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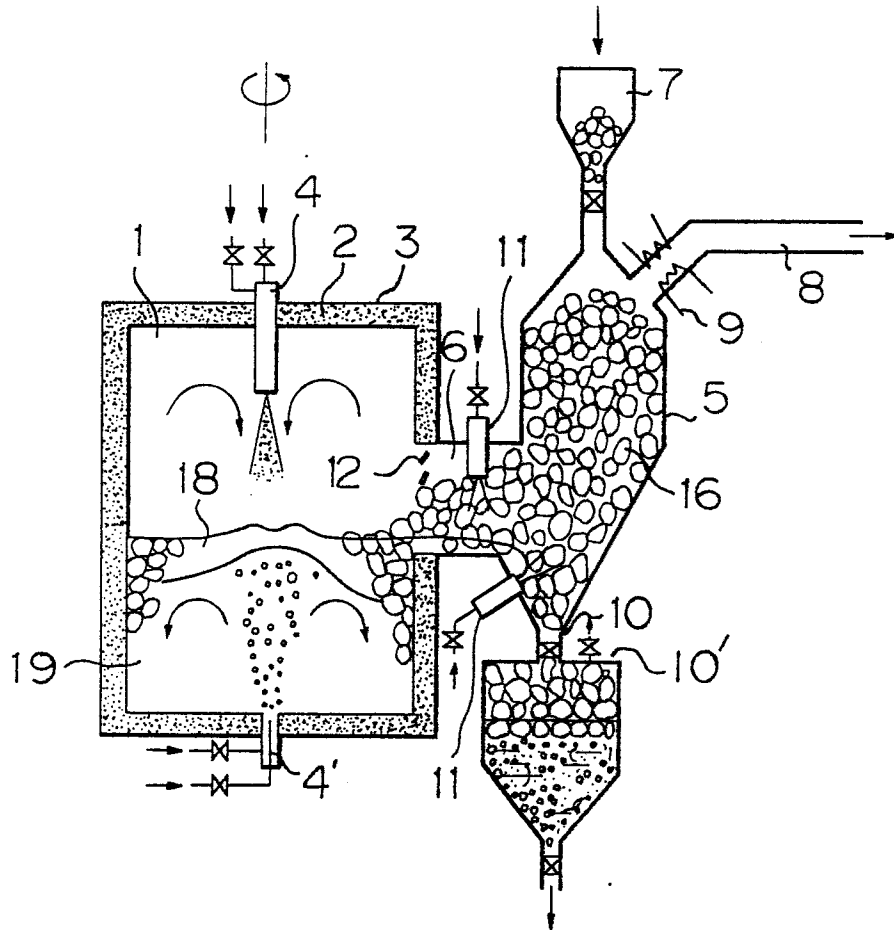
Method of gasifying solid carbonaceous materials and apparatus therefor.

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A method and apparatus for gasifying a solid carbonaceous material in a molten metal bath are disclosed. The solid carbonaceous material is blown onto and/or into the molten metal bath together with a gasifying agent in a gasification chamber and the resulting slag is removed through a slag chamber provided adjacent to the gasification chamber. At least part of the slag chamber is filled with lumps of a solid carbonaceous material, and the resulting slag

is removed through a space packed with the lumps, and the product gas is recovered through a space packed with the lumps.

Fig. 1



Method of Gasifying Solid Carbonaceous Materials and Apparatus Therefor

The present invention relates to a method of gasifying solid carbonaceous material and an apparatus therefor.

More particularly, the present invention relates to an improved method and apparatus for removing slag while carrying out gasification by blowing a solid carbonaceous material such as coal, coke, pitch, and the like (hereunder represented by "coal") together with a gasifying agent such as oxygen, steam, carbon dioxide, and the like - (hereunder represented by "oxygen") through a lance and/or tuyere onto and/or into a molten metal bath such as a molten iron bath (hereunder represented by "molten iron bath").

Many processes have been proposed for carrying out coal gasification by using a molten iron bath (hereunder referred to merely as "molten iron coal gasification"). See, for example, JPP - (Japanese Patent Publication) No. 10109/1960, JPP No. 1561/1971, JPA (Japanese Patent Application Laid-Open Specification) No. 41605/1977, JPA No. 130602/1979, JPA No. 130603/1979, JPA No. 89395/1980, JPA No. 38886/1982, JPA No. 104616/1982, JPA No. 171481/1983, and JPA No. 171482/1983.

However, conventional molten iron coal gasification processes have the following problems.

Namely, ash and the like contained in coal are melted at a temperature of 1500 °C in a gasification furnace. The thus-formed slag floats on the molten iron bath. The slag has to be removed from the furnace when the gasification is continued for a long period of time. However, the turbulence of the slag is quite severe since coal and oxygen are introduced into and/or onto the molten iron bath at a high velocity causing vigorous turbulence of the bath. The mere provision of a deslagging exit, i.e., a slag tapping hole in the wall of the furnace would allow spitting of slag, escape of gas and outflow of molten iron upon deslagging, making it difficult to smoothly carry out deslagging when the gasifier is being operated under high pressure.

Furthermore, when the temperature of slag is low, the viscosity thereof increases and smooth deslagging operation cannot be achieved due to blocking of the slag tapping holes. On the other hand, when the temperature of slag is high, it is easy to remove the slag, but severe erosion of the refractory lining of the furnace takes place to decrease the service life of the gasification furnace.

The object of the present invention is to provide a method and apparatus for carrying out continued and stable gasification using a molten iron bath in a gasification furnace while smoothly effecting deslagging.

The present invention resides in a method of gasifying solid carbonaceous material in a molten metal bath in which the solid carbonaceous material is blown onto and/or into the molten metal bath together with a gasifying agent in a gasification chamber and the resulting slag is removed from the molten metal bath through a slag chamber provided next to the gasification chamber, characterized in that at least part of the slag chamber is filled with lumps of a solid carbonaceous material, the resulting slag is removed via space packed with lumps of a solid carbonaceous material, a duct for recovery of the product gas is provided in an upper portion of the slag chamber, and the product gas is recovered via a space packed with the lumps of a solid carbonaceous material.

The present invention also resides in an apparatus for gasifying a solid carbonaceous material in a molten metal bath, which comprises a gasification chamber having lances and/or tuyeres for blowing a solid carbonaceous material and a gasifying agent onto and/or into a molten metal bath, and a slag chamber which is provided next to said gasification chamber and is at least partly packed with lumps of a solid carbonaceous material, a duct for recovering the product gas being provided in an upper portion of the slag chamber.

In a preferred embodiment of the present invention, a sedimentation chamber may be provided between the gasification chamber and the slag chamber. The sedimentation chamber has a shallow depth and is at least partially packed with lumps of a solid carbonaceous material. At the end of the sedimentation chamber may be provided a weir over which slag can flow into the slag chamber. The weir may be provided with a sloped trough over which slag flows into the slag chamber.

In a further preferred embodiment, the gasification chamber and the slag chamber may be provided inside a single furnace which is divided into two chambers by a partition wall.

As is apparent from the above, the present invention is characterized by the following:

1) The deslagging chamber is filled with lumps of a solid carbonaceous material such as coke, coal, and the like (hereunder represented by "coke"). Through a packed body of lump coke, the slag flows toward deslagging exits and the product gas is collected via a packed body of lump coke through a recovery port.

2) When the temperature of slag is relatively low, a reactive gas such as oxygen (hereunder represented by "oxygen") may be introduced to effect combustion of coke so as to heat up the

space packed with lump coke, so that the temperature of slag increases and the fluidity of slag is improved.

3) Part of the coke packed in the deslagging chamber is introduced into a gasification chamber so as to suppress the vertical vibration and turbulence of the slag surface so that the outflow of molten iron and escape of gas through slag tap holes can be successfully prevented and the erosion of the refractory lining of the furnace can also be avoided.

Therefore, according to the present invention, smooth deslagging as well as a prolonged service life of the gasification furnace can be achieved. In addition, according to the present invention, there is the unexpected result that slag/coal ash particles contained in the product gas is substantially entirely removed when the product gas passes through the coke-packed space. Furthermore, the coke will be able to reduce the iron oxide contained in the slag to metallic iron. Recycling of such metallic iron to the gasifying reactor can minimize consumption of iron.

As was explained above, at least part of the deslagging chamber of the gasification apparatus of the present invention is filled with particulate coke, i.e., lump coke. The diameter of the particulate coke is large enough for the product gas as well as slag to be able to pass through the packed body thereof. There are no other limitations on the coke. Usually, the coke is 20 to 50 mm in diameter. The slag chamber, i.e., deslagging chamber may be part of the gasification furnace, or it may be a discrete body which is connected thereto. The slag chamber may be equipped with either continuous or discontinuous slag tapping devices. It is to be noted that the structure of the slag chamber is not limited to a particular one.

Lump coke is introduced into the deslagging chamber through a supply port provided near to a recovery port for the product gas, since the packed body of coke may serve as a filtering means for the product gas. The arrangement of the supply port is not limited to a particular one.

When the vertical vibration of the slag surface should be suppressed by means of the provision of a packed body of lump coke which is extended to the gasification chamber, a lower portion of the packed coke extends into the gasification chamber so that the lower portion is immersed in a molten slag layer.

When a decrease in temperature is expected during gasification operation, as described above it is advisable to provide an oxygen lance for blowing a reactive gas such as oxygen into the packed layer of lump coke through a lance.

In a coal gasification furnace having the above arrangement, a product gas containing dust is passed through a coke-packed space to be recovered by way of a recovery port from the furnace. A substantial amount of the slag/ash particles contained therein can be caught by the packed body of lump coke, and purified product gas can be collected. Furthermore, at most 5 % of CO₂ and H₂O gases are contained in the product gas. When such a product gas is passed through a packed body of coke a reforming reaction is promoted, and the proportion of CO and H₂ gas is increased. Thus, the chemical composition of the product gas is improved.

In a lower portion of the space packed with coke, molten slag moves toward a slag tap hole. Therefore, when the temperature is low, the fluidity of the slag is lowered, sometimes resulting in blocking of the slag discharge holes.

However, according to the present invention, by adjusting the flow rate of oxygen gas supplied to the space packed with coke, it is possible to keep the temperature of slag at 1300 -1650 °C. Therefore, it is possible to avoid solidification of slag, which is caused by a decrease in temperature.

Furthermore, if oxygen gas as well as steam are blown into the space packed with coke, it is possible to control the rate of descent of the packed coke within the slag chamber. Therefore, the dust caught in the slag chamber by the coke can easily be removed from the apparatus, and it is possible to avoid a large pressure drop through the coke-packed slag chamber, which is sometimes caused by the accumulation of dust.

A sedimentation chamber is preferably arranged between the gasification chamber and the slag chamber in order to recover iron droplets from the slag. The sedimentation chamber is also at least partly filled with lumps of coke.

When a gasification chamber is connected to a slag chamber by means of a connecting conduit, it is preferable that the lump coke packed in the slag chamber may also cover the connecting conduit.

When the slag chamber as well as the gasification chamber are provided within a gasification furnace, lump coke may be charged into the slag chamber through a coke supply port provided on the roof or side wall portion of the furnace to make a packed body of coke. In this case, along at least part of the side wall of the furnace a space packed with lumps of coke is formed, through which the product gas and slag are collected and removed, respectively.

In both of the above embodiments, it is preferable that part of the space packed with lumps of coke extend to the gasification chamber. The coke in the gasification chamber floats on the surface of

the slag or sometimes in the molten iron bath especially in an area adjacent to the side wall portion of the furnace. This is because of the difference in specific gravity and movement of the coke and the molten metal.

Thus, the presence of the packed body of lump coke in the gasification chamber is effective to diminish the vertical vibration of the slag layer and is also effective to avoid not only mechanical erosion of the refractory lining of the furnace, but also the mixing of molten iron with the slag.

Fig. 1 is a schematic view of an embodiment of a coal gasification apparatus of the present invention;

Fig. 2 is a schematic view of another embodiment of a coal gasification apparatus of the present invention;

Fig. 3 is a schematic view illustrating another embodiment of the present invention; and

Fig. 4 is a schematic view illustrating still another embodiment of the gasification apparatus of the present invention with being partially broken.

A preferred embodiment of the present invention will now be described in conjunction with the attached drawings.

Fig. 1 is a schematic view of a portion of a coal gasification apparatus of the present invention.

The coal gasification apparatus is comprised of a cylindrical furnace body 1 lined with heat-resistant refractory bricks 2. The furnace body 1 is sealed with an outer panel sheet 3 and can resist a high inner pressure.

The top and bottom walls of the furnace body 1 are penetrated by multihole lance 4 and tuyere 4'. Coal, oxygen, and steam can be blown onto and into a molten iron bath 19 through the lance and tuyere.

A slag chamber 5 is provided next to the furnace body 1. The slag chamber 5 is filled with lump coke 16. The furnace body 1 and slag chamber 5 are connected with one another by a connecting conduit 6 whose lower portion is at about the same level as the slag line. In the upper portion of the slag chamber 5, a supply hopper 7 for coke and a product gas recovery duct 8 are provided. An exhaust gas boiler 9 is installed in the product gas recovery duct 8. In a lower portion of the slag chamber 5, a discharge port 10 for slag, dust, and coke is provided. In the illustrated embodiment, lances 11 for charging a reactive gas such as oxygen and steam to accelerate combustion of coke and consumption thereof are provided in the lower portion of the slag chamber 5 and in the connecting conduit 6. A venting hole 10' is provided in a lower portion of the slag chamber 5.

Part of the coke charged into the slag chamber 5 is pushed beyond baffle plates 12 and moves into the furnace body 1, which serves as a gasification chamber. When it reaches there, the coke falls into a molten slag layer. The coke which falls into the molten slag floats on or in the molten iron bath 19 due to a difference in specific gravity so that the vertical vibration and turbulence of the surface of the slag layer 18 can be largely suppressed.

An embodiment of the method of the present invention will be described by referring to an experimental apparatus in which the furnace body 1 had a diameter of 3 m and a height of 5 m. Gasification conditions were as follows:

In a coal gasification furnace like that illustrated in Fig. 1, 6.7 tons per hour of coal, 3000 Nm³ per hour of oxygen, and 1000 kg per hour of steam were blown onto and into a molten iron bath at 1450 °C to carry out coal gasification at a pressure of 3 bar.

The slag chamber was filled with lump coke. The average size of the lump coke was 35 mm in diameter.

The slag formation rate was about 700 kg/H. The slag discharge port 10 was intermittently opened to remove slag from the gasification chamber. Part of the coke introduced into the slag chamber was pushed into the gasification chamber and was immersed in the molten slag. Vibration and turbulence of the slag surface was completely suppressed at least in an area near the connecting conduit 6. There was no outflow of molten iron through the connecting conduit 6 into the slag chamber 5. Separation of molten iron from molten slag was completely achieved, and only a very small amount of metal droplets was suspended in the overflowed slag.

In order to prolong the service life of the furnace which is protected by a refractory lining, the gasification operation was carried out at a temperature 50 °C (ca.) lower than in the conventional process, and the average temperature of the molten iron bath was, a little lower than the level at which satisfactory fluidity could be obtained when the temperature fluctuated to the lower limit. In order to ensure a smooth flow of the slag even at a lower temperature, a few percent of the total amount of oxygen blown into the furnace was blown through a lance in the connecting conduit 6 and a small amount of steam was also injected so as to control the temperature in the connecting conduit and the temperature drop caused by the lump coke. Thus, the temperature was raised and the removal of slag could be effected smoothly.

The temperature of coke in the slag chamber 5 was measured. The presence of a high-temperature zone having a temperature of 1300 -1650 °C was confirmed. This zone extended along much of the path along which gas flowed from the gasification chamber to the gas recovery duct 8.

Since according to the present invention the coal gasification was carried out at a temperature of ca. 50 °C lower than in conventional gasification, the erosion rate of the heat resistant brick was reduced by ca. 50% and the service life of the furnace was extended by ca. 50%.

After the product gas was generated in the gasification chamber it passed through the coke-packed column and then was introduced into the waste heat boiler for heat exchange. Usually the product gas entrains a great amount of molten slag/coal ash particles which are generated by the vigorous turbulence of the bath as well as gas in the gasification chamber, and sticks onto the inside wall surface of a waste heat boiler, decreasing heat transfer from the gas to the boiler.

Furthermore, the gas contains 3 -10% of CO₂ + H₂O depending on the operating conditions. However, according to the present invention, most of the entrained slag/coal ash particles were removed while passing through the column of packed coke, and thus-removed slag/coal ash particles were taken out from the slag chamber together with the overflowed slag and lumps of coke. The slag/ash deposition on the boiler wall was decreased, and the product gas was cooled more efficiently. At the end of radiation zone, the temperature was decreased by ca. 100°C. The pressure difference between the top of the coke-packed column and the bottom thereof was slightly increased by ca. 200 mmAq, which did not result in any practical problems. As a result, the product gas contained less than 1% of CO₂ + H₂O.

Fig. 2 shows another embodiment of a coal gasification apparatus, in which in place of the connecting conduit 6 a sedimentation chamber 20 is provided between the gasification chamber 1 and the slag chamber 5. A water-cooled weir 22 is provided at the end of the sedimentation chamber 20. While a mixture of slag and molten iron is being held within the sedimentation chamber 20, they are effectively separated from each other. The slag generated in the gasification chamber continuously overflows the weir 22, and the thickness of the slag layer can be maintained constant. The other members in Fig. 2 are the same as in Fig. 1.

Fig. 3 shows another embodiment of the present invention. The apparatus shown therein has a coal gasification chamber and a deslagging chamber both housed inside the gasification furnace. The same members are referred to by the same reference figures in Fig. 1.

The furnace body 1 has substantially the same cylindrical shape as that shown in Fig. 1. In the ceiling thereof a multihole lance 4 and a product gas recovery duct 8 are provided. A lance 11 for blowing oxygen for the combustion of lump coke and a slag discharge port 10 are provided in the side wall thereof. A coke supply hopper 7 is connected to the product gas recovery duct 8.

Coal gasification was carried out using the apparatus of Fig. 3.

The apparatus was 3 m in diameter and 5 m tall. The process conditions for coal gasification were the same as those described in connection with Fig. 1.

The test results as to separation of molten iron from slag, control of fluidity of slag, erosion of the refractory lining, removal of dust at a high temperature, and reforming of CO₂ and H₂O of the product gas were substantially the same as those obtained by using the apparatus shown in Fig. 1.

Fig. 4 shows the case in which a sedimentation chamber 20 having a weir 22 connected to a sloped trough 24 is provided and the slag discharged from the gasification chamber 1 to the slag chamber 5 is tapped out intermittently through a slag tap hole 26. When the slag level in the slag chamber 5 is low, the tap hole is closed with a mud gun, and some period of time later it will be opened for slag tapping.

The slag chamber 5 and sedimentation chamber 20 are filled with lumps of coke (not shown), through which the product gas as well as slag is removed from the gasification chamber 1. While they are passing through the column of packed coke, the product gas can heat up the lumps of coke to compensate the heat taken away by the molten slag discharged into the slag chamber. In addition, there is no turbulence existing in the sedimentation chamber 20 and most of the metal droplets entrained by the slag is sedimented and returned to the molten iron bath. The generated slag overflows continuously the weir and is discharged into the slag chamber over the sloped trough connected to the weir. Thus, the thickness of the slag layer can be kept constant. The weir and trough may be made of a water-cooled panel.

The same members are referred to in Fig. 4 by the same reference figures as in Fig. 1.

Although the invention has been described with preferred embodiments it is to be understood that variations and modifications may be employed without departing from the concept of the invention as defined in the following claims.

Claims

1. A method of gasifying a solid carbonaceous material in a molten metal bath in which the solid carbonaceous material is blown onto and/or into the molten metal bath together with a gasifying agent in a gasification chamber and the resulting slag is removed from the molten metal bath through a slag chamber provided adjacent to the gasification chamber, characterized in that at least part of said slag chamber is filled with lumps of a solid carbonaceous material, and the resulting slag is removed through a space packed with the lumps of a solid carbonaceous material, and that a duct for recovery of the product gas is provided in an upper portion of the slag chamber and the product gas is recovered through a space packed with the lumps of a solid carbonaceous material.

2. A method as defined in Claim 1, in which said lumps of a solid carbonaceous material are charged into said slag chamber from above, and a reactive gas is injected into a packed body of said lumps of a solid carbonaceous material to burn part of said lumps.

3. A method as defined in Claim 2, in which a lower portion of said packed body of the lumps of a solid carbonaceous material is immersed in at least part of the slag layer in said gasification chamber to diminish the vibration and turbulence of this slag layer.

4. An apparatus for gasifying a solid carbonaceous material in a molten metal bath, which comprises a gasification chamber having a lance and/or tuyere for blowing a solid carbonaceous material

and a gasifying agent onto and/or into the molten metal bath, and a slag chamber which is provided adjacent to said gasification chamber and which has been packed at least partly with lumps of a solid carbonaceous material, the slag chamber having a duct for recovering the product gas in an upper portion thereof.

5. An apparatus as defined in Claim 4, in which said gasification chamber and said slag chamber are separate chambers and are connected by a connecting conduit having a baffle plate hung from the ceiling thereof.

6. An apparatus as defined in Claim 4, in which said gasification chamber and said slag chamber are provided in the same gasification furnace body, a supply port for said lumps of a solid carbonaceous material is provided on the ceiling or side wall portion, at least an area along the side wall of the furnace body is packed with said lumps of a solid carbonaceous material, and said supply port is connected to a duct for recovery of the product gas.

7. An apparatus as defined in Claim 4, which further comprises a sedimentation chamber provided between said gasification chamber and said slag chamber, at least part of said sedimentation chamber being filled with the lumps of a solid carbonaceous material.

8. An apparatus as defined in Claim 7, in which a weir is provided at the end of said sedimentation chamber.

9. An apparatus as defined in Claim 8, in which said weir is connected to a sloped trough over which the slag flows down into the slag chamber.

Fig. 1

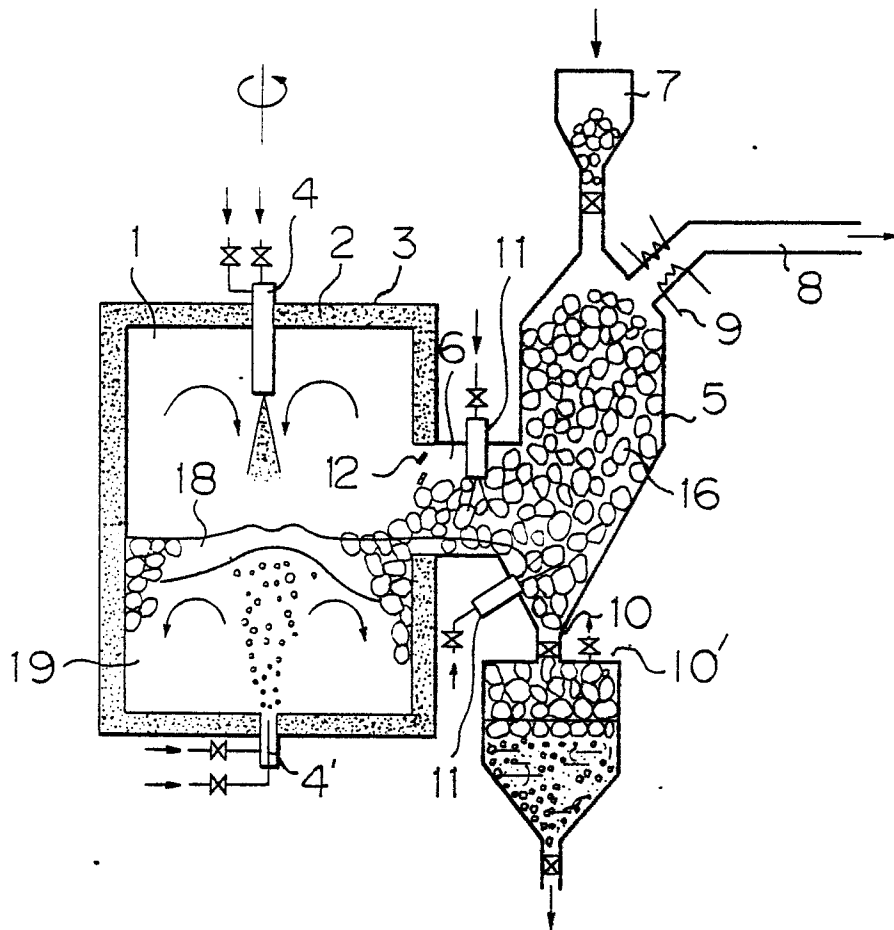


Fig. 2

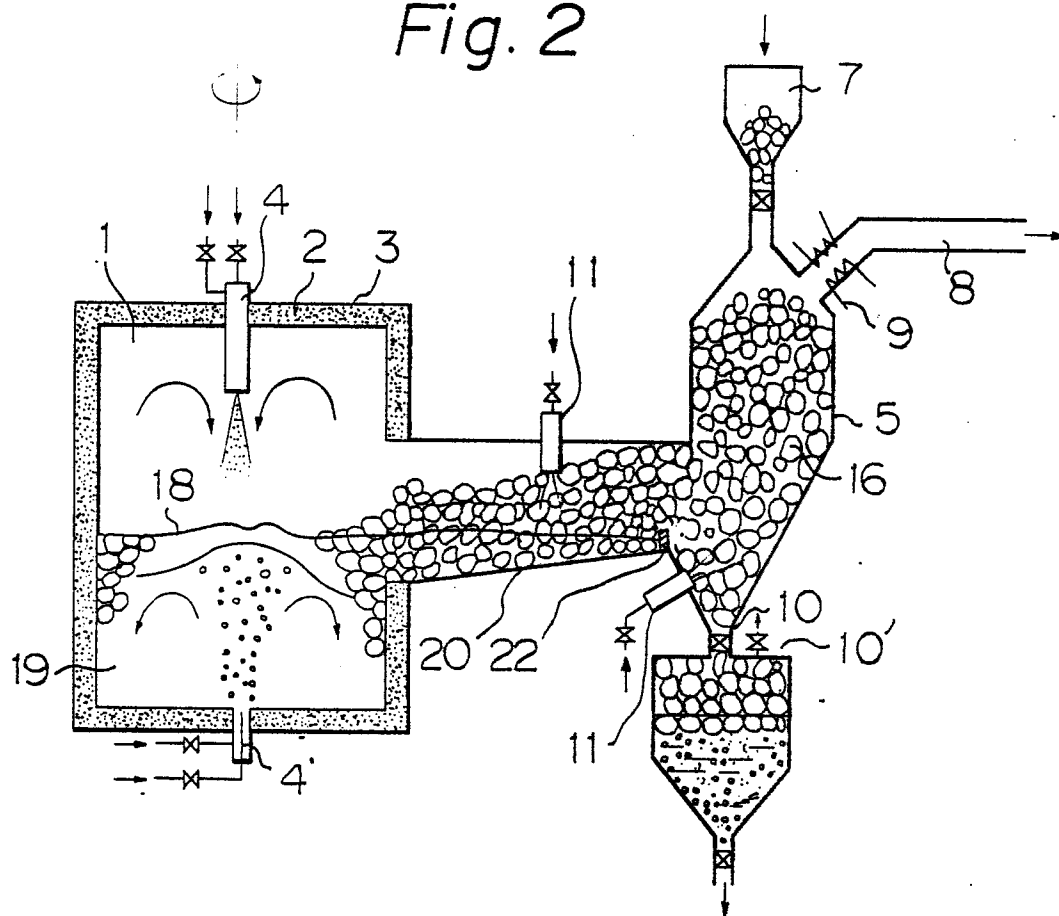


Fig. 3

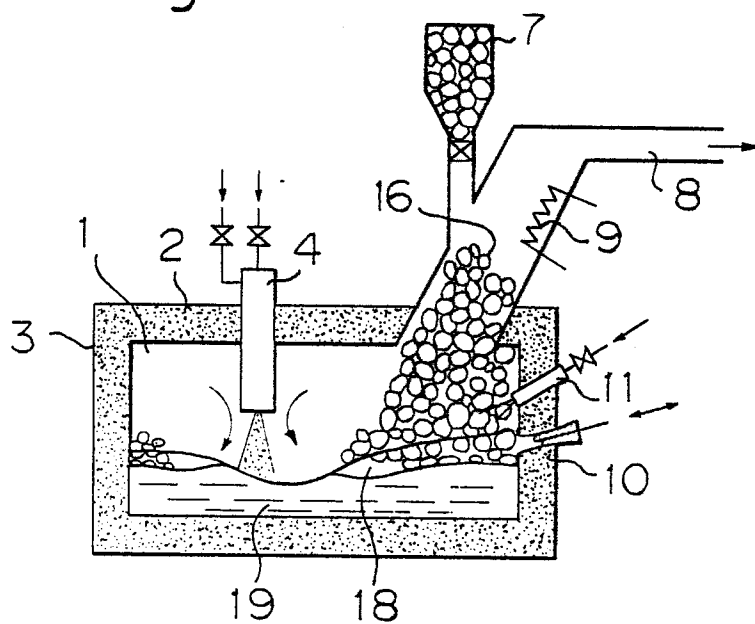


Fig. 4

