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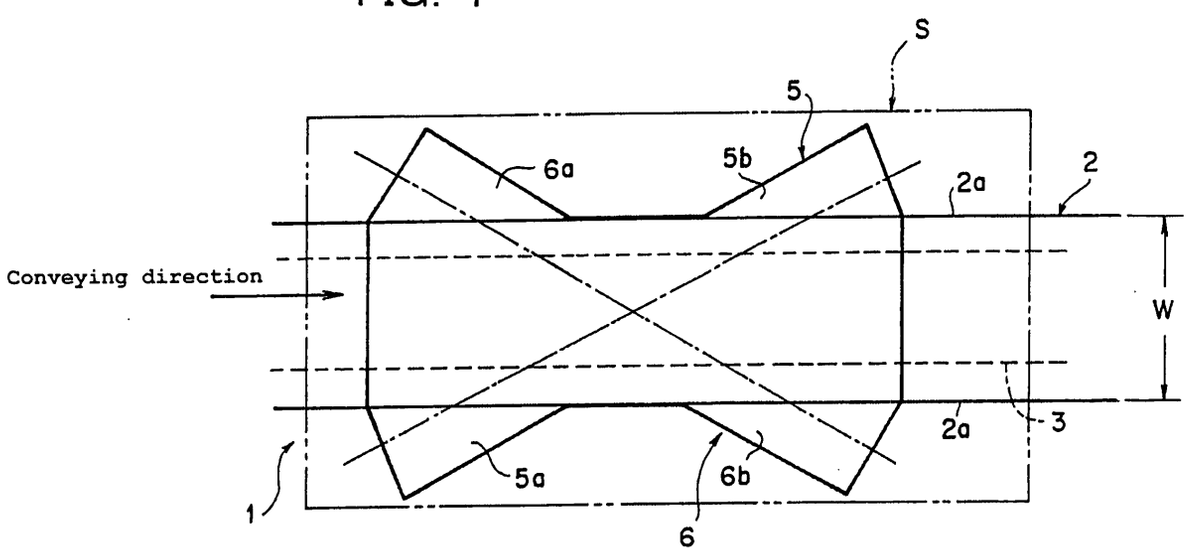
(54) CATENARY TYPE FURNACE

(57) An object of the present invention is to provide a catenary furnace which has high compatibility with environmental protection, is easy to maintain, and can satisfactorily perform heating treatment of a material by restraining fluctuations in furnace temperature.

In the present invention, in a catenary furnace (1) for heating a material (3), which is formed in a shape of a catenary curve and is conveyed in the longitudinal direction of a furnace casing (2), in the furnace casing (2) heated by burners, a lower burner, which is fired continuously toward the transverse direction of the furnace casing (2), is provided on the lower side of the material (3), and an alternate combustion type regenerative burner (5, 6), which has a pair of burners (5a, 5b, 6a, 6b) burned alternately and is fired toward the longitudinal direction of the furnace casing (2), is provided on the upper side of the material (3).

FIG. 1



EP 1 584 694 A1

Description

Technical field

[0001] The present invention relates to a catenary furnace which has high compatibility with environmental protection, is easy to maintain, and can satisfactorily perform heating treatment of a material to be treated by restraining fluctuations in furnace temperature.

Background Art

[0002] A catenary furnace, which is a kind of horizontal furnaces, performs heating treatment such as annealing to a material to be treated in a furnace casing heated by burners. The furnace casing of the catenary furnace is formed long in the longitudinal dimension corresponding to the direction in which the material is conveyed and short in the transverse dimension defined by a pair of furnace side walls so as to match the width of the material. The material is pulled by a horizontal tension, and is conveyed in the longitudinal direction of the furnace casing.

[0003] In this conveying process, as shown in Figure 7, the material (a) deflects due to its own weight against the tension for conveying the material (a), and sags down between support rolls (b) for supporting the material (a) thereon, whichprovides a catenary curve forming a catenary sag (c) with a considerable sagging amount (h) . Also, an ordinary burner of a general type is used as a burner for heating the material having a shape of such a catenary curve. A large number of the burner are arranged at the upper side and lower side of the material and toward the furnace width direction from one furnace side wall to the other furnace side wall, whereby the material is heated from the upper side and lower side by heat radiations of the furnace wall heated by the burners and the burner flames.

[0004] In the conventional catenary furnace having such a furnace casing construction, as described above, the width of furnace casing is narrow so as to match the width of the material. Therefore, if the capacity of burner is increased to obtain a larger heat input, the burner flames become longer than the transverse dimension of the furnace casing, and hence collide with the other furnace side wall facing thereto. Therefore, the other furnace side wall is overheated, and thereby refractories are damaged.

[0005] In view of such circumstances, the heat input of burners must be restricted so as to correspond to the width dimension of furnace casing. Therefore, burners with a low capacity have conventionally been arranged in a plural for the purpose of securing a necessary heat input. However, the conventional ordinary burner has a problem in terms of measures against exhaust gas, and also has low energy-saving performance. Therefore, a usage of a large number of such burners lacks compatibility with environmental protection, and it has been desired to constitute a furnace casing structure provided with burners replacing the above-described ordinary burners.

[0006] From the viewpoint of burner performance, it can be thought of the use of a regenerative burner called an alternate combustion type regenerative burner, disclosed in reference 1 (Tokkyo bunken 1), for example. As known well, the regenerative burner is constructed with a pair of burners that are arranged oppositely to alternately perform combustion operation and exhaust operation, a heat reservoir provided in each of the burners, and a selector valve for switching over the burner operation. The heat reservoir accumulates heat from exhaust gas during the exhaust operation of burner, and the heat reservoir accumulating heat heats combustion air, when the operation is switched over to the combustion operation. Therefore, the regenerative burner has excellent compatibility with environment.

[0007] The furnace casing structure may be constructed by means that this regenerative burner in place of the above-described ordinaryburner is providedon the furnace side wall and is located at the upper side and lower side of the material.

[0008] [Tokkyo bunken 1] Japanese Patent Laid-Open (Kokai) No. 10-267262

[0009] However, when the regenerative burner is merely used in place of the ordinaryburner based on the furnace casing structure of the conventional catenary furnace, although an effect of protecting environment increases, there arises a problem inwhich a drawback of poor heating treatment of the material and complex maintainability of equipment is involved.

[0010] Specifically, in designing the furnace casing, the heat input required to the regenerative burner is determined by the quantity of heat necessary for heating the material, the heat loss of exhaust gas, the preheating temperature of combustion air, the heat loss from furnace wall, and the like, and the necessary heat input per one burner of the regenerative burner is approximately two times, as comparing such input with the above-described ordinary burner. I f an attempt is made to secure the heat input two times, the flame length of burner naturally becomes long. Consequently, as in the case of the conventional ordinary burner, a problem of overheated furnace side wall occurs.

[0011] Therefore, even in the case of the regenerative burner, the each heat input thereof must be restricted so as to match the width dimension of furnace casing. In order to secure the necessary heat input, as in the case of the ordinary burner, a considerably large number of regenerative burners must be provided. Inparticular, in the case of the regenerative burner, if the number thereof is increased, the number of auxiliary device such as the selector valve and heat reservoir increases. Therefore, not only the equipment but also the maintenance works increases.

[0012] Further, in the case of the regenerative burner, since the switchover control of burner is involved, the

furnace temperature fluctuates greatly, so that the heating treatment of the material may be affected adversely.

Disclosure of the Invention

[0013] The present invention has been made to solve above problems with the related art, and accordingly an object thereof is to provide a catenary furnace which has high compatibility with environmental protection, is easy to maintain, and can satisfactorily perform heating treatment of a material to be treated by restraining fluctuations in furnace temperature.

[0014] The present invention provides a catenary furnace for heating a material, which is formed in a shape of a catenary curve and is conveyed in the longitudinal direction of a furnace casing, in the furnace casing heated by burners, characterized in that a lower burner, which is burned continuously toward the transverse direction of the furnace casing, is provided on the lower side of the material, and an alternate combustion type regenerative burner, which has a pair of burners burned alternately and is burned toward the longitudinal direction of the furnace casing, is provided on the upper side of the material.

[0015] Since the alternate combustion type regenerative burner is burned toward the longitudinal direction of the furnace casing, the regenerative burner can be burned with a necessary heat input without being restricted in the transverse dimension of furnace casing as compared with the case where the regenerative burner is arranged in the furnace width direction, by which the number of regenerative burners can be decreased as the whole of the furnace casing structure. Also, the regenerative burner is used as a burner located at the upper side of the material, and on the other hand, the lower burner fired continuously is provided on the lower side of the material. Therefore, since the lower burner is burned continuously even during the switchover operation of the regenerative burner, the furnace temperature can be kept substantially constant, whereby fluctuations in furnace temperature caused by the switchover control of regenerative burner can be restrained, and the temperature distribution of the material can be maintained satisfactorily, by which proper heating treatment can be performed.

[0016] Also, since the number of regenerative burners can be decreased, the maintenance work for auxiliary devices such as a selector valve and a heat reservoir can be lightened. Further, the use of the regenerative burner, which is excellent in terms of measures against exhaust gas and energy saving, can enhance the compatibility with environment of the catenary furnace.

[0017] Also, the catenary furnace in accordance with the present invention is characterized in that one set of the regenerative burner consisting of two is provided, so as to hold the furnace casing between the paired burners each of the regenerative burner from the width direction of the furnace casing. Thereby, the furnace temperature can also be controlled in the furnace width direction by the two regenerative burners, and hence the temperature in the furnace width direction can be uniformed.

[0018] Also, the catenary furnace in accordance with the present invention is characterized in that the regenerative burner is provided in plural numbers along the longitudinal direction of the furnace casing. Thereby, high compatibility with environmental protection, ease of maintenance, and high performance of heating treatment for the material can be secured as the whole of the catenary furnace.

[0019] Further, the catenary furnace in accordance with the present invention is characterized in that the heat input of the regenerative burner and the lower burner are controlled individually. Thereby, the furnace temperature distribution can be optimized.

[0020] Also, the catenary furnace in accordance with the present invention is characterized in that the furnace casing has a plurality of furnace temperature control zones arranged in the conveying direction of the material, the regenerative burner and the lower burner are provided in the furnace temperature control zone on the upstream side in the conveying direction, and a burner arranged on side and burned continuously is provided in the furnace temperature control zone on the downstream side in the conveying direction. Thereby, the material can be heated properly by the regenerative burner and the lower burner on the upstream side on which the necessary heat input is great, so that the catenary furnace can be configured rationally.

[0021] Further, the catenary furnace in accordance with the present invention is characterized in that the regenerative burner is of a diffusion combustion type. Thereby, the emission of NOx can be reduced.

Brief Description of the Drawings

[0022]

Figure 1 is a schematic plan view showing one preferred embodiment of a catenary furnace in accordance with the present invention;

Figure 2 is a side view of the catenary furnace shown in Figure 1;

Figure 3 is a schematic plan view showing a plurality of furnace temperature control zones of a catenary furnace in accordance with the present invention;

Figure 4 is a diagram showing the relationship between burner combustion operation and furnace temperature, in the case where alternate combustion type regenerative burners are provided on the upper side and lower side of a material to be treated;

Figure 5 is a diagram showing the relationship between combustion operation of each burner and furnace temperature in the catenary furnace shown in Figure 1;

Figure 6 is a schematic plan view showing a modi-

fication of the catenary furnace shown in Figure 1; and

Figure 7 is a schematic side view showing a conveying state of a material that is heated by a catenary furnace.

Best Mode for Carrying Out the Invention

[0023] One preferred embodiment of a catenary furnace in accordance with the present invention will now be described in detail with reference to the accompanying drawings. The catenary furnace is usually configured to provide a plurality of furnace temperature control zones in the longitudinal direction of the furnace casing corresponding to the direction of conveying a material to be treated. Figures 1 and 2 show one furnace temperature control zone (S) of the catenary furnace 1 in accordance with this embodiment. A furnace casing 2 of the catenary furnace 1 of this embodiment is formed, as in the conventional example, so that the longitudinal dimension thereof is long and the transverse dimension (W) thereof is short so as to match the width of a material 3. The material 3 is heated while being conveyed in the longitudinal direction of the furnace casing 2 in the shape of a catenary curve within the furnace casing 2 heated by burners.

[0024] The material 3 is conveyed so as to pass through a substantially central position in the height direction of the furnace casing 2. At the lower side of the material 3, a plurality of lower burners 4 are arranged, and at the upper side of the material 3, alternate combustion type regenerative burners 5 and 6 are arranged. The material 3 is heated from the upper side and lower side by heat radiation from a furnace wall heated by the lower burners 4 and the regenerative burners 5 and 6 and their burner flames, and is subjected to heat treatment such as annealing and the like.

[0025] The lower burners 4 are provided at intervals in the longitudinal direction of the furnace casing 2 in a lower part of a furnace side wall 2a considering a catenary sag of the material 3. As these lower burners 4, publicly known ordinary burners are used. These lower burners 4 are burned to the width direction of the furnace casing 2. Specifically, the lower burners 4 are fired so that the burner flames are directed in the transverse direction of the furnace casing 2, and also fired continuously or continually during the heating treatment of the conveyed material 3.

[0026] On the other hand, the publicly known alternate combustion type regenerative burners 5 and 6, which have a pair of burners 5a, 5b, 6a and 6b burned alternately, are arranged so that the paired burners 5a, 5b, 6a and 6b face to each other along the longitudinal direction of the furnace casing 2, and are fired toward the longitudinal direction of the furnace casing 2, and in other words, they are burned such that the burner flames are directed toward the longitudinal direction of the furnace casing 2. In the example shown in the figure, the paired burners 5a, 5b, 6a and 6b are provided along the longitudinal direction of the furnace casing 2 so as to hold the furnace casing 2 therebetween in the transverse direction because they are provided in upper parts of the furnace side wall 2a. However, it is a matter of course that the paired burners 5a, 5b, 6a and 6b may be arranged so as to face to each other along the longitudinal direction of the furnace casing 2 by appropriately selecting the installation positions of the regenerative burners 5 and 6 with respect to the furnace casing 2.

[0027] Especially in this embodiment, the two regenerative burners 5 and 6 are provided as one set so as to hold the furnace casing 2 therebetween. As known well, the paired burners 5a, 5b, 6a and 6b of the regenerative burners 5 and 6 perform combustion operation and exhaust operation alternately according to the switchover operation of the selector valve. Specifically, when the burners 5a and 6a in the upstream side in the conveying direction of the material 3 perform the combustion operation, the burners 5b and 6b in the downstream side perform the exhaust operation. When the burners 5b and 6b in the downstream side transfer to the combustion operation due to the switchover operation, the burners 5a and 6a in the upstream side perform the exhaust operation. Thereby, the furnace is operated while heat is stored in the heat reservoir and combustion air is heated.

[0028] For the regenerative burners 5 and 6 subjected to such switchover control and the lower burners 4 fired continuously, each heat input of them is controlled individually. As the regenerative burners 5 and 6, a diffusion combustion type burner is preferably used for keeping the burner flame temperature low by means of mixing fuel and combustion air with each other within the furnace casing, so as to reduce the emission of NOx having high temperature dependency.

[0029] In the catenary furnace 1 in accordance with this embodiment, in some furnace temperature control zones (Sa) being located at the upstream side of a plurality of the furnace temperature control zones (S) provided continuously along the conveying direction of the material 3, as shown in Figure 3, a plurality of burner combinations consisting of the regenerative burners 5 and 6 and the lower burners 4 are provided repeatedly along the longitudinal direction of the furnace casing 2. In each of the furnace temperature control zones (Sa), each heat input of the regenerative burners 5 and 6 and the lower burners 4 is controlled individually. On the other hand, in some furnace temperature control zones (Sb) located at the downstream side, publicly known burners 7 arranged on a side are provided. These burners 7 are fired continuously during the heating treatment of the material 3.

[0030] Next, the operation of the catenary furnace 1 of this embodiment will be explained. The catenary furnace 1 heated by burners continuously performs the heating treatment of the material 3 in a process in which

the material 3 is conveyed along the longitudinal direction of the furnace casing 2 from the upstream side of the furnace temperature control zone (S) to the downstream side of the furnace temperature control zone (S) . The alternate combustion type regenerative burners 5 and 6 in the furnace temperature control zone (Sa) of the upstream side repeat the operation of alternately burning the paired burners 5a, 5b, 6a and 6b, and on the other hand, the lower burners 4 are burned continuously.

[0031] In this embodiment, since the alternate combustion type regenerative burners 5 and 6 are fired toward the longitudinal direction of the furnace casing 2, these regenerative burners 5 and 6 can be burned with a necessary heat input without being restricted by the transverse dimension (W) of the furnace casing 2, as compared with the case where the regenerative burners are arranged toward the furnace width direction. Therefore, the number of the regenerative burners 5 and 6 can be decreased as the whole of the furnace casing structure.

[0032] In the configuration using the regenerative burners 5 and 6, if all burners arranged at the upper side and lower side of the material were the regenerative burners as described above, when the necessary heat input is small, as shown in Figure 4, a period (Ta) for which all burners stop their combustion occurs. If the combustion of regenerative burner is restarted according to the decrease in furnace temperature caused by this stop period (Ta), the furnace temperature fluctuates greatly due to hunting (indicated by α in Figure 4).

[0033] By contrast, in the catenary furnace 1 of this embodiment, as the burners located at the upper side of the material 3, the regenerative burners 5 and 6 are adopted, and on the other hand, the lower burners 4 fired continuously are provided on the lower side of the material 3, so that as shown in Figure 5, the lower burners 4 are burned continuously even for a period (Tb) during the switchover operation of the regenerative burners 5 and 6, by which the furnace temperature can be kept substantially constant. Thereby, fluctuations in furnace temperature caused by the switchover operation of the regenerative burners 5 and 6 can be restrained (indicated by β in Figure 5), and the temperature distribution of the material 3 can be maintained satisfactorily, by which appropriate heating treatment can be performed.

[0034] Also, since the number of the regenerative burners 5 and 6 can be decreased, the maintenance service for auxiliary devices such as the selector valve and heat reservoir provided for the regenerative burners 5 and 6 can be lightened. Also, the use of the regenerative burners 5 and 6, which are excellent in terms of measures against exhaust gas and energy saving, can enhance the compatibility with environment of the catenary furnace 1.

[0035] Further, since the paired burners 5a, 5b, 6a and 6b of the regenerative burners 5 and 6 are provided with two burners as one set in order to hold the furnace casing 2 therebetween in the transverse direction of the furnace casing 2, the furnace temperature can be also controlled in the furnace width direction by controlling each heat input of these two regenerative burners 5 and 6 individually, and hence the temperature in the furnace width direction can be uniformed. Also, since each heat input of the regenerative burners 5 and 6 and the lower burners 4 is controlled individually, the furnace temperature distribution can be optimized.

[0036] Also, since a large number of furnace temperature control zones (Sa) for arranging the regenerative burners 5 and 6 are provided, and the regenerative burners 5 and 6 are provided in plural numbers along the longitudinal direction of the furnace casing 2, the above-described operation and effects can be achieved not only as a single furnace temperature control zone (S) but also as the whole of the catenary furnace 1. Further, since the regenerative burners 5 and 6 and the lower burners 4 are provided in the furnace temperature control zone (Sa) on the upstream side in the conveying direction of the material 3, and side burners 7 fired continuously are provided in the furnace temperature control zone (Sb) on the downstream side in the conveying direction of the material 3, the material 3 can be heated properly by the regenerative burners 5 and 6 and the lower burners 4 on the upstream side on which the necessary heat input is great, so that the catenary furnace 1 can be configured rationally.

[0037] In the above-described embodiment, description has been made about the case where the regenerative burners 5 and 6 are provided with two burners as one set so as to hold the furnace casing 2 in the transverse direction therebetween, as one example. However, it is a matter of course that, as shown in Figure 6, one regenerative burner may be provided in each furnace temperature control zone (S).

[0038] In sum, according to the catenary furnace in accordance with the present invention, the compatibility with environmental protection is high, the maintenance service is easy, and a material can be heated properly by restraining fluctuations in furnace temperature.

Claims

1. A catenary furnace for heating a material, which is formed in a catenary curve and is conveyed in the longitudinal direction of a furnace casing, in said furnace casing heated by burners, is **characterized in that**

   a lower burner, which is burned continuously toward the transverse direction of said furnace casing, is provided on the lower side of said material, and an alternate combustion type regenerative burner, which has a pair of burners burned alternately and is burned toward the longitudinal direction of said furnace casing, is provided on the upper side of said material.

2. The catenary furnace according to claim 1, wherein one set of said regenerative burner consisting of two is provided, so as to hold said furnace casing between said paired burners of each of said regenerative burner from the width direction of said furnace casing.

3. The catenary furnace according to claim 1 or 2, wherein said regenerative burner is provided in plural numbers along the longitudinal direction of said furnace casing.

4. The catenary furnace according to either one of claims 1 to 3, wherein each heat input of said regenerative burner and said lower burner is controlled individually.

5. The catenary furnace according to either one of claims 1 to 4, wherein said furnace casing has a plurality of furnace temperature control zones arranged in the conveying direction of said material, said regenerative burner and said lower burner are provided in said furnace temperature control zone on the upstream side in the conveying direction, and burner arranged on side and burned continuously is provided in said furnace temperature control zone on the downstream side in the conveying direction.

6. The catenary furnace according to either one of claims 1 to 5, wherein said regenerative burner is of a diffusion combustion type.

FIG. 1

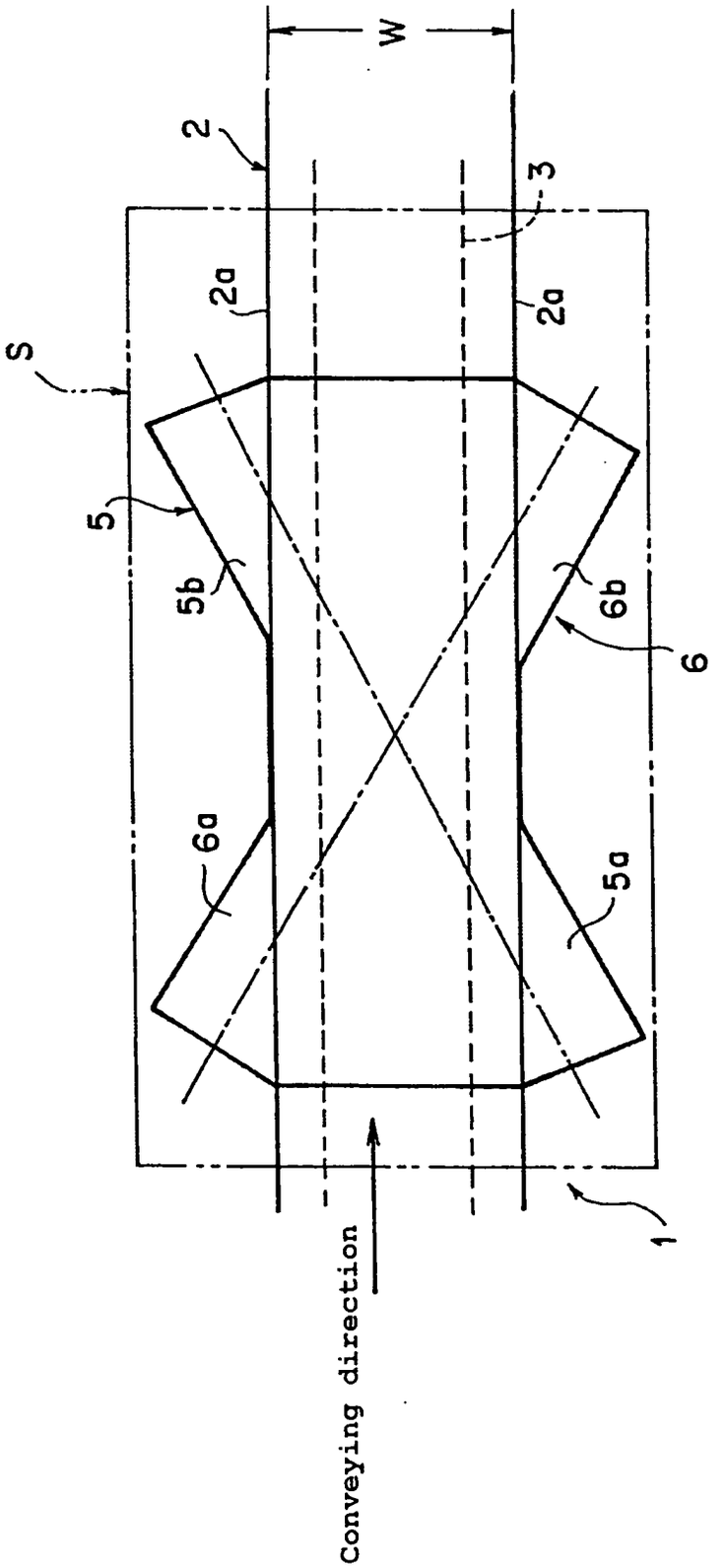


FIG. 2

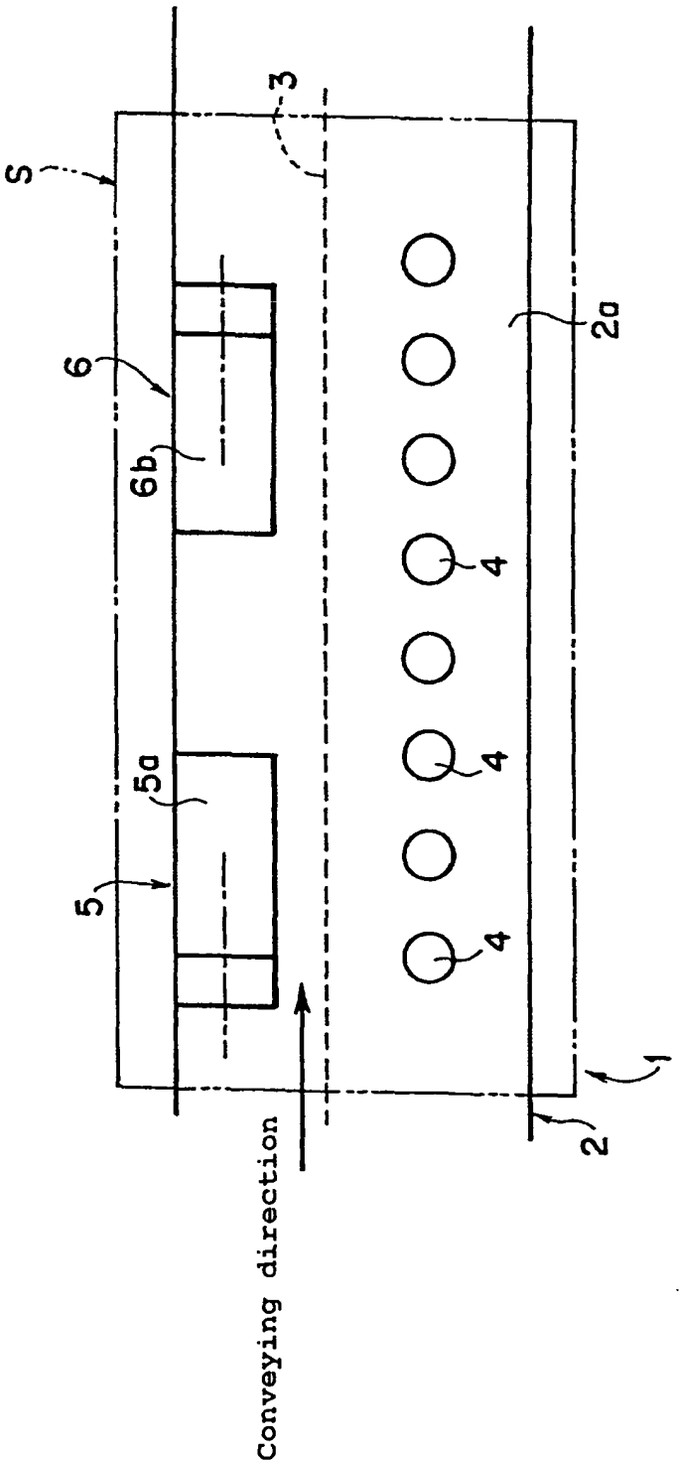


FIG. 3

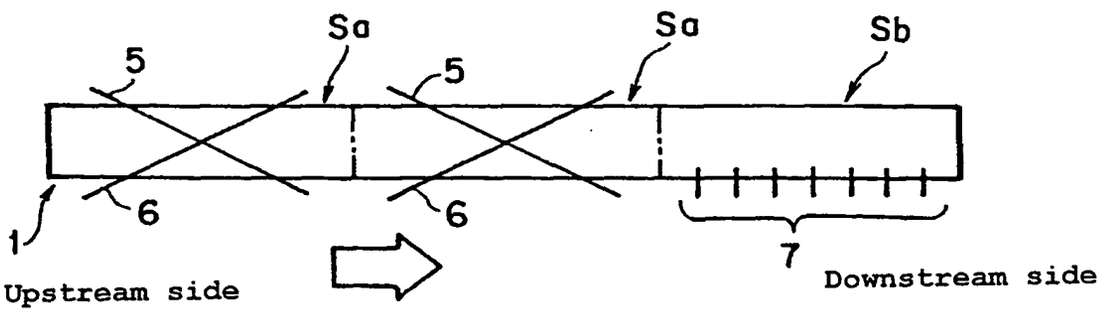


FIG. 4

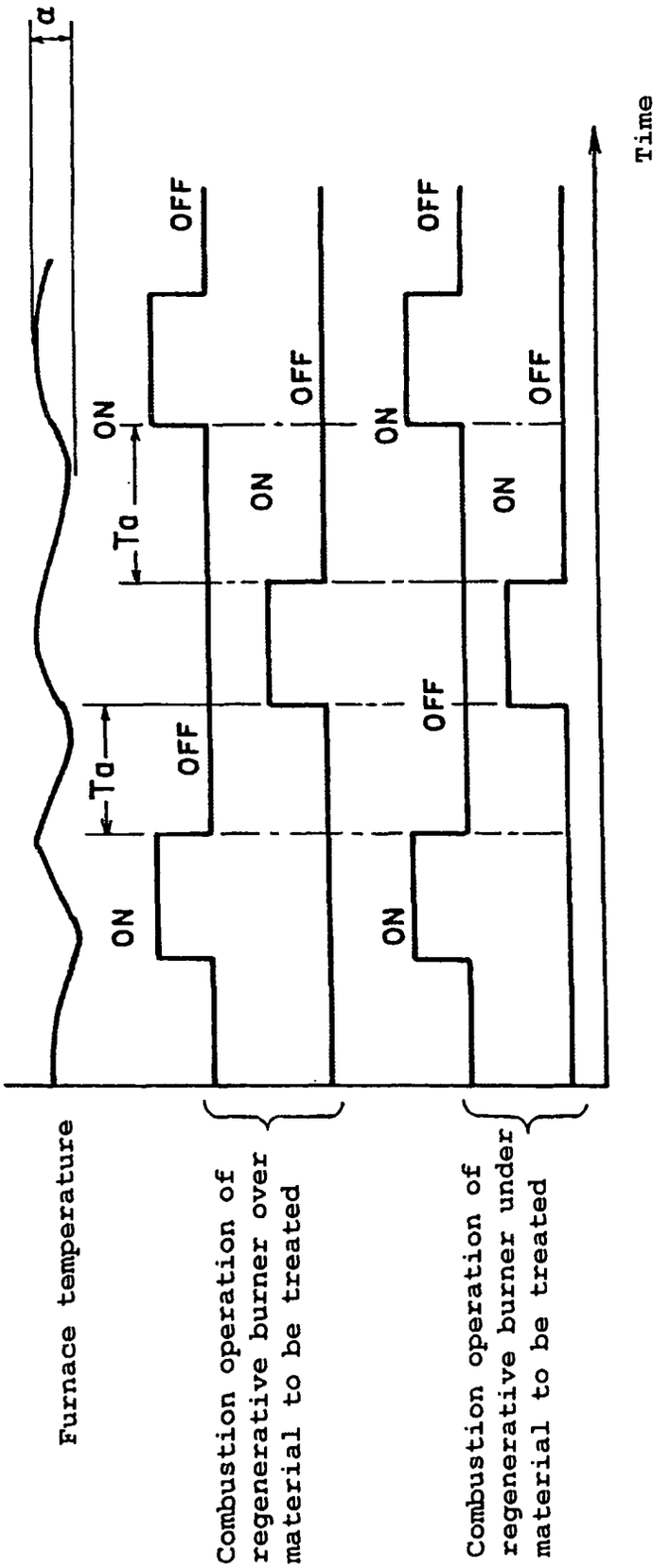

α
Furnace temperature
Ta
Ta
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
Time
Combustion operation of regenerative burner over material to be treated
Combustion operation of regenerative burner under material to be treated

FIG. 5

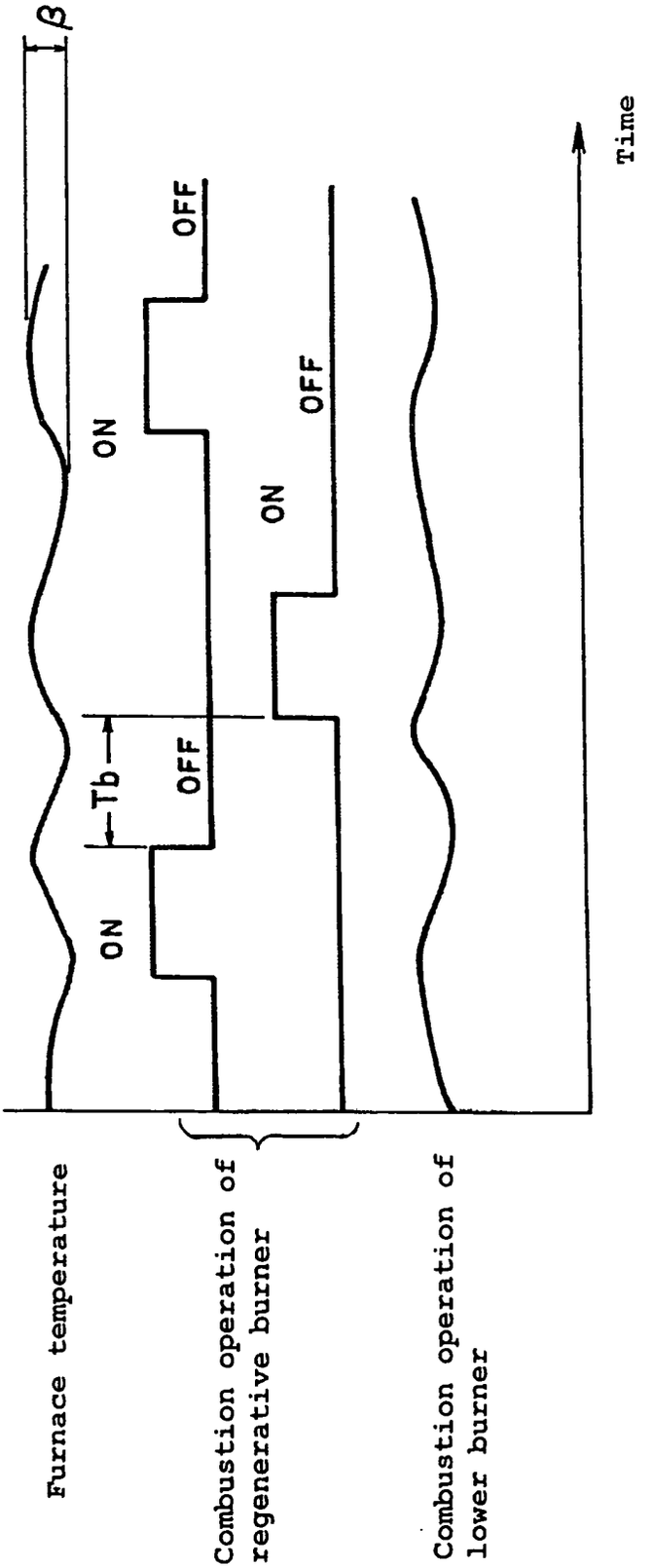

β
ON
OFF
Tb
ON
OFF
ON
OFF
Time
Furnace temperature
Combustion operation of regenerative burner
Combustion operation of lower burner

FIG. 6

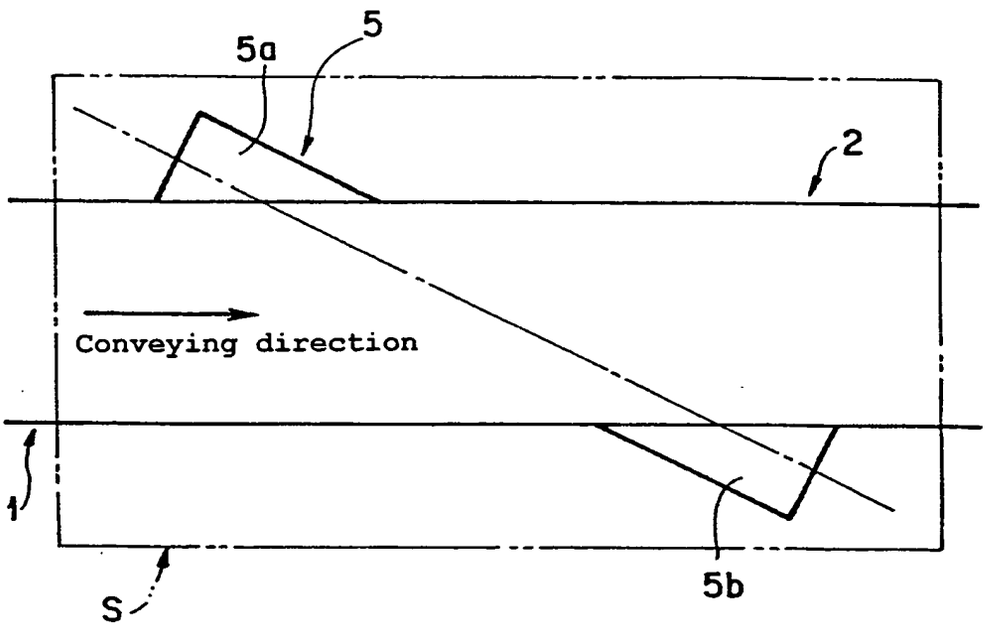
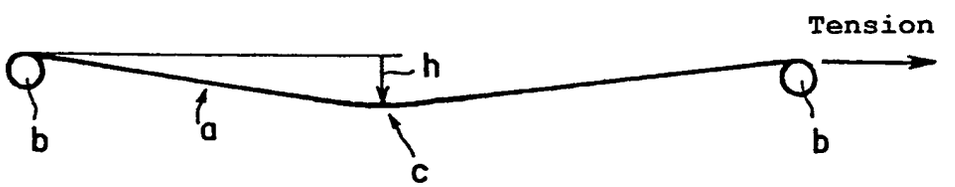


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/15394

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] C21D9/56, C21D1/52

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] C21D9/56, C21D1/52, F23L15/02, F23C11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2004
Kokai Jitsuyo Shinan Koho 1971-2004 Jitsuyo Shinan Toroku Koho 1996-2004

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 5-54538 U (Rozai Kogyo Kabushiki Kaisha), 20 July, 1993 (20.07.93), Full text; Fig. 1 (Family: none)	1-6
Y	JP 11-248360 A (Nippon Steel Corp.), 14 September, 1999 (14.09.99), Par. No. [0019] (Family: none)	1-6
Y	JP 8-311555 A (Nippon Steel Corp.), 26 November, 1996 (26.11.96), Fig. 5 (Family: none)	2-6

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

* Special categories of cited documents:
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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
19 February, 2004 (19.02.04)	09 March, 2004 (09.03.04)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/15394

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-159613 A (Nippon Furnace Kogyo Kaisha, Ltd.), 07 June, 1994 (07.06.94), Full text (Family: none)	6
E,A	JP 2003-129132 A (Nippon Steel Corp.), 08 May, 2003 (08.05.03), Full text (Family: none)	1-6

Form PCT/ISA/210 (continuation of second sheet) (July 1998)