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Okuno

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[54] APPARATUS FOR PREHEATING STEEL INGOT OR BLOOMS BY THE USE OF HIGH-SPEED JET STREAMS AS WELL AS HEATING FURNACE USING THE SAME

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[30] Foreign Application Priority Data

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[52] U.S. Cl. ..... 266/5, 266/2 A, 266/5 R, 266/5 F, 432/171

[51] Int. Cl. C21d 9/100

[58] Field of Search ..... 266/5 H; 432/121, 123, 432/126, 133, 171

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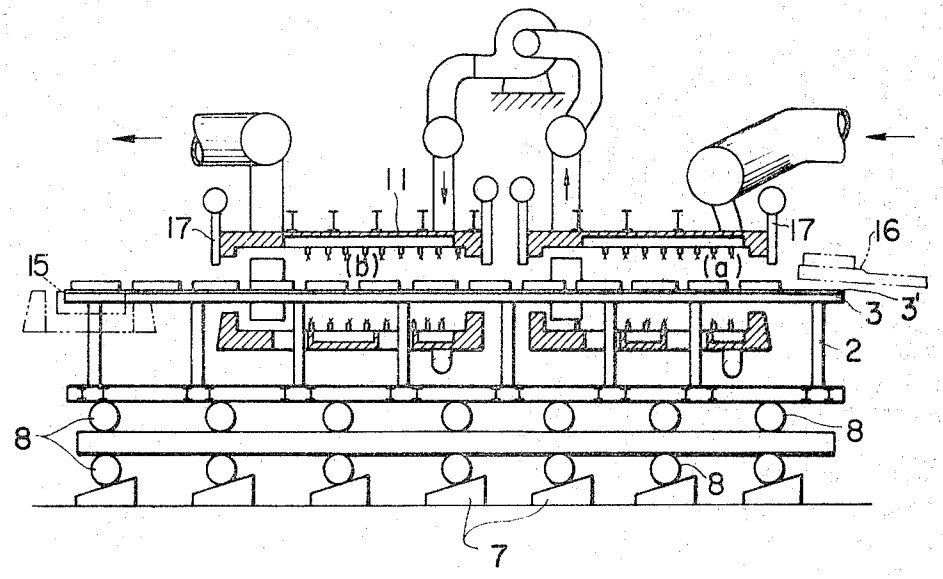
[57] ABSTRACT

Apparatus for preheating substances such as steel ingots, slabs, blooms, billets or the like to be treated in a reheating furnace by the use of high-speed jet streams is provided with a casing which consists of two parts, one of them being a high-speed jet zone of a hot fluid having a high temperature which has been exhausted from the said reheating furnace and the other a convection zone (or a high-speed jet zone) connected with the said jet zone. A conveyor operates to successively feed the said substances to be treated such as steel ingots or blooms into the said casing and to successively extract the thus treated substances from the said casing.

The present invention also relates to a reheating furnace for industrial use which is provided within a part of its combustion zone with a numer of jet nozzles being equipped to the upper and lower portions of the said combustion zone (high-speed jet zone) each at a determined distance from substances to be treated, wherein a high temperature exhaust gas which has been fed from another combustion zone is jetted from the said nozzles under high speed into the said high-speed jet zone whereby a heat transfer is efficiently conducted therein between the said gas streams and the said substances by utilizing the high coefficient of heat transfer occurred on the surface of the said substances due to the said high-speed gas streams.

7 Claims, 8 Drawing Figures



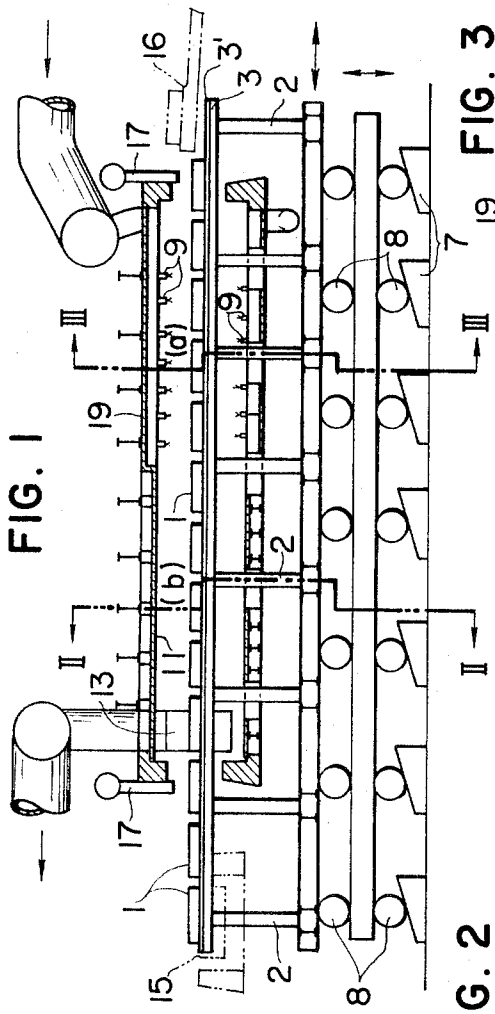


FIG. 1

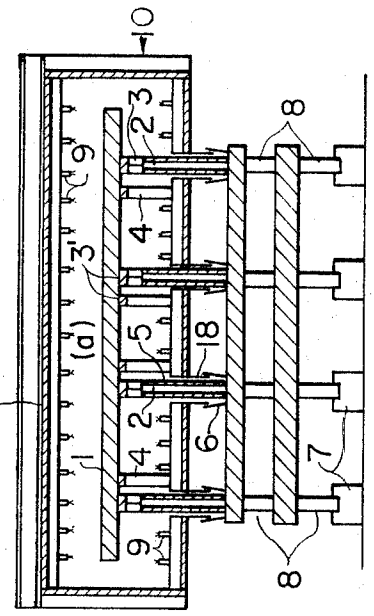


FIG. 3

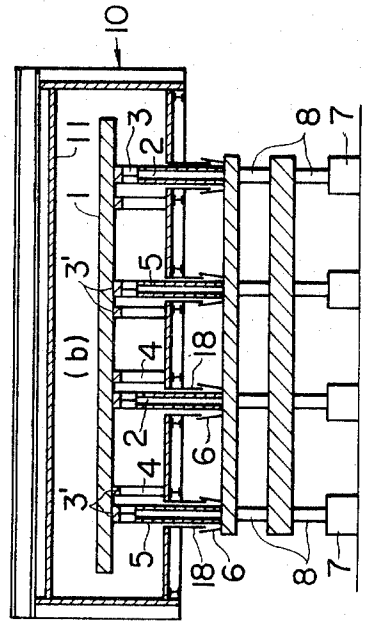


FIG. 2

FIG. 4

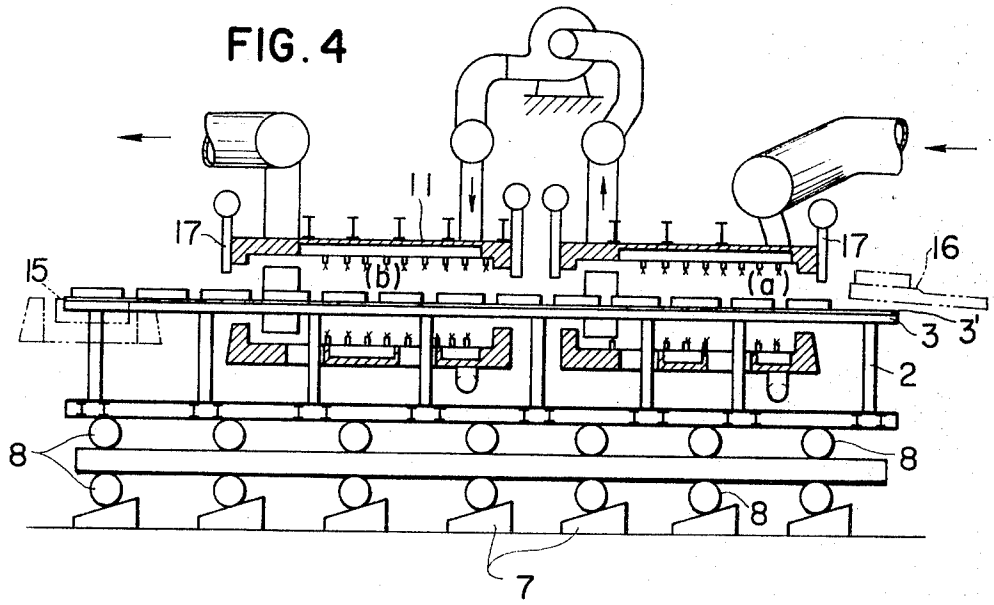


FIG. 8

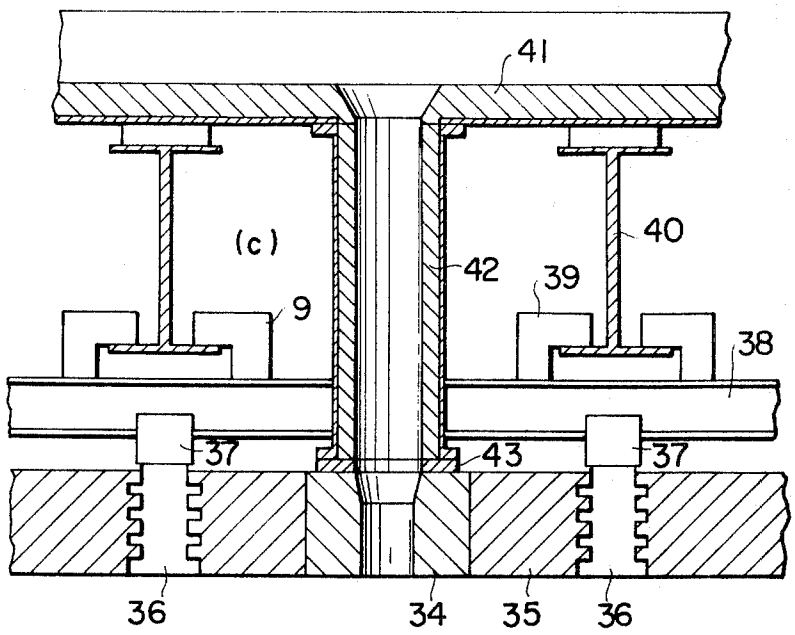


FIG. 5 (PRIOR ART)

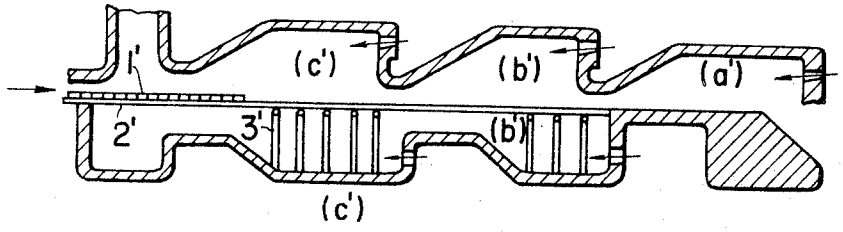


FIG. 6

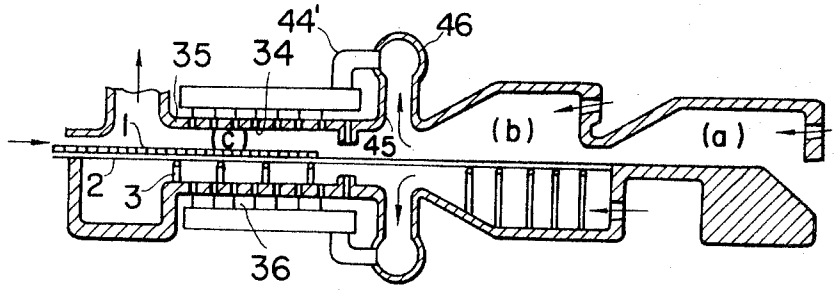
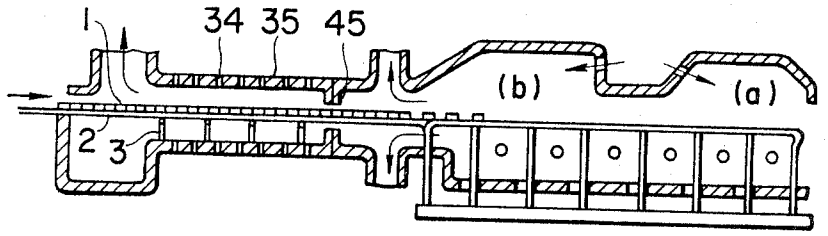


FIG. 7



APPARATUS FOR PREHEATING STEEL INGOT OR BLOOMS BY THE USE OF HIGH-SPEED JET STREAMS AS WELL AS HEATING FURNACE USING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject matter of the present invention resides in a pre-heating apparatus in which heat transfer is conducted between the substances to be treated such as steel ingots or blooms around which a large number of nozzles are arranged, and high-speed jet streams which gush out from the said nozzles, by utilizing the high coefficient of heat transfer on the surface of the said substances which results from the said jet streams.

As to the coefficient of heat transfer on a plate to which jet streams are blown off, it has been proved that a considerably high heat transfer may be achieved on the surface of the said plate by various experimental results or by means of the experiments on jet streams conducted by Gardon, Cobonpue, etc.

As the well known experimental equation of Gardon and Cobonpue illustrates, the average coefficient of heat transfer (hm) on the surface of a plate, to which the jet streams gushing out from the arranged nozzles flow vertically, is as follows:

$$Num = hmx/\lambda = 0.286\ uax/\gamma^{0.625}$$

where

hm is defined with respect to the difference between the temperature of air before flow into the nozzles and the temperature of the plate,

ua is the flow speed in the center of the jet streams at the position of the plate,

x is a distance between the respective nozzles,

λ is a thermal conductivity, and

γ is a coefficient of kinematic viscosity.

The present invention also resides in a heating operation of the said substances such as steel ingots or blooms by means of a continuous type reheating furnace for industrial use which is provided within a part of its combustion zone a number of jet nozzles being equipped to the upper and lower portions thereof each at a distance from the said substances, wherein a high temperature exhaust gas is introduced directly from another combustion zone to the said nozzles and then is jetted therefrom under high speed into the said high-speed jet zone whereby the substances are preheated by means of thus jetted high temperature and high-speed jet streams.

2. Description of the Prior Art

The conventional preheating apparatus in the prior art techniques are explained in the following: In the industrial furnaces for heating which have hitherto been used, a heat energy involved in an exhaust gas is recovered by preheating air for combustion, by using a heat exchanging apparatus (=recuperator), for the purpose of decreasing the specific heat consumption of the furnace (=rate of necessary heat quantity Kcal per ton of blooms to be treated). In this case, however, the temperature of the exhaust gas at the outlet of the recuperator is about 700° - 800° C. Thus, a large amount of heat energy is in fact thrown away. For example, in the case of five-zone type continuous reheating furnace (=pusher type furnace) having a heating capacity of 170 T/H, the specific heat consumption thereof is about 430 kcal/kg, and it is a common knowledge that in the case of walking beam type furnaces which have rapidly developed in these days, the same unit is about 500 kcal/kg (due to a larger water cooling loss than the case of the former pusher type furnaces).

With respect to the conventional reheating furnace (including a walking beam type furnace), the specific heat consumption thereof is represented by the following equation:

$$Qz = \epsilon Q = Qn + Qw + Qs + Qk + Qabs \quad 1.$$

where;

Qz: total heat quantity required in the furnace in kcal/h

Qn: net heat quantity required to heat the steel substance in kcal/h

Qw: heat quantity released through wall, etc. (loss of heat quantity) in kcal/h

Qs: heat quantity released and radiated through shutter, etc. in kcal/h

Qk: loss of heat quantity due to water cooling skid, etc. in kcal/h

Qabs: heat quantity of exhaust gas being thrown away in kcal/h

In case the capacity of the furnace is D kg/h, then the specific heat consumption Ws of the furnace is represented as follows:

$$Ws = Qz/D \text{ Kcal/kg} \quad 2.$$

That is, the above is a proportion of the heat quantity required per kg of the steel substance to be treated, on the basis of the total heat quantity.

On the other hand, the necessary quantity of fuel Bf is represented by the following:

$$Bf = \Sigma Q/Hu = (Qn + Qw + Qs + Qk + Qabs/\text{Hu}) \quad 3.$$

One embodiment for heat calculation is shown in the following, with respect to the five-zone pusher type furnace of 170 T/H.

Necessary net quantity of heat	$Qn=34.9\times10^6$ kcal/hr	47%
Wall loss, etc.	$Qw + Qs=2.8\times10^6$ kcal/hr	3.5%
Water cooling loss (skid)	$Qk=10.6\times10^6$ kcal/hr	14.5%
Exhaust gas loss	$Qabs=25.9\times10^6$ kcal/hr	35%
$\epsilon Q = Qz = 74.2 \times 10^6$ kcal/hr		100%

Specific heat consumption	$Ws=Qz/D= 74.2\times10^6/1.7\times10^5 = 435$ Kcal/kg
D: treated value	170,000 kg/hr.
Fuel consumption value (heavy oil)	Hu=9,800 Kcal/kg
$Bf = Qz/Hu = 74.0 \times 10^6/9{,}800 = 7{,}600$ Kg/hr	

Thus, the necessary amount of heavy oil per hour is 7,600 kg/hr. In this case, the exhaust gas loss occupies 35 percent of the total heat quantity. It is noted that this has a great significance to affect the amount of the specific heat consumption.

As is understood from the above equations, it is necessary, in order to decrease the specific heat consumption and the fuel quantity, to reduce the heat quantity of exhaust gas which has been exhausted from a reheating furnace. The said value depends upon the furnace to be used, and in general, is 35 – 40 percent.

In the conventional technical arts, a heat recovery has hitherto been tried by using a recuperator in a flue for the exhaust gas, as a countermeasure for the above defects. However, even if some heat recovery is achieved in the recuperator, as a practical matter the heat quantity of 35 – 40 percent is still exhausted.

SUMMARY OF THE INVENTION

The present invention improves such uneconomical operation as in the conventional means wherein a large amount of heat energy contained in an exhaust gas is thrown away.

It is a primary object of the present invention to impart a heat energy contained in a high temperature fluid into substances to be treated so as to elevate the temperature of the said substances, by jetting the said high temperature fluid from nozzles onto the substances under high speed, and by utilizing the high coefficient of heat transfer occurred on the surface of the said substances.

Still another object of the present invention is to preheat substances which are fed into a reheating furnace, by utilizing an exhaust gas which has been exhausted from a generally used industrial heating furnace as a high temperature fluid, directly or via a heat exchanging device.

Further, the present invention reduces the heat energy contained in the exhaust gas which has been exhausted from a reheating furnace for the purpose of eliminating the defects of the conventional furnaces as explained above, by increasing the heat transfer effect or the coefficient of heat transfer in a convection or a preheating zone which is connected with an outlet for the exhaust gas.

More precisely, the present invention is based upon the application of such phenomenon to a heating furnace that a high coefficient of heat transfer may be attained on a surface of a plate onto which jet streams are blown. Thus, the present reheating furnace comprises a plurality of jet nozzles which are provided in the upper and lower portions of its combustion zone (say preheating zone), the materials to be treated being conveyed between the said upper and lower nozzles, whereby a high temperature exhaust gas which has been forwarded from another combustion zone is jetted from the respective nozzles thereby to efficiently carry out the heat transfer between the said substances and the said gas.

By virtue of the provision of the said jet nozzles, in the combustion zone, heat transfer may efficiently be carried out between the substances to be treated and the high temperature exhaust gas in the said zone (hereunder referred to as a jet zone), and thus the temperature of the exhaust gas is extremely lowered. Accordingly, great advantage may result therefrom, such as decrease of specific heat consumption of the furnace, economization of fuel, etc.

DETAILED DESCRIPTION OF THE INVENTION

In the present apparatus for preheating, the pressure of an exhaust gas which has a temperature of 700° – 800° C. and which has been passed through a recuperator is elevated by means of a hot gas blower and then is fed into jet nozzles which are arranged around the substances to be treated in the preheating apparatus. From the said nozzles the high-speed exhaust gas having the said high temperature is jetted and a direct heat transfer is conducted on the surface of the substances, by utilizing the high coefficient of heat transfer (150 – 200 kcal/m²h°C) on the said surface which results from the jet streams fed from the nozzles, thereby elevating the temperature of the substances to about 500° C. In this case, the temperature of the exhaust gas becomes lower than 400° C. after the said heat transfer treatment. In such case that the temperature of the exhaust gas is 400° C., the exhaust gas loss Qabs is as follows:

$Qabs = 10.4 \times 10^6$ kcal/hr

The exhaust gas loss $Qabs$ is as follows:

$Qabs = 10.4 \times 10^6$ Kcal/hr

Therefore, in such case that the aforementioned values are employed for Qn, $Qw+Qs$ and Qk, respectively, the total heat quantity Qz' is as follows:

$Qz' = 58.7 \times 10^6$ Kcal/hr

Thus, the specific heat consumption thereof (Ws') in the said case is as follows:

$Ws' = Qz'/D = (58.7 \times 10^6)/(1.7 \times 10^5) = 345$ Kcal/Kg

This value shows that the reduction of the said unit amounts to about 20 percent of that of the conventional furnace. With regard to the fuel consumption value Bf', the same is as follows:

$Bf' = 58.7 \times 10^6/9{,}800 = 6{,}000$ Kg/hr

Therefore, against 7,600 Kg/hr of previous time the fuel amount of 1,600 Kg/hr will be economized.

In case that the operation period is set for average 6,000 hours per year and that unit price of the heavy oil to be used is 7 yen/kg, the economized value of the fuel amounts to the following:

$6{,}000 \times 1{,}600 \times 7 = 67{,}200{,}000$ yen/year

Now, some preferable embodiments of the present invention will be explained with reference to the drawings attached hereto, wherein like numerals designate like elements in the several embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partly cut-away, side elevation of a preheating apparatus embodying the present invention.

FIG. 2 is a sectional view taken about line II — II of FIG. 1.

FIG. 3 is a sectional view taken about line III — III of FIG. 1.

FIG. 4 is a partly cut-away, side elevation of another modification of the preheating apparatus according to the present invention.

FIG. 5 is a sectional view of a conventional five-zone continuous pusher type reheating furnace.

FIG. 6 is a sectional view of a reheating furnace which is provided with jet nozzles in its preheating zone, embodying the present invention.

FIG. 7 is a sectional view of a walking beam type furnace to which the jet nozzles of the present invention are applied.

FIG. 8 is an enlarged sectional view of jet nozzle parts.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1, FIG. 2 and FIG. 3, the sub-

stances 1 to be preheated which are put on fixed beams 4 are successively conveyed in the apparatus, by the upper and lower movement and the front and rear movement of walking beams 3, that is, the rectangular movement of the same, via wheels 8 located on inclined rails 7.

Posts 2 of the walking beams 3 are connected with a driving beam in a lower portion of the apparatus, piercing a lower portion of a casing 10. In the piercing portion, gas seal boxes 6 and seal plates 18 are provided so as to prevent from a gas leakage in the apparatus.

Each of the posts 2 and the walking beams 3 is covered with heat shielding plates 5, since these are exposed to a high temperature gas. On the beams, casting rails 3' are equipped on both of the fixed beam side and the walking beam side thereof so as to prevent oxidation erosion.

The preheating apparatus is divided into two parts at the center thereof, and in the high temperature side is a jet zone *a* wherein a number of nozzles are provided at the upper and lower portions. This jet zone *a* is a main part of the present apparatus, and is composed of a casing box 10. The exterior surface of the casing box is coated with an insulating material 19 and the interior casing is made of a heat resistant steel plate to which nozzles 9 are fixed. The other part of the apparatus is a convection current zone *b*. The exhaust gas fed into the jet zone *a* is thereafter introduced into this zone *b* wherein a heat supply is conducted by the convection current of the said gas. Thus, the convection current zone *b* has such a role as conducting an auxiliary heat supply therein. Since the gas temperature of the interior part of the zone *b* is considerably high, such as about 500° C., the interior surface of the casing in this part is coated with an insulating material 11 so as to prevent, as much as possible, oxidation erosion of the casing and heat loss from the wall. An exhaust gas port 13 is equipped on one end of the zone *b*, from which the exhaust gas is removed and is introduced into a chimney.

In each feeding inlet and extracting outlet of the present apparatus, a nozzle 17 is provided wherein a jet film of an air or high temperature gas and the gas in the interior of the apparatus is sealed by the said jet film. The substances 1 to be preheated are fed to the front of the apparatus by means of a rollgang 15 and then are conveyed into the interior thereof by means of the walking beams 3.

At the extracting outlet, the preheated substances are extracted by means of an extractor 16. In addition, a pusher may also be used for the said feeding and conveying means.

FIG. 4 shows another embodiment of the present preheating apparatus wherein a jet zone *a* and a convection current zone *b* are entirely separated from each other. The pressure of the high temperature gas which has been exhausted from the jet zone *a* is elevated further by means of a hot gas blower and the said gas is fed into nozzles which are arranged in the corresponding parts of the convection current zone *b*. In this zone b, high temperature jet streams also gush out from the nozzles to supply heat to the substances to be treated. In this apparatus, a two-stage jet zone a is provided, for the purpose of increasing the heat recovery efficiency and of compactly integrating the whole apparatus. Like elements to that of FIG. 1 carry like numerical designations.

As explained in the above, the furnace efficiency is improved and the specific heat consumption thereof is lowered, by the use of the present apparatus. According to the present apparatus, the temperature of the exhaust gas which is exhausted from the industrial heating furnace may be lowered, and so the expense for the attendant equipments in the works may be decreased. Thus, the present apparatus includes various merits. In addition, the present invention may be utilized for any and every apparatus for preheating substances by the use of high-speed jet streams.

Next, some embodiments of the reheating furnaces according to the present invention will be explained in the following:

FIG. 5 is a sectional view of a conventional five-zone continuous heating furnace. This furnace is a pusher type furnace which is provided with a soaking pit bed at the extraction outlet part and which consists of five combustion zones in all in the upper and the lower portion.

In the said FIG. 5 *a'* is a soaking zone, *b'* is a heating zone, and *c'* is a preheating zone.

Substances 1' to be treated are pushed into the furnace from the side of the preheating zone by means of a pusher and are forwarded to the extraction outlet part, sliding on the skid pipe 2' which is supported by post pipes 3' and being heated successively. The temperature of each combustion zone varies, depending upon the quality of the substances to be treated, and, in general, in the case of normal steels, *a'* is 1,250° – 1,300° c., and *b'* and *c'* are 1,300° – 1,350° C., respectively.

Referring to FIG. 6, a number of jet nozzles 34 composed of refractory materials are provided in upper and lower portions of a preheating zone *c*, each with a determined distance from the substances to be heated. The constitution of the nozzle section is shown in the enlarged FIG. 8.

The jet zone is a hanging ceiling type zone which consists of a conventional refractory body 35 and anchor bricks 36. In the part of the refractory body 35, nozzles 34 are inserted.

To ceiling large size crawl beams 40 is fixed a small size beam 38 by means of hanging metal fittings 39, and the anchor bricks 36 are fixed via a brick hanging metal fitting 37 thereby to support the refractory body 35. On the other hand, the nozzles 34 are supported by a refractory body metal fitting 43 via a joint duct 42 leading to a forwarding duct 41 for the high temperature exhaust gas being coated with a refractory material in its interior part.

In the furnace of FIG. 6 the means for feeding and supporting the substances 1 to be treated are the same as those of FIG. 5.

As to the constitution of the furnace, it is possible to provide the heating zone *b* and the jet zone *c* thereof, as being completely separated from each other. In addition, it may also be possible, as shown in the embodiments of the present invention, to integrally constitute the two zones, a partition wall being provided in the center therebetween. Thus, the two zones may be kept independent by means of the jet film gushing from a nozzle 45.

The high temperature exhaust gas is collected in a header 46 at the end part of the heating zone and is introduced into the forwarding duct 41 by means of the

hot gas blower or the present pressure elevating device.

FIG. 7 shows a walking beam type furnace embodying the present invention wherein a combination of a pusher and a walking beam is used. In addition, the walking beam may also be used in the whole length of the furnace.

According to the use of the present apparatus, the following effects may be attained:

The temperature of exhaust gas after recuperator is now 850°C and it is applied directly to the jet zone.

In this case, when jet speed W_N is 85 m/s, according to the test result of jet flow group conducted by the inventor of the present invention and other people the average heat transfer coefficient

$\alpha m = 185$ Kcal/m²h°C is obtained.

Based on this value, when the substance to be fed to the furnace is preheated from normal temperature up to 450°C, average temperature difference Δtm is 590°C and heat transfer area A is 120m² (total of the upper and lower surfaces).

In this case, the heat quantity Qj absorbed by the substances, including jet zone is as follows:

$Qj = A\ \alpha\ m\ \Delta tm$

$= 120 \times 185 \times 590$

$= 13.1 \times 10^6$ Kcal/hr.

Here, Ql is the total loss of water cooling loss, etc. Therefore, exhaust gas loss $Qabs$ Kcal/hr can be obtained by subtracting the aforementioned Qj from the heat quantity corresponding to the exhaust gas temperature of 850°C ($Q' = 24.2 \times 10^6$ Kcal/hr).

$Qabs = (Q' - Qj - Ql)$

$= (24.2 - 13.8) \times 10^6$ Kcal/hr

$= 10.4 \times 10^6$ Kcal/hr.

In this case, the temperature of exhaust gas is approximately 400°C. This value agrees with the aforementioned exhaust gas loss Qabs.

Applying the present invention to the above mentioned 170 T/H reheating furnace, the following data are obtained.

By installing the jet zone according to the present invention in the feeding portion of conventional reheating furnace and preheating the steel ingot or steel piece to be fed to the furnace making use of high temperature exhaust gas exhausted from furnace, the following effects can be obtained.

1. Utilizing effectively the high temperature exhaust gas, heat quantity of exhaust gas loss is lowered by more than 20 percent. In one embodiment example, specific heat consumption is reduced from 435 Kcal/Kg to 345 Kcal/Kg and the big economization of fuel consumption from 7,600 Kg/hr down to 6,000 Kg/hr becomes possible.
2. Any burners which have been required in the preheating zone of the conventional furnaces are unnecessary in the present furnace.
3. The exhaust gas temperature is about 400° C., and thus the use of any recuperator is unnecessary.

Thus, the present invention has various merits say for drastic economization of expenses, etc.

What is claimed is:

1. A preheating apparatus for treating substances such as steel ingots, blooms, slabs, billets or the like to be treated in a reheating furnace, the improvement comprising:

a casing defining a chamber having at a first end means forming a high-speed jet zone of a hot fluid having a high temperature which has been exhausted from said reheating furnace and at a second end a convection zone connected with the said jet zone;

means for directing said exhaust gases from said reheating furnace to said jet nozzles; and

a conveyor which operates to successively feed the said substances into the said casing and to successively extract the thus treated substances from the casing,

wherein; heat transfer is conducted on the surface of the said substances by a high coefficient of heat transfer occurring on the said surface by the impingement of the said hot jet streams.

2. The preheating apparatus of claim **1** wherein said high speed jet zone at said first end comprises a plurality of jet nozzles located on each side of said substances to be treated to direct the high temperature exhaust fluid toward the surface of said substance and means for directing said exhaust gases from said reheating furnace to said jet nozzles.

3. The preheating apparatus of claim **1** wherein said casing forms a first chamber containing the high-speed jet zone and a separate second chamber containing the convection zone, said first and second chambers being interconnected via a duct having pumping means connected thereto to pump said high temperature exhaust fluid from said first chamber to said second chamber.

4. The preheating apparatus of claim **3** wherein said first and second chambers contain a plurality of jet nozzles to direct the high temperature exhaust fluids at both sides of said substances to be treated.

5. In an industrial furnace having a plurality of independent, fire proof combustion chambers and conveying means inside of said combustion chambers for transporting materials to be reheated, the improvements comprising:

a. a preheating chamber adjacent the first combustion chamber through which the material to be reheated passes,

b. a plurality of jet nozzles in said preheating chamber to direct high temperature exhaust gas from the industrial furnace onto both sides of the material to be reheated so as to raise the temperature of the material to approximately 500°C,

c. means to prevent said high temperature exhaust gas from entering said combustion chamber after passing through said nozzles, and

d. means to direct the high temperature exhaust gas from the industrial furnace to said jet nozzles.

6. The improved industrial furnace of claim **5** wherein said nozzles are composed of fire proof brick.

7. The improved industrial furnace of claim **5** wherein said means to prevent the high temperature exhaust gases from entering the combustion chamber comprises a high-speed gas curtain between said preheating chamber and said combustion chamber.

* * * * *