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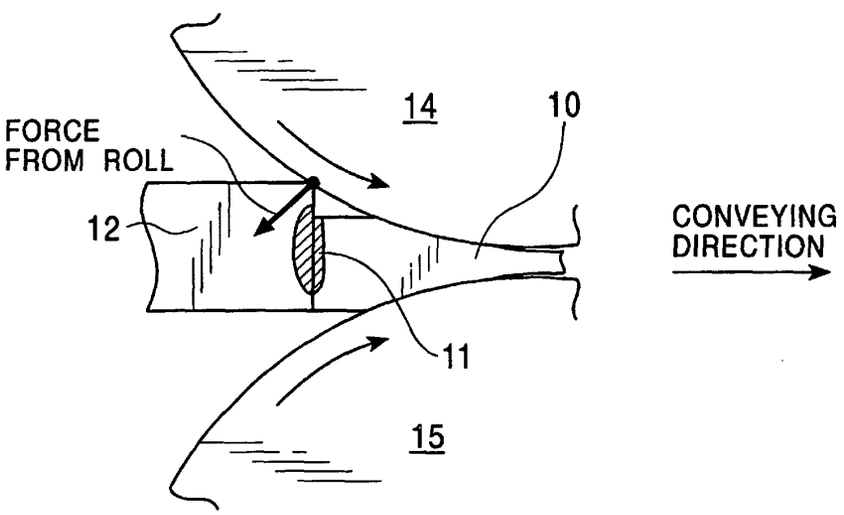
(54) ENDLESS HOT ROLLING METHOD

(57) The present invention provides an endless rolling method in which destruction of a sheet is prevented and damage of fixing plates and rolling rolls are prevented by maintaining the strength of a junction and by reducing the load applied to rolls. In the method, when sheet bars previously joined together are continuously treated in finish rolling, a step formed at the junction between the sheet bars is eliminated by setting the thicknesses of the sheet bar to the minimum thickness among the instruction thicknesses of the sheet bars to be joined together to form a unit.

FIG. 1



EP 1 327 487 A1

Description

Technical Field

[0001] The present invention relates to a method for setting operating conditions of endless hot rolling.

Background Art

[0002] In general, a rolling process for a hot rolled steel sheet is as follows: a slab is heated in a furnace, the heated slab is rolled with a roughing mill to form a sheet bar, and the sheet bar is then rolled with a finishing mill to form a hot rolled steel sheet. The slab, the sheet bar, and the hot rolled steel sheet are collectively referred to as a rolling material. Hitherto, sheet bars rolled with the roughing mill are rolled with the finishing mill one by one. Such a method is known as batch rolling. Recently, the following technique has been commercialized: the tail end of a preceding sheet bar is joined to the leading end of a succeeding sheet bar one after another between a roughing mill and a finishing mill, and the plurality of resulting sheet bars are continuously rolled with the finishing mill without interruption. This technique is known as endless rolling. During actual operation of finish rolling, batch rolling and endless rolling are individually performed.

[0003] A method for determining rolling conditions in a conventional batch rolling operation will now be described. An upper computer predetermines the rolling conditions according to information including the steel type, the standard, the size, the product thickness, the product width, of each rolling material. The rolling material is then fed to a hot rolling line. A lower computer detects the location of the rolling material at many points in the hot rolling line. The lower computer sets the rolling conditions of an apparatus located downstream of the place where the rolling material is detected, according to predetermined rolling conditions. The rolling material is fed to the downstream apparatus and then rolled.

[0004] In endless rolling, joining the sheet bars together is necessary. Exemplary joining techniques are disclosed in Japanese Unexamined Patent Application Publication No. 8-300008 and Japanese Unexamined Patent Application Publication No. 7-24504 filed by the applicant.

[0005] Japanese Unexamined Patent Application Publication No. 8-300008 discloses a laser welding equipment in which a vertical aligning device for vertically aligning junction ends is provided to either one or both of a clamping device for a preceding sheet bar and another clamping device for a succeeding sheet bar. Japanese Unexamined Patent Application Publication No. 7-24504 discloses a clamping device for joining sheet bars as follows: the tail end of a preceding sheet bar and the leading end of a succeeding sheet bar which are both heated are vertically clamped with arms individually in such a manner that a clearance is provided between both ends, pressed by moving both arms clamping each end, and then joined together. Another clamping device having a horizontal level-maintaining system including fixing plates for clamping across a sheet bar to another sheet bar is disclosed.

[0006] In the equipment disclosed in Japanese Unexamined Patent Application Publication No. 8-300008, a system for vertically aligning junction ends is necessary for either one or both of a preceding clamping device and a succeeding clamping device. Thus, there is a problem in that the equipment is complicated. When a succeeding sheet bar 12 is thicker than a preceding sheet bar 10, a step is formed at a junction 11 of the sheet bars. As shown in FIG. 1, in a finishing mill, a force is applied to the step between the sheet bars from upper and lower rolls 14 and 15 in the direction shown in the figure. As a result, there is a problem in that the junction 11 between the succeeding sheet bar and the preceding sheet bar is possibly destroyed.

[0007] FIG. 2 shows equipment disclosed in Japanese Unexamined Patent Application Publication No. 7-24504. In FIG. 2, reference numerals 16 and 17 denote upstream upper and lower clamps and reference numerals 18 and 19 denote downstream upper and lower clamps. In a case where a succeeding sheet bar is thinner than a preceding sheet bar and both sheet bars are clamped with fixing plates spreading across the succeeding sheet bar and the preceding sheet bar, there is a problem in that the fixing plates are bent.

[0008] On the other hand, the applicant has proposed a technique for setting conditions of endless rolling in Japanese Unexamined Patent Application Publication No. 10-5830 and Japanese Unexamined Patent Application Publication No. 11-169926. Japanese Unexamined Patent Application Publication No. 10-5830 discloses a technique in which a junction order of materials for endless rolling is determined such that a material to be rolled into a finished steel sheet having a small thickness is rolled in the middle of a rolling order. Japanese Unexamined Patent Application Publication No. 11-169926 discloses a technique in which a rolling method is immediately switched to batch rolling when rolling materials subjected to endless rolling cannot be treated by endless rolling. Thus, rolling conditions are previously determined for both endless rolling and batch rolling. In the techniques disclosed in Japanese Unexamined Patent Application Publication No. 10-5830 and Japanese Unexamined Patent Application Publication No. 11-169926, the following problems are not solved: the sheet bar described above is possibly destroyed and the fixing plates clamping sheet bars are bent.

Disclosure of the Invention

[0009] The present invention provides a solution to the conventional problems described above. It is an object of the present invention to prevent fixing plates from being damaged, to obtain junction strength in endless rolling, and to reduce a rolling load.

[0010] In the present invention, the above problems are solved by rolling sheet bars each having the same thickness. In hot rolling, an upper computer determines rolling conditions for each rolling material according to information including the steel type, the standard, the size, the product thickness, and the product width. When the rolling materials are subjected to endless rolling, a lower computer performs the following calculations: the lower computer compares the predetermined thicknesses of sheet bars for individual rolling materials from the leading material to the end material, and finds the minimum thickness among them. The above problems are solved by performing rolling in such a manner that the sheet bar thicknesses are set to the minimum thereof.

[0011] Hitherto, when a succeeding sheet bar is thicker than a preceding sheet bar, a force is applied to a step at the junction between the sheet bars from rolls for finish rolling; hence, there is a problem in that the junction is possibly destroyed. Furthermore, there is a problem in that fixing plates are bent or destroyed when the step is clamped with the fixing plates. In the present invention, the sheet bar thicknesses are set to the same value for a plurality of rolling materials subjected to endless rolling; hence, the above problems do not arise.

[0012] FIGS. 3A and 3B show the effects of the present invention. As shown in FIG. 3A, the junction is smoothly fed into rolls for finish rolling. As shown in FIG. 3B, the fixing plates 16 and 17 of the clamping devices are not bent.

Brief Description of the Drawings

[0013]

Fig. 1 is an illustration showing a problem of a technique disclosed in Japanese Unexamined Patent Application Publication No. 8-300008 and shows a cross section in finish rolling.

Fig. 2 is an illustration showing a problem of a technique disclosed in Japanese Unexamined Patent Application Publication No. 7-24504 and shows a cross section of a clamped portion.

Fig. 3A is an illustration showing an effect of the present invention and shows a cross section in finish rolling.

Fig. 3B is an illustration showing another effect of the present invention and shows a cross section of a clamped portion.

FIG. 4 is an illustration showing an exemplary hot rolling line according to the present invention.

FIG. 5 is a block diagram showing an embodiment of a controlling unit according to the present invention.

FIG. 6 is a flow chart showing a treating procedure of the above embodiment.

FIG. 7 is a chart showing information about rolling materials used in an embodiment of the present invention.

Best Mode for Carrying out the Invention

[0014] Embodiments of the present invention will now be described in detail with reference to the drawings.

[0015] Referring to FIG. 4, an outline of an exemplary hot rolling line for performing endless rolling is illustrated. An endless rolling process using the hot rolling line will now be described. A tail end 10e of a preceding sheet 10 is joined to a leading end 12t of a succeeding sheet 12 with a joining apparatus 30 provided between a roughing mill 20 having three stands and a finishing mill 40 having seven stands. The preceding sheet 10 and the succeeding sheet 12 joined together are continuously treated in finish rolling. A cutter 50 for rolling materials is provided downstream of the finishing mill 40, and two reels 60 are provided downstream of the cutter 50. Using the'cutter 50, the finished rolling material having the preceding sheet 10 and the succeeding sheet 12 joined together is cut into sheets each having a length which is equivalent to the winding capacity of each of the reels 60. A rolling material positioned downstream of the cut point and another rolling material positioned upstream of the cut point are separately wound onto each of the reels in turn.

[0016] In the endless finish rolling, the preceding sheet 10 and the succeeding sheet 12 are continuously rolled without intermittence; thereby performing stable rolling over the entire length. This method is specifically suitable for a rolling material having a small thickness, which causes difficulty in insertion of the rolling material between rolls due to an unstable tip.

[0017] FIG. 5 is a block diagram showing a control unit used for the present invention. As shown in FIG. 5, operating conditions of apparatus in the hot rolling line are set by computers. Information including the steel type, the standard, the rolling size, and so on is input with an order input terminal 80 for each slab, which is a rolling material. The information of the slab is sent to an upper computer 70 via, for example, in-house LAN 82. The upper computer 70 determines rolling conditions such as rolling temperature, reduction schedule, rolling rate, tension between stands, and cooling

rate for each rolling material. The upper computer sends the rolling conditions to a lower computer 72.

[0018] When the slab is fed into the rolling line, the lower computer 72 reads detection data output by detectors placed at some points in the rolling line. In FIG. 5, the detectors include a detector 24 placed downstream of the roughing mill, another detector 32 placed downstream of the joining apparatus, and another detector 44 placed downstream of the finishing mill. The detection data include the temperature, the thickness, and the width of the plate. The lower computer 72 simultaneously reads actual operation data of the apparatus. The apparatus includes the roughing mill 20, the joining apparatus 30, the finishing mill 40, the cutter 50, the reels 60, and so on. The actual operation data include rolling forces loaded by a screw-down device 22 of the roughing mill 20 and another screw down-device 42 of the finishing mill 40. A combination of the detection data output by the detectors and the actual operation data of the apparatus is referred to as rolling material information. According to the rolling material information, the lower computer 72 calculates the operating conditions of the apparatus located downstream of the place where the rolling material is currently situated such that the rolling material is rolled under rolling conditions received from the upper computer 70. The lower computer 72 sends operating condition signals based on the calculation results to each apparatus, thus operating the apparatus.

[0019] The present invention will now be further described in detail with an example. For example, in a batch rolling operation, the lower computer 72 calculates the operating conditions of the finishing mill 40, that is, roll position and the roll peripheral speed for each stand, according to rolling material information in rough rolling such that finish rolling is performed under finish rolling conditions received from the upper computer 70. The rolling material information in rough rolling includes the size and the temperature of a sheet bar after rough rolling. The information is detected with the detector 24 placed downstream of the roughing mill or is calculated according to the actual operation data of the roughing mill 20.

[0020] On the other hand, for example, in an endless rolling operation, the preceding plate 10 is joined to the succeeding plate 12 with the joining apparatus 30 and the lower computer 72 then calculates the operating conditions of the finishing mill 40 for the succeeding plate 12. After that, the lower computer 72 calculates the operating conditions of the finishing mill 40 such that finish rolling is performed under finish rolling conditions received from the upper computer 70, in the same way as described above.

[0021] FIG. 6 shows the entire procedure described above. In the present invention, the sheet bar thicknesses predetermined for individual rolling materials are compared and are set to the minimum thereof.

[0022] In the block indicated by reference numeral 130 in FIG. 6, the sheet bar thickness is determined for each rolling material. FIG. 7 shows a method of the determination. For each slab, the sheet bar thickness is retrieved from a setting table registered in the upper computer 70 by using keys such as the steel type, the standard, the rolling size, the instruction thickness after hot rolling, and the instruction width after hot rolling. As shown in FIG. 7, the sheet bar thickness is preferably registered for each of endless rolling and batch rolling.

[0023] The predetermined sheet bar thickness is previously input into the table. In order to obtain products having excellent mechanical properties such as strength and elongation after rolling, the following conditions are necessary: (1) reduction in energy loss caused by radiation and (2) a high temperature in finish rolling. Subsequently, the sheet bar thickness is preferably large. However, when the thickness of a sheet after finish rolling is small, the sheet bar thickness is preferably small to reduce the load of the finishing mill. The sheet bar thickness is determined in consideration of the above contradictory conditions. The sheet bar thickness may be determined for batch rolling only or for both batch rolling and endless rolling.

[0024] In this description, it is assumed that the number of rolling materials for endless rolling is n and the sheet bar thickness is determined as t_1, t_2, ..., t_n for each rolling material according to the above logic. A group consisting of a plurality of rolling materials for endless rolling is referred to as an endless unit. In the present invention, t_1, t_2, ..., t_n in the endless unit are compared with one another to replace a preset value with the following formula:

$$\text{Min}\ (t_1, t_2, \ldots, t_n).$$

Min ( ) denotes a function selecting the minimum among the plurality of variables in the parentheses. When the sheet bar thicknesses are determined for batch rolling only, Min (t_1, t_2, ..., t_n) may be determined for that. When the sheet bar thicknesses are determined for both batch rolling and endless rolling, Min (t_1, t_2, ..., t_n) may be determined for endless rolling only.

[0025] As described above, the sheet bar thicknesses predetermined for individual rolling materials are compared and the sheet bar thicknesses are set to the minimum thereof.

EXAMPLE

[0026] Table 1 shows an exemplary schedule in which the thicknesses of sheet bars for batch rolling are determined

and the thicknesses of sheet bars for endless rolling are then determined. Samples shown in Table 1 were manufactured as follows: sheet bars of rolling materials No. 1 to 6 that were the same steel (low carbon steel) were joined together upstream of a finishing mill and were then continuously treated in finish rolling. In conventional batch rolling methods, the thickness of a sheet bar was determined for each rolling material. In contrast, in the endless rolling method, the thicknesses of the sheet bars are set to the minimum thickness of 30 mm (No.4 in Table 4).

Table 1

Rolling Order	Thickness mm After Rolling	Width mm After Rolling	Sheet Bar Thickness mm in Batch Rolling	Sheet Bar Thickness mm in Endless Rolling
1	1.6	1219	35	30
2	1.8	1200	37	30
3	1.4	1188	32	30
4	1.2	1205	30	30
5	1.4	1188	32	30
6	1.6	1100	35	30

Industrial Applicability

[0027] According to the present invention, the sheet bar thicknesses of rolling materials for endless rolling are unified in the unit. In conventional methods, when the thickness of a succeeding sheet bar is larger than that of a preceding sheet bar, there is a problem in that a junction between sheet bars is broken due to a force applied to a step formed at the junction from rolls in finish rolling. Furthermore, when the thickness of a succeeding sheet bar is smaller than that of a preceding sheet bar, there is a problem in that fixing plates for clamping the step are bent or broken. However, according to the present invention, junction and finish rolling are smoothly performed as shown in FIG. 3.

Claims

1. A method of hot rolling performed under rolling conditions previously determined for individual rolling materials based on rolling material information including the type, the standard, the size, the product thickness, and the product width of the rolling materials, wherein the tail end of a preceding sheet bar is joined to the leading end of a succeeding sheet bar to treat the rolling materials in endless finish rolling, the method comprising the steps of:

comparing the sheet bar thicknesses predetermined for the individual rolling materials in an endless unit in which the rolling materials are arranged from a lead to an end in the order of the rolling;
setting the thicknesses of the sheet bars to the minimum thereof; and
performing endless finish rolling.

FIG. 1

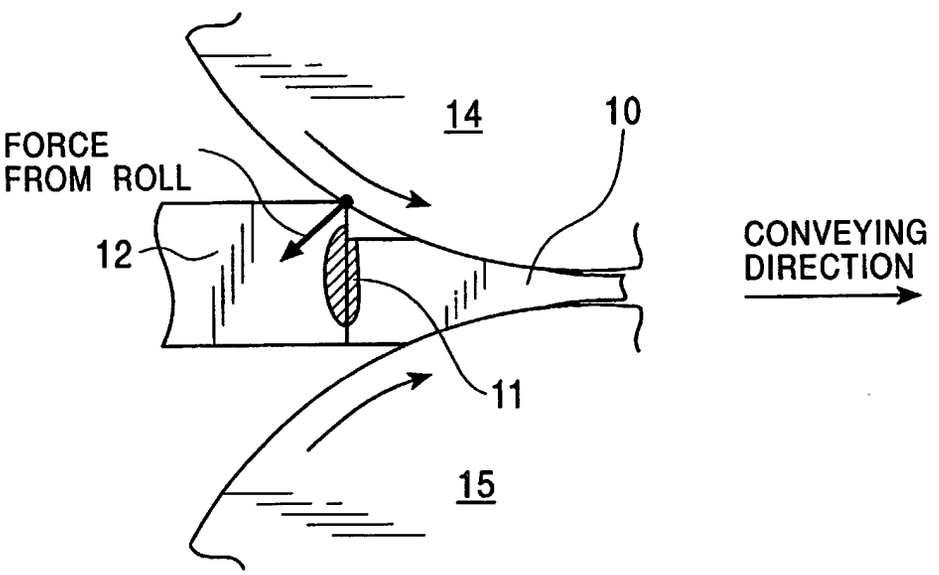


FIG. 2

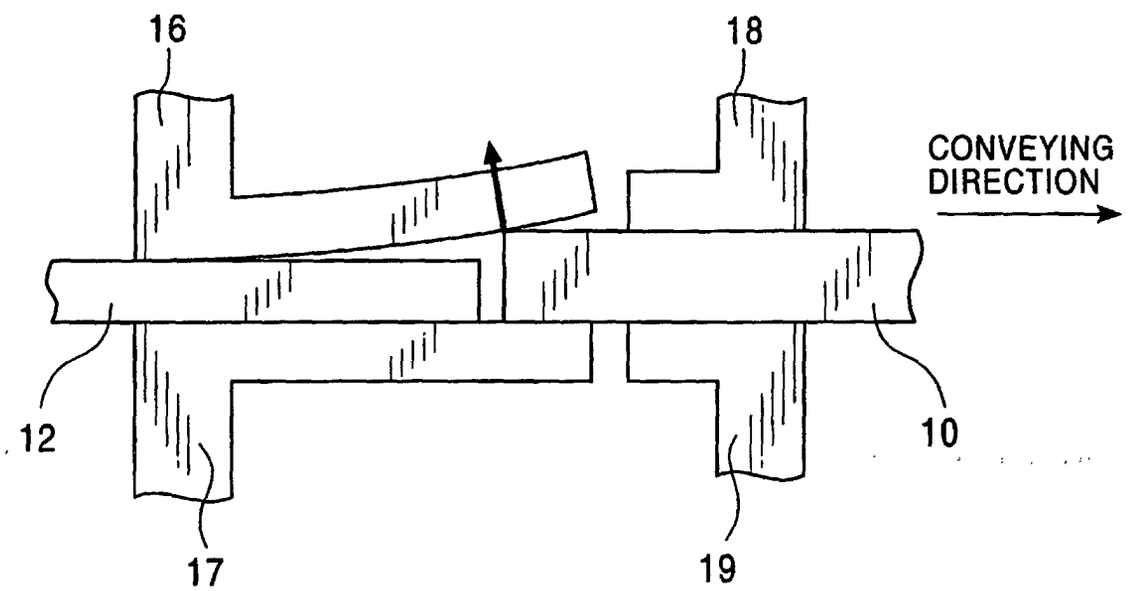


FIG. 3A

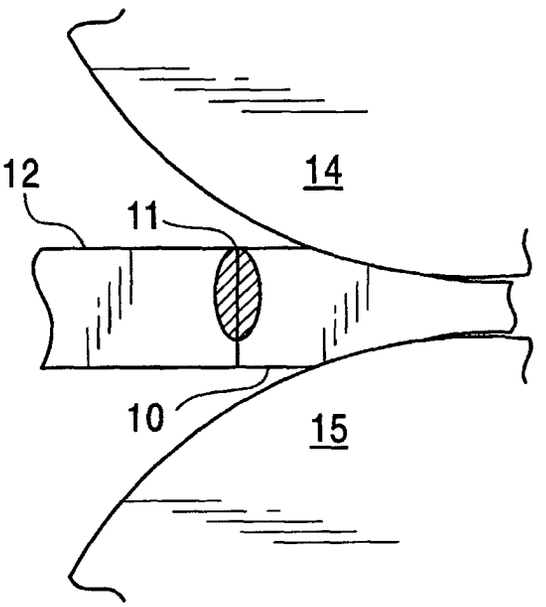


FIG. 3B

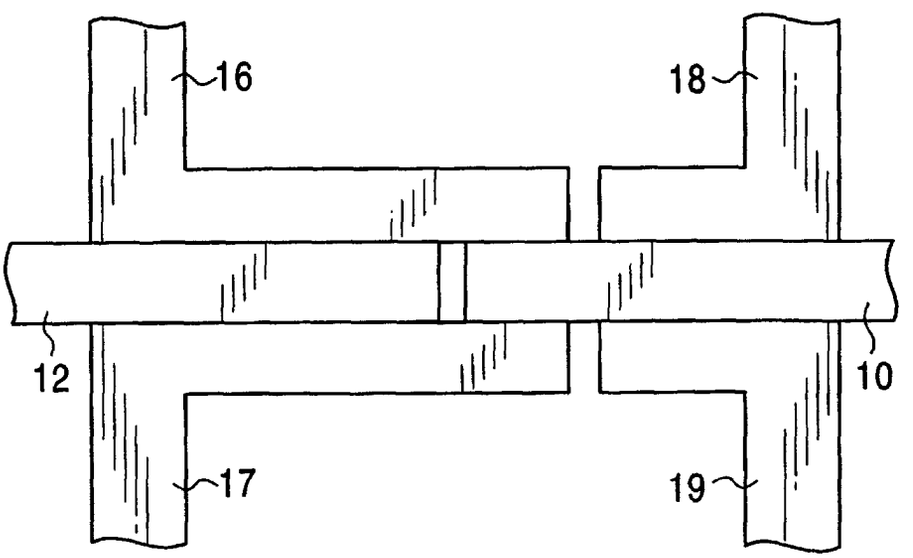


FIG. 4

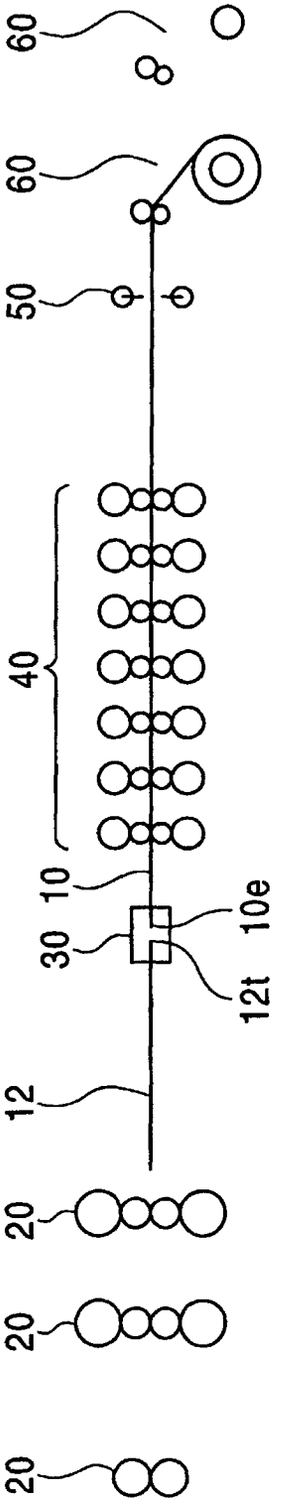


FIG. 5

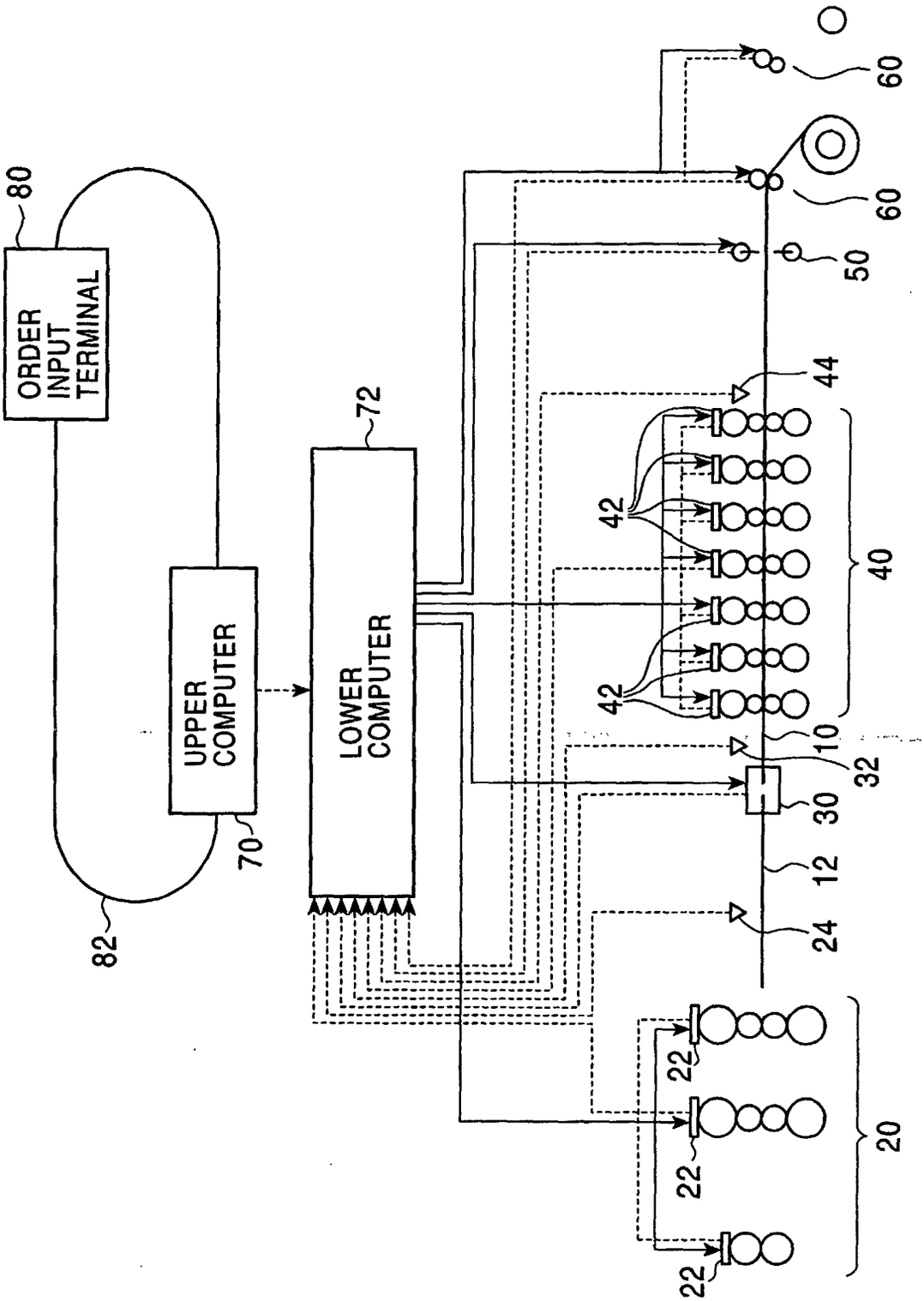

ORDER INPUT TERMINAL
80
UPPER COMPUTER
70
LOWER COMPUTER
72
82
60
60
50
44
42
42
40
10
32
30
12
24
22
22
22
20

FIG. 6

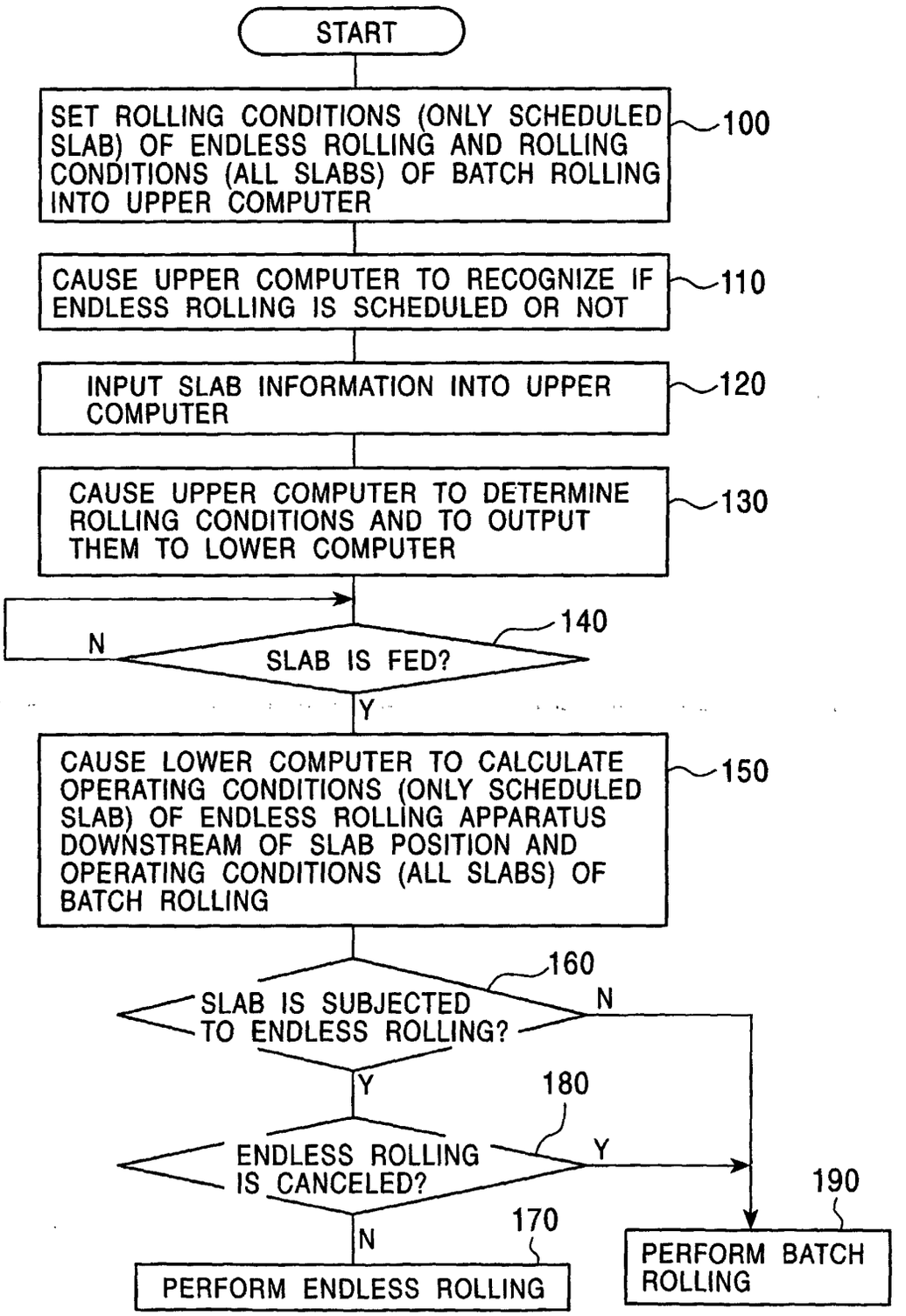
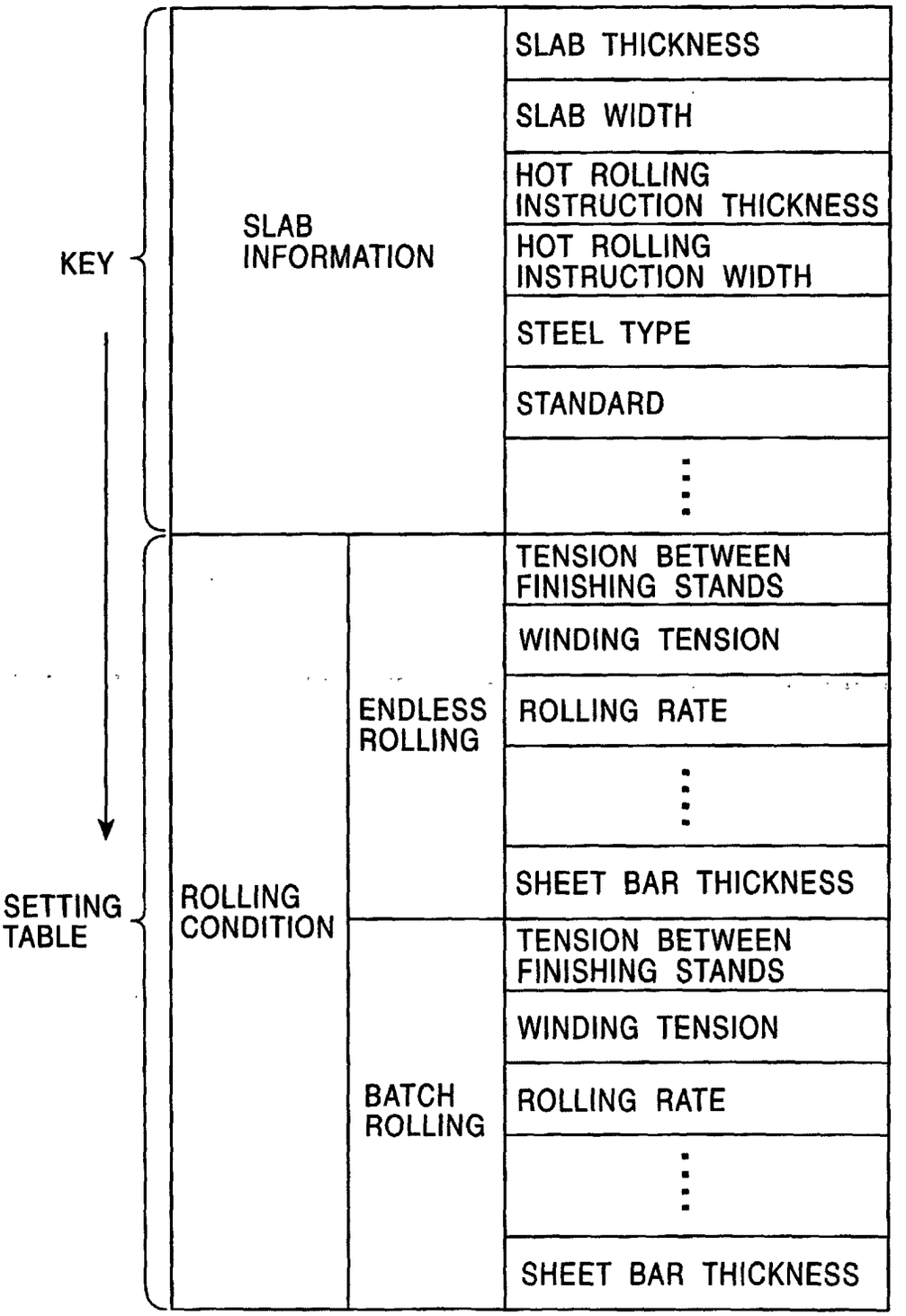

START
SET ROLLING CONDITIONS (ONLY SCHEDULED SLAB) OF ENDLESS ROLLING AND ROLLING CONDITIONS (ALL SLABS) OF BATCH ROLLING INTO UPPER COMPUTER
100
CAUSE UPPER COMPUTER TO RECOGNIZE IF ENDLESS ROLLING IS SCHEDULED OR NOT
110
INPUT SLAB INFORMATION INTO UPPER COMPUTER
120
CAUSE UPPER COMPUTER TO DETERMINE ROLLING CONDITIONS AND TO OUTPUT THEM TO LOWER COMPUTER
130
140
N
SLAB IS FED?
Y
CAUSE LOWER COMPUTER TO CALCULATE OPERATING CONDITIONS (ONLY SCHEDULED SLAB) OF ENDLESS ROLLING APPARATUS DOWNSTREAM OF SLAB POSITION AND OPERATING CONDITIONS (ALL SLABS) OF BATCH ROLLING
150
160
SLAB IS SUBJECTED TO ENDLESS ROLLING?
N
Y
180
ENDLESS ROLLING IS CANCELED?
Y
N
170
PERFORM ENDLESS ROLLING
190
PERFORM BATCH ROLLING

FIG. 7


KEY
SETTING TABLE
SLAB INFORMATION
SLAB THICKNESS
SLAB WIDTH
HOT ROLLING INSTRUCTION THICKNESS
HOT ROLLING INSTRUCTION WIDTH
STEEL TYPE
STANDARD
ROLLING CONDITION
ENDLESS ROLLING
TENSION BETWEEN FINISHING STANDS
WINDING TENSION
ROLLING RATE
SHEET BAR THICKNESS
BATCH ROLLING
TENSION BETWEEN FINISHING STANDS
WINDING TENSION
ROLLING RATE
SHEET BAR THICKNESS

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/08513

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B21B1/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B21B1/00-1/46

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2001
Kokai Jitsuyo Shinan Koho 1971-2001 Jitsuyo Shinan Toroku Koho 1996-2001

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 9-216008 A (Sumitomo Metal Industries, Ltd.), 19 August, 1997 (19.08.97), Fig. 7 (Family: none)	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December, 2001 (14.12.01)	25 December, 2001 (25.12.01)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)