putting into operation of other cooling sections as indicated.

When applying the invention a large number of cooling sections is applied, usually both above and below the strip, which sections will never or only in an extreme case, e.g. with the maximum thickness or strip which could be rolled in the mill, all be in operation together.

Preferably there are at least sixty cooling sections in total above and underneath the strip, e.g. 35 above and 25 underneath the strip, and a quite preferable number is about 90 sections or more, as will be described below.

Thus when applying the invention there is always, apart from this extreme situation, a considerable number of cooling sections out of operation, which are situated between cooling sections in operation and, particularly for lower than maximum strip speed, also in part past the end of the field of operative cooling sections. The total number of cooling sections is intentionally chosen to be so high as to allow much freedom in the choice of the pattern of cooling sections in operation along the run-out table to provide for the application of different desired predetermined cooling courses and for the maintaining thereof with considerably varying strip speeds and accelerations as suggested by the invention.

The invention will now be explained in more detail on the basis of the annexed drawings.

FIG. 1 gives diagrammatically a sideview of the last finishing rolls of a rolling mill and of a run-out table for hot-rolled metal strip, with an adjusting and control device for governing and controlling the operation of the cooling sections.

FIG. 2 gives diagrammatically part of the strip with two full cooling sections above the strip and two full cooling sections underneath the strip.

FIG. 3 also gives diagrammatically part of the strip with two cooling sections on top and two cooling sections underneath the strip for another type of cooling sections.

A steel strip 100 is rolled from a slab in several rolling stages and the last two sets of rolls of the finishing train are indicated by 101 and 102. Thereafter the rolled strip having a temperature of e.g. 900° C. moves over rollers 103 of a run-out table and is finally, after being cooled on said table coiled on coiling means 104.

Along the run-out table there are cooling sections above and underneath the strip 100 dispensing water onto the upper and lower surface of the strip to cool it. In the arrangement shown there are fifty cooling sections on

top of the strip and forty cooling sections below it, which is about a preferred number. Such sections will be described in more detail below. Only the first and end parts of the run-out table are given in FIG. 1, the intermediate part being broken away for sake of simplicity.

In FIG. 1 the serial numbers of the cooling sections for the first and for each fifth cooling section are given, numbering from left to right. Each cooling section has a valve to be described later for opening and closing the water supply and each valve has means such as a solenoid to open and close it electrically by a governing and control device not shown in detail and indicated by 105 in FIG. 1. This device could include analog or digital computing means programmed for this purpose. Said governing and control device is adapted to receive signals from one or more inputs and to transfer these inputs according to the desired prescribed way of cooling into signals for opening and closing certain valves of cooling sections. This device 105 first of all has an input 106, adapted to feed into the device 105 a desired course of the cooling speed of the strip, being the course of the desired temperature with cooling time (at each moment of cooling) for each part of the strip. In a more simple form, e.g. when the strip is not accelerated during rolling, this input 106 could consist of a number of keys operated by hand and representing the several cooling sections such that it is immediately put into the device 105 by hand which cooling sections will be put into operation and which will not.

From the device 105 signal lines 107 lead to each of the valves for each cooling section above the strip, there being the same number of lines 107 as there are such cooling sections, and signal lines 108 lead to the cooling sections underneath the strip, there being one line 108 for each such cooling section.

Moreover several other data are fed into the device 105. The first and most important thereof is the speed of the strip and this could be fed into the device 105 by measuring the speed of the lower roll of the set 102 of the last finishing rolling step, a signal for this speed being fed into the device 105 through line 109.

Important in cases in which the speed is varied during rolling of a strip is the acceleration, with which this takes place, as during varying speed the average speed of the strip is of importance for determining the correct moment of putting cooling section into operation. Otherwise, points of the strip already in the cooling zone when the speed varies could be cooled too much. Thus it is important to know the average speed with which points of the strip, leaving the cooling zone, were having in said cooling zone. This could be derived by integrating the acceleration by time. The acceleration could be derived from line 109 feeding the speed into device 105 by differentiating this speed by time and thereafter integrating the acceleration thus calculated by time taking into account the time lag for points of the strip between the last finishing rolls and the end of the cooling zone. Thus acceleration is an important datum fed to the device 105 via the speed.

Another datum to be fed into the device 105 is the measured temperature of the strip immediately after rolling, which could be measured at 110 and fed into the device 105 by signal line 111.

Still another datum to be fed into the device 105 is the thickness of the strip. It could be that this is known exactly and that there is no need to measure it, in which case it could be fed into the device 105 by hand. It could be desirable to measure the thickness of the strip and in FIG. 1 this is done at 112 and the signal for the thickness is fed to device 105 through signal line 113.

Still another datum of importance for the control of the cooling sections is the temperature of the strip after cooling (for which it is known to have it influence the amount of cooling) and in FIG. 1 this temperature is

measured before the coiler 104 at 114 and fed to device 105 through signal line 115.

For sake of clarity only part of lines 108 and 109 has been shown in FIG. 1.

Imagine that a strip with less than maximum thickness has to be rolled, that it is known that the rolling takes place in such a way that a known, finishing temperature of rolling will occur (which for normal low carbon steels keeps the steel in the austenitic field), and that it is necessary to cool this strip to a known temperature sufficiently low for handling the strip after cooling and for preventing undesired oxidation, structural changes etc. in the steel after cooling.

Now when applying the invention the expert will choose a desired cooling course of temperature in relation to time for each part of the strip and with a given speed of the strip on the run-out table and a given type of cooling sections, of which the cooling behaviour is known, the expert is able to calculate or have the computer calculate which cooling sections should be put into operation. So it is known that the strip will lose heat by radiation, the heat losses to the air by conduction and convection will be negligible and the only thing to be calculated further is the amount of heat to be removed by each cooling section.

With cooling means according to FIG. 2 the bottle-neck of heat removal will be the heat conduction through the strip to the surface and in cooling sections embodied as in FIG. 3 the quantity of heat removed will be proportional to the heat transfer coefficient from the metal of the strip to the water on its surface, so that this heat transfer coefficient is the bottle-neck of heat removal. These figures will be described in more detail below.

In both cases from these data a number of cooling sections necessary to cool the strip can easily be calculated, being dependent upon the temperature at the beginning and the temperature at the end of the cooling zone, on the thickness of the strip, the specific heat of the metal and the average speed of a considered point of the strip through the cooling zone, and at last dependent upon constant factors representing the geometry and the physical constants of the cooling plant.

The division of the required number of operating cooling sections between cooling sections above and underneath the strip is chosen so that as far as possible the quantity of heat removed is about the same for the upper and the lower surface of the strip.

EXAMPLE

For a given type of plant the following situation occurred:

The finishing temperature of rolling was 890° C., the temperature of the strip after cooling was required to be 600° C., the thickness of the strip was 2 mm. and the initial speed of the strip was 800 cm. per second. In the calculation it was taken into account that it was desired to have the cooling speed for each part of the strip being constant, so that the graph of temperature by time was simply linear and it was taken into account that it was desired to increase the speed of the strip after the beginning of the rolling to a value of 1600 cm. per second and that with the maximum speed which could be somewhat higher than 1600 cm. per second it was desirable to use cooling sections distributed as far as possible along the entire length of the cooling zone. The calculation made for the speed of 1600 cm. per second indicated that it was desired to have in operation at that speed thirteen cooling sections above the strip and twelve cooling sections underneath the strip. This meant that for that speed the following serial numbers of cooling sections above the strip had to be put into operation:

1—5—9—12—16—20—24—27—31—35—39—42—46.

For the cooling sections underneath the strip the fol-

lowering cooling section serial numbers were chosen for that speed:

1—4—8—11—14—17—21—24—27—30—34—37

Moreover it was calculated that at the initial speed of the strip of 800 cm. per second it was necessary to have seven cooling sections above the strip and six cooling sections underneath the strip in operation. Thus for this initial speed the following sections were chosen to be put into operation above the strip:

1—5—9—12—16—20—24

For the cooling sections underneath the strip the following serial numbers of cooling sections were chosen to be put into operation for that lower speed:

1—4—8—11—14—17

It could be calculated that for the following intermediary speeds a number of sections should be put into operation given behind these speeds in the following table:

TABLE

Average speed of strip in cooling zone	Number of sections	
	Above the strip	Underneath the strip
1000.....	9	8
1200.....	10	10
1400.....	12	11
1600.....	13	12

The governing and control device 105 could now be adjusted by hand to give a simply linear cooling course of temperature by time and thus when the speed of the strip is raised from 800 cm. per sec. gradually to 1600 cm. per sec. the device 105 will at the right moments put another cooling section into operation, so that in the above case as soon as the average speed of the strip in the cooling zone reaches e.g. 850 cm. per sec. the lower cooling section 21 is put into operation, and at 900 cm. per second the upper cooling section 27 is put into operation. At about 950 cm. per sec. average speed lower cooling section 24 is put into operation and at 1000 cm. per sec. upper cooling section 31 and so on.

Particularly if the cooling course representing temperature by time is not simply linear but shows curves or bends, e.g. straight parts at different angles connected by sharp bends, it could be necessary in order to maintain such a cooling course a constant for different speeds of the strip, to put into operation at lower speeds (800 cm. per second) of the strip the following serial numbers of cooling sections:

for the upper side of the strip:

1—9—16—18—20—22—24

and for the lower side of the strip:

1—8—14—16—17—19

For a higher speed (1200 cm. per second) the following serial numbers could be put into operation:

for the upper side of the strip:

1—9—16—24—26—28—30—32—34—36

and for the lower side of the strip:

1—8—14—21—23—24—26—27—29—30

In FIG. 2 part of the strip 100 is shown with three cooling sections above it, indicated by 120, and two cooling sections underneath the strip, indicated by 121. Each cooling section above the strip consists of two cooling units, indicated by 122. Each cooling unit consists of a closed box extending over the entire width of the run-out table, each box having a number of short pipes 123 extending therefrom in syphon-like fashion. Each cooling section underneath the strip consists of five cooling units each having a closed box also indicated by 122,

with upwardly directed discharge orifices. The water is introduced into each box through a supply pipe, the supply pipes for the units of one cooling section being supplied with water through a common duct 124 fed with water from a main water line 125. Each duct 124 has a valve 126 for opening and closing the ducts 124 and said valves are operated e.g. by electrical solenoids operated electrically through signals from lines 107 for the sections above the strip and 108 for the sections underneath the strip. The valves could be servo-operated, e.g. by air pressure, in a manner known as such. If desired the valves could have the possibility to be positioned in intermediate positions, partly opened, to adjust the quantity of water supplied by each cooling section. Moreover for testing, inspection and emergency cases each valve 126 could have means to be closed or opened by hand.

These cooling units operate according to the so-called laminar flow principle, with relatively low pressure on the water in the boxes, although the flow is not laminar in the strict sense of the word. Such cooling units are known from the paper by A. Sigalla: The Cooling of Flat Steel Strip with Water Jets, published in Journal of the Iron and Steel Institute, May 1957, pp. 90-93. The quantity of heat to be removed by such cooling units is determined by the heat conduction coefficient through the metal strip, and not by the heat transfer coefficient from metal to water, as the water flows are not much atomized, rather coherent, and of relatively low speed when contacting the steel strip.

Of course each cooling section could have another number of cooling units, even one unit only. It is possible to have the cooling sections embodied with mutually different numbers of cooling units along the length of the run-out table if desired.

In FIG. 3 the main water lines 130 supply water at a much higher pressure to the cooling sections and in this case each cooling section 131 is provided with three high pressure spray nozzles 132 atomizing the water to a considerable extent. Here are also valves 126 in lines 124 supplying the water to the sprays, the valves 126 being governed by signal lines 107 for the upper cooling sections and 108 for the cooling sections below the strip. For such types of sprays the heat transfer coefficient from metal to water is critical for the amount of heat to be transferred. Such high pressure spray nozzles are also known to the expert for cooling hot-rolled metal strip, e.g. from the book The Making, Shaping and Treating of Steel, edited by U.S. Steel Co., April 1957, pp. 592-4.

What we claim is:

1. In a method for cooling hot-rolled metal strip with the aid of apparatus of the type that includes:

- (i) a run-out table to the upstream end of which the hot-rolled strip is fed and to the downstream end of which it travels during cooling, and
- (ii) a multiplicity of selectively operable cooling devices arranged in groups, respectively, along the run-out table between its upstream and downstream ends in position to discharge cooling fluid against the strip for forming a cooling zone for cooling the strip in its travel therebetween,

the improvement which comprises:

- (a) continuously detecting the temperature of the strip being fed to the upstream end of said table,
- (b) continuously detecting the thickness of the strip being fed to the upstream end of said table,
- (c) continuously detecting the speed at which the strip is being fed along said table,
- (d) continuously detecting the temperature of the strip leaving the downstream end of said table, and
- (e) for reducing variations in crystal structure and mechanical characteristics between various parts of the cooled strip produced by differences in rates of cooling thereof,

- (1) varying the flow and distribution of the cooling fluid against respective parts of the moving

strip, by operating, at any given time, only selected ones of the selectively operable cooling devices in said groups of cooling devices, such selected ones being always separated by cooling devices not in operation at said given time, the number of said groups, and their respective locations along the run-out table, and the number of devices operated within each group and their locations therein being at all times selected to conform to a pattern which is varied, in accordance with the detected conditions (a), (b), (c) and (d), to cause all parts of the moving strip to attain substantially a predetermined temperature as detected in step (d) despite variations in one or more of conditions (a), (b), and (c), and to simultaneously cause the cooling of each part of the moving strip travelling over the run-out table to conform to substantially the same predetermined course of change of temperature with time despite such variations.

2. An improvement as claimed in claim 1, in which: (f) on an increase in the speed of travel of the strip along said table one or more additional cooling devices positioned downstream of those in operation at a lower speed are put into operation with cooling devices not in operation positioned between at least part of said additional cooling devices.

3. An improvement as claimed in claim 2, in which in step (f) on the increase of speed more than one additional cooling device is put into operation and a lesser number of said cooling devices previously in operation is shut down, the devices then being in operation in total covering a greater length of the cooling zone than those in operation before such increase of speed.

4. An improvement as claimed in claim 1 in which at maximum speed of the strip cooling devices are put into operation positioned in places including the first and last parts of the zone in which the selectively operable cooling devices are provided.

5. In the cooling of hot-rolled metal strip which, after hot rolling, is fed to and travels over a run-out table, such cooling being effected with the aid of cooling means comprising a multiplicity of cooling fluid nozzles positioned sequentially in groups in a cooling zone extending along the path of travel of the strip over said table, and operable selectively in said groups, the improvement which comprises:

(a) predetermining:

- (1) a final temperature value to which it is desired to cool and strip, and
- (2) a desired course of cooling rate, that is, of change of temperature with time, to be followed in the cooling;

(b) detecting:

- (3) the temperature of the strip being fed to the cooling zone,
- (4) the thickness of the strip fed to the cooling zone,
- (5) the rate of feeding of the strip to the cooling zone, and
- (6) the final temperature to which the strip is cooled in said cooling zone, and

(c) varying the discharge of cooling fluid by the nozzles of said respective groups of nozzles in accordance with the detected conditions (3), (4), (5) and (6) to conform the final temperature of the strip and the change of temperature of the strip with time to substantially the predetermined value (1) and course (2), respectively, despite variations in one or more of conditions (3), (4) and (5), the nozzles operated in any group at any given time being separated by nozzles not operated at such given time.

6. In an apparatus for the cooling of hot-rolled metal strip, said apparatus being of the type which comprises:

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- (a) a run-out table on which the rolled strip travels during cooling and
 (b) cooling means comprising a multiplicity of valved cooling fluid delivery means positioned sequentially in cooling sections in a cooling zone extending along the path of travel of the strip over said table,
 the improvement which comprises:

- (c) means for detecting, and deriving signals from:
 (1) the temperature of the strip being fed to the cooling zone,
 (2) the thickness of the strip fed to the cooling zone,
 (3) the rate of feeding of the strip to the cooling zone, and
 (4) the final temperature of the strip leaving the cooling zone; and

- (d) adjusting and control means having in-puts connected to receive the signals from said means (c) and having out-puts connected to control selectively the valves of the valved cooling fluid delivery means in the respective cooling sections, said adjusting and control means being programmed to adjust said valved cooling fluid means in response to said derived signals, to conform the final temperature of the strip and the rate of change of temperature of the strip with time to substantially a predetermined value and course, respectively, despite variations in one or more of conditions (1), (2) and (3) above,
 (e) the adjusting and control means always opening, at any given time of operation, a part only of the valved delivery means in each cooling section, said opened means being always separated by unopened valved delivery means.

7. An improvement as defined in claim 6, in which the number of cooling sections is more than sixty in total, above and underneath the strip.

8. An improvement as defined in claim 7, in which said total number of cooling sections is more than ninety.

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9. An improvement as defined in claim 6, in which the programmed adjusting and control means is programmed and connected to put into operation a number of cooling sections at least in part separated by cooling sections not in operation.

10. An improvement as defined in claim 6, in which the adjusting and control means has an input to program it, at will, with each one chosen desired course out of different desired courses of cooling speed of each part of the strip to put such cooling sections into operation as will give such chosen desired course of cooling speed.

11. An improvement as defined in claim 6, said adjusting and control means having means to calculate the average speed for points of the strip in passing through the cooling zone during acceleration of the strip and means to put cooling sections into operation dependent on said average speed.

12. An improvement as defined in claim 6, in which the cooling sections each include more than one cooling fluid delivery means along the length of the cooling zone having supply valve means adapted to supply or shut down all the delivery means of one cooling section at the same moment.

References Cited

UNITED STATES PATENTS

2,851,042	9/1958	Spence	266—6
3,176,355	4/1965	Ljungstromer	164—283
3,289,449	12/1966	O'Brien	72—201
3,300,198	1/1967	Clumpner et al.	266—6

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