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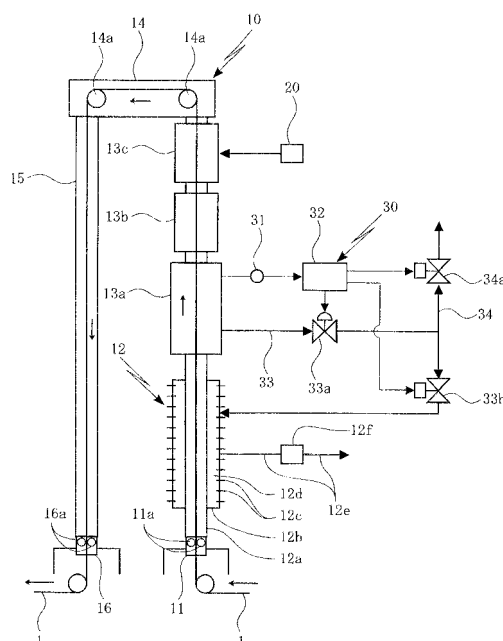
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(54) **CONTINUOUS ANNEALING FURNACE**

(57) In a continuous annealing furnace 10, a subject material 1 introduced through an inlet sealing portion 11 is continuously transported from a heating zone 12 to cooling zones 13a to 13c in the hydrogen-gas containing ambient gas so as to anneal the subject material by indirectly heating the subject material in the heating zone 12 followed by cooling the subject material in the cooling zones. The resultant subject material is discharged from the continuous annealing furnace through an outlet sealing portion 16. The continuous annealing furnace 10 is provided with an ambient gas feeder 20 for feeding the ambient gas into the continuous annealing furnace 10, a guide duct 33 for introducing the excess ambient gas from the continuous annealing furnace into a combustion portion of the heating zone and an ambient-gas control unit 30 for controlling the introduction of the excess ambient gas through the guide duct into a combustion portion of the heating zone.

Fig. 2



## Description

### [Technical Field]

**[0001]** The present invention relates to a continuous annealing furnace in which a subject material introduced through an inlet sealing portion is continuously transported from a heating zone to a cooling zone in a hydrogen-gas containing ambient gas so as to anneal the subject material by indirectly heating the subject material in the heating zone followed by cooling the heated subject material in the cooling zone and from which the annealed subject material is discharged through an outlet sealing portion. Particularly, the invention is characterized as follows. An ambient gas feeder feeds the hydrogen-gas containing ambient gas into the continuous annealing furnace in order to replenish the ambient gas leaked through the inlet sealing portion and outlet sealing portion and to remove oxygen by reaction with the hydrogen gas, the oxygen accompanying the subject material introduced into the continuous annealing furnace. In this case, the invention is adapted to suppress the discharge of the excess ambient gas fed into the continuous annealing furnace and to provide an effective utilization of the hydrogen gas present in the excess ambient gas.

### [Background Art]

**[0002]** In a case where an elongate subject material such as a stainless steel strip formed by cold rolling or the like is annealed in the continuous annealing furnace, it has been a common practice in the art to bright anneal the subject material so as not to impair the brilliance of the material.

**[0003]** In the continuous annealing furnace, the elongate subject material is bright annealed as follows. As shown in Fig.1, an elongate subject material 1 is introduced through an inlet sealing portion 11 into a continuous annealing furnace 10 filled with the hydrogen-gas containing ambient gas or generally an ambient gas consisting primarily of hydrogen gas and nitrogen gas. The subject material 1 is indirectly heated in a heating zone 12 in the continuous annealing furnace 10. The heated subject material 1 is cooled by introducing the subject material into cooling zones 13a to 13c. The subject material 1 is further led from a top roll chamber 14 provided with rollers 14a to an outlet sealing portion 16 via a chute 15. The subject material is discharged from the continuous annealing furnace 10 through the outlet sealing portion 16 (see, for example, Patent Documents 1, 2).

**[0004]** In such a continuous annealing furnace 10, an ambient gas feeder 20 feeds the hydrogen-gas containing ambient gas into the continuous annealing furnace 10 in order to replenish the ambient gas leaked through the inlet sealing portion 11 and outlet sealing portion 16 and to remove oxygen by reaction with the hydrogen gas present in the ambient gas, the oxygen accompanying the subject material 1 introduced into the continuous an-

nealing furnace 10.

**[0005]** When the ambient gas feeder 20 feeds the hydrogen-gas containing ambient gas into the continuous annealing furnace 10, as just described, it is a common practice for the ambient gas feeder 20 to feed an excess of the above ambient gas into the continuous annealing furnace 10 such that the oxygen accompanying the subject material 1 introduced into the continuous annealing furnace 10 may be sufficiently removed by reaction with the hydrogen gas present in the ambient gas.

**[0006]** In the case where the excess ambient gas is fed into the continuous annealing furnace 10 by the ambient gas feeder 20 as just described, the pressure of the ambient gas in the continuous annealing furnace 10 is gradually increased, which dictates the need for discharging the ambient gas from the continuous annealing furnace 10 to the outside. More recently, the inlet sealing portion 11 and the outlet sealing portion 16, in particular, employ roll seals or the like having high air-tightness so that the amount of ambient gas leaked through the inlet sealing portion 11 or the outlet sealing portion 16 is decreased. Accordingly, the ambient gas to be discharged from the continuous annealing furnace 10 tends to increase.

**[0007]** When the ambient gas is discharged from the continuous annealing furnace 10, it is necessary to cool the ambient gas or to dilute the ambient gas with air in order to prevent the combustion of the hydrogen gas present in the ambient gas. This leads to problems of increased costs and wasted hydrogen gas present in the excess ambient gas.

### Prior Art Documents

#### Patent Documents

#### [0008]

Patent Document 1: JP-A No.H3-134120

Patent Document 2: JP-A No.H7-268493

### [Disclosure of the Invention]

### [Problems to Be Solved by the Invention]

**[0009]** The invention addresses the above-described problems encountered by the continuous annealing furnace in which the subject material introduced through the inlet sealing portion is continuously transported from the heating zone to the cooling zone in the hydrogen-containing ambient gas so as to anneal the subject material by indirectly heating the subject material in the heating zone followed by cooling the heated subject material in the cooling zone and from which the annealed subject material is discharged through the outlet sealing portion.

**[0010]** In the case where the ambient gas feeder feeds the above-described ambient gas into the continuous annealing furnace in order to replenish the ambient gas

leaked through the inlet sealing portion and outlet sealing portion and to sufficiently remove oxygen by reaction with the hydrogen gas, the oxygen accompanying the subject material introduced into the continuous annealing furnace, the invention seeks to suppress the discharge of the excess ambient gas fed into the continuous annealing furnace and to provide an effective utilization of the hydrogen gas present in the excess ambient gas.

#### [Means for Solving the Problems]

**[0011]** In accordance with the invention for achieving the above objects, a continuous annealing furnace which comprises an inlet sealing portion allowing the introduction of an elongate subject material, a heating zone for indirectly heating the subject material by means of combustion in a combustion portion, a cooling zone for cooling the heated subject material, and an outlet sealing portion allowing the discharge of the cooled subject material and which anneals the subject material introduced through the inlet sealing portion by continuously transporting the subject material from the heating zone to the cooling zone in a hydrogen-gas containing ambient gas and discharges the annealed subject material through the outlet sealing portion, further comprises an ambient gas feeder for feeding the ambient gas into the continuous annealing furnace, a guide duct for introducing excess ambient gas from the continuous annealing furnace into the combustion portion of the heating zone, and an ambient-gas control unit for controlling the introduction of excess ambient gas through the guide duct into the combustion portion of the heating zone.

**[0012]** The continuous annealing furnace may employ a so-called muffle heater as the heating zone for indirectly heating the subject material. The muffle heater includes an internal pipe allowing the passage of the subject material and an external pipe disposed around an outer periphery of the internal pipe and effects combustion in the combustion portion defined between the internal pipe and the external pipe.

**[0013]** The external pipe may be provided with a combustion device such as a burner so as to effect the combustion in the combustion portion defined between the internal pipe and the external pipe.

**[0014]** In the continuous annealing furnace, the ambient-gas control unit introduces the excess ambient gas from the continuous annealing furnace through the guide duct into the combustion portion of the heating zone. If, in this case, the temperature of the ambient gas is extremely high, the ambient gas cannot be introduced into the combustion portion of the heating zone because of the heat resistance and the like of meters and gauges. It is therefore preferred to introduce the excess ambient gas from the cooling zone into the combustion portion of the heating zone, the cooling zone in which the ambient gas is cooled to some degree.

**[0015]** In the case where the ambient-gas control unit introduces the excess ambient gas from the continuous

annealing furnace through the guide duct into the combustion portion of the heating zone, it is preferable that, in a case where the combustion portion has a temperature which is not lower than an ignition temperature of the hydrogen gas, the excess ambient gas is introduced to the combustion part by means of the ambient-gas control unit for the purpose of ensuring that the hydrogen gas present in the ambient gas is adequately burned up in the combustion portion.

**[0016]** Further, in the continuous annealing furnace, it is preferable that a gas refining unit for refining the ambient gas, a refining guide duct for introducing the excess ambient gas which is introduced through the guide duct into the gas refining unit, and a returning duct for returning the excess ambient gas which is refined by the gas refining unit into the ambient gas feeder are provided.

**[0017]** In the continuous annealing furnace comprised as above, in the case where the combustion portion has the temperature lower than the ignition temperature of the hydrogen gas, the excess ambient gas introduced through the guide duct by the ambient-gas control unit is introduced through the refining guide duct into the gas refining unit, and the refined ambient gas is returned through the returning duct to the ambient-gas feeder.

#### [Advantageous Effects of the Invention]

**[0018]** In the continuous annealing furnace according to the invention, the excess ambient gas in the continuous annealing furnace is introduced into the combustion portion of the heating zone by means of the ambient-gas control unit. Therefore, the hydrogen gas present in the excess ambient gas thus introduced is combusted in the combustion portion.

**[0019]** In the continuous annealing furnace according to the invention, therefore, the hydrogen gas present in the excess ambient gas in the continuous annealing furnace is effectively utilized for the combustion in the combustion portion of the heating zone, while the discharge of the excess ambient gas from the continuous annealing furnace is suppressed. This negates the need for cooling the ambient gas or diluting the ambient gas with air. In addition, the cost is also reduced.

**[0020]** According to the present invention, the continuous annealing furnace further comprises the gas refining unit, the refining guide duct for introducing the excess ambient gas introduced through the guide duct into the gas refining unit, and the returning duct for returning the excess ambient gas which is refined by the gas refining unit to the ambient-gas feeder. In such a continuous annealing furnace, the following effects may be obtained. For example, in a case where the combustion portion has the temperature lower than the ignition temperature of the hydrogen gas, the excess ambient gas introduced through the guide duct is introduced through the refining guide duct to the gas refining unit for refinement and the refined ambient gas is returned through the returning duct to the ambient-gas feeder, so that the excess ambient

gas is effectively utilized even if the combustion portion has the temperature lower than the ignition temperature of the hydrogen gas.

#### [Brief Description of the Drawings]

#### [0021]

[Fig.1] Fig.1 is a schematic diagram showing an example of the conventional continuous annealing furnace;

[Fig.2] Fig.2 is a schematic diagram showing a continuous annealing furnace according to one embodiment of the invention; and

[Fig.3] Fig.3 is a schematic diagram showing a variation example of the continuous annealing furnace according to one embodiment of the invention.

#### [Best Mode for Carrying Out the Invention]

[0022] A continuous annealing furnace according to an embodiment of the invention will be specifically described as below with reference to the accompanying drawings. It is to be noted that the continuous annealing furnace according to the invention is not particularly limited to the embodiment disclosed hereinbelow but may be embodied in any other suitable forms without departing from the spirit or essential characteristics thereof.

[0023] According to the embodiment, as shown in Fig. 2, an elongate subject material 1 such as a stainless steel strip formed by cold rolling or the like is introduced through an inlet sealing portion 11 into a continuous annealing furnace 10 filled with a hydrogen-gas containing ambient gas or generally an ambient gas consisting primarily of hydrogen gas and nitrogen gas.

[0024] It is noted here that the above inlet sealing portion 11 employs a roll seal 11a such as to inhibit the leakage of the ambient gas filled in the continuous annealing furnace 10.

[0025] In this continuous annealing furnace 10, the subject material 1 introduced through the inlet sealing portion 11a as described above is indirectly heated in a heating zone 12.

[0026] The following arrangement is made for indirectly heating the subject material 1 in the heating zone 12 as described above. The heating zone 12 is constructed in a double pipe structure wherein the subject material 1 is passed through an internal pipe 12a of the heating zone 12 while an external pipe 12b is provided with a combustion device 12c such as a burner. The combustion device 12 effects combustion in a combustion portion 12d defined between the internal pipe 12a and the external pipe 12b so that the subject material 1 passed through the internal pipe 12a is indirectly heated.

[0027] The heating zone 12 is arranged such that a combustion exhaust gas resulting from the combustion in the above combustion portion 12d is introduced into a cooler 12f via an exhaust gas pipe 12e. After cooled by

the cooler 12f, the combustion exhaust gas is discharged to the outside via the exhaust gas pipe 12e.

[0028] Next, the subject material 1 thus heated in the heating zone 12 is cooled by sequentially introducing the subject material into first to third cooling zones 13a to 13c. The subject material 1 thus cooled is introduced into a top roll chamber 14 provided with rollers 14a. The subject material 1 is led from the top roll chamber 14 to an outlet sealing portion 16 via a chute 15. The subject material 1 is discharged from the continuous annealing furnace 10 through this outlet sealing portion 16.

[0029] The above outlet sealing portion 16 also employs a roll seal 16a such as to inhibit the leakage of the ambient gas filled in the continuous annealing furnace 10.

[0030] In the continuous annealing furnace 10 of the embodiment as well, an ambient gas feeder 20 feeds the excessive hydrogen-gas containing ambient gas into the continuous annealing furnace 10 in order to replenish the ambient gas leaked through the inlet sealing portion 11 and the outlet sealing portion 16 and to sufficiently remove oxygen, accompanying the subject material introduced into the continuous annealing furnace 10, by reaction with the hydrogen gas present in the ambient gas. In the continuous annealing furnace 10 according to the embodiment, the ambient gas feeder 20 is arranged to feed the hydrogen-gas containing ambient gas into the third cooling zone 13c when feeding the ambient gas into the continuous annealing furnace 10. However, the portion to be supplied with the ambient gas is not particularly limited.

[0031] The continuous annealing furnace 10 of the embodiment is further provided with a guide duct 33 which introduces the excess ambient gas supplied by the ambient gas feeder 20 from the continuous annealing furnace 10 into the combustion portion 12d of the heating zone 12. Still further, the continuous annealing furnace 10 of the embodiment is provided with an ambient-gas control unit 30 which controls the introduction of the ambient gas through the guide duct 33 to the Combustion portion 12d of the heating zone 12.

[0032] The ambient-gas control unit 30 is provided with a pressure gauge 31 for measuring the pressure of the ambient gas in the continuous annealing furnace 10. The pressure of the ambient gas in the continuous annealing furnace 10, as measured by the pressure gauge 31, is outputted to a controller 32.

[0033] In the ambient-gas control unit 30, a first valve 33a and a second valve 33b are disposed in a guide duct 33 for introducing the excess ambient gas from the continuous annealing furnace 10 into the combustion portion 12d of the heating zone 12. Further, a discharge pipe 34 for discharging the ambient gas to the outside is connected to a part of the guide duct 33 that extends between the first valve 33a and the second valve 33b. The discharge pipe 34 is provided with a third valve 34a. The first valve 33a, the second valve 33b and the third valve 34a are controlled by the above-described controller 32.

[0034] In a case where the temperature of the com-

bustion portion 12d is not lower than an ignition temperature of the hydrogen gas, the controller 32 introduces the excess ambient gas from the continuous annealing furnace 10 into the combustion portion 12d of the heating zone 12 via the guide duct 33 by opening the first valve 33a and the second valve 33b and closing the third valve 34a, such that the pressure of the ambient gas in the continuous annealing furnace 10 may be set to a predetermined value, as determined by the pressure gauge 31.

**[0035]** The hydrogen gas present in the ambient gas thus introduced into the combustion portion 12d is combusted by the combustion device 12c and is discharged along with the combustion exhaust gas to the outside of the furnace via the exhaust gas pipe 12e.

**[0036]** This approach prevents the hydrogen-gas containing ambient gas in the continuous annealing furnace 10 from being directly discharged to the outside of the furnace. Furthermore, the hydrogen gas present in the ambient gas to be discharged is effectively utilized for the combustion in the combustion portion 12d of the heating zone 12.

**[0037]** In a case where the combustion is not conducted in the combustion portion 12d of the heating zone 12, for example, in the case where the combustion portion 12d of the heating zone 12 has the temperature lower than the ignition temperature of the hydrogen gas, the controller 32 may also discharge the ambient gas to the outside via the discharge pipe 34 by opening the first valve 33a and the third valve 34a and closing the second valve 33b.

**[0038]** According to the embodiment, the heating zone 12 is constructed in the double pipe structure for indirectly heating the subject material 1 in the heating zone 12. The heating zone 12 is constructed such that the external pipe 12b is provided with the combustion device 12c such as a burner and the combustion device 12c effects the combustion in the combustion portion 12d defined between the internal pipe 12a and the external pipe 12b. However, an alternative arrangement may also be made such that a radiant tube burner (not shown) constituting the combustion portion is provided around an outer periphery of the internal pipe 12a and the hydrogen-gas containing ambient gas is introduced into this radiant tube burner (not shown).

**[0039]** Further, the continuous annealing furnace 10 according to the above embodiment may also have an arrangement (not shown) wherein the ambient gas leaked out of the continuous annealing furnace 10 through the inlet sealing portion 11 or the outlet sealing portion 16 is introduced into the combustion portion 12d of the heating zone 12 so that the hydrogen gas present in the ambient gas is combusted in the combustion portion 12d. Reference Characters List

**[0040]** In the continuous annealing furnace 10 according to the above embodiment, in the case where the combustion is not conducted in the combustion portion 12d of the heating zone 12, for example, in the case where the combustion portion 12d of the heating zone 12 has

the temperature lower than the ignition temperature of the hydrogen gas, the controller 32 may also discharge the ambient gas to the outside via the discharge pipe 34 by opening the first valve 33a and the third valve 34a and closing the second valve 33b. However, as shown in the variation example of Fig. 3, the continuous annealing furnace may be composed such that the ambient gas discharged to the outside via the discharge pipe 34 is effectively utilized.

**[0041]** As shown in Fig.3, in the continuous annealing furnace 10 of the variation example, a refining guide duct 36 which introduces the excess ambient gas into a gas refining unit 35 is connected to a guide duct 33 which introduces the excess ambient gas into the combustion portion 12d of the heating zone 12, and a fourth valve 36a is provided with the refining guide duct 36. Further, the gas refining unit 35 is provided with a returning duct 37 which returns the excess ambient gas refined by the gas refining unit 35 into the ambient gas feeder 20.

**[0042]** In the continuous annealing furnace 10 of the variation example, in the case where the combustion is not conducted in the combustion portion 12d, for example, in the case where the combustion portion 12d of the heating zone 12 has the temperature lower than the ignition temperature of the hydrogen gas, the controller 32 of the ambient-gas control unit 30 closes the second valve 33b and the third valve 34a and opens the first valve 33a and the fourth valve 36a, so that the excess ambient gas is introduced through the refining guide duct 36 into the gas refining unit 35.

**[0043]** The gas refining unit 35 refines the excess ambient gas by applying deoxidation process and dehydration process and returns the refined ambient gas through the returning duct 37 into the ambient gas feeder 20, so that the refined ambient gas is reused.

**[0044]** This approach further suppresses the discharge of the ambient gas containing hydrogen gas from the continuous annealing furnace 10 to the outside of the furnace via the discharge pipe 34, and therefore, the ambient gas is more effectively utilized.

**[0045]** In the case where the excess ambient gas introduced through the guide duct 33 is burned in the combustion portion 12d of the heating zone 12, for example, in the case where the temperature of the combustion portion 12d is not lower than the ignition temperature of the hydrogen gas, one part of the excess ambient gas supplied into the combustion portion 12d may be introduced into the gas refining unit 35 by adjusting the fourth valve 36a and the excess ambient gas may be refined and returned to the ambient gas feeder 20, so that the volume of the excess ambient gas supplied into the combustion 12d of the heating zone 12 is adjusted.

Reference Characters List

**[0046]**

1: Subject material

10: Continuous annealing furnace  
 11: Inlet sealing portion  
 11a: Roll seal  
 12: Heating zone  
 12a: Internal pipe  
 12b: External pipe  
 12c: Combustion device  
 12d: Combustion portion  
 12e: Exhaust gas pipe  
 12f: Cooler  
 13a-13c: First to third cooling zones  
 14: Top roll chamber  
 14a: Roller  
 15: Chute  
 16: Outlet sealing portion  
 16a: Roll seal  
 20: Ambient gas feeder  
 30: Ambient-gas control unit  
 31: Pressure gauge  
 32: Controller  
 33: Guide duct  
 33a: First valve  
 33b: Second valve  
 34: Discharge pipe  
 34a: Third valve  
 35: Gas refining unit  
 36: Refining Guide duct  
 36a: Fourth valve  
 37: Returning duct

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nal pipe allowing the passage of the subject material and an external pipe disposed around an outer periphery of the internal pipe and performs combustion in the combustion portion defined between the internal pipe and the external pipe.

3. The continuous annealing furnace according to Claim 2, wherein the external pipe is provided with a combustion device.

4. The continuous annealing furnace according to any one of Claims 1 to 3, wherein the guide duct introduces the excess ambient gas from the cooling zone into the combustion portion of the heating zone.

5. The continuous annealing furnace according to any one of Claims 1 to 4, wherein the ambient-gas control unit introduces the excess ambient gas into the combustion portion in a case where the combustion portion has a temperature not lower than an ignition temperature of hydrogen gas.

6. The continuous annealing furnace according to any one of Claims 1 to 5 which comprises a gas refining unit for refining the ambient gas, a refining guide duct for introducing the excess ambient gas which is introduced through the guide duct into the gas refining unit, and a returning duct for returning the ambient gas which is refined by the gas refining unit to the excess ambient gas feeder.

7. The continuous annealing furnace according to Claim 6, wherein the ambient-gas control unit introduces the excess ambient gas into the gas refining unit in a case where the combustion portion has a temperature lower than an ignition temperature of hydrogen gas.

## Claims

1. A continuous annealing furnace which comprises an inlet sealing portion allowing the introduction of an elongate subject material, a heating zone for indirectly heating the subject material by means of combustion in a combustion portion, a cooling zone for cooling the heated subject material, and an outlet sealing portion allowing the discharge of the cooled subject material and which anneals the subject material introduced through the inlet sealing portion by continuously transporting the subject material from the heating zone to the cooling zone in a hydrogen-gas containing ambient gas and discharges the annealed subject material through the outlet sealing portion, the continuous annealing furnace further comprising an ambient gas feeder for feeding the ambient gas into the continuous annealing furnace, a guide duct for introducing excess ambient gas from the continuous annealing furnace into the combustion portion of the heating zone and an ambient-gas control unit for controlling the introduction of excess ambient gas through the guide duct into the combustion portion of the heating zone.
2. The continuous annealing furnace according to Claim 1, wherein the heating zone includes an inter-

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Fig. 1

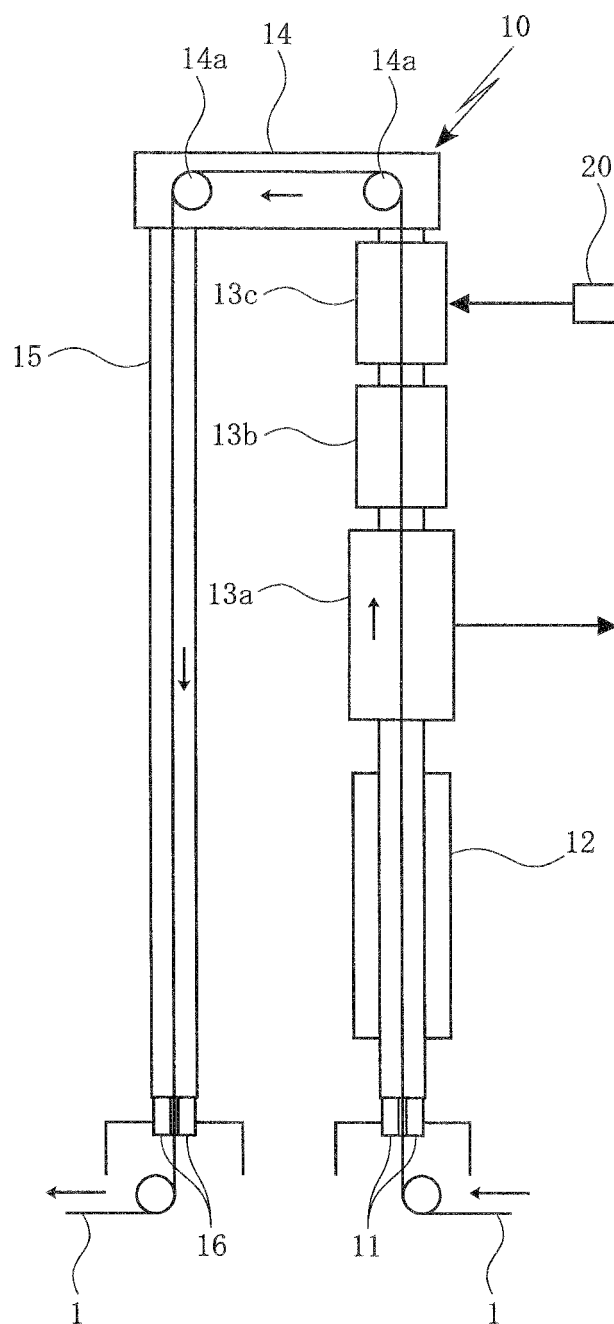


Fig. 2

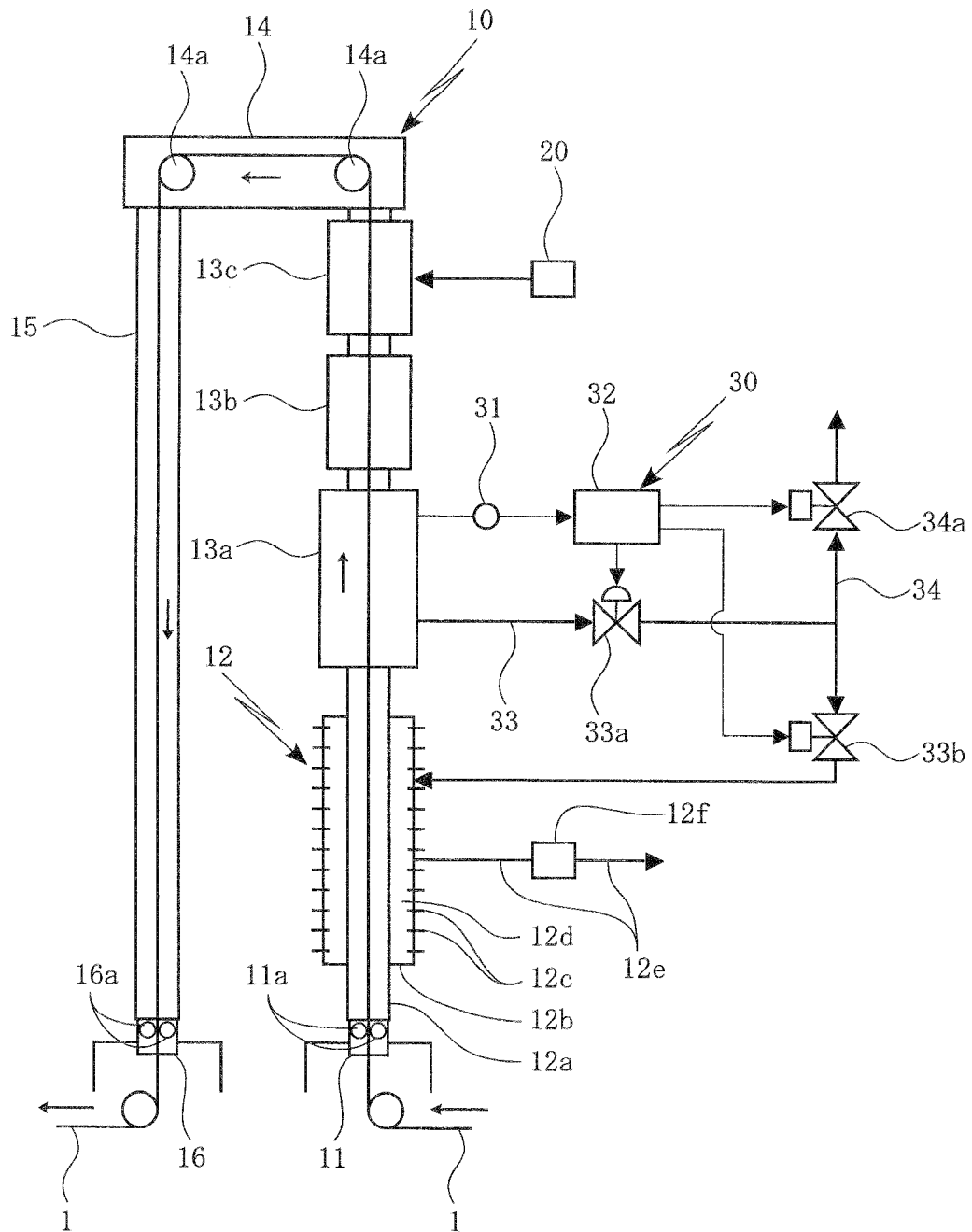
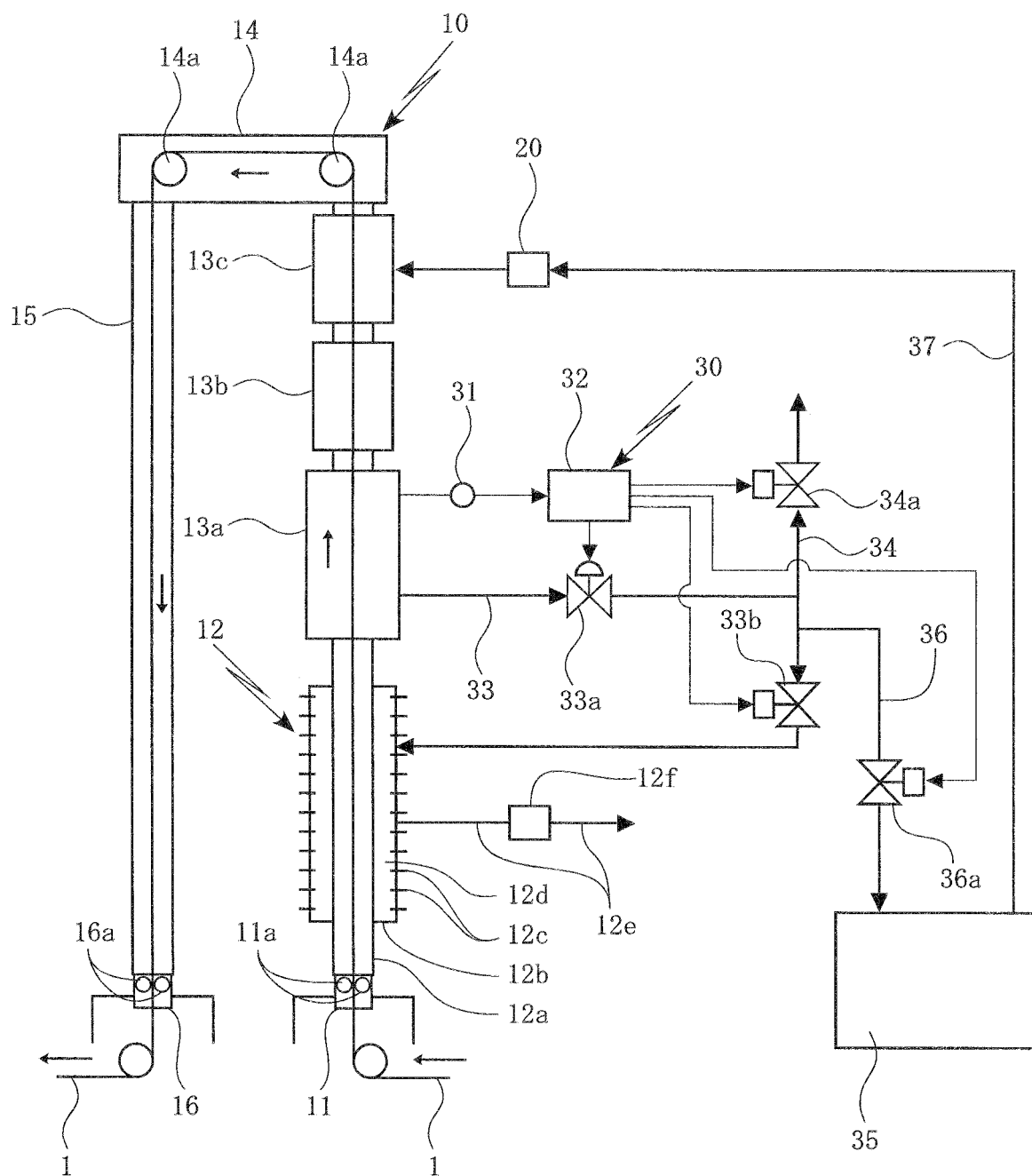




Fig. 3



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/057851

## A. CLASSIFICATION OF SUBJECT MATTER

C21D9/56(2006.01) i, C21D1/74(2006.01) i, F27B5/10(2006.01) i

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)

C21D9/56, C21D1/74, F27B5/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010

Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

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 3-134120 A (Nisshin Steel Co., Ltd.), 07 June 1991 (07.06.1991), (Family: none)	1-7
A	JP 7-268493 A (Chugai Ro Co., Ltd., Acerinox, S.A.), 17 October 1995 (17.10.1995), & CN 1112607 A & EP 675208 A1 & KR 332319 B & TW 261636 B & US 5588828 A	1-7

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

## \* Special categories of cited documents:

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Date of the actual completion of the international search

27 July, 2010 (27.07.10)

Date of mailing of the international search report

03 August, 2010 (03.08.10)

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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- JP H7268493 A [0008]