

(19) **DANMARK**

(10) **DK/EP 3149422 T3**



Patent- og
Varemærkestyrelsen

(12) Oversættelse af
europæisk patentskrift

-
- (51) Int.Cl.: **F 27 B 7/20 (2006.01)** **C 04 B 7/43 (2006.01)** **F 27 D 17/00 (2006.01)**
- (45) Oversættelsen bekendtgjort den: **2019-08-05**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2019-05-01**
- (86) Europæisk ansøgning nr.: **15729328.3**
- (86) Europæisk indleveringsdag: **2015-05-27**
- (87) Den europæiske ansøgnings publiceringsdag: **2017-04-05**
- (86) International ansøgning nr.: **AT2015050136**
- (87) Internationalt publikationsnr.: **WO2015179892**
- (30) Prioritet: **2014-05-27 AT 500822014**
- (84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
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- (54) Benævnelse: **ANORDNING TIL FREMSTILLING AF CEMENTKLINKER**
- (56) Fremdragne publikationer:
EP-A1- 2 287 126
EP-B1- 2 545 337
WO-A1-2009/110356
DE-A1- 19 713 068

The invention relates to a device for producing cement clinker, comprising a kiln for firing raw materials to form cement clinker, comprising a preheating stage for preheating the raw materials in a counter-flow to kiln exhaust gases, 5 comprising a clinker cooler for cooling the cement clinker, comprising a nitrogen oxide removal stage for removing nitrogen oxide from kiln exhaust gases, comprising a heat exchanger for heating the kiln exhaust gases, upstream of the nitrogen oxide removal stage, by means of heat exchange 10 with a heat-exchange medium, comprising at least one additional heat exchanger for heating the heat-exchange medium by means of heat exchange with kiln exhaust gases or exhaust air from the clinker cooler, the heat exchanger being connected to the additional heat exchanger by means of 15 a line for the heat-exchange medium.

Such a device for the production of cement clinker is known from EP 2 545 337 B1, wherein the (optionally cooled) flue gas downstream of a preheater is dedusted in a flue gas filter and then fed to a so-called SCR ("selective catalytic 20 reduction") plant for catalytic nitrogen oxide removal. The dedusted flue gas is brought to the required temperature by means of heat exchangers upstream of the nitrogen oxide removal. The one heat exchanger is connected by means of a circuit for a heat transfer fluid to another heat exchanger, 25 which is arranged downstream of the clinker cooler. Part of the air heated in the clinker cooler is discharged from the clinker cooler via a central air tapping point. This exhaust air flow is subjected to coarse dedusting in a cyclone, before the dedusted exhaust air is used to heat the heat 30 transfer fluid in the heat exchanger on the side of the clinker cooler. The heated heat transfer fluid is fed to the heat exchanger upstream of the SRC plant. Accordingly, it is already known from the prior art to use the heat of the exhaust air for the heat displacement system of the SRC 35 plant. The exhaust air is first dedusted and then fed to a heat exchanger, which communicates via a heat transfer fluid with an additional heat exchanger upstream of the SCR plant.

A disadvantage, however, is that a cyclone is used in the exhaust air flow in this prior art in order to reduce the dust content upstream of the heat exchanger. In this embodiment, however, there is also a dust load in the exhaust air of for example several grams per standard cubic metre of air. An essential drawback of this embodiment, therefore, is that the use of the cyclone does not allow, with economically acceptable pressure losses, clean gas dust contents in the range below 100 mg/Nm^3 to be achieved. The wear on the pipes and possible dust deposits (so-called fouling or scaling) therefore had to be taken into account in the process-related and structural design of the heat exchanger in the exhaust air line in order to achieve the required heat displacement capacity. The effect of these reserve provisions is that the heat exchangers have to be dimensioned correspondingly larger, since otherwise the desired performance could not be delivered in the ongoing operation.

EP 2 287 126 A1 describes a cement clinker plant, wherein the exhaust gases are first conveyed through a cyclone and then through a high-temperature bag filter, before the exhaust gases are fed to a chimney. In an embodiment, a heat exchanger for cooling the exhaust gases to a temperature between 150°C and 400°C is provided downstream of the high-temperature bag filter, in order that the exhaust gases can be treated in a catalytic converter. This prior art cannot therefore contribute towards the thermal energy of the exhaust gases being used for the heat displacement system of a nitrogen oxide removal stage.

EP 1 649 922 A1 describes a conventional cement clinker plant with a nitrogen oxide removal device, wherein a heat exchanger is disposed both upstream and downstream of a nitrogen oxide removal tower.

US 8,765,066 B2 discloses a further generic cement clinker plant.

In contrast with this, the problem of the present invention consists in mitigating or eliminating the drawbacks of the prior art. In particular, therefore, the

invention sets itself the task of using the thermal energy of kiln exhaust gases or clinker cooler exhaust air as efficiently as possible and with little structural outlay for the heat displacement system of the nitrogen oxide
5 removal stage.

To solve this problem, a device for producing cement clinker is provided with the features of claim 1. Preferred embodiments of the invention are stated in the dependent claims.

10 According to the invention, a hot gas filter is arranged in the direction of flow upstream of the additional heat exchanger.

For the purposes of this disclosure, hot gas filters are designed for the dedusting of a dust-laden gas flow at
15 temperatures of at least more than 260°C, preferably at temperatures of at least 450°C. Such hot gas filters are known per se in the prior art. In EP 2 545 337 B1, hot gas filters, with which approx. 450°C hot gases can be dedusted, are however characterised as being costly and having a large
20 volume. For this reason, the use of such hot gas filters was rejected in the prior art in favour of simpler bag filters for dedusting the exhaust gases. In contrast, the invention is based on the surprising finding that the arrangement of such a hot gas filter directly upstream of the additional
25 heat exchanger brings particular advantages. An efficient and reliable dust separation at temperatures above 260°C can thus be achieved, which enables the use of a compact, efficient heat exchanger for absorbing the exhaust gas heat or exhaust air heat. With the use of conventional
30 separators, such as cyclones, the degrees of separation were usually limited at best to 50-100 mg/Nm³ (standard cubic metre), so that the downstream heat exchanger had to be adapted to such dust loads. According to the invention, on the other hand, the additional heat exchanger downstream of
35 the hot gas filter can be designed much more compact. As a result of the absence of the dust load, it is also possible to reliably prevent the heat displacement capacity being reduced as a result of dust deposits, such as fouling and

scaling. An increased operational reliability of the entire heat displacement system can thus advantageously be achieved, with which the energy balance of the entire device can be increased. A heat displacement from a flow of kiln exhaust gas and/or of exhaust air of the clinker cooler at high temperatures of more than 260°C can thus be achieved in an efficient and economical manner. The heat-exchange medium, for example water vapour or thermal oil, is fed to the heat exchanger upstream of the nitrogen oxide removal stage, with which heat losses of a heat exchanger module, through which exhaust gasses flow in a counter-flow upstream and downstream of the nitrogen oxide removal, are preferably compensated for. A plate heat exchanger can be provided as a heat exchanger module.

According to a preferred embodiment, a hot gas filter and an additional heat exchanger are arranged in a kiln exhaust gas line between the preheating stage and a raw mill for grinding the raw materials.

According to a further preferred embodiment, a hot gas filter and an additional heat exchanger are arranged in a bypass line in order to remove chloride loads from a partial flow of the kiln exhaust gases.

Cement clinker is discharged continuously from the kiln, said cement clinker usually being cooled with a clinker cooler. As a cooling agent, use can preferably be made of air, which leaves the clinker cooler as heated exhaust air.

According to a further preferred embodiment of the invention, a hot gas filter and an additional heat exchanger are arranged in an exhaust air line of the clinker cooler. The additional heat exchanger for absorbing heat from the exhaust air can thus advantageously be dimensioned in a compact manner.

To achieve an efficient heat displacement system, it may be necessary for at least two additional heat exchangers with upstream hot gas filters to be provided in the kiln exhaust gas line and/or in the bypass line and/or in the exhaust air line of the clinker cooler, the at least two

additional heat exchangers being connected to the heat exchanger, upstream of the nitrogen oxide removal stage, by portions of the line for the heat-exchange medium. In this embodiment, therefore, at least two different lines comprise

5 the additional heat exchangers designed for the heat displacement to the heat exchanger upstream of the nitrogen oxide removal stage, a hot gas filter for filtering the respective exhaust gas flow or exhaust air flow being arranged in each case upstream of the additional heat

10 exchangers. The thermal energy of the exhaust gas or exhaust air flows can be transferred at various points of the device to the heat-exchange medium and transported to the heat exchanger upstream of the nitrogen oxide removal stage. The exhaust gases can thus be brought reliably to the

15 temperature required for the nitrogen oxide removal. The additional heat exchangers with the upstream hot gas filters can be connected by separate line portions, in particular in the form of circulation lines, to the heat exchanger upstream of the nitrogen oxide removal stage. Alternatively,

20 the line portions for the heat-exchange medium leading away from the additional heat exchangers can be brought together in a junction portion, wherein the junction portion is connected to the heat exchanger upstream of the nitrogen oxide removal stage.

25 In order to make available the thermal energy required for the heat displacement to the heat exchanger upstream of the nitrogen oxide removal stage, it is advantageous if the kiln exhaust gas line and/or the bypass line and/or the exhaust air line comprises a branch for branching off a

30 partial flow of the kiln exhaust gases or the exhaust air to the additional heat exchanger. In this embodiment, therefore, only a part of the exhaust gases or the exhaust air is branched off in the respective line, i.e. in the kiln exhaust gas line, the bypass line or the exhaust air line,

35 in order to heat the heat-exchange medium in the associated additional heat exchanger and then to feed the heated heat-exchange medium to the heat exchanger upstream of the nitrogen oxide removal stage.

In order to be able to adapt the thermal energy required for the heat displacement system to the current operating status, it is advantageous if the branch is connected to an open-loop or closed-loop control means for
5 adjusting the volume flow rate of the kiln exhaust gases or the exhaust air from the clinker cooler in the branch. The open-loop or closed-loop control means can comprise a control unit commonly used in the prior art, with which a control or regulating valve adjusting the volume flow rate
10 in the branch is controlled.

In order to remove dust from the exhaust gas flow or exhaust air flow at high temperatures, it is advantageous if the hot gas filter comprises at least one filter element, preferably made of a ceramic material, through which kiln
15 exhaust gases or exhaust air from the clinker cooler can flow, a plurality of substantially vertical filter elements preferably being provided. Such hot gas filters are generally known in the prior art, reference being made for example to DE 19 713 068 A1.

20 In a preferred embodiment, the hot gas filter is connected to a discharge element for discharging dust separated at the filter element. A mechanical discharge element, for example a screw conveyor, is preferably provided, which is arranged beneath the filter element.

25 In order to secure the function of the hot gas filter in the continuous operation, it is advantageous if the hot gas filter comprises a supply for a clean gas for cleaning the filter element. In this embodiment, it is advantageous if the hot gas filter is provided with flaps at the clean
30 gas side, in order to clean the filter elements in the flow-free state and thus to lengthen the service life of the ceramic filter elements.

The invention will be explained in greater detail below using preferred examples of embodiment represented in the
35 drawing, to which however it is not intended to be limited. In detail, in the drawing:

Fig. 1 shows a diagram of a device according to the invention for producing cement clinker from raw meal with an

SCR nitrogen oxide removal stage, wherein a heat displacement system is provided to compensate for heat losses of a plate heat exchanger for heating the exhaust gases upstream of the nitrogen oxide removal, which heat displacement system comprises additional heat exchangers, connected to a heat exchanger upstream of the SCR nitrogen oxide removal stage, for utilising the heat of kiln exhaust gases or exhaust air from a clinker cooler, a hot gas filter for filtering the kiln exhaust gases or the exhaust air at temperatures of more than 450°C is being arranged in each case upstream of the additional heat exchangers.

Fig. 2 shows diagrammatically the nitrogen oxide removal stage of the device according to fig. 1, wherein the heat losses of the plate heat exchanger are compensated for with the heat exchanger of the heat displacement system; and

Fig. 3 shows diagrammatically an embodiment of the hot gas filter of the device according to fig. 1.

Fig. 1 shows a flow diagram of a device for producing cement clinker from raw materials in the form of raw meal, wherein the plant components known per se in the prior art are first described. The device comprises in particular a (rotary) kiln 3, in which the raw materials for producing the cement clinker are fired. Rotary kiln 3 is arranged between a clinker cooler 4 and a preheating stage 2. Preheating stage 2 comprises a plurality of cyclones (not shown), with which the raw materials are preheated. For this purpose, the raw materials are delivered via a material delivery point 14 into preheating stage 2. The raw material enters into rotary kiln 3 according to the counter-flow principle, while kiln exhaust gases or flue gases 1, arising during the firing, flow against the flow of the raw material through preheating stage 2. The materials are separated off by the cyclones, heated up to 800°C and transported in the direction of rotary kiln 3. Kiln exhaust gas 1 is simultaneously cooled from approx. 850°C down to 300°C to 400°C. Before the raw materials pass into rotary kiln 3, a so-called calciner (not shown in the figure) is installed in modern plants, which comprises a separate firing unit and

has the task of deacidifying the limestone through high temperatures and a sufficient dwell time. The raw materials are heated further in rotary kiln 3 and are finally sintered at material temperatures of up to 1600°C to form clinker, wherein typical clinker phases (calcium-aluminium-silicates) are formed.

After preheating stage 2, exhaust gases 1 are conveyed via a riser 15 ("down comer duct") into a raw mill 7, in which fresh raw material 10 is ground and dried before use in the process. Exhaust gases 1, which exit from preheating stage 2 at a temperature of 280 to 450°C, are used to dry the raw materials and fuels in raw mill 7. Arising raw meal 11 is fed to a homogenisation silo 13, which is connected to material delivery point 14 for preheating stage 2. After flowing through raw mill 7, the exhaust gases are conveyed into a filter stage 8 and dedusted. Filter stage 8 can be constituted by bag filters or electrostatic filters. Separated filter dust 12 is conveyed into homogenisation silo 13. Following filter stage 8, exhaust gases 1 dedusted and with the nitrogen oxide removed pass via a chimney 9 into the atmosphere.

As can further be seen from fig. 1, clinker 21 is discharged from rotary kiln 3, said clinker being cooled in clinker cooler 4 with fresh air down to 200°C. A major part of the fresh air is used in the process as secondary and tertiary air for the combustion and a part leaves the clinker cooler as exhaust air 24 at temperatures between 200°C and 500°C. Exhaust air 24 is finally discharged via an exhaust air chimney 6 into the atmosphere.

In modern cement works, conventional fuels such as coal dust, natural gas or heating oil are increasingly being replaced by alternative fuels. The effect of the increased use of alternative fuels is that the concentrations of alkalis or chlorides are increased in the production process. The physical properties of the chloride compounds are such that they evaporate in hot regions of the kiln and are transported with the exhaust gas into colder zones, where they are able to condense again on the hot meal.

Chloride circulations are subsequently formed, which can lead to blockages in the pipe lines. In order to remove the chloride loads, device 1 comprises a chloride bypass 16, to which a part of the flue gas exiting from rotary kiln 3 is fed at a temperature of for example approx. 1000°C thereby bypassing preheating stage 2. The hot exhaust gas is cooled in a quench stage 17 with fresh air 22 to approx. 400°C. The chlorides are predominantly bound to the dust. Bypass exhaust gas 18 can be conveyed into a second quench stage (not shown), with which the temperature of the bypass exhaust gas is reduced further, in order to enable efficient dedusting in a bag filter or electrostatic filter (not shown) at temperatures below 250°C. The cleaned bypass exhaust gas can then be carried away via a separate bypass exhaust gas chimney or via chimney 9 of rotary kiln 3.

As can further be seen from fig. 1, the device also comprises a nitrogen oxide removal stage 20, which is constituted as an, in itself, standard SCR plant (selective catalytic reduction) for converting nitrogen oxides NO_x into harmless compounds before discharge via chimney 9. For this purpose, nitrogen oxide removal stage 20 comprises at least one reduction catalytic converter 23, in which nitrogen oxides NO_x are partially converted into nitrogen N_2 and water H_2O by a suitable catalytic reaction. In order to increase the service life of nitrogen oxide removal stage 20, nitrogen oxide removal stage 20 is arranged between filter stage 8 and chimney 9.

As can be seen from fig. 2, a heat exchanger module 31 is arranged upstream of nitrogen oxide removal stage 20, with which heat exchanger module the kiln exhaust gases are brought, after dedusting, to the temperatures of usually 160°C to 550°C required for catalytic converter 23. In the shown embodiment, a plate heat exchanger is provided as a heat exchanger module 31, through which plate heat exchanger kiln exhaust gases 1 flow in one direction before the removal of their nitrogen oxide and through which kiln exhaust gases 1 flow in the other direction after the removal of their nitrogen oxide. The heat of outflowing kiln

exhaust gases 1 can thus be used to preheat inflowing kiln exhaust gases 1. The inevitable energy losses in heat exchanger module 31 have to be compensated for by an external energy source. In the embodiment shown, a heat exchanger 25 operated with a heat-exchange medium such as steam or thermal oil is provided as an energy source. Heat exchanger 25 is provided between heat exchanger module 31 and a device 30 for jetting-in and distributing a reducing agent.

Such devices for producing cement clinker are generally known in the prior art, wherein the device in the embodiment shown comprises additional plant components, which are to be explained below.

As can be seen from fig. 1, the device comprises additional heat exchangers 27', 27'', 27''', with which the heat from flows of exhaust gas 1 or exhaust air 24 from clinker cooler 4 is used for heating a heat-exchange medium, which is fed to heat exchanger 25 to compensate for the heat losses of heat exchanger module 31. Additional heat exchangers 27', 27'', 27''' are connected to heat exchanger 25 upstream of nitrogen oxide removal stage 20 via lines 28', 29'; 28'', 29''; 28''', 29''' transporting the heat-exchange medium. Lines 28', 29'; 28'', 29''; 28''', 29''' are constituted as circulation lines, which each comprise a supply line 28'; 28''; 28''' transporting the heated heat-exchange medium from additional heat exchanger 27', 27'', 27''' to heat exchanger 25 and a discharge line 29'; 29''; 29''' conveying the cooled heat-exchange medium from heat exchanger 25 to additional heat exchanger 27', 27'', 27'''.

As can be seen from fig. 1, the device in the shown embodiment in each case comprises a hot gas filter 26, 5, 19 in the flow direction of the gas flow concerned, i.e. the exhaust gas or the exhaust air from clinker cooler 4, directly upstream of additional heat exchanger 27', 27'', 27'''. For the purposes of this disclosure, the "direct" arrangement of hot gas filter 26, 5, 19 upstream of additional heat exchanger 27', 27'', 27''' is intended in particular to mean that the kiln exhaust gas flow or exhaust

air flow concerned, after dedusting in hot gas filter 26, 5, 19, is conveyed, without flowing through any other plant components, into additional heat exchanger 27', 27'', 27''', in order to deliver a part of the heat stored in kiln exhaust gases 1 or in the exhaust air from clinker cooler 4 to the heat-exchange medium.

As can be seen from fig. 1, a hot gas filter 26 is arranged upstream of an additional heat exchanger 27' in the kiln exhaust gas line between preheating stage 2 and a raw mill 7 for grinding the raw materials.

As can be seen from fig. 1, a hot gas filter 19 is also arranged upstream of an additional heat exchanger 27''' in bypass line 16 for the removal of chloride loads from a partial flow of the kiln exhaust gases.

As can be seen from fig. 1, an additional hot gas filter 5 is finally arranged upstream of an additional heat exchanger 27'' in the exhaust air line of clinker cooler 4.

Lines 28'', 29'' of additional heat exchanger 27'' in the exhaust air line of clinker cooler 4 and lines 28''', 29''' of additional heat exchanger 27''' in bypass line 16 can be brought together in junction portions with lines 28', 29' of additional heat exchanger 27' in the kiln exhaust gas line (not shown). Moreover, the kiln exhaust gas line and/or the bypass line and/or the exhaust air line can comprise a branch (not shown), with which only a partial flow of the respective flow of kiln exhaust gases or exhaust air is branched off to additional heat exchanger 27', 27'', 27'''. In this embodiment, the branch can be connected to an open-loop or closed-loop control means (not shown) for adjusting the volume flow rate of the kiln exhaust gases or the exhaust air from the clinker cooler in the branch.

As can be seen from fig. 3, hot gas filter 26 (the other hot gas filters 5, 19 are designed correspondingly) comprises a plurality of filter elements 32, through which the respective gas flow, here kiln exhaust gases 1, flow in order to separate the dust loads. Ceramic filter elements are provided in the shown embodiment. It can also be seen in fig. 3 that hot gas filter 26 is connected to a mechanical

discharge element 33 for discharging the dust separated at filter elements 32. Moreover, hot gas filter 26, 5, 19 can comprise a supply for a clean gas for cleaning filter elements 32 (not shown).

Patentkrav

- 1.** Indretning til fremstilling af cementklinker, med en ovn (3) til afbrænding af råmaterialer til cementklinker, med et forvarmningstrin (2) til forvarmning af råmaterialerne i en modstrøm til ovnrøggasser, med en klinkerkøler (4) til afkøling af cementklinkerne, med et denitreringstrin (23) til denitrering af ovnrøggasser, med en varmeveksler (25) til opvarmning af ovnrøggasser fra denitreringstrinnet (23) ved hjælp af varmeveksler med et varmevekslermedium, med mindst en yderligere varmeveksler (27', 27'', 27''') til opvarmning af varmevekslermediet ved hjælp af varmeveksler med ovnrøggasser eller afgangsluft fra klinkerkøleren (4), hvor varmeveksleren (25) via en ledning (28', 29'; 28'', 29''; 28''', 29''') til varmevekslermediet er forbundet med den yderligere varmeveksler (27', 27'', 27'''), **kendetegnet ved, at** et varmgasfilter (26, 5, 19) er indrettet i de yderligere varmeveksleres (27', 27'', 27''') strømningsretning.
- 2.** Indretning ifølge krav 1, **kendetegnet ved, at** et varmgasfilter (26) og en yderligere varmeveksler (27') er indrettet i en ovnrøggasledning mellem forvarmningstrinnet (2) og en råmølle (7) til formaling af råmaterialerne.
- 3.** Indretning ifølge krav 1 eller 2, **kendetegnet ved, at** et varmgasfilter (19) og en yderligere varmeveksler (27''') er indrettet i en omløbsledning (16) til fjernelse af chloridbelastninger fra en delstrøm af ovnrøggasserne.
- 4.** Indretning ifølge et hvilket som helst af kravene 1 til 3, **kendetegnet ved, at** et varmgasfilter (5) og en yderligere varmeveksler (27'') er indrettet i en afgangsluftledning i klinkerkøleren (4).
- 5.** Indretning ifølge et hvilket som helst af kravene 1 til 4, **kendetegnet ved, at** mindst to yderligere varmevekslere (27', 27'', 27''') med opstrøms varmgasfiltre (26, 5, 19) er tilvejebragt i ovnrøggasledningen og/eller i omløbsledningen (16) og/eller afgangsluftledningen i klinkerkøleren (4), hvor de mindst to yderligere varmevekslere (27', 27'', 27''') via afsnit af ledningen (28', 29'; 28'', 29''; 28''', 29''') til varmevekslermediet er forbundet med varmeveksleren (25) før denitreringstrinnet (23).

6. Indretning ifølge et hvilket som helst af kravene 1 til 5, **kendetegnet ved, at** ovnrøggasledningen og/eller omløbsledningen (16) og/eller afgangsluftledningen har en forgrening til forgrening af en delstrøm af ovnrøggasserne eller afgangsluften til de yderligere varmevekslere (27', 27", 27''').

5

7. Indretning ifølge krav 6, **kendetegnet ved, at** forgreningen er forbundet med en styre- eller reguleringsindretning til indstilling af volumenstrømmen af ovnrøggasser eller afgangsluft fra klinkerkøleren (4) i forgreningen.

10 **8.** Indretning ifølge et hvilket som helst af kravene 1 til 7, **kendetegnet ved, at** varmgasfilteret omfatter mindst et filterelement (32), hvorigennem ovnrøggasser eller afgangsluft fra klinkerkøleren (4) kan strømme, fortrinsvis fremstillet af et keramisk materiale, hvor fortrinsvis en flerhed af i alt væsentligt vertikale keramiske filterelementer (32) er tilvejebragt.

15

9. Indretning ifølge krav 8, **kendetegnet ved, at** varmgasfilteret (26, 5, 19) er forbundet med et udledningselement (33) til udledning af støv som er blevet opsamlet af filterelementet (32).

20 **10.** Indretning ifølge krav 8 eller 9, **kendetegnet ved, at** varmgasfilteret (26, 5, 19) omfatter en tilførsel af en rensset gas til rensning af filterelementet (32).

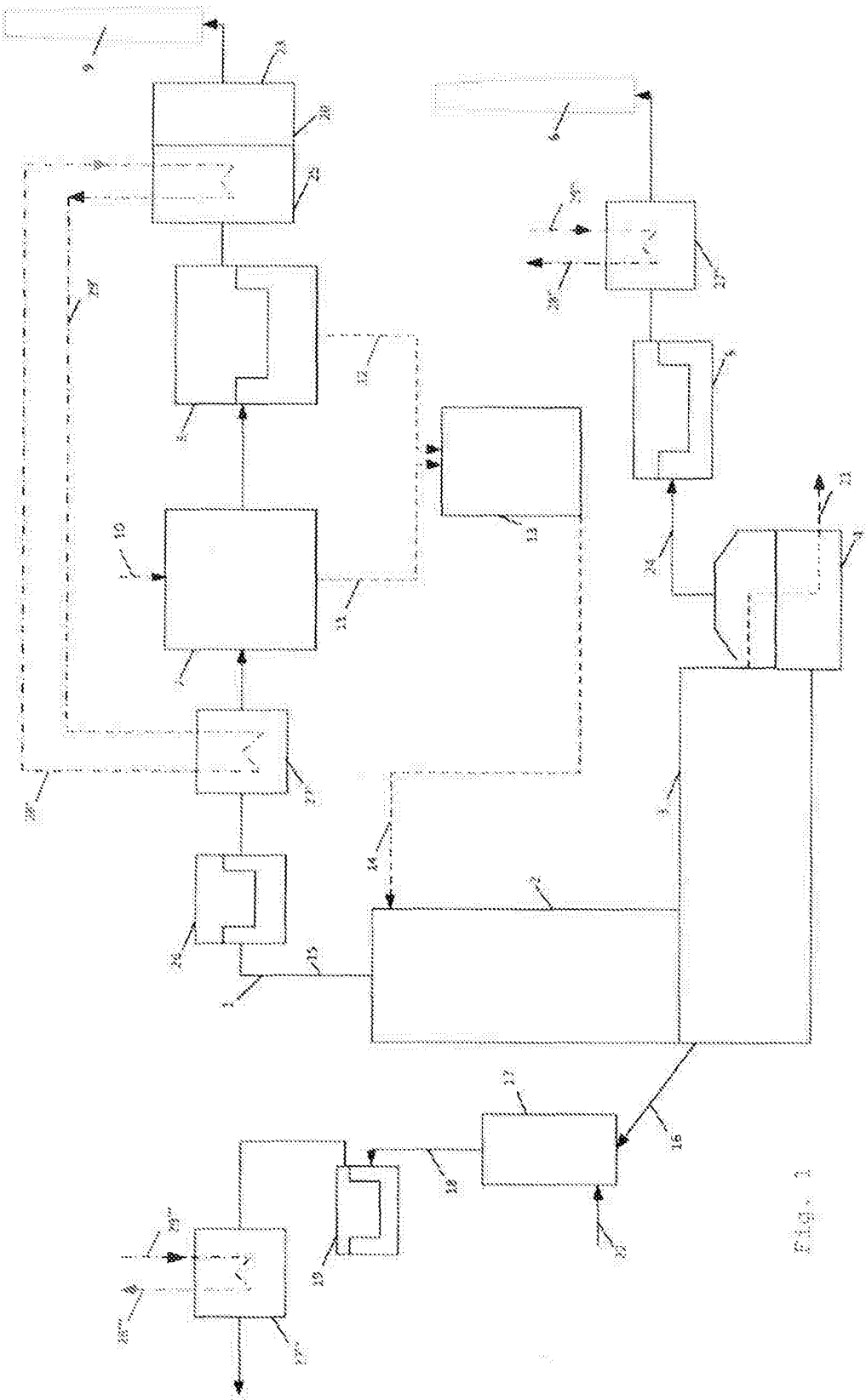


Fig. 1

2/3

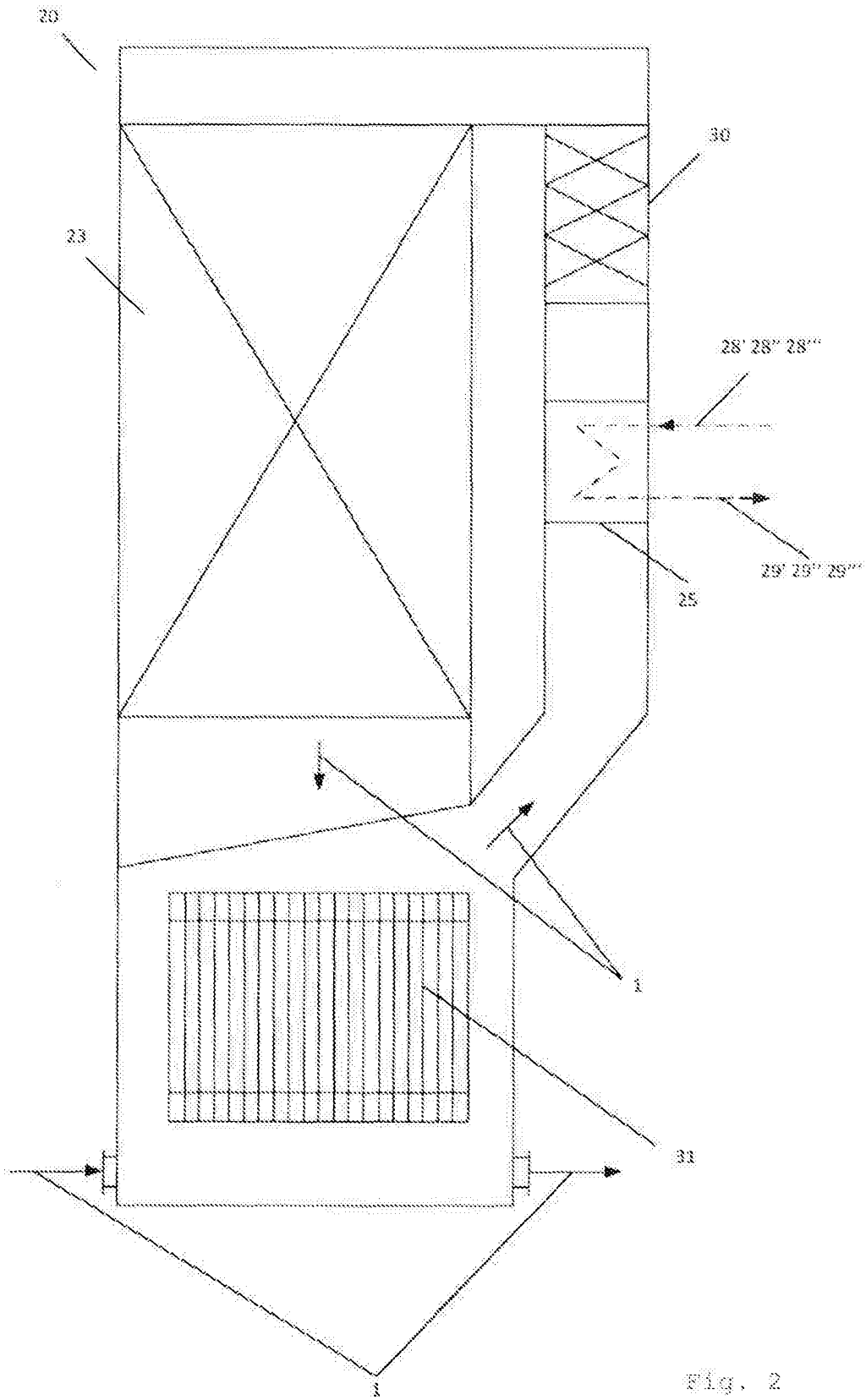


Fig. 2

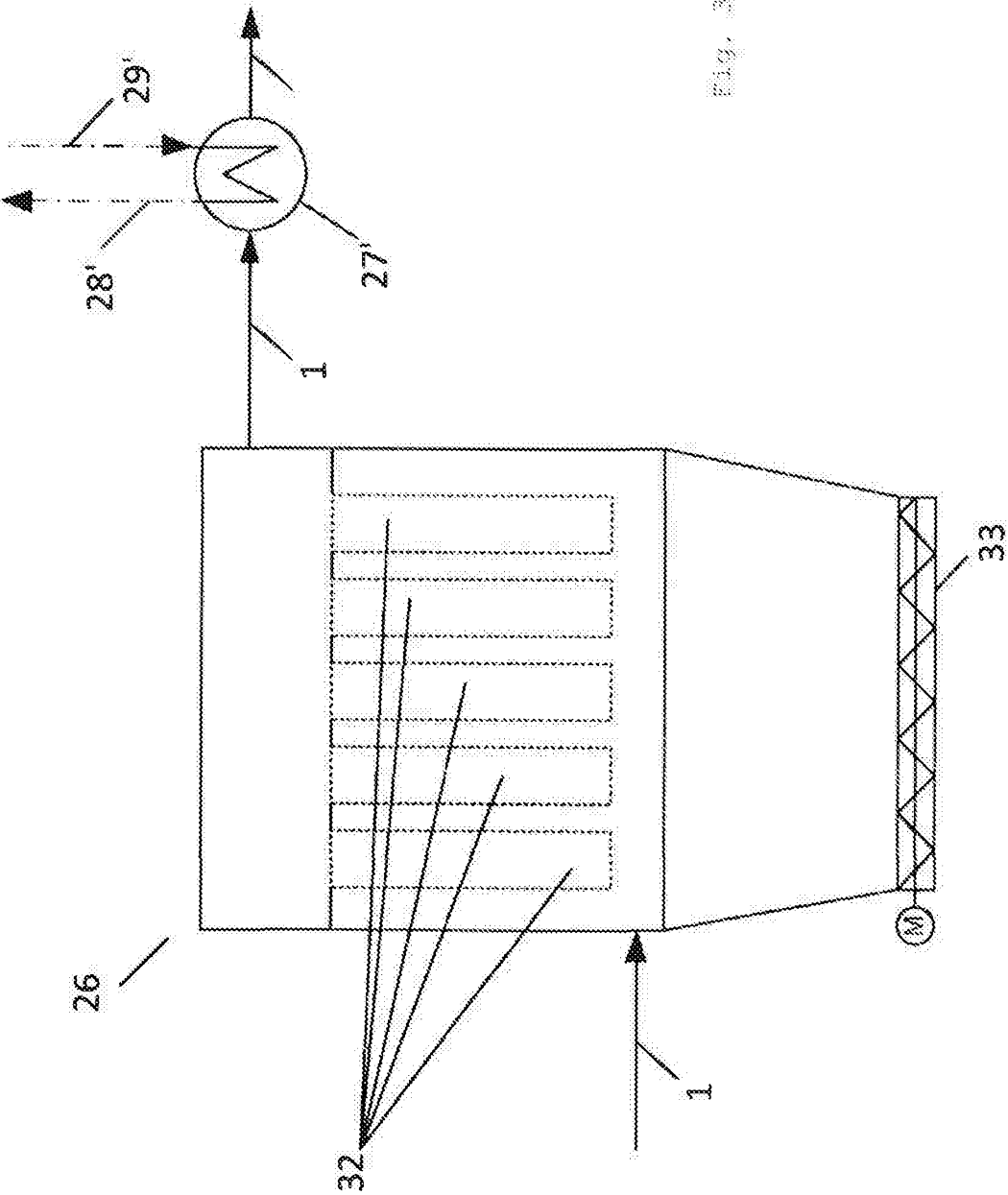


Fig. 3