(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 052 429**
B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **25.07.84**

(51) Int. Cl.³: **C 04 B 7/44,** F 27 B 7/20

(21) Application number: **81304899.8**

(22) Date of filing: **20.10.81**

(54) **Method and apparatus for thermally treating pulverulent material.**

(30) Priority: **17.11.80 GB 8036836**

(43) Date of publication of application:
26.05.82 Bulletin 82/21

(45) Publication of the grant of the patent:
25.07.84 Bulletin 84/30

(84) Designated Contracting States:
BE DE FR GB IT LU NL

(56) References cited:
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FR - A - 2 279 043
GB - A - 457 957
GB - A - 1 396 402
GB - A - 1 446 241
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EP 0 052 429 B1

Courier Press, Leamington Spa, England.

Description

The present invention relates to a method of and an apparatus for thermally treating pulverulent materials, i.e. keeping the material at a certain temperature, the treating temperature, for a certain period of time, in particular sintering, pulverulent material in a cylindrical reaction chamber with an axis slightly inclined to the horizontal after the material has been heated to the treating temperature outside the reaction chamber suspended in a gas.

The method is especially applicable for thermally treating materials which tend to become sticky at the treating temperature, in particular for sintering pulverulent materials, i.e. agglomerating these by heating without complete melting. However, the method is also useful for general thermal treatment where sintering is not intended, e.g. for burning Bauxite, Mesa and phosphate bearing ores.

An example of a sintering process to which the invention is particularly applicable is the manufacture of cement clinker where the pulverulent material to be sintered is hot calcined cement raw meal.

According to the traditional, and within the cement industry until now only feasible, method of sintering pulverulent materials the material is introduced in the form of a layer of material, and sintered on its way through a rotary kiln, possibly co-currently but usually countercurrently to a flow of combustion gas passed through the rotary kiln and generated by combustion of fuel introduced at an air inlet end of the rotary kiln. Usually, the raw materials are subjected to preheating and calcination, i.e. decomposition of $CaCO_3$ to CaO and CO_2, in suspension outside the rotary kiln. However, at least the heating from calcination temperature to sintering temperature as well as the sintering proper take place in the rotary kiln.

This type of rotary kiln is however not an ideal apparatus. The essential drawback is the relative inefficient heat transfer during the process of heating the material to the treating, e.g. the sintering temperature. Because of this the machinery dimensions are necessarily large, resulting in high initial apparatus costs, a substantial heat loss and a considerable thermal inertia leading to long starting up periods and control problems as well.

Another disadvantage of the rotary kiln is the rather limited number of variable process parameters available; as a result of which it is difficult at the same time to optimise the heating up process and the thermal treating process.

Numerous proposals for eliminating these drawbacks have been made and can be classified in two groups:

The first group comprises methods for obtaining an improved heat economy of the rotary kiln.

The second group comprises attempts to replace the rotary kiln by another more efficient heat treating apparatus.

The first group includes a method for improving the heat exchange between particles of raw material and the hot combustion gasses by alternatively lifting and dropping the particles during their passage down the kiln by means of trough-shaped conveyor flights to produce curtains of falling particles extending across the kiln as described in US—A—3,799,735. (Jensen). An improved heat economy is thus achieved but it cannot be said that the above drawbacks of the traditional rotary kiln have been eliminated satisfactorily.

To the same group belong two methods in which the rotary kiln is also used as a suspension preheater, as described in Japanese Patent publication No. 3916 (Mamoto) of 1963 and GB—A—1,396,402 (KHD).

The Japanese Patent publication relates to a process and kiln apparatus for burning cement wherein the heat transfer to the non-preheated material delivered to the kiln is sought to be maximized. According to this process cement raw materials are introduced either at the forward or at the intermediate position of the kiln suspended in a stream of hot air and allowed to be heated while flowing with the kiln gases towards the rear end of the kiln. Before the kiln gases reach the rear end of the kiln the material is supposed to be precipitated onto the kiln floor inside the kiln and the precipitated material is then subjected to further heat treatment while moving along the inclined kiln bottom toward its lower-lying forward end. For many reasons this method has not been in practical use. In order to obtain proper precipitation of the suspended material excessive kiln dimensions both with respect to kiln length and kiln diameter at the rear end would be necessary.

Another process and kiln apparatus, wherein the material passes through a reaction drum, e.g. a rotary kiln twice, first in suspension and then in a precipitated state has been suggested. Thus GB—A—1396402 discloses a method, hereinafter referred to as of the kind described, comprising separating the material heated to the treating temperature from the suspension in the upper end of the reaction chamber; keeping the reaction chamber rotating slowly whereby the separated material is thermally treated during its passage down the reaction chamber; discharging the thermally treated material from the lower end of the reaction chamber; and withdrawing the gas from the reaction chamber through one of its ends. As particularly described in that specification, the material is passed through the reaction chamber which is constructed as a rotational drum provided with a burner, i.e. a rotary kiln, as a suspension in a gas, withdrawn from the rotary kiln in suspension, precipitated from the gas in a separator and reintroduced into the rotary kiln in the form of a layer of material and further heat treated while moving along the inclined kiln bottom.

Instead of arranging a burner in a rotational drum a combustion chamber may be provided upstream of the reaction chamber. In this case the material is suspended in and heated by the hot exit gas from the combustion chamber.

In both cases the precipitation problems inherent in the Japanese method are solved, but these methods are not suited for treating sticky materials such as cement raw meal at a temperature close to the sintering temperature because the material will build up in the precipitator and quickly block it.

The second group comprises proposals for abolishing the rotary kiln entirely.

Thus US—A—2,776,132 (Pyzel) discloses a method of manufacturing cement clinker according to which cement raw meal and fuel are introduced into a fluid bed where the heat generated by combusion of the fuel evokes partly calcining of raw meal and partly heating of the calcined raw meal to the temperature (approximately 1400°C—1450°C) at which the material sinters into cement clinker.

A later US—A—3,013,786 (Pyzel) discloses a similar method differing from the previous one in that the raw material is calcined not in a fluid bed, but suspended in a hot gas, whereafter the calcined material is separated from the gas and sintered in a fluid bed under simultaneous addition of fuel.

By both methods an improved heat economy is obtained because the heat transfer in suspension and in a fluid bed is far more efficient than in a rotary kiln. On the other hand another significant disadvantage is encountered which has prevented these methods from ever having been of practical use. The pulverulent materials are partly molten and extremely sticky at the sintering temperature. Consequently, a fluid bed with such material has a marked tendency to form cakings, leading to frequent interruptions in operation.

Previously, e.g. in US—A—2,489,211 (Witt) it has been proposed to sinter cement raw meal in suspension by head on collision of a flow of raw meal suspended in air with a flow of hot gas. This collision takes place in a reaction chamber in which the solid material is separated from the gas and sinks while the gas leaves the reaction chamber at the top.

This method has not been in practical use primarily because the material is not allowed sufficient reaction time for the mineral formation occuring at the sintering temperature, and secondly because, should any sintering occur, the material would deposit on the walls of the reaction chamber during the separation phase as a consequence of its sticky nature, ultimately blocking the chamber.

GB—A—959,446 (Heidelberg) proposes another method of manufacturing cement clinker by suspension sintering, according to which fine raw material in a reaction zone is introduced into an ascending hot gas stream having a temperature sufficient to cause calcining and sintering of the raw material, and a flow velocity sufficient to keep the raw material suspended in the gas stream until calcined and sintered. The calcined and sintered material is precipitated from the suspension and withdrawn from the reaction zone by briefly interrupting the introduction of raw material and hot gas.

This method has found no practical use either, partly because its batchwise nature makes it very difficult to achieve a homogeneous product, and partly because this method also leads to serious problems with cakings formed wherein the sticky material collides with the walls in the reaction zone.

US—A—3,603,568 (Ritzmann) discloses a continuous process with heating to sintering temperature and sintering of material in suspended state. The specification further discloses an apparatus for such heat treatment of fine material e.g. cement raw material, comprising a multicyclone material preheater and a multicyclone cooler, and a burning section comprising a tubular firing chamber in which a suspension of preheated material is burned, the firing chamber being connected to a separating chamber constructed as an ordinary cyclone in which the product is precipitated.

This apparatus has not found practical use either within the cement industry, partly because of a marked tendency to the formation of cakings in the separating cyclone, and partly because realistic gas velocities and apparatus dimensions only allow a very short period of treatment which is insufficient for obtaining the desired mineral formation.

Finally, GB—A—457,957 (Saint Jacques) discloses a furnace for the treatment of pulverulent material said to be particularly suited for use in the production of cement clinker. The raw material, suspended in an air flow, is introduced tangentially at the top of this furnace which has the form of a vertically oriented cylinder. Further down additional air is introduced along with fuel. During the combustion the raw material is heated to sintering temperature in a suspended state. As the only exit for the gas is an outlet in the top of the furnace, the gas with the suspended raw material particles will follow a spiral path downwards inside the furnace, after which the gas changes direction and leaves the furnace through the gas outlet, whereas the material particles are separated and sink to a rotating hearth provided with one or more tangential burners arranged at the bottom of the furnace.

This apparatus has not been used within the cement industry. One of the reasons for this is strong tendency to the formation of cakings on the kiln walls.

It is an object of the invention to provide a method of thermally treating, in particular sintering, pulverulent material in a cylindrical reaction chamber with an axis slightly inclined to the horizontal after the material has been heated to the treating temperature outside the reaction chamber suspended in a gas thereby providing advantages of heat economy achieved by heating to treating temperature in suspension, and permitting a variable and controllable period of treatment, while simultaneously avoiding the disadvantages mentioned above due to the sticky nature of the treated materials.

Further, it is the object of the invention to provide a compact apparatus for carrying out the method according to the invention.

Surprisingly, it has now been found that the object of the invention can be achieved by a method of the kind described, characterised in that the suspension is introduced with a tangential velocity component into the upper end of the reaction chamber.

The thermal treatment can thus be performed in a particularly advantageous way. The material is heated to the treating temperature in suspension providing a heating up which is far more rapid and efficient than in the traditional rotary kiln.

The improved heat transfer permits a radical reduction of the apparatus dimensions with consequent advantages, and the use of low grade fuel not usable in traditional sintering due to an insufficiently high flame temperature.

The critical phase during which the material heated to the treating temperature is separated from the suspension takes place in the upper part of the reaction chamber which acts as a horizontal cyclone because the tangential velocity component of the suspension causes a rapid helical movement of the suspension in the upper part of the reaction chamber.

Since the reaction chamber is kept slowly rotating, a tendency of the material to stick together and form cakings will lead to no problems because the reaction chamber will act not only as a separator but at the same time as a rotating agglomeration drum.

On the contrary a sticky character of the material will be advantageous in causing a preliminary agglomeration of the fine material during the separation, leading to an improved separation efficiency.

Even a tendency to the formation of cakings will be advantageous, because it will lead to a lining-protecting crust formation in the reaction chamber as in the hot zones of a traditional rotary kiln.

The thermal treatment proper, in particular a final agglomeration and sintering, will take place while the separated material is passing through the rotating reaction chamber, i.e. under conditions which can be controlled independently of the heating and separating process, e.g. by varying the speed of rotation of the reaction chamber.

The material discharged from the reaction chamber may be fed directly to a cooler of known type, e.g. a grate cooler or a rotary drum cooler, but it may also be subjected to an after-treatment in a small rotating drum before it is fed to the cooler.

The advantage of carrying out the thermal treatment in two stages is that the material separation phase and part of the thermal treatment phase are kept apart so that the latter may take place in a drum having a particularly small radius, i.e. having particularly small heat loss.

The tangential velocity component of the suspension may be provided by introducing the suspension close to the cylindrical wall of the reaction chamber in a direction substantially parallel to a tangent to the closest part of the wall and almost perpendicular to the axis of the reaction chamber. Collisions between suspended particles and between particles and walls outside the reaction chamber may thus be kept to a minimum, i.e. the risk of formation of cakings outside the reaction chamber is minimized.

Alternatively, the tangential velocity component of the suspension may be provided by bringing the suspension into rotation before it is introduced axially in to the reaction chamber.

The advantage of axial introduction of a rotating suspension is that it is possible to reduce the area of a stationary upper end wall part of the reaction chamber whereby a peripheral part of the upper end wall may be fixed to the reaction chamber. The problems of procuring an air-tight connection between movable and stationary apparatus parts are thus reduced.

The gas may be withdrawn from the reaction chamber through its upper or lower end.

The advantage of withdrawing the gas through the upper end of the reaction chamber is that all risks of resuspending the precipitated material are eliminated.

However, withdrawing the gas through the lower end of the reaction chamber present several disadvantages, e.g. compensation of heat loss in the lower part of the reaction chamber, improved gas flow characteristics with axial introduction of the suspension.

The present invention also includes an apparatus for thermally treating, in particular sintering, pulverulent materials by the method according to the invention, the apparatus comprising a cylindrical member which is rotatable about an axis slightly inclined to the horizontal and which has stationary end walls and a rotary drive, to provide the cylindrical reaction chamber; a suspension inlet duct leading to the upper end of the reaction chamber; a gas outlet duct connected to one end of the reaction chamber; and an outlet for the thermally treated material at the lower end of the reaction chamber; characterised in that the suspension inlet duct leads to the upper end of the reaction chamber in a plane substantially tangential to the inner circumferential surface of the reaction chamber.

In one construction, the reaction chamber is provided with a constriction member situated at a distance from the suspension inlet duct connection constituting approximately one third of the total length of the reaction chamber.

This constriction member, which is preferably provided as a thickening of the lining in the reaction chamber, and preferably has an inner diameter consituting 40—50% of the inner diameter of the reaction chamber provides a division of the reaction chamber into separating and thermally treating sections ensuring a highly efficient material separation.

According to one preferred embodiment the tangential relationship between the suspension inlet duct and the upper end of the reaction chamber is provided by connecting the suspension inlet duct to an inlet opening in the upper end wall close to the cylindrical wall of the reaction chamber so that the inlet duct leads substantially parallel to a tangent to the closest part of the cylindridcal wall and almost perpendicular to the axis of the reaction chamber.

According to another preferred embodiment the tangential relationship between the suspension inlet duct and the upper end of the reaction chamber is provided via a stationary cylindrical member which is coaxial with and smaller in diameter than the reaction chamber and which provides a spiral flow chamber with a tangential suspension inlet and an axial suspension outlet communicating with the reaction chamber.

The connection between the gas outlet duct and the reaction chamber may be provided by mounting the gas outlet duct at an outlet opening in one or other stationary end wall parts of the reaction chamber.

The outlet for the thermally treated material may be an opening in the lower part of the lower end wall of the reaction chamber, which may communicate with a cooler for the discharged material.

The invention is illustrated diagrammatically by way of example in the accompanying drawings, in which:—

Figures 1 to 6 show modifications of the suspension inlet end of the reaction chamber;

Figures 7 to 12 show modifications of the material outlet end of the reaction chamber; and,

Figures 13 to 14 show plants for producing cement comprising the apparatus according to the invention as a sintering reaction, replacing the traditional rotary kiln.

In the figures the same reference numbers are used for identical apparatus parts.

Figures 1 and 3 are schematic side views and Figures 2 and 4 are corresponding schematic front views showing direct tangential inlets of a suspension inlet duct 1 into a rotatable reaction chamber 2 having an end flange 3 sealed with a seal ring 4 to a stationary end wall 5 equipped with an opening 6 connected with the suspension inlet duct 1. In the example shown in Figures 1 and 2 a combustion gas outlet duct is situated at the opposite end of the reaction chamber 2. In the example shown in Figures 3 and 4 a gas outlet duct 7 is situated at the upper end of the reaction chamber 2 communicating with the reaction chamber via an opening 8 in the end wall 5. The suspension inlet duct 1 is provided with inlets 9 and 10 for fuel and material, respectively. Figures 3 and 4 further show a constriction member 2′ provided as a thickening of the lining in the reaction chamber 2.

Figures 5 and 6 show as a schematic side view and a schematic front view, respectively, a suspension inlet with a spiral flow chamber 11 having a flange 12 sealed with a seal ring 13 to a flange 14 on the upper end of the reaction chamber 2, defining an axial suspension inlet opening 15. A peripheral part 16 of the end wall of the reaction chamber 2 is fixed to the reaction chamber. The suspension inlet duct 1 is provided with inlets 9 and 10 for fuel and material, respectively and tangentially connected to the spiral flow chamber 11.

Figures 7, 9 and 11 are schematic side views showing details of the material outlet end of a reaction chamber 2. Figures 8, 10 and 12 are schematic sections taken on the lines VIII—VIII, X—X, and XII—XII, respectively in Figures 7, 9, and 11.

Figures 7—12 show the lower part of the reaction chamber 2 provided with an inner lining 17 and a flange 18 sealed with a seal ring 19 to a stationary end wall 20 which is mounted to an air outlet 21 of a cooler 22. The lower part of the end wall 20 is provided with an opening 23 defining the material outlet of the reaction chamber 2 and the material inlet of the cooler 22.

In figures 7, 8, 11 and 12 the upper part of the end wall 20 is provided with a section opening 24 defining an exhaust gas exit communicating with a gas outlet duct 7 at the lower end of the reaction chamber 2.

In figures 7 and 8 the cooler 22 is a grate cooler with a double air outlet 21, the first for removing excess hot exit air from the cooler, situated at the top of the cooler, and the second being box shaped with sidewalls 124 one of which is provided with an opening 25 communicating with the gas inlet end of the suspension inlet duct 1.

In figures 9—12 the cooler 22 is a rotary drum cooler comprising a drum with an end flange 26 which by a seal ring 27 is sealed to a flange 28 on an exit air hood defining the cooler air outlet 21. The exit air hood is provided with an inclined bottom plate 29 leading the material from the materal outlet opening 23 to the cooler drum and with sidewalls 124 one of which is provided with an opening 25 communicating with the gas inlet end of the suspension inlet duct 1.

In figures 9 and 10 the top of the exit air hood is provided with a duct 30 for removing excess hot exit air from the cooler 22.

In figures 11 and 12 the area of the material outlet opening 23 is greater than in figures 9 and 10 permitting a part of the exit air from the cooler 22 to pass through the opening 23, quenching the gas at the lower end of the reaction chamber 2 and providing a precooling of the product before it is discharged to the cooler 22.

In the operation of the apparatus illustrated in figures 1—12 the material to be thermally treated is suspended in hot exit air from the cooler 22 in the suspension inlet duct 1. The material to be treated is advantageously preheated, e.g. in suspension by exit gas from the reaction chamber. Fuel is introduced in the suspension inlet duct above, below or at the same height as the material.

The gas velocity in the suspension inlet duct 1 is kept at a level so high that the suspended particles and the gas have almost the same velocity. In order to minimize the risk of formation of cakings it may be desirable that the gas is not subjected to violent changes of direction so that the number of collisions between particles and the wall is kept to a minimum. The risk of cakings may be further reduced in a known manner by drawings in a gas along the walls of the suspension inlet duct.

The suspended material is heated to the treating temperature in a few seconds. Then it is introduced into the upper part of the reaction chamber 2 with a tangential velocity component. Due to this velocity component the suspension will perform a rapid helical movement in the upper part of the reaction chamber 2, and the material will be precipitated from the suspension as in an ordinary horizontal cyclone.

In the upper part of the reaction chamber 2 the precipitated material will rotate along the inner surface in an annular material layer, but due to friction the speed of rotation will decrease as the material moves further into the reaction chamber 2 and finally the precipitated material will settle on the bottom of the reaction chamber 2 and form a material layer which will be carried through and subjected to thermal treatment in the reaction chamber with a retention time being determined by the rotational speed of the reaction chamber.

At the lower end of the reaction chamber 2 the material is discharged through the material outlet opening 23 and is introduced into the air cooler 22 where it is cooled countercurrently to cooling air. The hot exit air from the cooler 22 or part thereof is introduced into the suspension inlet duct 1, the air flow being provided by means of a fan (not shown) and, if desired, being controlled by means of a valve (not shown) in the air inlet end of the suspension inlet duct 1.

A certain amount of (false) air may bypass the suspension inlet duct 1 and pass directly from the cooler 22 to the lower end of the reaction chamber 2 via the material outlet opening 23. However, if desired, the amount of false air can be kept very low by minimizing the area of the material outlet opening 23. As mentioned above a certain amount of false air may be desirable, especially when the gas outlet is arranged at the lower end of the reaction chamber 2, because it provides a quenching of the exit gas from the reaction chamber 2 and a precooling of the thermally treated material.

The plant shown in figures 13—14 comprises a suspension preheater comprising cyclones 31, 32 and 33, an inlet 34 and an outlet 35 for heating gas, and an inlet 36 and an outlet 37 for pulverous cement raw material; a suspension calciner with a calcination chamber 38 provided with a separating cyclone 39, an inlet 40 for fuel, and an inlet 41 for combustion air and preheated raw material, and an outlet 42 for calcined material from the separating cyclone 39; and a sintering apparatus 43 comprising a reaction chamber 2 rotatable around an axis slightly inclined to the horizontal, a suspension inlet duct 1 provided with inlets 9 and 10 for fuel material, respectively, the inlet duct 1 having a first end connected to an air cooler 22 and a second end connected to the upper end of the reaction chamber 2, the reaction chamber 2 being provided with a gas outlet duct 7 connected to the lower or upper end of the reaction chamber 2 in figures 13, 14 respectively.

The arrangement at the upper end of the reaction chamber 2 in figure 13 may be shown in figures 1, 2, or figures 5, 6, and at the lower end as shown in figures 7, 8, or 11, 12. As mentioned with reference to figures 9 to 12, the rotary drum cooler 22 may be replaced by a grate cooler. The arrangement at the upper end of the reaction chamber 2 in figure 14 may be as shown in figures 3, 4, or figures 5, 6 and at the lower end as shown in figure 14 or as shown in figures 9, 10. The gas outlet duct 7 may be axially connected to the reaction chamber 2.

An air cooler 22 for the cooling the sintered material has an air outlet 21 connected to both the inlet duct 1 of the sintering apparatus 43 and the air inlet 41 of the calciner.

The inlet duct 1 is arranged to introduce material with a tangential component into the reaction chamber 2 as shown in more detail in figures 1—4.

Figures 13 and 14 show a grate cooler as cooler 22 which may be provided with a duct (not shown) for excess hot cooling air. Of course the grate cooler can be replaced by a rotary drum cooler.

The method of thermally treating pulverulent material is well suited for sintering material comprising oxides of calcium, silicon, aluminium, and iron, such as calcined cement raw meal to cement clinker. The method can also advantageously be used when extracting alumina from low grade alumina bearing ores e.g. by the so-called lime and lime/soda processes where a fine ground mixture of alumina bearing ore and limestone/limestone and alkali metal carbonate, respectively, are calcined and sintered to clinker containing and alumina component in soluble form as calcium aluminate and alkali metal aluminate, respectively, and the impurities in insoluble form, e.g. the SiO_2 component as insoluble dicalcium-silicate.

When using the apparatus shown in figures 13 or 14 for manufacturing cement clinker, the procedure will normally be to introduce and preheat the cold cement raw meal in the suspension preheater, suspending the preheated raw meal in an oxygen containing gas in the calcination chamber 38 with simultaneous addition of fuel. The calcined material is then separated from the gas in the separating cyclone 39 and suspended in hot oxygen containing gas, i.e. hot exit air from the clinker cooler 22, in the suspension inlet duct 1.

The hot calcined material coming from the calciner will have an oxide composition typically within the range CaO: 62—66%, Al_2O_3: 6—10% SiO_2: 17—24% and Fe_2O_3: 1—6% and a temperature of 800—850°C. Fuel such as oil, gas or coal dust is introduced in the hot air flow in the suspension inlet duct 1 before, after, simultaneously with, or together with the hot precalcined cement raw meal.

In a few seconds, the material temperature will be raised to 1350—1450°C, being the sintering temperature of the materials involved.

The suspended material is then introduced into the reaction chamber 2 as previously described.

In the upper part of the reaction chamber 2 the material is separated from the suspension and the separated agglomerating material is then sintered on its way down towards the material outlet. The retention time is controllable by setting the rotational speed of the reaction chamber 2, and will normally be 7—12 minutes.

The temperature of the discharged cement clinker is typically approximately 1400°C. The discharged clinker is then air cooled in the clinker cooler 22.

Part of the hot cooling air, typically having a temperature of 750—900°C, is used as the above mentioned hot air in which the calcined raw meal is suspended in the suspension inlet duct 1. The remaining part is passed to the calciner in which it is used as combustion air for the raw meal calcining.

The hot gas discharged from the reaction chamber 2 typically has a temperature of 1400—1500°C and is introduced through the duct 7 to the bottom of the calcination chamber 38 and is used as a supplementary heat source for calcining the material. The exit gas from the calciner is used in known manner for preheating the raw meal to the calcined.

To avoid problems of clogging in the exit for the reaction chamber exit gas, it is advantageous to introduce uncalcined or calcined raw meal into the hot gas flow at a position close to the reaction chamber 2. The raw meal is at once suspended in the gas reducing the gas temperature to approximately 850°C/1050°C when uncalcined/calcined material is introduced. At these temperatures the risk of cakings is completely eliminated. Then the gas flow may be introduced into a separator, e.g. a cyclone separator for separating solid material which is passed to the calciner or to the suspension inlet duct when calcined material is introduced.

Typical reaction chamber 2 dimensions are diameter 4m., length 12—20 m. The rotational speed of the reaction chamber 2 typically 1—4 r.p.m. A typical inclination of the reaction chamber will be 3° which is barely preceptible in the accompanying drawings. The degree of filling in the reaction chamber is typically 15—20 per cent. The production capacity of such a plant is 2000 tons/24 hrs.

Claims

1. A method of thermally treating pulverulent material in a cylindrical reaction chamber (2) with an axis slightly inclined to the horizontal after the material has been heated to the treating temperature outside the reaction chamber suspended in a gas, the method comprising separating the material heated to the treating temperature from the suspension in the upper end of the reaction chamber; keeping the reaction chamber rotating slowly whereby the separated material is thermally treated during its passage down the reaction chamber; discharging the thermally treated material from the lower end of the reaction chamber; and withdrawing the gas from the reaction chamber through one of its ends; characterised in that the suspension is introduced with a tangential velocity component into the upper end of the reaction chamber.

2. A method according to claim 1, characterised in that the tangential velocity component of the suspension is provided by introducing the suspension close to the cylindrical wall of the reaction chamber in a direction substantially parallel to a tangent to the closest part of the wall and almost perpendicular to the axis of the reaction chamber.

3. A method according to claim 1, characterised in that the tangential velocity component of the suspension is provided by bringing the suspension into rotation before it is introduced axially into the reaction chamber.

4. A method according to any one of the preceding claims, characterised in that the gas is withdrawn from the reaction chamber through its upper end.

5. A method according to any one of claims 1 to 3, characterised in that the gas is withdrawn from the reaction chamber through its lower end.

6. Apparatus for thermally treating pulverulent material by a method according to any one

of claims 1 to 5, the apparatus comprising a cylindrical member (2) which is rotatable about an axis slightly inclined to the horizontal and which has stationary end walls and a rotary drive, to provide the cylindrical reaction chamber; a suspension inlet duct (1) leading to the upper end of the reaction chamber; a gas outlet duct (7) connected to one end of the reaction chamber; and an outlet (23) for the thermally treated material at the lower end of the reaction chamber; characterised in that the suspension inlet duct leads to the upper end of the reaction chamber in a plane substantially tangential to the inner circumferential surface of the reaction chamber.

7. Apparatus according to claim 6, characterised in that the reaction chamber is provided with a constriction member (2′) situated at a distance from the suspension inlet duct constituting approximately one third of the total length of the reaction chamber.

8. Apparatus according to claim 6 or claim 7, characterised in that the tangential relationship between the suspension inlet duct and the upper end of the reaction chamber is provided by connecting the suspension inlet duct (1) to an inlet opening (6) in the upper end wall (5) close to the cylindrical wall of the reaction chamber so that the inlet duct leads substantially parallel to a tangent to the closest part of the cylindrical wall and almost perpendicular to the axis of the reaction chamber.

9. Apparatus according to claim 6 or claim 7, characterised in that the tangential relationship between the suspension inlet duct and the upper end of the reaction chamber is provided via a stationary cylindridcal member (11) which is coaxial with and smaller in diameter than the reaction chamber and which provides a spiral flow chamber with a tangential suspension inlet (1) and an axial suspension outlet (15) communicating with the reaction chamber.

Patentansprüche

1. Verfahren zum thermischen Behandeln pulverförmigen Materials in einer zylindrischen Reaktionskammer (2) mit einer zu Horizontalen leicht geneigten Achse, nachdem das Material in einem Gas suspendiert außerhalb der Reaktionskammer auf die Behandlungstemperatur erwärmt worden ist, wobei das auf die Reaktionstemperatur erwärmte Material aus der Suspension in dem oberen Ende der Reaktionskammer abgeschieden wird, die Reaktionskammer in langsamer Rotation gehalten wird, wodurch das abgeschiedene Material während seines Hindurchlaufs durch die Reaktionskammer thermisch behandelt wird, wobei das thermisch behandelte Material aus dem unteren Ende der Reaktionskammer abgeführt wird und das Gas aus der Reaktionskammer durch eines ihrer Enden abgezogen wird, dadurch gekennzeichnet, daß die Suspension mit einer tangentialen Geschwindigkeitskomponente in das obere Ende der Reaktionskammer eingeführt wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die tangentiale Geschwindigkeitskomponente der Suspension bewirkt wird, indem die Suspension nahe der zylindrischen Wand der Reaktionskammer in einer Richtung im wesentlichen parallel zu einer Tangente zu dem nächstgelegenen Teil der Wand und nahezu rechtwinklig zur Achse der Reaktionskammer eingeführt wird.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die tangentiale Geschwindigkeitskomponente der Suspension bewirkt wird, indem die Suspension in Rotation versetzt wird, bevor sie axial in die Rotationskammer eingeführt wird.

4. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das Gas aus der Reaktionskammer durch deren oberes Ende abgezogen wird.

5. Verfahren nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß das Gas aus der Reaktionskammer durch deren unteres Ende abgezogen wird.

6. Vorrichtung zum thermischen Behandeln pulverförmigen Materials mittels eines Verfahrens nach einem der Ansprüche 1 bis 5, welche Vorrichtung verfügt über ein zylindrisches Teil (2), das um eine zum Horizontalen leicht geneigte Achse drehbar ist und stationäre Stirnwände und einen Rotationsantrieb zur Bildung einer zylindrischen Rotationskammer aufweist, über einen Suspensionseinlaßkanal (1), der zum oberen Ende der Rotationskammer führt, über einen Gasauslaßkanal (7), der an einem Ende der Rotationskammer angeschlossen ist, über einen Auslaß (23) für das thermisch behandelte Material am unteren Ende der Reaktionskammer, dadurch gekennzeichnet, daß der Suspensionseinlaßkanal zum oberen Ende der Reaktionskammer in einer Ebene im wesentlichen tangential zur inneren Umfangsfläche der Rotationskammer führt.

7. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß die Reaktionskammer mit einem Einschnürungsteil (2′) ausgestattet ist, das von dem Suspensionseinlaßkanal in einem Abstand angeordnet ist, der etwa einem Drittel der Gesamtlänge der Rotationskammer enspricht.

8. Vorrichtung nach Anspruch 6 oder Anspruch 7, dadurch gekennzeichnet, daß die tangentiale Beziehung zwischen dem Suspensionseinlaßkanal und dem oberen Ende der Rotationskammer dadurch bewirkt ist, daß der Suspensionseinlaßkanal (1) an eine Einlaßöffnung (6) in der oberen stirnwand (5) nahe der zylindrischen Wand der Rotationskammer angeordnet ist, so daß der Einlaßkanal im wesentlichen parallel zu einer Tangente zum nächstgelegenen Teil der zylindrischen Wand und nahezu rechtwinklig zur Achse der Rotationskammer führt.

9. Vorrichtung nach Anspruch 6 oder

Anspruch 7, dadurch gekennzeichnet, daß die tangentiale Beziehung zwischen dem Suspensionseinlaßkanal und dem oberen Ende der Reaktionskammer über ein stationäres zylindrisches Teil (11) bewirkt ist, das koaxial zu der Reaktionskammer verläuft und im Durchmesser kleiner als diese ist und das eine Spiralstromkammer mit einem tangentialen Suspensionseinlaß (1) und einem axialen Suspensionsauslaß (15) bildet, der mit der Reaktionskammer in Verbindung steht.

Revendications

1. Procédé pour traiter thermiquement de la matière pulvérulente dans une chambre cylindrique (2) de réaction présentant un axe légèrement incliné sur l'horizontale, après chauffage de la matière, en suspension dans un gaz à l'extérieur de la chambre de réaction, jusqu'à la température de traitement, le procédé comprenant la séparation de la matière chauffée jusqu'à la température de traitement d'avec la suspension à l'extrémité supérieure de la chambre de réaction; le maintien de la chambre de réaction en lente rotation de sorte que la matière séparée est thermiquement traitée au cours de son passage de descente dans la chambre de réaction; la décharge de la matière thermiquement traitée de l'extrémité inférieure de la chambre de réaction; et le retrait du gaz de la chambre de réaction par une de ses extrémités, procédé caractérisé en ce que la suspension est introduite avec une composant tangentielle de vitesse à l'extrémité supérieure de la chamber de réaction.

2. Procédé selon la revendication 1, caractérisé en ce qu'on obtient la composante tangentielle de vitesse de la suspension en introduisant, près de la paroi cylindrique de la chambre de réaction, la suspension en une direction sensiblement parallèle à une tangente à la partie la plus proche de la paroi et quasi perpendiculaire à l'axe de la chambre de réaction.

3. Procédé selon la revendication 1, caractérisé en ce qu'on obtient la composante tangentielle de vitesse de la suspension en mettant la suspension en rotation avant de l'introduire axialement dans la chambre de réaction.

4. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce qu'on retire de la chambre de réaction le gaz par son extrémité supérieure.

5. Procédé selon l'une quelconque des revendications 1 à 3 caractérisé en ce qu'on retire de la chambre de réaction le gaz par son extrémité inférieure.

6. Dispositif destiné au traitement thermique d'une matière pulvérulent par le procédé selon l'une quelconque des revendications 1 à 5, ce dispositif comprenant un élément cylindrique (2) qui peut tourner autour d'un axe légèrement incliné sur l'horizontale et qui comporte des parois extrêmes fixes et un entraînement en rotation, pour constituer la chambre cylindrique de réaction; un conduit (1) d'admission de suspension conduissant à l'extrémité supérieure de la chambre de réaction; un conduit (7) de sortie de gaz relié à une extrémité de la chambre de réaction; et, à l'extrémité inférieure de la chambre de réaction, une sortie (23) de la matière thermiquement traitée, dispositif caractérisé en ce que le conduit d'admission de la suspension conduit à l'extrémité supérieur de la chambre de réaction dans un plan essentiellement tangentiel à la surface circonférentielle interne de la chambre de réaction.

7. Dispositif selon la revendication 6, caractérisé en ce que la chambre de réaction comporte un élément (2') de constriction situé à une distance du conduit d'admission de la suspension représentant environ un tiers de la longueur totale de la chambre de réaction.

8. Dispositif selon la revendication 6 ou la revendication 7, caractérisé en ce qu'on obtient la relation tangentielle entre le conduit d'admission de la suspension et l'extrémité supérieure de la chambre de réaction en reliant le conduit (1) d'admission de la suspension à un orifice (6) d'admission ménagé dans la paroi extrême supérieure (5) près de la paroi cylindrique de la chambre de réaction, de sorte que le conduit d'admission conduit de façon sensiblement parallèle à une tangente à la partie la plus proche de la paroi cylindrique et quasi perpendiculairement à l'axe de la chambre de réaction.

9. Dispositif selon la revendication 6 ou 7, caractérisé en ce qu'on obtient la relation tangentielle entre le conduit d'admission de la suspension et l'extrémité supérieure de la chambre de réaction, à l'aide d'un élément cylindrique fixe (11), qui a même axe que la chambre de réaction et un diamètre plus petit que celle-ci et qui donne une chambre à écoulement en spirale comportant une admission (1) tangentielle de la suspension et une sortie (15) axiale de la suspension communiquant avec la chambre de réaction.

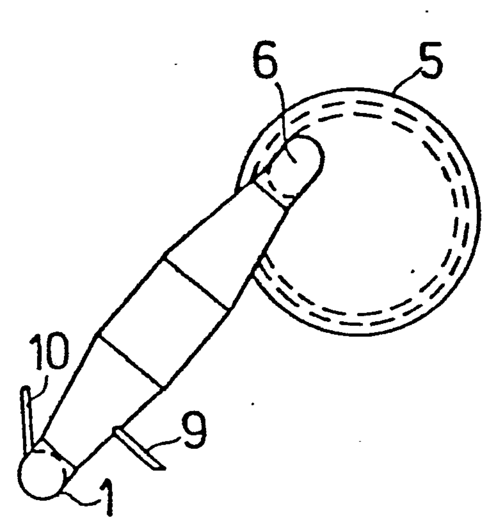


Fig. 2

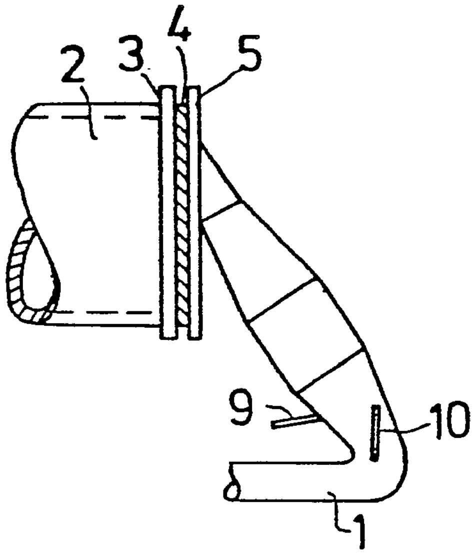
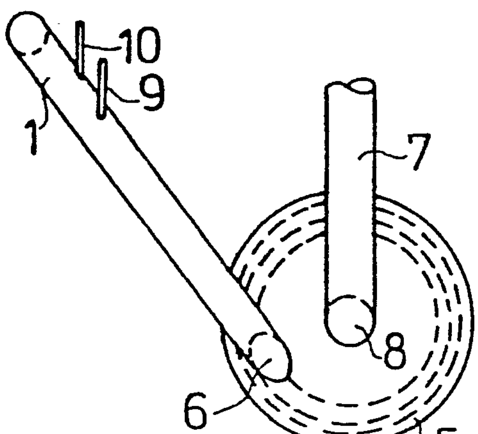


Fig. 1



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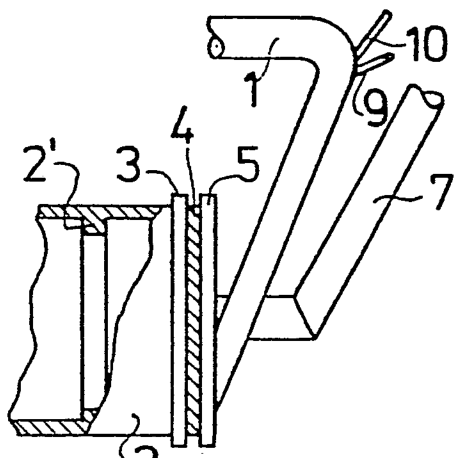

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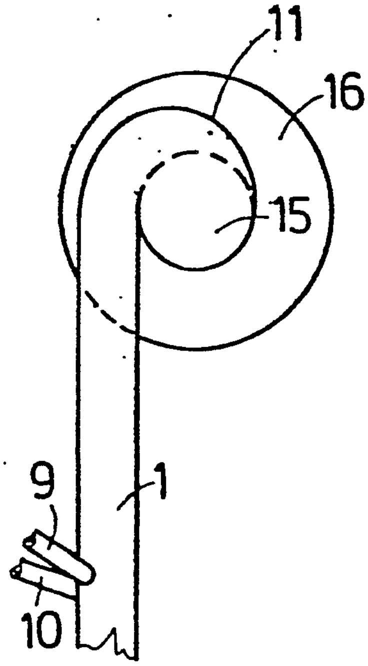

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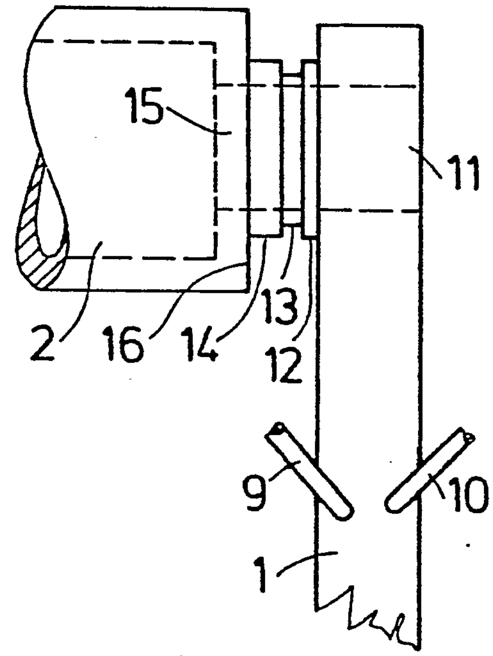


Fig 5

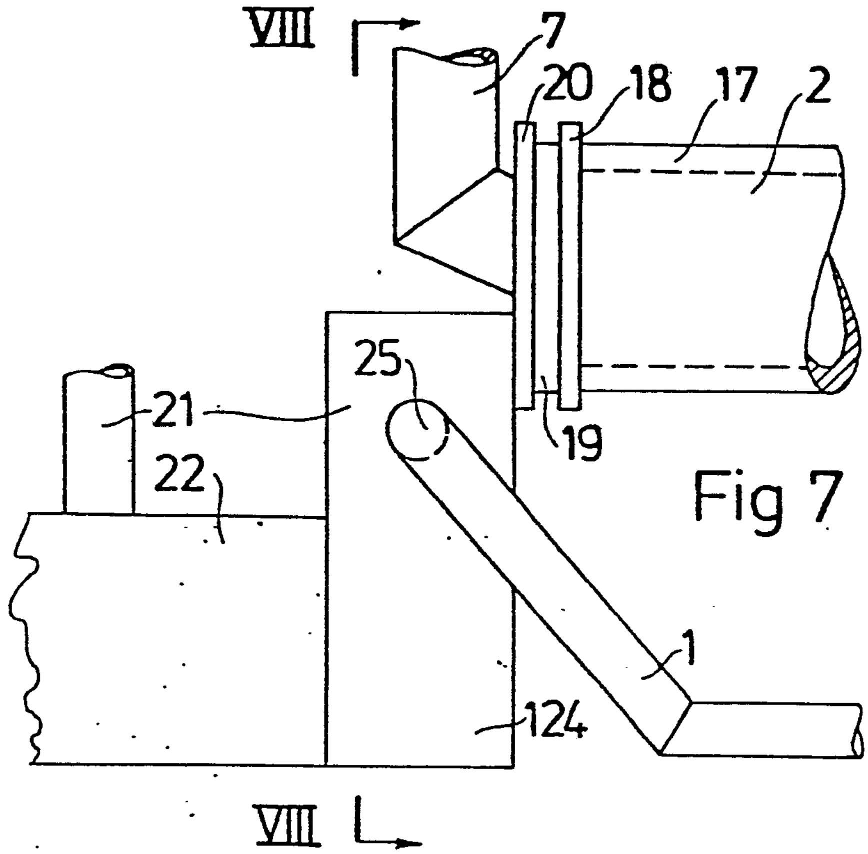
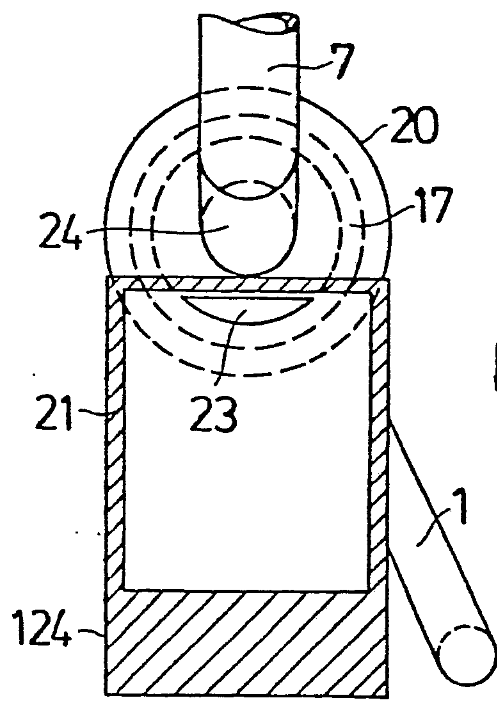


Fig 7



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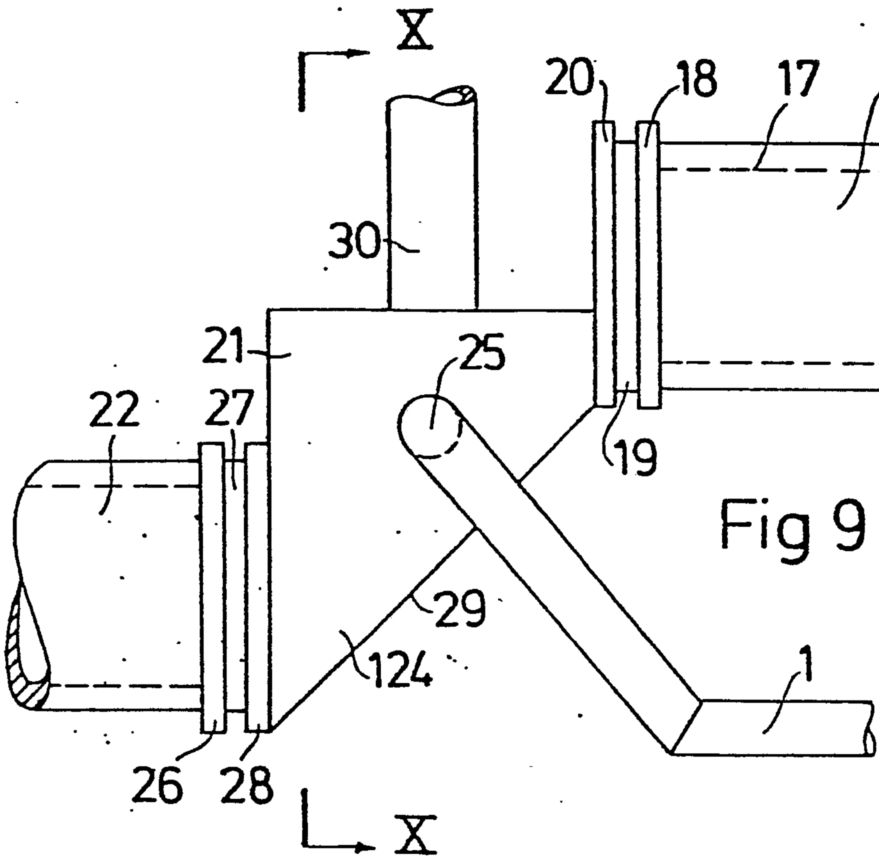

Fig 9

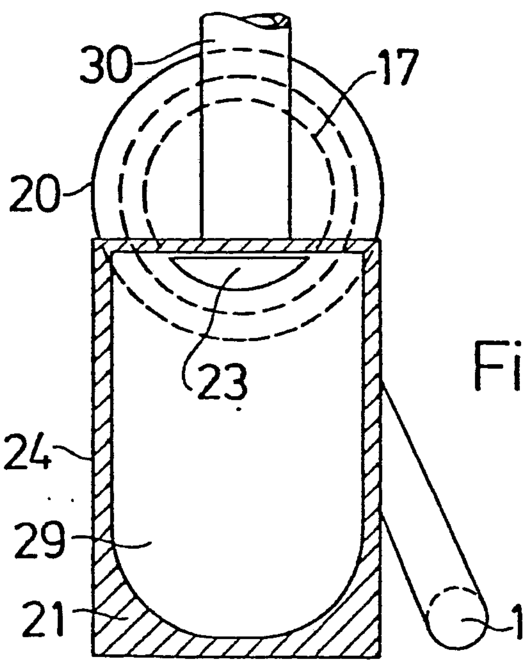

Fig 10

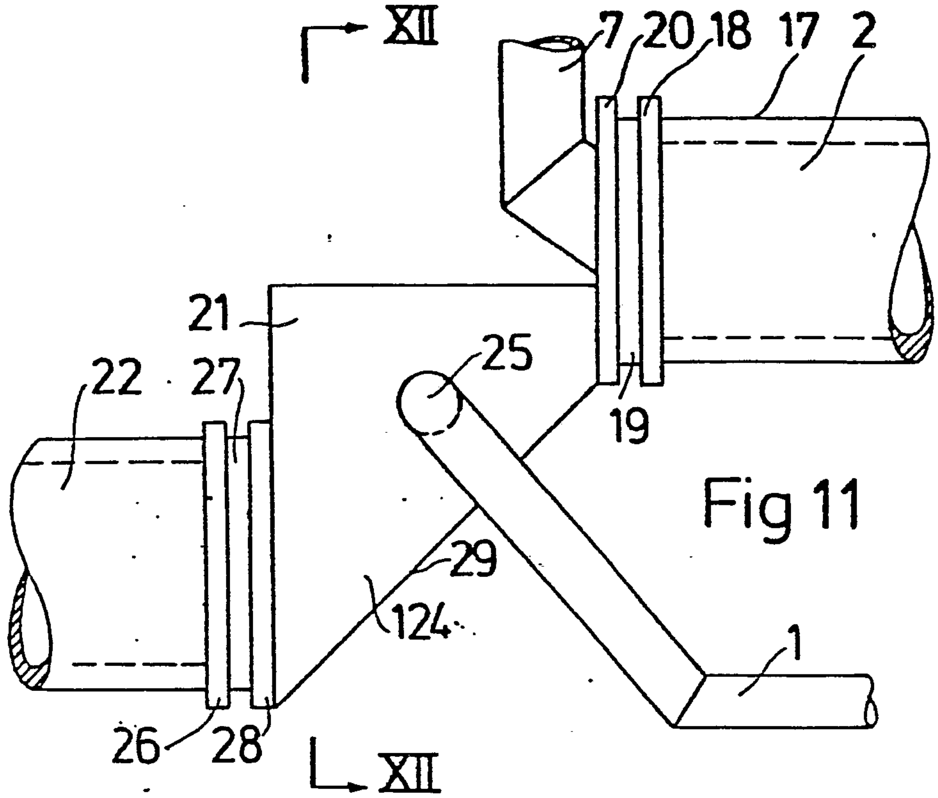
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Fig 11

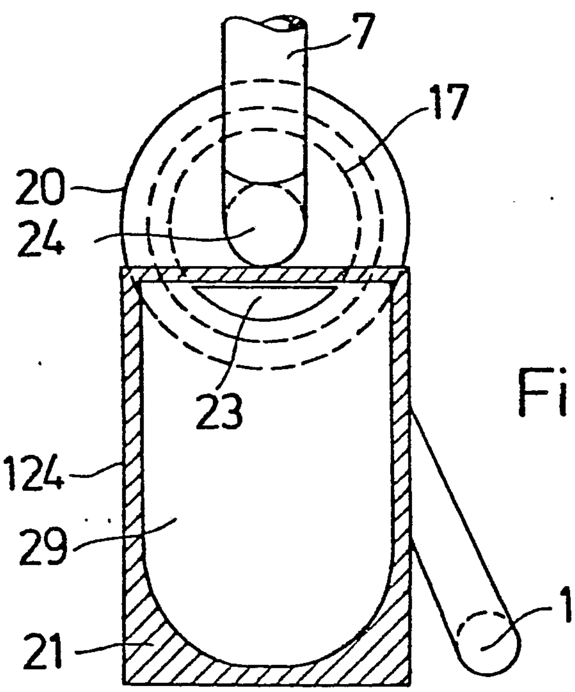
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Fig 12

Fig.13

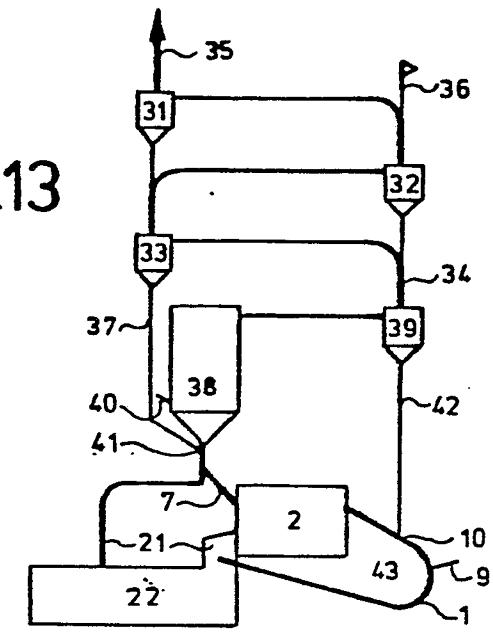
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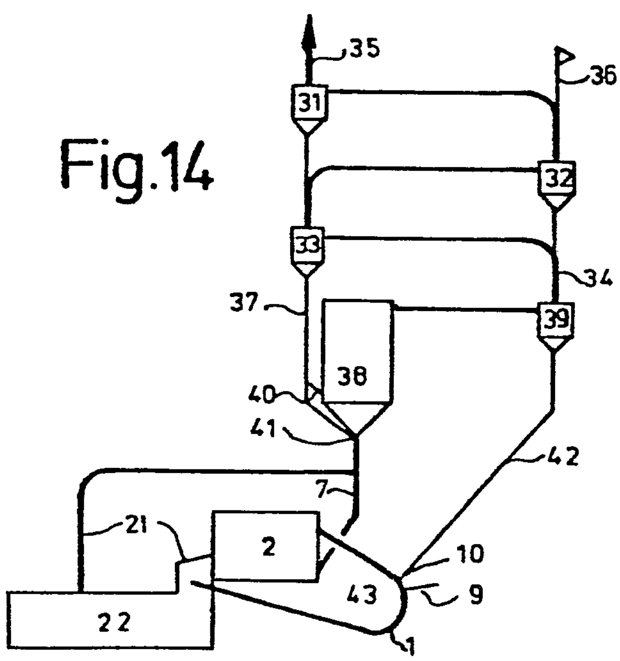
Fig.14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