

608064
FORM 1
REGULATION 9

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-1973

APPLICATION FOR A PATENT

We KAWASAKI STEEL CORPORATION

of 1-8, Kitahonmachidori 1-chome, Chuo-ku, Kobe-shi, Hyogo-ken,
JAPAN

hereby apply for the grant of a Patent for an invention entitled:

ROLLING PROCESS FOR CLAD STEEL

which is described in the accompanying complete specification. This Application is a Convention Application and is based on the Application(s) numbered: 62-244190 and 62-244191 for a Patent or similar protection made in Japan (both) on 30 September 1987 (both).

Our address for service is:

GRIFFITH HACK & CO.
71 YORK STREET
SYDNEY N.S.W. 2000
AUSTRALIA

DATED this 28th day of September, 1988.

KAWASAKI STEEL CORPORATION
By their Patent Attorneys

GRIFFITH HACK & CO.

TO: THE COMMISSIONER OF PATENTS
COMMONWEALTH OF AUSTRALIA

0526A:rk

APPLICATION ACCEPTED AND AMENDMENTS

ALLOWED 17.12.90

DECLARATION IN SUPPORT OF A CONVENTION OR NON-CONVENTION
APPLICATION FOR A PATENT OR PATENT OF ADDITION

INSTRUCTIONS

- (a) Insert No. if available.
(b) Insert full name(s) of applicant(s).

- (c) Insert title of invention.

- (d) Insert full name(s) of declarant(s) who must be PERSON or PERSONS, NOT a corporate body. (See head note).

- (e) Insert address(es) of declarant(s).

- (f) Delete entirely if applicant is corporate body.
(g) Delete entirely if applicant is person or persons.

- (h) Delete entirely if Convention priority NOT claimed.

- (i) Insert country in which first basic application was filed.

- (j) Insert date of first basic application.

- (k) Insert full name(s) of basic applicant(s).

- (l) Delete entirely if applicant(s) NOT inventor(s).

- (m) Insert full name(s) of actual inventor(s) if applicant(s) NOT inventor(s).

- (n) Insert address(es) of actual inventor(s) if applicant(s) NOT inventor(s).

- (o) Recite manner in which applicant(s) derive(s) title from actual inventor(s) if applicant(s) NOT inventor(s).

- (p) Delete entirely if Convention priority NOT claimed.

- (q) Recite manner in which applicant(s) derive(s) title from basic applicant(s) if applicant(s) NOT basic applicant(s).

- (r) Signature(s) of declarant(s).

- (N.B.—No seal or stamp impression to be applied).

In support of the application No. (a) _____
made by (b) Kawasaki Steel Corporation

for a patent/~~patent of addition~~ for an invention entitled (c) ROLLING PROCESS FOR CLAD STEEL

I, (d) Takao Kadooka
of (e) c/o Kawasaki Steel Corporation, Hibiya Kokusai Bldg., 2-3, Uchisaiwai-cho 2-chome, Chiyoda-ku, Tokyo, Japan

do solemnly and sincerely declare as follows:—

~~XXXXXX I am the applicant(s) for the patent/patent of addition~~

1. (g) I am authorized by the abovementioned applicant for the patent/~~patent of addition~~ to make this declaration on its behalf.

2. The basic application(s) as defined by Section 141 of the Act was/were made in the following country or countries on the following date(s) by the following applicant(s) namely:—

in (i) Japan on (j) September 30, 1987

by (k) Kawasaki Steel Corporation

in (i) Japan on (j) September 30, 1987

by (k) Kawasaki Steel Corporation

in (i) _____ on (j) 19

by (k) _____

~~XX~~

3. (m) Toshiki Hiruta, Ikuo Yarita and Hideo Abe of (n) c/o Kawasaki Steel Corporation Technical Research Division, 1, Kawasaki-cho, Chiba-shi, Chiba-ken, Japan, c/o Kawasaki Steel Corporation Technical Research Division, 1, Kawasaki-cho, Chiba-shi, Chiba-ken, Japan and c/o Kawasaki Steel Corporation Technical Research Division, 1, Kawasaki-cho, Chiba-shi, Chiba-ken, Japan

~~is/are~~ are the actual inventor(s) of the invention and the facts upon which the applicant(s) ~~is/are~~ are entitled to make the application are as follows:—

—as regards entitlement under Section 34 of the Act:—(o) _____

The said applicant is the assignee of the said invention from the said inventors.

—as regards entitlement under Part XVI of the Act:—(q) _____

4. The basic application(s) referred to in paragraph 2 of this Declaration was/were the first application(s) made in a Convention country in respect of the invention the subject of the application.

Declared at Tokyo, Japan

this 20th day of September 1988
KAWASAKI STEEL CORPORATION.

(r) Takao Kadooka
Takao Kadooka, General Manager
of Patent Dept.
(Authorized Signing Officer)

To: The Commissioner of Patents,
Commonwealth of Australia.

(12) PATENT ABRIDGMENT (11) Document No. AU-B-22903/88
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(54) Title
ROLLING PROCESS FOR CLAD STEEL

International Patent Classification(s)
(51)⁴ B21B 001/38

(21) Application No. : 22903/88 (22) Application Date : 28.09.88

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(56) Prior Art Documents
AU 21402/67 417393 73.1
AU 18798/48 141383 71.4
AU 547/46 122086 71.4

(57) Claim

1. A process of rolling an elongated clad steel composed of a first layer of a first material and a second layer of a second material which has lower malleability than that of said first material, comprising the steps of:

 performing pre-form rolling at a first given draft from one longitudinal end of said elongated clad steel for rolling the clad steel in a length of 20% to 80% of the overall length of clad steel;

 performing reduction rolling at a second given draft which is greater than or equal to said first given draft from the other longitudinal end of said elongated clad steel for rolling; and

 repeating the cycle of said pre-form rolling and reduction rolling at least for two cycles.

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

Form 10

COMPLETE SPECIFICATION

FOR OFFICE USE

Short Title:

Int. Cl:

608064

Application Number:
Lodged:

Complete Specification-Lodged:

Accepted:

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Priority:

Related Art:

This document contains the
amendments made under
Section 49 and is correct for
printing.

TO BE COMPLETED BY APPLICANT

Name of Applicant: KAWASAKI STEEL CORPORATION

Address of Applicant: 1-8, Kitahonmachidori 1-chome, Chuo-ku,
Kobe-shi, Hyogo-ken, JAPAN

Actual Inventor: Toshiki Horuta; Ikuo Yarita and Hideo Abe

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Complete Specification for the invention entitled:

ROLLING PROCESS FOR CLAD STEEL

The following statement is a full description of this invention,
including the best method of performing it known to me/us:-

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ROLLING PROCESS FOR CLAD STEEL

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates generally to a process for rolling a clad steel which combines iron base plate and stainless steel plate, cupronickel plate, monel metal plate, titanium plate, aluminium plate or the like. More specifically, the present invention
10 relates to a hot rolling process for the clad steel which successfully avoids influence of difference of draft of the different materials of the clad steel.

Description of the Background Art

15 Generally, the different material metal plates composed into the clad steel have different deformation resistance in hot rolling. This causes a difference in drafts which ^{results} ~~results~~ in difference of rolling reductions. Therefore, ^{the} thickness ratio of the different material plates is differentiated at the entrance of a
20 rolling mill and at the exit thereof. Namely, the plate made of the material having smaller deformation resistance relative to the other, is reduced at greater magnitude than that of the other. This naturally causes
25 difference of expansion length of composed plates, ^{and} to lowering the yield of the hot rolling process. This is because the material having the 'smaller deformation resistance tends to flow toward the material having greater deformation resistance to form ~~the~~ single layer longitudinal ends where only the smaller deformation
30 resistance material exists.

 In order to eliminate influence of the difference in expansion rates between the material metal plates forming the clad steel, Japanese Patent First (unexamined) Publication (Tokkai) Showa 61-232003,
35 published on October 16, 1986, discloses a process for rolling of clad steel, in which pre-form rolling is



performed at least at one of longitudinal ends. After pre-forming rolling, reduction rolling is performed for the overall length of the clad steel. The publication further discloses that the preferred length of the end portion of the clad steel, for which pre-forming rolling is to be performed, is equal to the thickness of the clad steel at the maximum. When the shown process is practically applied to the clad slab, the section on which the perform pre-formed rolling is performed, becomes less than 10% of the overall length of the slab. Furthermore, the above-mentioned prior proposal suggests the process of pre-form rolling to reduce the thickness to the thickness of the final product. This conventional process including pre-form rolling for the longitudinal end did not satisfactorily avoid the adverse influence of the expansion rates of the different deformation resistance of the materials from which the clad steel was formed.

Furthermore, when hot rolling was experimentally performed according to the process proposed in the aforementioned publication, the portion where the thickness ratios of the layers form the clad metal fluctuates and is not maintained constant. The thickness ratio of the layers will be hereafter referred to as "clad ratio" and are formed at the longitudinal ends. The portion where the clad ratio fluctuates, will be hereafter referred to as "uneven clad ratio portion". The presence of uneven clad ratio portions, results in the yield of the hot rolling of the clad steel being degraded even though an attempt is made for improving yield.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a process for rolling a clad steel which



satisfactorily reduces the influence of the difference between the deformation resistances of the material metals composing the layers in the clad steel and can improve yield of rolling.

5 According to the present invention there is provided a process of rolling an elongated clad steel composed of a first layer of a first material and a second layer of a second material which has lower malleability than that of said first material, comprising the steps of:

10 performing pre-form rolling at a first given draft from one longitudinal end of said elongated clad steel for rolling the clad steel in a length of 20% to 80% of the overall length of clad steel;

15 performing reduction rolling at a second given draft which is greater than or equal to said first given draft from the other longitudinal end of said elongated clad steel for rolling; and

20 repeating the cycle of said pre-form rolling and reduction rolling at least for two cycles.

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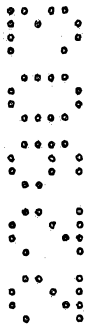
BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given herebelow and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to limit the invention to the specific embodiment but are for explanation and understanding only.

In the drawings:

Figs. 1(A), 1(B), 1(C), 1(D), 1(E), 1(F) and 1(G) are illustrations showing the preferred process of rolling for a clad steel, according to the present invention;

Figs. 2(A), 2(B), 2(C), 2(D) and 2(E) and Figs. 3(A), 3(B), 3(C) and 3(D) are illustrations showing conventional rolling processes for clad steels,

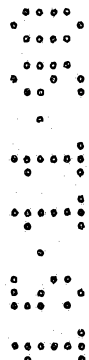


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in which Figs. 2(A), 2(B), 2(C), 2(D) and 2(E) illustrate the process disclosed in the aforementioned Tokkai Showa 61-232003 and Figs. 3(A), 3(B), 3(C) and 3(D) illustrate the conventional reverse rolling process;

Fig. 4 is a sectional view of the clad steel rolled through the process of Figs. 2(A), 2(B), 2(C), 2(D) and 2(E);

Fig. 5 is a graph showing the relationship between pre-form rolling length, uneven clad ratio portion of the longitudinal ends formed due to difference of the expansion of the material metal plates, and clad rate;

Fig. 6 is a graph showing relationship between pre-form rolling length, uneven clad ratio portion, and rolling temperature;

Fig. 7 is a graph showing relationship between pre-form rolling length, uneven clad ratio portion, and draft;

Fig. 8 is a graph showing relationship between uneven clad ratio portion and number of passes in rolling process;

Fig. 9 is a graph showing relationship between pre-form rolling length and uneven clad ratio portion;

Fig. 10 is a graph showing relationship between rolling speed ratio and uneven clad ratio portion;

Fig. 11 is a graph showing relationship between pre-form rolling length and uneven clad ratio portion;

Fig. 12 is a graph showing relationship between pre-form rolling length and uneven clad ratio portion; and

Fig. 13 is a graph showing relationship between number of passes in rolling and uneven clad ratio portion.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, Figs. 1(A), 1(B), 1(C), 1(D), 1(E), 1(F) and 1(G) illustrates the preferred rolling process according to the present invention. Rolling is performed by upper and lower rolls 1a and 1b by passing a clad steel 4 in the form of a plate, slab or so forth. The clad steel 4 is composed of a pair of layer of different material metals 2 and 3. A portion of the clad steel 4 is subject pre-form rolling by being passed through the clearance between the upper and lower rolls 1a and 1b. The pre-form rolling is performed from one longitudinal end of the clad steel 4, for a length L_0 that is in the range of 20% to 80% of the overall length L of the clad steel 4.

After the pre-form rolling process set forth above, reduction rolling is performed from the the opposite longitudinal end of the clad steel 4 over the portion nopt rolled in the pre-form rolling process. The draft in the reduction rolling is greater than or equal to the draft in the pre-form rolling.

In the preferred rolling process, the pre-form rolling and reduction rolling processes are performed in one rolling pass cycle. The rolling process is performed at least for two cycles.

In order to compare the performance of the preferred rolling process according to the invention to those of the prior art, comparative rolling processes are performed through the processes shown in Figs. 2(A), 2(B), 2(C), 2(D) and 2(E) and Figs. 3(A), 3(B), 3(C) and 3(D), in which Figs. 2(A), 2(B), 2(C), 2(D) and 2(E) illustrate the process disclosed in the aforementioned Tokkai Showa 61-232003 and Figs. 3(A), 3(B), 3(C) and 3(D) illustrate the conventional reverse rolling process.

In the process of Figs. 2(A), 2(B), 2(C), 2(D) and 2(E), pre-form rolling is performed on both

longitudinal ends of the clad steel 4. According to the disclosure of Tokkai Showa 61-232003, pre-form rolling was performed over a distance corresponding to the thickness of the clad steel. On the other hand, in the process of Figs. 3(A), 3(B), 3(C) and 3(D), the clad steel 4 passes, at first, from one end thereof and then from the other end.

As observed from Fig. 1(E), the clad steel 4 rolled by the preferred process has a substantially even clad ratio over the entire length. On the other hand, as seen from Fig. 2(E), the clad steel rolled by the process shown in Tokkai Showa 61-232003 had portions at both ends where no layer of the metal 2 is formed. The single layer portions extend for lengths of λ_1 and λ_2 , as seen from Fig. 4. Furthermore, as shown in more detail in Fig. 4, at the regions C_1 and C_2 adjacent both end portion, the clad ratio becomes uneven. The region where single layer is formed, and uneven clad ratio region are hereafter referred to as "inferior quality region". On the other hand, the clad steel 4 processed by the process of reverse rolling of Figs. 3(A), 3(B), 3(C) and 3(D) had metal layers 2 and 3 where difference in length corresponded to the difference between the expansion ratios of the respective layers.

Figs. 5 to 7 show results of experimentally performed rolling utilising the preferred processes. In the experiments, clad steel slab composed of a layer of stainless steel and a layer of soft steel was used. The slab was 200 mm thick and 5 m length. The clad slab was a total draft of 50% in total including the reduction in the pre-form rolling and reduction rolling stages. In rolling according to the preferred process, rolling was performed in two rolling pass cycles.

In the first experiments, rolling temperature was fixed at 1000 °C. In the sample slabs wherein the layer thickness were 10%, 20%, 30% and 40%, the ratio of

the length of single layer regions ($\lambda_1 + \lambda_2$) to the length L_0 of the portion of clad slab, over which pre-form rolling was performed, was checked. The result is shown in Fig. 5. As will be seen from Fig. 5, the length of the single layer region could be maintained at a minimum value when pre-form rolling was performed over of 20% to 80% of the overall length of the slab. In the secondary experiments, clad ratio was fixed at 30%. Experimental rollings were performed respectively at 900 °C, 1000 °C and 1200 °C. In the second set of experiments, the relationship between the length of the single layer regions and the rolling temperature was checked. The result of the experiments is shown in Fig. 6. In the third experiments, experimental rollings were performed of 5%, 10% and 20% drafts. Relationship between the length of the single layer regions and the draft was checked. The results of the experiments is shown in Fig. 7. The second and third sets of experiments confirm that the pre-form rolling length is preferred in a range of 20% to 80%.

The relationship between number of pass cycles and the length of the single layer regions was observed. The result is shown in Fig. 8. As seen from Fig. 8, by performing of rolling two pass cycles or more, the length of the single layer regions as significantly reduced.

Further experimentation was performed to determine the relationship between the layer thickness ratio and length ($C_1 + C_2$) of the uneven clad ratio region. Clad ratios were respectively 30% and 40%. The results of these tests are shown in Fig. 9. From the results of experiments shown in Fig. 9, it can be confirmed that the preferred range of length of portion of the clad slab, for which the pre-form rolling is to be performed is 20% to 80% of the overall length. Furthermore, similarly to the length of the single layer

region, the length of the uneven clad ratio region can be significantly reduced by performing rolling for two pass cycles of rolling or more.

In another experiment, rotation speeds of the upper and lower rolls 1a and 1b were differentiated relative to each other. In the experiments performed, upper roll 1a was rotated at higher speed than the lower roll 1b. The higher speed upper roll 1a mated the material 2 which has higher deformation resistance. Naturally, the other material 3 having higher malleability mates with the lower roll 1b which rotates at lower speed. The roll speed ratio was varied. Result of experiments is shown in Fig. 10. As seen from Fig. 10, when the roll speed ratio, i.e. roll speed of the upper roll 1a versus roll speed of the lower roll 1b is greater than or equal to 1.1, the length of inferior quality regions can be substantially reduced in comparison with that obtained from rolling utilizing the rolls of equal roll speed.

Example

In order to further confirm the improved performance of the preferred process according to the present invention, further experiments were performed for clad steel composed of a layer of stainless steel and a layer of soft steel. The clad steel was in the form of a slab having length of 5m and thickness of 200 mm. Rolling was performed in two pass cycles, each of which pass cycles included pre-form rolling from one longitudinal end of the clad slab and reduction rolling from the other longitudinal end. The draft was 50%. In order to compare this, comparative experiments were performed utilizing the conventional process. In the conventional rolling process, pre-form rolling was performed on one longitudinal end portion of the clad slab. Then, reduction rolling was performed from the other end. After one pass cycle, normal rolling was

performed for another pass cycle.

Additional experiments were performed in which the roll speeds of the upper and lower rolls were different. In the experiments, ratio of the roll speed of the upper roll versus the roll speed of the lower roll is set at 1.1.

Results of the experiments are shown in Figs. 11 and 13. In Figs. 11 and 12, the result of the comparative example is shown by solid line, the result of the preferred process with equal roll speed is shown by the broken line, and the result of the preferred process with different roll speed is shown by the one-dot chain line. As will be seen from Figs. 11 and 12, by setting the pre-form rolling length within the range of 20% to 80% of the overall length of the slab, substantial reduction of the single layer region ($\lambda_1 + \lambda_2$) and the uneven clad ratio region ($C_1 + C_2$) can be obtained. Furthermore, the length of single layer region ($\lambda_1 + \lambda_2$) and the uneven clad ratio region ($C_1 + C_2$) in the slab rolled by the preferred process of the present invention is much smaller than that of the slab rolled by the conventional process.

In addition, the length of the inferior quality region in relation to the number of pass cycles performed for obtaining the desired draft versus the original thickness was observed and the results are shown in Fig. 13. As will be seen from Fig. 13, the rolling processes were performed for obtaining the desired draft, i.e. 50% by two pass cycles or more substantially reduces the length of the inferior quality region.

As will be appreciated herefrom, the preferred process for rolling of clad steel provides a substantially increased yield when pre-form rolling is performed from one end on a portion, the length of which is 20% to 80% of the overall length of the clad steel,

and the reduction rolling is performed subsequently from the other end with a draft that is greater than or equal to the draft used in the pre-forming. A still greater increase in yield can be obtained by repeating the foregoing rolling process at least two passes. Differentiating of the roll speed to mate the higher speed roll to the layer having lower malleability, further assist for improvement of the yield by reducing length of inferior quality portions.

Therefore, the present invention fulfills all of the objects and advantages sought therefor.

While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding of the invention, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modifications to the shown embodiments which can be embodied without departing from the principle of the invention set out in the appended claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

WHAT IS CLAIMED IS:

1. A process of rolling an elongated clad steel composed of a first layer of a first material and a second layer of a second material which has lower malleability than that of said first material, comprising the steps of:
- 5 performing pre-form rolling at a first given draft from one longitudinal end of said elongated clad steel for rolling the clad steel in a length of 20% to 80% of the overall length of clad steel;
- 10 performing reduction rolling at a second given draft which is greater than or equal to said first given draft from the other longitudinal end of said elongated clad steel for rolling; and
- 15 repeating the cycle of said pre-form rolling and reduction rolling at least for two cycles.
2. A rolling process for an elongated clad steel as set forth in claim 1, in which said reduction rolling is performed for the portion of the clad steel ^{maintained unrolled} ~~left~~ in pre-form rolling.
- 20
3. A rolling process for an elongated clad steel as set forth in claim 1, in which said reduction rolling is performed for the overall length of said clad steel.
- 25
4. A process of rolling an elongate clad steel composed of a first layer of a first material and a second layer of a second material which has lower malleability than that of said first material, comprising the steps of:
- 30 defining a path between a first and second rolls to pass said clad steel therethrough during rolling;
- 35 driving said second roll mating with said second layer at higher speed than that of said first



roll which mates said first layer;

performing pre-form rolling for a first given draft
from one longitudinal end of said elongated clad steel for
rolling the clad steel in a length of 20% to 80% of the
5 overall length of clad steel;

performing reduction rolling for a second given draft
which is greater than or equal to said first given draft
from the other longitudinal end of said elongated clad steel
for rolling; and

10 repeating the cycle of said pre-form rolling and
reduction rolling at least for two cycles.

5. A rolling process substantially as hereinbefore
described with reference to any one of the referred
15 embodiments shown in the accompanying drawings.

DATED this 12th day of November 1990.

20 KAWASAKI STEEL CORPORATION

By their Patent Attorneys
GRIFFITH HACK & CO.



0962s/SMcL

FIG.1

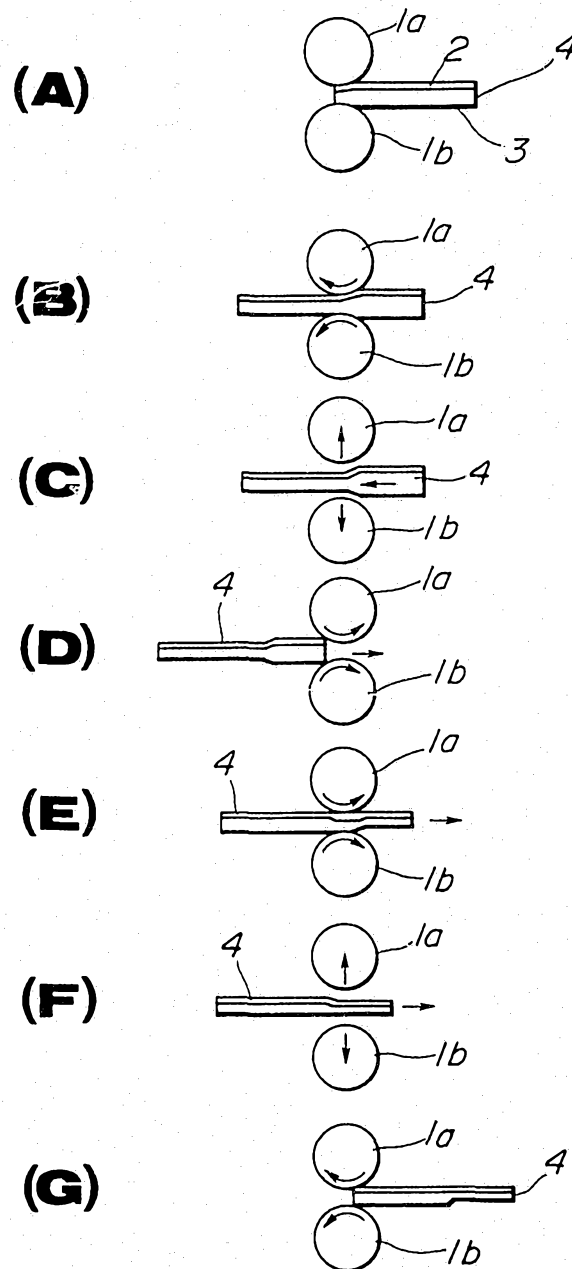


FIG. 2

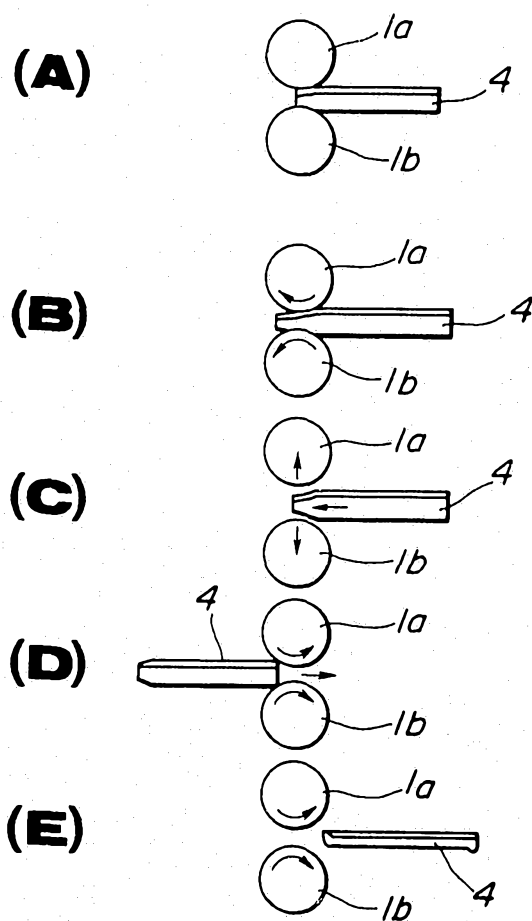


FIG. 3

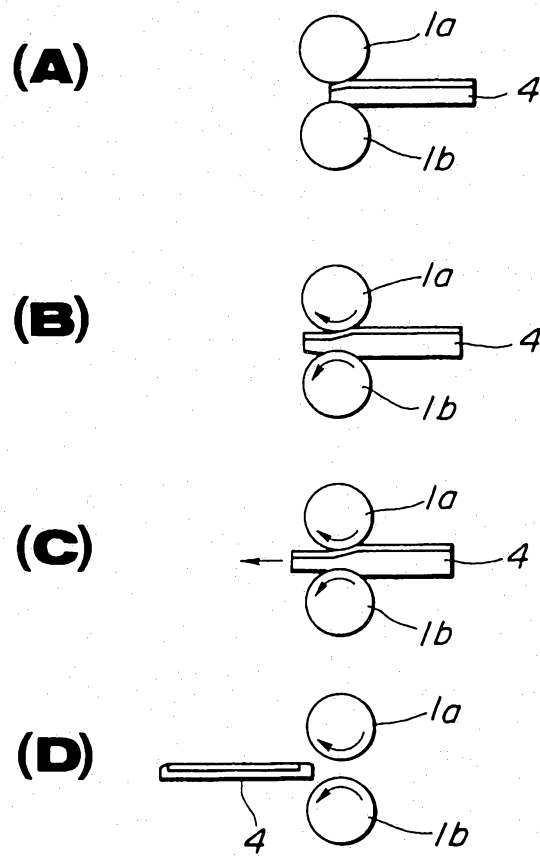


FIG.4

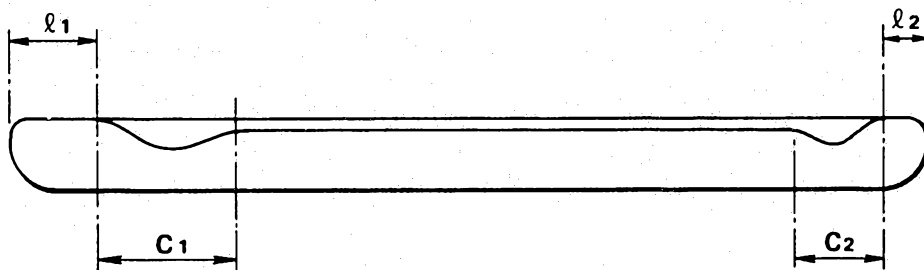


FIG.5

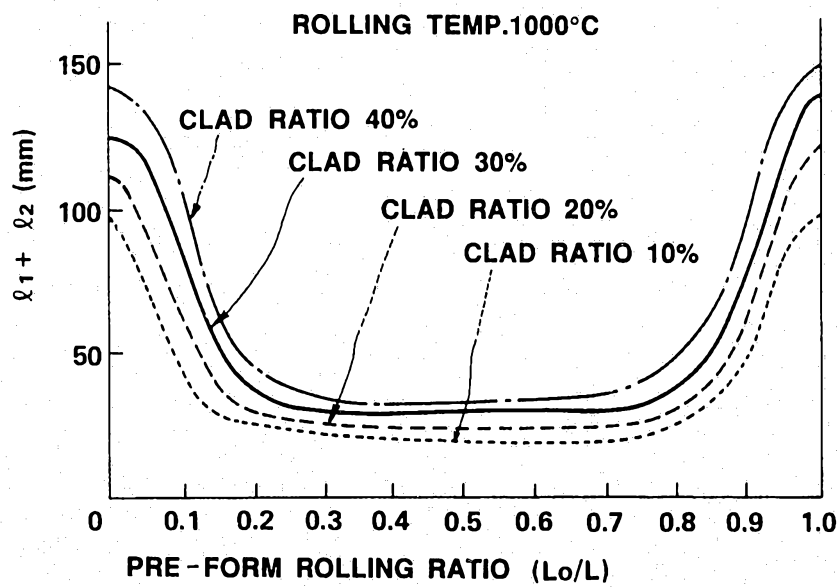


FIG.6

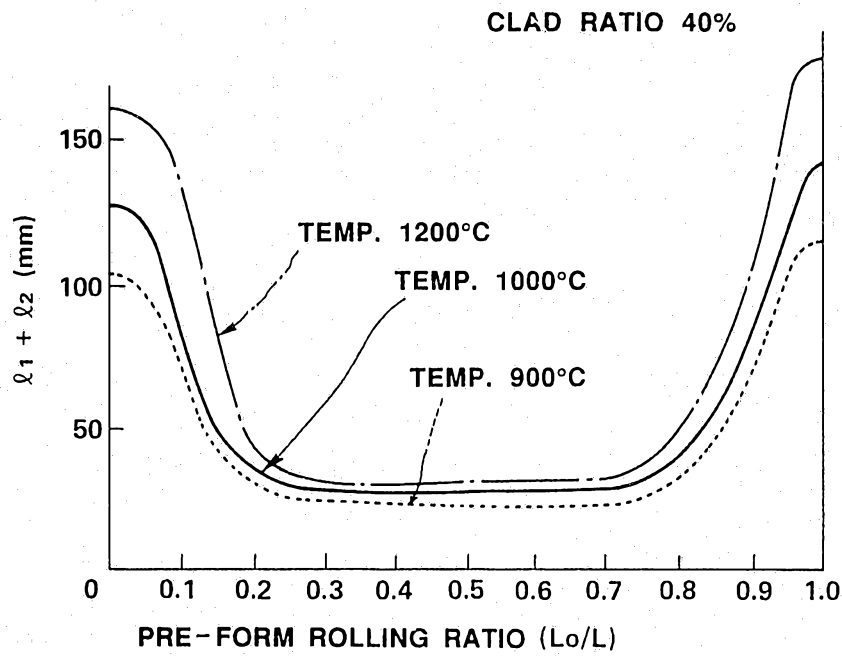


FIG.7

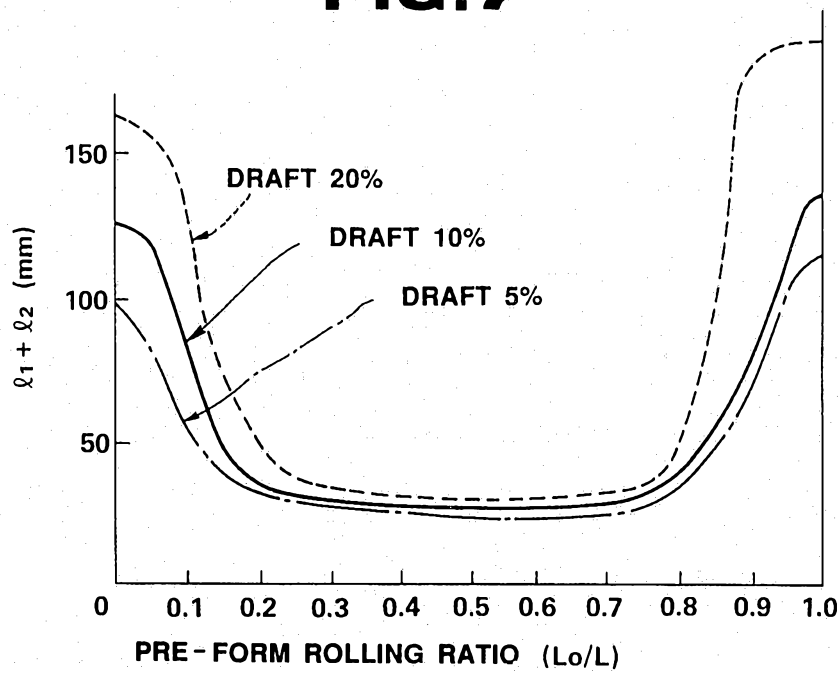


FIG. 8

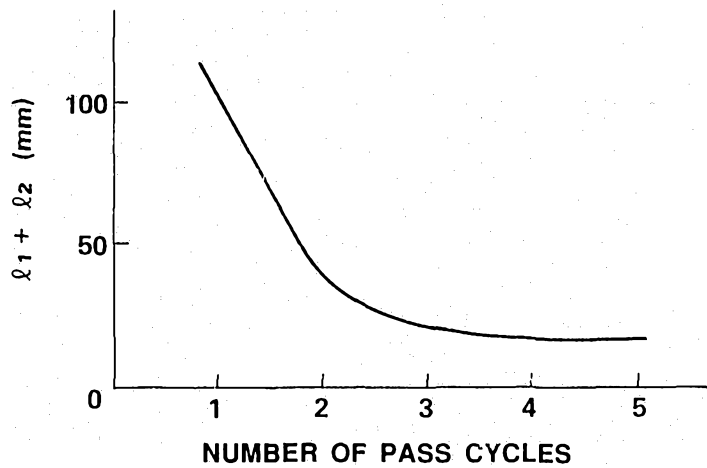


FIG. 9

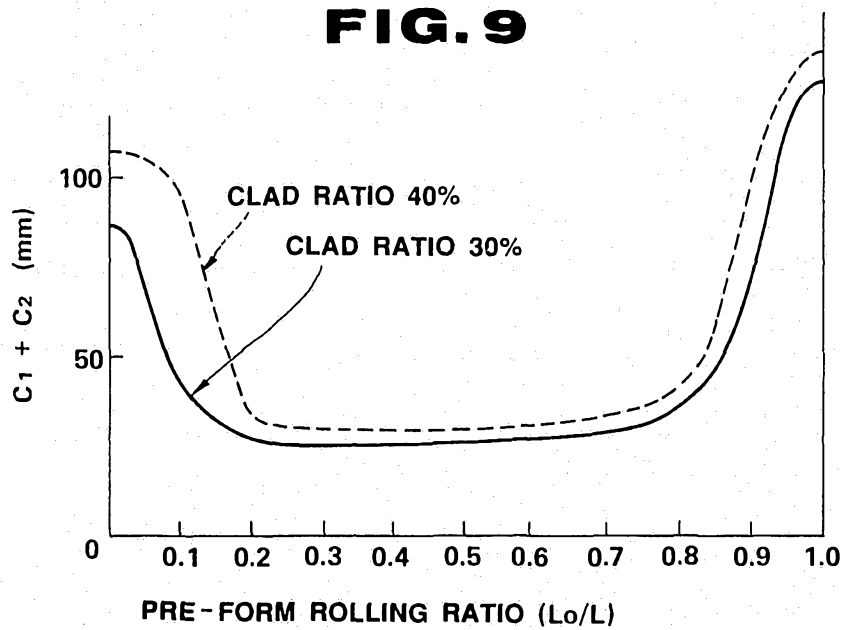


FIG. 10

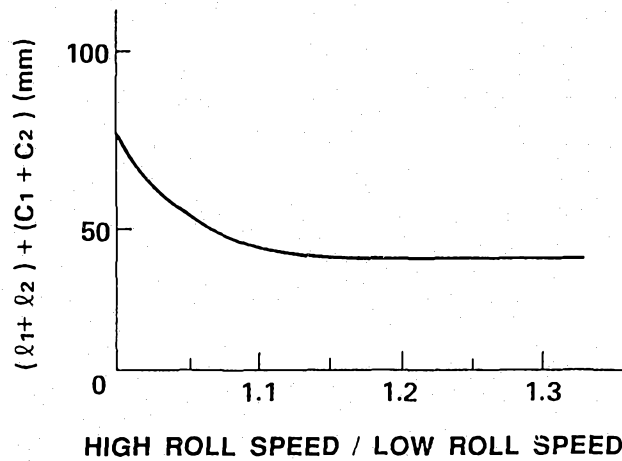


FIG. 11

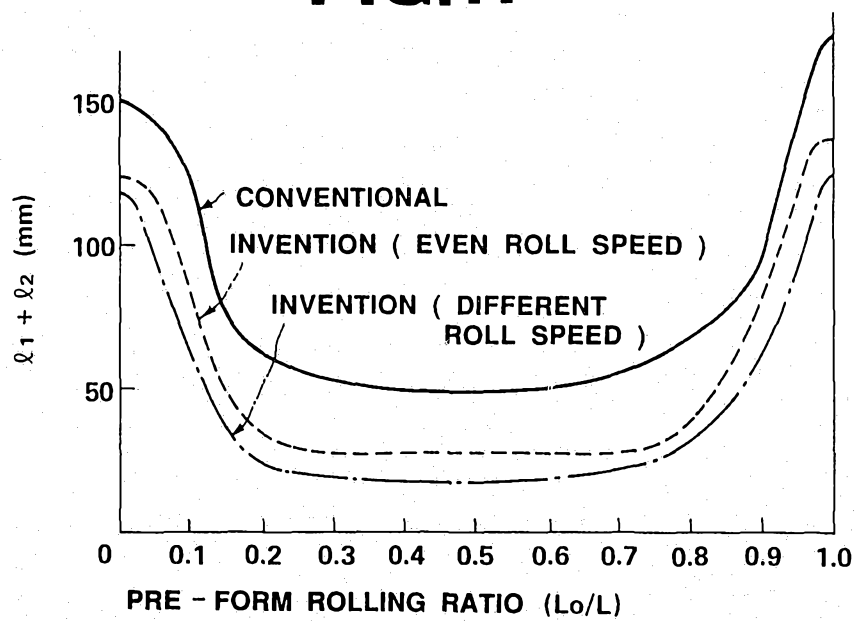


FIG.12

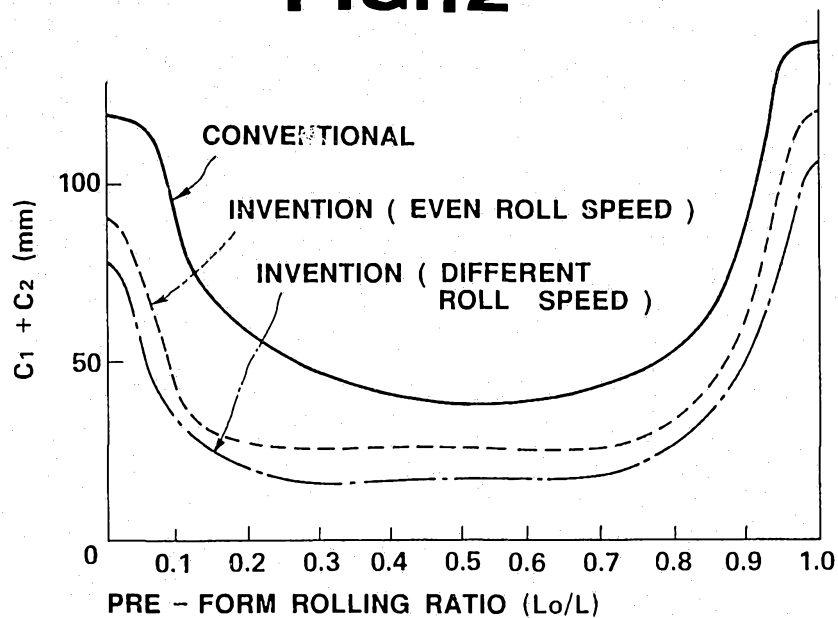


FIG.13

