

[54] METHOD AND APPARATUS FOR SHAPE CONTROL OF METAL PRODUCTS IN CONTINUOUS ROLLING MILL

[75] Inventors: Seiji Fujii; Masamoto Kamata; Masayuki Ishida; Hiroshi Kuwamoto, all of Fukuyama, Japan

[73] Assignee: Nippon Kokan Kabushiki Kaisha, Tokyo, Japan

[22] Filed: Mar. 15, 1973

[21] Appl. No.: 341,579

[44] Published under the Trial Voluntary Protest Program on January 28, 1975 as document no. B 341,579.

[30] Foreign Application Priority Data

Mar. 28, 1972 Japan..... 47-30962

[52] U.S. Cl..... 72/10; 72/6

[51] Int. Cl.²..... B21B 37/00

[58] Field of Search..... 72/6-10, 12, 72/16

[56]

References Cited

UNITED STATES PATENTS

3,714,805	2/1973	Stone	72/8
3,727,441	4/1973	Morooka et al.	72/6
3,750,437	8/1973	Fujii et al.	72/12

Primary Examiner—Milton S. Mehr

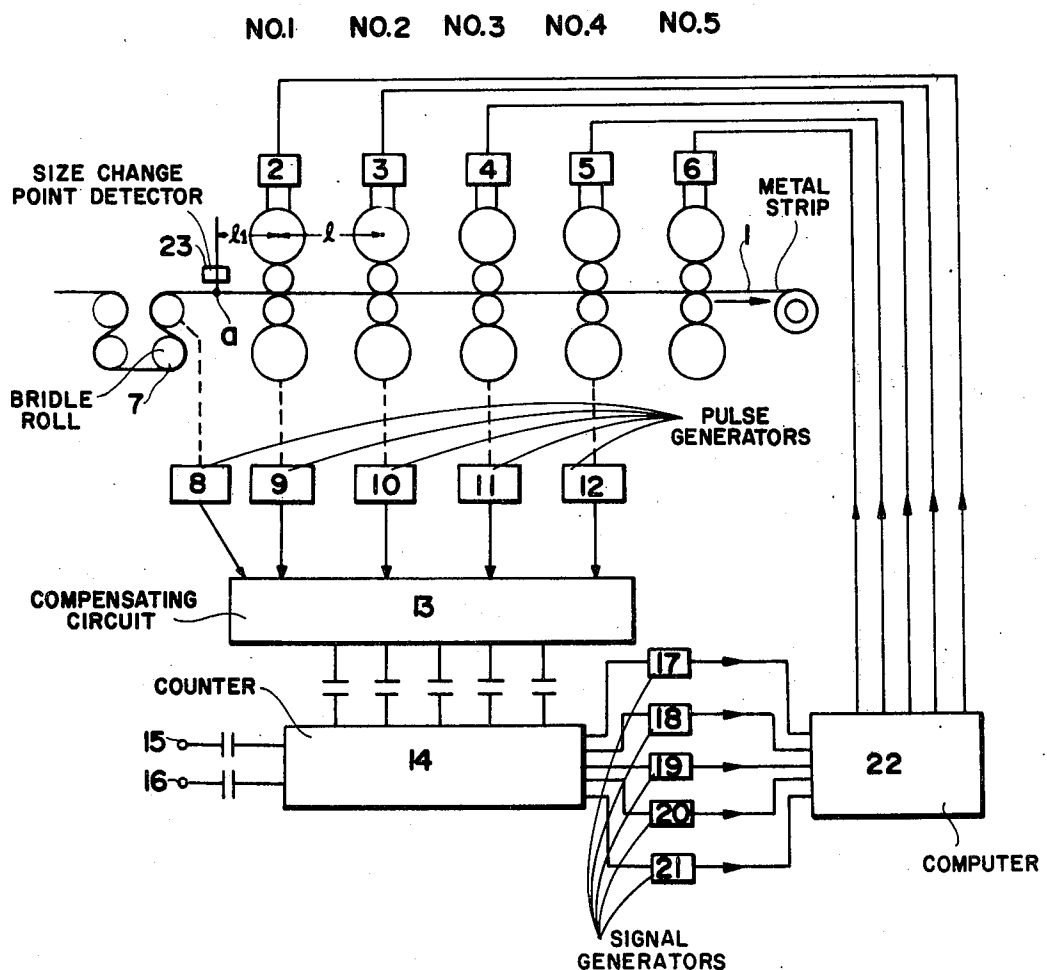
Attorney, Agent, or Firm—Flynn & Frishauf

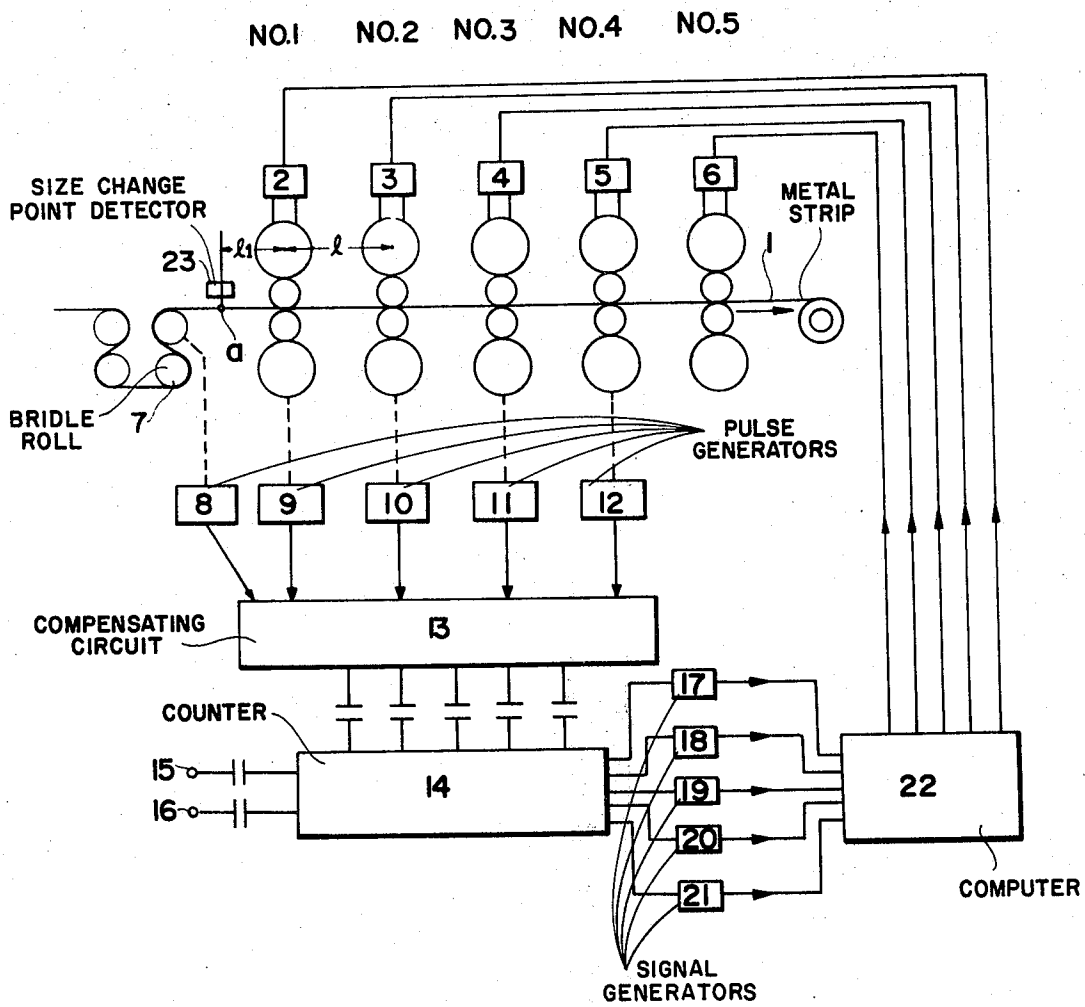
[57]

ABSTRACT

In a method of continuously rolling a metal strip by a tandem mill including a plurality of mill stands, when the strip size is to be varied, pass signals are generated when a given size change point of the strip passes successively through respective mill stands. A computer generates control signals in response to the pass signals and each control signal varies the degree of bending of each roll when the size change point reaches a mill stand.

15 Claims, 1 Drawing Figure





METHOD AND APPARATUS FOR SHAPE CONTROL OF METAL PRODUCTS IN CONTINUOUS ROLLING MILL

BACKGROUND OF THE INVENTION

This invention relates to an apparatus and method for rolling a metal strip and more particularly to an apparatus and method for shape control while continuously rolling a metal strip by means of tandem mills wherein when the strip size is to be varied by changing a pass schedule, an adequate degree of roll bending is automatically established at the point of varying the strip size.

Where a so-called step rolling operation is performed on a continuous strip, the operator has been required to adjust various settings necessary for size change while the rolling mill is stopped or its speed is reduced to an extremely low speed. We have already proposed an improved method of step rolling wherein while the mill is running at a high speed the roll peripheral speeds and roll gaps of respective stands are automatically controlled to values required for size change so as to minimize the variation in the strip tension during the transition at the time of size change, thereby minimizing off-gauge products, as disclosed in Japanese patent application No. 19211 of 1970.

As is well known in the art, in order to produce well shaped rolled strips, uniform thickness of the strip not only in the longitudinal direction but also in the transverse direction is required and for this purpose the work rolls of mill stands are generally crowned. This is generally accomplished by bending work rolls by applying pressure to the roll necks thereof. As it is necessary to vary the degree of crowning in accordance with the strip size it is necessary to change the degree of crowning when the roll gap is adjusted.

It is an object of this invention to provide a novel method and apparatus for continuously rolling a metal strip wherein, when the size of the rolled strip is to be changed, the degree of roll bending of respective mill stands of a tandem mill is successively adjusted as a given point of the strip at which the size is to be varied passes through respective mill stands.

SUMMARY OF THE INVENTION

According to one aspect of this invention there is provided a method of rolling a metal strip by means of a tandem mill including a plurality of mill stands comprising the steps of successively generating pass signals when a given size change point of the strip successively passes through said mill stands, generating control signals in response to said pass signals and varying the degree of roll bending of respective mill stands in response to said control signals when said size change points pass through respective mill stands.

According to another aspect of this invention, there is provided a control system for a tandem mill including a plurality of mill stands through which a metal strip is passed, the control system comprising a detector provided on the inlet side of the first mill stand for detecting a size change point on the strip, a plurality of pulse generators operated by respective mill stands, a counter responsive to the pulses for generating pass signals, a computer responsive to the pass signals for generating control signals for respective mill stands, and a plurality of roll bending devices provided for respective mill stands, the roll bending devices respectively re-

sponding to respective control signals for varying the degree of roll bending when the size change point passes through respective mill stands.

When the invention is applied to the invention of the above described application, the roll peripheral speed, roll gap and crown of respective mill stands are automatically adjusted when the size change point passes through respective mill stands, thus enabling the gauge of the rolled strips to be varied without stopping the mill, thus producing well shaped rolled strips of uniform thickness not only in the longitudinal direction but also in the transverse direction.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a diagram showing tandem mill stands and an electrical control system for carrying out the method of this invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The accompanying drawing shows an electric control system applied to a tandem mill including five mill stands No. 1 through No. 5 arranged to roll a metal strip. Respective mill stands are equipped with roll bending devices 2 through 6 of known construction which may be operated by pressurized oil. Before entering the mill stands, the metal strip passes through a bridle roll 7. Pulse generators 9, 10, 11 and 12 are connected to respective mill stands to be operated in accordance with the rotation of their rolls. Output pulses of the pulse generators are applied to a counter 14 through a compensating circuit 13. An initial value signal is applied to counter 14 through input terminals 15. A plurality of pass signal generators 17 through 21 are connected to the output of the counter 14 and the outputs of the pass signal generators are applied to a computer 22, the output thereof being applied to roll bending devices 2 through 6. A size changing point detector 23 is provided at a distance l_1 from the first mill stand between bridle roll 7 and the first mill stand. (l is the distance between adjacent mill stands.) P_{B1} , P_{B2} , P_{B3} , P_{B4} and P_{B5} represent roll bender pressures of respective mill stands before size change and P_{B1}' , P_{B2}' , P_{B3}' , P_{B4}' and P_{B5}' the roll bender pressures after size change. Values of P_{B1}' through P_{B5}' are calculated by a computer or by utilizing an appropriate table and are stored in the computer 22.

In operation, the control system starts its operation when the size changing points a passes by the detector 23. The distance l_1 between the detector 23 and the No. 1 mill stand is set in counter 14 through input terminal 15. Bridle roll 7 is used to operate a pulse generator 8 and the output of the pulse generator 8 is applied through compensating circuit 13 to counter 14 for subtraction counting. The circuit is designed such that the count of counter 14 is reduced to zero when size changing point a passes through No. 1 mill stand at which time pass signal generator 17 generates a pass signal which causes computer 22 to generate a stored signal. This signal is applied to roll bending device 2 of the No. 1 mill stand to vary its roll bender pressure from P_{B1} to P_{B1}' . At the same time, the distance l between mill stands No. 1 and No. 2 is set in counter 14 through input terminal 16 and the output pulse of pulse generator 9 driven by No. 1 mill stand is applied to counter 14 through compensating circuit 13 whereby subtraction of counter 14 is commenced. As the size changing

point *a* passes through No. 2 mill stand the count of counter 14 is reduced to zero whereby pass signal generator 18 generates a pass signal which causes computer 22 to generate another control signal. This control signal is applied to roll bending device 3 of No. 2 mill stand to change its roll bender pressure from P_{B2} to P_{B2}' . In the same manner, pulse generators 10, 11 and 12 associated with mill stands No. 3, No. 4 and No. 5 are operated sequentially to produce pass signals when size changing point *a* passes sequentially through these mill stands whereby the computer 22 operates sequentially to vary their roll bender pressures from P_{B3} , P_{B4} and P_{B5} , to P_{B3}' , P_{B4}' and P_{B5}' , respectively. The purpose of the compensating circuit 13 is to vary the relationship between the number of pulses and distances l_1 and l in accordance with variations in the diameters of the bridle roll and the mill rolls and to compensate for the effect of the forward slip rate during rolling operation. Respective roll bender pressures after the size change can also be provided by immediately feeding back the rolling condition to the computer 22 to cause it to provide control signals for respective roll bending devices.

Thus, the invention provides a method and apparatus for controlling the degree of roll bending of a tandem mill including a plurality of mill stands wherein pass signals are successively generated by the passage of a size change point of a metal strip through respective mill stands, control signals are generated in response to the pass signals and the degree of roll bending of respective mill stands are varied from those of before size change to those of after size change in response to respective control signals.

By combining the method and apparatus of this invention with above described method disclosed in said patent application it becomes possible to control the degree of roll bending in addition to the control of roll peripheral speed and roll gap, thus enabling ideal continuous control of the size and shape of the products.

What is claimed is:

1. A method of rolling a metal strip by means of a tandem mill including a plurality of spaced apart mill stands comprising:

detecting a size change point of said strip prior to said size change point entering said mill stands, successively generating pass signals when said size change point of the strip successively passes through respective mill stands, generating control signals in response to said pass signals, and varying the degree of roll bending of respective mill stands in response to said control signals when said size change point passes through respective mill stands.

2. A control system for a tandem mill including a plurality of spaced apart mill stands through which a metal strip is passed, each mill stand including a respective roll bending device, said control system comprising:

a detector provided on the inlet side of the first mill stand for detecting a size change point on said strip, a plurality of pulse generators corresponding to and operated by respective mill stands, a counter responsive to the pulses generated by said respective pulse generators for generating pass signals respectively corresponding to the passing of said size change point through each mill stand, said

pass signals being generated responsive to said counter counting to a predetermined count, a computer responsive to said pass signals for generating respective control signals for respective mill stands, and

means coupling said control signals to said roll bending devices of said respective mill stands, said roll bending devices respectively responding to respective control signals for varying the degree of roll bending when said size change point passes through respective mill stands.

3. The control system according to claim 1 wherein each roll bending device includes means responsive to one of said control signals for varying the oil pressure applied to said roll bending device.

4. The control system according to claim 1 which further comprises a bridle roll provided before said detector, an additional pulse generator driven by said bridle roll and means for applying the output of said additional pulse generator to said counter, said counter being responsive to said additional pulse generator for generating a first pass signal corresponding to the passing of said size change point through the first mill stand.

5. The control system according to claim 4 comprising a compensating circuit connected between said counter and said pulse generators associated with respective mill stands and said bridle roll.

6. The control system according to claim 2 further comprising means for setting the distance between said detector and the first mill stand and the distances between adjacent mill stands in said counter.

7. The control system according to claim 6 wherein said pass signals are generated by said counter at time intervals respectively corresponding to said distances set into said counter.

8. The control system according to claim 6 wherein said setting means sets said counter to a predetermined count corresponding to each of said distances.

9. The control system according to claim 8 wherein said predetermined counts are respectively set after the generation of a pass signal.

10. The control system according to claim 8 wherein said counter generates respective pass signals after counting to said predetermined counts.

11. The method according to claim 1 wherein said step of successively generating pass signals comprises generating a plurality of pulse signals at each of said mill stands, and counting the pulses respectively generated at each of said mill stands, said pass signals being generated at predetermined counts during said counting operation.

12. The method according to claim 11 wherein said step of counting includes setting said counter to a predetermined count corresponding to each of the distance between adjacent mill stands.

13. The method according to claim 12 wherein a bridle roll is provided before a detector which detects said size change point, and comprising generating a pass signal corresponding to the passing of said size change point through the first mill stand.

14. The method according to claim 13 comprising generating an additional plurality of pulses responsive to the operation of said bridle roll, counting said additional pulses and generating a first pass signal responsive to a predetermined count of said additional pulses and corresponding to the passing of said size change point through the first mill stand.

15. The method according to claim 12 comprising pre-setting a given count of said pulse signals, and generating said pass signals responsive to counting to said predetermined counts.

* * * * *