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**(54) THE METHOD OF SIMULTANEOUS REMOVAL OF NO AND CARBON PARTICLES AND INORGANIC DUST FROM FLUE GASES AND CATALYTIC REACTOR FOR REMOVAL OF NO AND CARBON PARTICLES AND INORGANIC DUST FROM FLUE GASES**

VERFAHREN ZUR GLEICHZEITIGEN BESEITIGUNG VON NO- UND KOHLENSTOFFPARTIKELN UND ANORGANISCHEM STAUB AUS RAUCHGASEN UND KATALYTISCHER REAKTOR ZUR BESEITIGUNG VON NO- UND KOHLENSTOFFPARTIKELN UND ANORGANISCHEM STAUB AUS RAUCHGASEN

PROCÉDÉ D'ÉLIMINATION SIMULTANÉE DU NO, DES PARTICULES DE CARBONE ET DE LA POUSSIÈRE INORGANIQUE PRÉSENTS DANS DES GAZ DE COMBUSTION ET RÉACTEUR CATALYTIQUE PERMETTANT D'ÉLIMINER LE NO, LES PARTICULES DE CARBONE ET LA POUSSIÈRE PRÉSENTS DANS DES GAZ DE COMBUSTION

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**EP-A1- 2 311 549 US-A- 4 834 962**

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## Description

**[0001]** The subject of the invention is the method of nitric oxide (NO) removal from flue gases containing oxygen and the reactor for removal of NO, first of all from dusty flue gases which are generated by the stationary emission sources.

**[0002]** Hitherto the removal of NO from the dusty flue gases is carried out in this way, that the flue gases containing NO flow axially to the inlets of the channels of a monolithic catalyst and the flow is laminar. The catalyst is prepared using a ceramics, fire-resistant material or metal foil and it is covered by catalytic active substance. During laminar flow through the channels of the monolithic catalyst the flue gases come to contact with the catalyst and the chemical reactions occur. Reduction of NO to N<sub>2</sub> is the result of these reactions. Simultaneously the solid particles deposit on the surface of the monolithic catalyst and it is necessary to remove those particles periodically using a mechanical methods.

**[0003]** A catalytic reactor for cleaning the dust-free flue gases in which cleaning of gases occur almost evenly in central and outer part of the metallic monolithic catalyst is well-known from the description of the Japanese patent No. 2006-196988. In the appliance, a magnetic substance and catalytically active substance are contained in a layers created on surface of the channels of a metallic monolith. The monolith is cylindrical or elliptical or quadrangular and it is made out of undulating austenitic stainless steel. On the outer side of the monolithic catalyst a stable magnet is placed or a magnetic field generator. The monolithic catalyst is located in a casing, which is made of non-magnetic material with high thermal resistance. The casing is located between the stable magnet or the magnetic field generator and the monolithic catalyst, which is enveloped by a ceramic fibre mat. The mat is a thermal insulator of heat transported from cleaned gases to the stable magnet or the magnetic field generator. The cleaned flue gases are directed to an inlet cross-section of the monolithic catalyst using a flue gas channel. The geometric axis of the flue gas channel and the geometric axis of the monolithic catalyst overlap. A diffuser is installed at the end of the flue gas channel and it is a coupler between the flue gases channel and the metallic casing of the monolithic catalyst. The flue gases are cleaned as a result of a chemical reaction proceeding on the catalyst during their flow through the channels of the monolithic catalyst created from an undulating metallic foil.

**[0004]** The European Patent Application No. EP 2311549 discloses an air pollution control apparatus which has a denitration catalyst layer that removes nitrogen oxides in flue gas, and atomizes hydrochloric acid into flue gas to oxidize mercury, and also includes a swirling-flow generating member including a vertical axis provided in a passage of a honeycomb catalyst, and four swirling-flow generating vanes provided radially with respect to the vertical axis for generating a turbulent flow

in flue gas, with the swirling-flow generating vanes being arranged in a direction of the vertical axis with a predetermined gap therebetween. With this configuration, by generating a swirling flow in flue gas in the passage in the denitration catalyst layer, a contact time between flue gas and a denitration catalyst can be increased, and the oxidation reaction efficiency between mercury in flue gas and the denitration catalyst can be improved.

**[0005]** US Patent Application No. US 4,834,962 discloses a process for the catalytic gaseous phase reaction of a reactive gas wherein the heat of reaction generated produces a temperature elevation of less than about 150°C in the substantially adiabatic reaction system, the improvement comprising: heating the cold reactive gas by passing it through a heated regenerative material present in the first portion of a vessel; passing the heated reactive gas through a solid catalyst for the reaction present in a second portion of the vessel to form a gaseous product stream; redirecting the gaseous product stream; passing the redirected gaseous product stream through the solid catalyst for the reaction present in the second portion of the vessel to form additional gaseous product, cooling the gaseous product stream by passing it through a cooled regenerative material present in the first portion of the vessel; and periodically reversing the flow direction in the portions of the reaction system.

**[0006]** The aim of the invention is the method and the reactor for the direct removal of nitric oxide from the dusty flue gases allowing for simultaneous efficient decomposition of nitric oxide and systematic removal of solid particles, especially carbonic particles.

**[0007]** The method of the flue gases cleaning according to the invention consists in simultaneous removal of NO and the solid particles from the flue gases as well as in the possible combustion of the carbon particles carried by the flue gases. Those processes proceed due to repeated contacts of the flue gases and the dust with the surfaces containing the active catalyst. The contacts are ensured by the changes of the flue gases jet flow direction in the reactor.

**[0008]** The removal of nitric oxide and the solid particles from the dusty flue gases according to the invention is performed in the reactor with the catalyst for direct decomposition of nitric oxide deposited on metallic monolith. According to the method of the invention the dusty flue gases enter the reactor tangentially to a circumference. It causes a rotational flow of the flue gases downwards. The flow undergoes disturbance because of the contact of the flue gases jet with undulating surface of the metallic foil placed on an internal wall of the reactor chamber and a split of the flue gases jet due to contact with a spiral band of the foil. The surface of the metallic foil placed on internal wall of reactor chamber as well as the surface of the spiral band are covered by the active component of the catalyst. Afterwards flue gases jet is directed countercurrently to a cylindrical inner chamber, in which the slices of the monolithic catalyst are installed and the laminar flow of the flue gases is disturbed. In the

course of the cleaning process the falling solid particles are accumulated on a bottom of the reactor.

**[0009]** The preferred disturbance of flue gases laminar flow in the inner chamber of the reactor is achieved by spacers present between parallel slices of the monolithic catalyst in the reactor or by nonparallel location of the slices of the monolithic catalyst.

**[0010]** Preferably, the porous slices of the monolithic catalyst with variable porosity are used. The preferred temperature in the reactor is in the range of 150°C - 450°C. Preferably an oxide catalyst made by direct oxidation of the foil, especially of the acid-proof austenitic steel foil is used. The catalyst in the most favourable form contains the phase with  $\alpha\text{Fe}_2\text{O}_3$  structure and the phases with spinel structure having the lattice parameters closed to those of  $\text{NiFe}_2\text{O}_4$  or the spinel phases only. The phases create microcrystallities, which contain Cr and Mn additionally and possibly also Si (Polish patent application P. 395905). Using this kind of a catalyst it's possible to remove simultaneously the nitric oxide, the solid particles and to combust the carbon particles contained in the dust transported in the flue gases jet.

**[0011]** The catalytic reactor for removal of nitric oxide and the carbon particles and the inorganic dust from dusty flue gases according to the invention comprises the catalyst on the metallic support for the direct removal of nitric oxide. The reactor is at least partially cylindrical and is equipped with a thermal insulation and its inlet is located in an upper part in such a way, that the flue gases are introduced tangentially to the reactor circumference. The upper part contains a chamber with an undulating inner surface, which is covered by an active catalyst phase. The spiral band made of acid-proof steel foil and covered by the active phase of the catalyst is located inside of the chamber with the undulating inner surface and moreover the spiral band falls downwards. There is an inner chamber heated with an inner heater in the geometric axis of the chamber with the undulating inner surface. The slices of the monolithic catalyst are installed in that chamber. The reactor is equipped with a casing containing two cylindrical coaxial walls with an insulating material between them. A casing heater adjoins at least to a part of the inner wall of the casing. In the lower part of the reactor a tight closure is located and it is simultaneously a dust container.

**[0012]** Preferably, the catalyst is also located on the outer surface of the inner chamber.

**[0013]** It is possible to locate slices of the catalyst parallel towards each other and vertically towards the reactor axis. In this case the directing spacers are installed between the slices of the monolith catalyst. The shape of the directing spacers induces the rotational flow of the flue gas jet. The most preferred is the shape of a propeller or similar to the shape of the propeller.

**[0014]** If the front of the monolithic slices of the catalyst is located in such a way, that the ratio of the distance L measured from the inlet to the heated chamber of the slices of the monolithic catalyst to the inner diameter d

of the heated chamber of the slices of the monolithic catalyst  $L/d > 50$ , then the directing spacer is being set in front of the inlet to the slice of the monolithic catalyst. But if the ratio  $L/d < 50$ , then the directing spacer is not being set before inlet to the porous support of the catalyst.

**[0015]** It is possible to situate the slices of the monolithic catalyst at an angle towards other slices and towards the axis of the reactor.

**[0016]** Preferably, there is an additional heater in axis 10 of the heated chamber of the slices of the monolithic catalyst located.

**[0017]** Preferably, the reactor has a cylindrical shape in the part, where the cylindrical chamber with undulating surface is located, and a conical shape in the remaining 15 part. The chamber with undulating surface may be in contact with the internal wall of the reactor casing.

**[0018]** The method and the reactor according to the invention are designed especially for the removal of NO and carbonic particles and inorganic dust from flue gases 20 created in the stationary emission sources.

**[0019]** Multi-stage process of the decomposition of nitric oxide and the removal of the solid particles occurs in the reactor according to the invention. Flue gases in the reactor come to contact with the catalyst located on the 25 metallic surfaces. They simultaneously direct the flow of flue gases, making a countercurrent arrangement of the jets in the reactor. The first stage of the catalytic reactor is the chamber with undulating inner surface, the second one is the spiral band. The spiral band forms a spiral flow 30 of flue gases around its geometrical axis, directing flue gases downwards of the reactor, besides the catalytic performance. The change of the direction of flue gases flow causes removal of the solid particles from the cleaned flue gases jet and increases an inlet effect in the 35 slices of the monolithic catalyst. Removal of the dust containing the solid particles from flue gases jet is caused by the flow of the gaseous jet according to a curved trajectory. Dust from the flue gases comes to the contact with the catalyst located on the surface of the first stage 40 of the multistage catalytic reactor and while it is falling down under influence of the gravitational force, it is being removed from the flue gases jet and moreover the carbonic particles contained in the dust are totally oxidized due to the activity of the catalyst, if the catalyst contained 45 in the reactor enables the oxidation process.

**[0020]** The flue gases jet with lower contents of the solid particles flows to the heated chamber of the slices of the monolithic catalyst. The inlet to the heated chamber of the slices of the monolithic catalyst, which is next stage 50 of the multistage catalytic reactor is located in the lower part of the cylindrical chamber with undulating inner surface and the spiral band in such a way, that the cleaned flue gases change the flow direction turning back to the heated chamber of the slices of the monolithic catalyst and countercurrently come to the reactor inlet being already cleaned in a significant degree from the dust contained in the inlet flue gases of the reactor. In the inner chamber of the multistage catalytic reactor the slices of 55

the monolithic catalyst are installed and the cleaned flue gases flow through their channels. Gas flowing in countercurrent continuously comes into the contact with the catalyst causing its cleaning, but to make the contact easier and to increase a purity degree of the flue gases, the flow of the flue gases jet in the last stage of the multi-stage catalytic reactor is subjected to often changes of the direction, forcing the cleaned flue gases jet into an alternating rotational or rectilinear flow. The change of the direction of the flow is achieved by means of the directing spacers or due to location of the slices of the monolithic catalyst at an angle towards the plane of the cross-section of the reactor. The directing spacer is never located on the outlet of the last slice of the monolithic reactor. Flow of the cleaned gas through the slices of the monolithic catalyst depends on the shape and area of the cross-section of their channels, which are variable in an preferred version. The change of the direction of the flow of cleaned flue intensifies contact between dusty gas and the catalyst. The dust removed from flue gases jet is collected in a tight closure of the reactor and it is periodically removed from the tight closure of the reactor. During normal exploitation of the reactor the tight closure does not allow for an entrainment of the air from environment.

**[0021]** The method and the reactor according to the invention enable intensive, continuous contact of flue gases with highly developed surface of the catalyst and assure changeability of the flue gases flow direction. The contact of the flue gases with the catalyst located on the surface of the channels is facilitated due to very often changes of the flow direction of flue gases simultaneously enabling of the removal of dust from the flue gases jet.

**[0022]** The examples of reactor structure according to the invention are shown on the schematic drawings. A longitudinal-section and cross-section of the reactor are shown in fig. 1 for the ratio  $L/d < 50$ . The longitudinal-section of the reactor for ratio  $L/d > 50$  is shown in fig. 2. The spiral band, which is performed in one part is shown on fig. 3. The spiral band, which is prepared in separate parts is shown in fig. 4. The directing spacer is shown in fig. 5. The slices of the monolithic catalyst installed under the various angles are shown in fig. 6. The slices of the monolithic catalyst situated parallel towards each other are shown in fig. 7. And the slices of the monolithic catalyst with various sizes of their cross-section are shown in fig. 8.

**[0023]** The example of the reactor structure according to the invention is made out for ratio of the dimensions  $L/d < 50$ . The dusty gas generating in a stable emission source is supplied using feeding channel 1 which is thermally insulated from environment impact and the gas is introduced using the dusty gas inlet 2 tangentially to the surface of the cylindrical chamber with the undulating inner surface 3 for removal of NO and solid particles as well as for the oxidation of carbonic particles presented in dust transported by the gaseous jet. The catalyst enabling the removal of NO from the gaseous mixture and

oxidation of carbonic particles occurs on the undulating cylindrical surface prepared using acid-proof austenitic steel foil. The oxide phases created on the acid-proof austenitic steel foil by oxidation are liable to arise as the catalyst. Inside the cylindrical and undulating chamber 3 the spiral band 4 made of the austenitic acid-proof steel covered by the oxide phases is located and it is falling downwards of the chamber 3 and it is the support of the catalyst for removal of NO and for the oxidation of carbonic particles contained in the dust. The spiral band may be prepared as one part or it may be prepared from separate parts creating the band, as it is shown on fig. 4, but distances between the individual bond parts should not overlap according to the band pitch. The spiral band 4 is stretched out on the band frame 15. The cylindrical and undulating reactor chamber 3 is placed in the casing composed of the cylindrical part 5a and the conical part 5b. The casing contains thermal insulation, e.g. a light heat-resistant insulating material, and the insulation is placed between the two coaxial walls: the outer casing wall 6a and the inner casing wall 6b but the heater 7 of the casing is in touch with the inner casing wall 6b. The conical part 5b of the reactor in its lower part is equipped with the tight closure 8, which is simultaneously a periodically cleaned dust container. In the geometrical axis of the cylindrical undulating chamber 3 a heated chamber of the slices of the monolith catalyst 9 is placed and its surface are covered by the active component of the catalyst. In the heated chamber of the slices of the monolith catalyst 9 the slices of the monolithic catalyst 10 and/or 16 are located and they are of different area of the channel cross-sections. The slices of the monolithic catalyst 10 and/or 16 are covered by the same active component of the catalyst as the cylindrical chamber of the reactor with undulating surface 3 and the spiral band 4.

**[0024]** If the ratio  $L/d < 50$  the directing spacer 11, shown on fig. 5, is not situated in the front of the inlet to porous support of the catalyst 10 and/or 16. The directing spacer 11 consists of the blades 17, which are sloped at small angle towards level and fastened between the outer ring 18 and the inner ring 19. On the wall of heated chamber of the slices of the monolithic catalyst 9 the chamber heater 12 is installed. In the geometrical axis of the heated chamber of the slices of the monolithic catalyst 9 an additional axial heater 13 is located. The heated chamber of the slices of the monolithic catalyst 9 is equipped with the gaseous outlet 14. The slices of the monolithic catalyst 10 may be placed under the various angles  $\alpha$  (alpha) or  $\beta$  (beta) towards the axis of the heated chamber of the slices of the monolith catalyst 9 as it is shown in fig. 6, in order to attain a change of the flow direction for achieving an effect of inlet flow to the slice of the monolith catalyst. At the time the directing spacers 11 are not applied. The channels 20 in slice of the monolithic catalyst are shown in fig. 6. The change of the flow direction before the inlet to the slices of the monolithic catalyst is achieved when the slices of the monolithic reactor are parallel towards themselves, but under angle  $\alpha$  (alpha) towards the axis

of the heated chamber of the monolithic slices of the catalyst 9, as it is shown in fig. 7. There is a space filled by the flue gases jets between the slices of the monolithic catalyst 10 with both arrangement of the slices of the monolith catalyst 10 shown in figs. 6 and 7.

**[0025]** The example of the structure of the reactor according to the invention shown in fig. 2 is designed for the case of the dimensions ratio  $L/d > 50$ . The difference in the example of the structure shown in fig. 2 in comparison with the structure shown in fig. 1 is in the location of the directing spacer 11 in the front of the inlet to the porous slice of the monolithic catalyst 10 or 11, when the front of the porous support of the catalyst 10 is in position that the ratio  $L/d > 50$ .

**[0026]** In both the cases of the realization the length of the heated chamber of the slices of the monolithic catalyst 9 should be as long as possible in order to achieve maximum distance for the flow of the flue gases.

**[0027]** It is possible to apply the slices of the monolithic catalyst 16 with the area cross-sections of the channels different from the area cross-sections of the channels of the slices of the monolithic catalyst 10, that is seen in fig. 8.

**[0028]** The slices of the monolithic catalyst 10 are of the same or the various shapes and dimensions of the channels cross-sections and each chamber may contain the slices of the monolithic catalyst with the various shapes and cross-sections.

## NOTATION

### [0029]

- 1 - feeding channel
- 2 - dusty gas inlet
- 3 - cylindrical chamber of reactor with undulating inner surface
- 4 - spiral band
- 5a - cylindrical part of casing
- 5b - conical part of casing
- 6a - outer casing wall
- 6b - inner casing wall
- 7 - heater
- 8 - tight closure
- 9 - heated chamber of the monolith slices of catalyst
- 10 - slice of monolithic catalyst
- 11 - directing spacer
- 12 - chamber heater
- 13 - axial heater
- 14 - gas outlet
- 15 - band frame
- 16 - slice of monolith catalyst with variable shape and dimensions of cross - section of the channels
- 17 - blade
- 18 - outer ring
- 19 - inner ring
- 20 - channel of slice of a monolithic catalyst

## Claims

1. Method of simultaneous removal of NO and carbonic particles and inorganic dust from flue gases in the reactor equipped in a catalyst for direct decomposition of nitric oxide located on a metallic monolith, is characterized by: the flue gases flow tangentially to the reactor circumference generates rotational flow of flue gases downwards of the reactor with simultaneous disturbance of the flow due to contact of the flue gases jet with undulating surface of metallic folic covered by an active component of the catalyst, located circumferentially on the inner casting wall (6b) of the reactor chamber and division of the flue gases jet due to contact with the catalyst occurring on a spiral band (4) falling to the lower part of the reactor, and next the flue gases jet is directed countercurrently to a cylindrical heated chamber of monolith slices of catalyst (9) and laminar flow of the flue gases jet is disturbed, but the deposited solid particles of pollutants are removed from lower part of the reactor.
2. The method according to claim 1 is characterized by: disturbance of the flue gases laminar flow in the heated chamber of monolith slices of catalyst (9) is achieved by placing the directing spacer (11) between parallel slices of monolithic catalyst (10).
3. The method according to claim 1 is characterized by: disturbance of flue gases laminar flow in the heated chamber of monolith slices of catalyst (9), which is achieved by nonparallel arrangement of the slices of monolithic catalyst (10) in relation to each other.
4. The method according to claim 1 is characterized by: the slices of monolithic catalyst (10) with various shapes and dimensions are applied.
5. The method according to claim 1 is characterized by: the temperature inside the reactor is maintained between 150°C to 450°C.
6. The method according to claim 1 is characterized by: simultaneous removal of nitric oxide and burn-up of carbonic particles contained in the dust transported by the flue gases.
7. The method according to claim 1 is characterized by: removal of nitric oxide originating from the stationary emission sources.
8. The catalytic reactor for removal of NO and carbonic particles and inorganic dust from flue gases, containing the slices of the monolithic catalyst for direct removal of nitric oxide having at least partially cylindrical shape with thermal insulation, with inlet located in the upper part and generating tangential introduc-

- tion of dusty gas into the reactor is **characterized by:** the cylindrical chamber with undulating inner surface (3), with an active phase of the catalyst, located in the upper part of the reactor and inside the chamber (3) with undulating inner surface a spiral band (4) falling towards lower part with applied of active component of the catalyst on its surface is located, whereas in the geometric axis of the cylindrical chamber of reactor with undulating inner surface (3) a heated chamber of monolith slices of catalyst (9) by a chamber heater (12) is situated and the slices of monolithic catalyst (10) and/or (16) are placed in the heated chamber of monolith slices of catalyst (9), moreover the reactor is equipped with a casing with two coaxial walls (6a) and (6b) and a heat resistant material is placed between the walls (6a) and (6b), but a heater (7) is in touch with at least a part of the wall of the inner casing wall (6b) while in the lower part of the reactor a tight closure (8) is located and it is simultaneously a dust container.
9. The reactor according to claim 8 is **characterized by:** presence of the active component of the catalyst on the outer wall of heated chamber (9).
10. The reactor according to claim 8 is **characterized by:** the slices of monolithic catalyst (10) are situated parallel towards themselves and vertically to axis of the reactor.
11. The reactor according to claim 8 or 10 is **characterized by:** the directing spacers (11) are located between the slices of monolithic catalyst (10).
12. The reactor according to claim 11 is **characterized by:** the shape of the directing spacers (11), which forces rotational flow of flue gases jet.
13. The reactor according to claim 12 is **characterized by:** the shape of the directing spacers (11) is similar to a propeller.
14. The reactor according to claim 8 is **characterized by:** axial heater (13), which is located in the axis of heated chamber of monolith slices of catalyst (9).
15. The reactor according to claim 8 is **characterized by:** directing spacer (11) located in front of the inlet to slice of monolithic catalyst (10) when the front of the slice of monolithic catalyst (10) is in the position that the ratio  $L/d > 50$ , but when the ratio  $L/d < 50$  then the directing spacer (11) is not situated before the inlet to the slice of monolithic catalyst (10).
16. The reactor according to claim 8 is **characterized by:** the slices of monolithic catalyst (10) are positioned in angle to each other and towards the axis of the reactor.
17. The reactor according to claim 8 is **characterized by:** inner casing wall (6b) is in touch with cylindrical chamber of reactor with undulating inner surface (3).
- 5 18. The reactor according to claim 8 is **characterized by:** the cylindrical part in which cylindrical chamber of reactor with undulating inner surface (3) is located and the remaining part is conical.
- 10 19. The reactor according to claim 8 is **characterized by:** the using for simultaneous removal of nitric oxide from flue gases, burn-up of carbonic particles contained in dust transported by flue gases and removal of inorganic dust.
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- Patentansprüche**
1. Verfahren zur gleichzeitigen Entfernung von NO- und Kohlepartikeln, sowie von anorganischem Staub aus Rauchgasen im Reaktor, der mit einem auf einem metallischen Grundkörper angeordneten Katalysator für direkte Zersetzung von Stickstoffoxid ausgestattet ist, **dadurch gekennzeichnet, dass** die Rauchgasesströmung, tangential zum Reaktorumfang, eine Rotationsströmung von Rauchgasen absteigend im Reaktor erzeugt, mit gleichzeitiger Aufwirbelung der Strömung wegen des Kontakts des Rauchgasstroms mit einer gewellten Fläche von metallischen Folie, die mit einer aktiven Katalysatorkomponente bedeckt ist und umlaufend an der inneren Gehäusewand (6b) der Reaktorkammer angeordnet ist, und mit einer Aufteilung des Rauchgasstroms wegen des Kontakts mit dem Katalysator, die am Spiralband (4) auftritt, das den Reaktor hinunter fällt, und anschließend wird der Rauchgasstrom zu einer zylindrischen beheizten Kammer aus monolithischen Katalysatorscheiben (9) gegenläufig weitergeleitet und laminarer Strom von Rauchgasen gestört, aber die abgeschiedenen festen Schmutzpartikeln vom unteren Teil des Reaktors entfernt werden.
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2. Verfahren nach Anspruch 1 **dadurch gekennzeichnet, dass** die Störung der laminaren Strömung von Rauchgasen in der beheizten Kammer aus monolithischen Katalysatorscheiben (9) mithilfe von Lenkabstandhalter (11) zwischen parallelen Scheiben des monolithischen Katalysators (10) erreicht wird.
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3. Verfahren nach Anspruch 1 **dadurch gekennzeichnet, dass** die Störung der laminaren Strömung von Rauchgasen in der beheizten Kammer aus monolithischen Katalysatorscheiben (9), die mithilfe der nicht parallelen Anordnung von den Scheiben des monolithischen Katalysators (10) zueinander erreicht wird.
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4. Verfahren nach Anspruch 1 **dadurch gekennzeichnet, dass** die Scheiben des monolithischen Katalysators (10) mit verschiedenen Formen und Abmessungen verwendet werden.
5. Verfahren nach Anspruch 1 **dadurch gekennzeichnet, dass** die Temperatur innerhalb des Reaktors zwischen 150°C und 450°C gehalten wird.
6. Verfahren nach Anspruch 1 **dadurch gekennzeichnet, dass** gleichzeitige Entfernung von Stickstoffoxid und Verbrennung von Kohlepartikeln, die in dem Staub enthalten sind, der durch die Gase befördert wird.
7. Verfahren nach Anspruch 1 **dadurch gekennzeichnet, dass** das Stickoxid, das von den stationären Emissionsquellen stammt, entfernt wird.
8. Katalytischer Reaktor zur Entfernung von NO und von Kohlepartikeln, sowie von anorganischem Staub von Rauchgasen, der Scheiben des monolithischen Katalysators für direkte Entfernung von Stickstoffoxid enthält, mindestens teilweise zylindrische Form mit Wärmedämmung aufweist, mit einem Einlauf im oberen Teil, der die tangentiale Einführung von Staubgasen in den Reaktor generiert, **dadurch gekennzeichnet, dass** die zylindrische Kammer mit gewellter Innenfläche (3), mit einer aktiven Katalysatorphase, angeordnet im oberen Teil des Reaktors, und innerhalb der Kammer (3) mit einer gewellten Innenfläche eine Spiralband (4) angeordnet ist, das zum unteren Teil herunter fällt, mit der auf ihrem Oberfläche ausgetragenem aktiven Katalysatorkomponente, während in der geometrischen Achse der zylindrischen Kammer des Reaktors mit gewellter Innenfläche (3) eine beheizte Kammer aus monolithischem Katalysatorscheiben (9) bei einer Kammerheizung (12) angeordnet ist und die monolithischen Katalysatorscheiben (10) und/oder (16) sich in der beheizten Kammer aus monolithischen Katalysatorscheiben (9) befinden, darüber hinaus ist der Reaktormit einem Gehäuse mit zwei koaxialen Wänden (6a) und (6b) und mit einem hitzebeständigen Material versehen, das zwischen den Wänden (6a) und (6b) angeordnet ist, aber die Heizung (7) berührt mindestens einen Teil der Gehäuseinnenwand (6b), wobei im unteren Teil des Reaktors sich ein dichter Verschluss (8) befindet, der gleichzeitig ein Staubbehälter ist.
9. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** die aktive Katalysatorkomponente an der Außenwand der beheizten Kammer (9) vorhanden ist.
10. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** die monolithischen Katalysatorscheiben
- 5 (10) zueinander parallel und zur Reaktorachse vertikal angeordnet sind.
11. Reaktor nach Anspruch 8 oder 10 **dadurch gekennzeichnet, dass** die Lenkabstandhalter (11) zwischen den monolithischen Katalysatorscheiben (10) angeordnet sind.
- 10 12. Reaktor nach Anspruch 11 **dadurch gekennzeichnet, dass** die Form von Lenkabstandhalter (11), die die Rotationsströmung der Rauchgasstroms erzwingt.
- 15 13. Reaktor nach Anspruch 12 **dadurch gekennzeichnet, dass** die Form der Lenkabstandhalter (11) einem Propeller ähnlich ist.
- 20 14. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** eine axiale Heizung (13) in der Achse der beheizten Kammer aus monolithischen Katalysatorscheiben (9) angeordnet ist.
- 25 15. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** vor dem Einlauf zur monolithischen Katalysatorscheibe (10) ein Lenkabstandhalter (11) angeordnet ist, wenn die Vorderseite der monolithischen Katalysatorscheibe (10) sich in der Stellung befindet, in der L/d > 50, aber wenn L/d < 50, dann ist der Lenkabstandhalter (11) nicht vor dem Einlauf zur monolithischen Katalysatorscheibe (10) angeordnet.
- 30 16. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** die monolithischen Katalysatorscheiben (10) zueinander und gegenüber der Achse des Reaktors unter einem Winkel geneigt angeordnet sind.
- 35 17. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** die innere Gehäusewand (6b) die zylindrische Reaktorkammer mit einer gewellten Innenfläche (3) berührt.
- 40 18. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** den zylindrischen Teil, in dem eine zylindrische Reaktorkammer mit gewellter Innenfläche (3) angeordnet ist und der verbleibende Teil konisch ist.
- 45 19. Reaktor nach Anspruch 8 **dadurch gekennzeichnet, dass** die Verwendung für gleichzeitiger Entfernung vom Stickstoffoxid aus Rauchgasen, Verbrennung von Kohlepartikeln, die im durch Rauchgase befördertem Staub enthalten sind sowie Entfernung von anorganischem Staub.
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**Revendications**

1. Procédé d'élimination simultanée de NO et de particules carboniques et de poussières inorganique des gaz de combustion dans le réacteur équipé d'un catalyseur pour la décomposition directe de l'oxyde nitrique situé sur un monolithe métallique, est **caractérisé par**: les gaz de combustion s'écoulant tangentielle à la circonférence du réacteur génèrent un flux rotatif des gaz de combustion vers le bas du réacteur avec une perturbation simultanée du flux due au contact du jet des gaz de combustion avec la surface ondulante du film métallique couverte par un composant actif du catalyseur, situé circonférentiellement sur la paroi intérieure du boîtier (6b) de la chambre du réacteur et division du jet des gaz de combustion en raison du contact avec le catalyseur se produisant sur une bande en spirale (4) tombant à la partie inférieure du réacteur, puis le jet des gaz de combustion est dirigé à contre-courant vers une chambre cylindrique chauffée des tranches monolithes de catalyseur (9) et flux laminaire du jet des gaz de combustion est perturbé, mais les particules solides des polluants déposées sont évacuées de la partie inférieure du réacteur.
2. Procédé selon la revendication 1, **caractérisé en ce que**: la perturbation du flux laminaire des gaz de combustion dans la chambre chauffée des tranches monolithes de catalyseur (9) est obtenue en plaçant l'espaceur (11) de direction entre des tranches parallèles de catalyseur monolithique (10).
3. Procédé selon la revendication 1, **caractérisé par**: la perturbation du flux laminaire des gaz de combustion dans la chambre chauffée des tranches monolithiques de catalyseur (9), ce qui est obtenu par un agencement non parallèle des tranches de catalyseur monolithique (10) les unes par rapport aux autres.
4. Procédé selon la revendication 1, **caractérisé par**: les tranches de catalyseur monolithique (10) de formes et de dimensions variées sont utilisées.
5. Procédé selon la revendication 1, **caractérisé par**: la température à l'intérieur du réacteur est maintenue entre 150°C et 450°C.
6. Procédé selon la revendication 1, **caractérisé par**: l'élimination simultanée de l'oxyde nitrique et la combustion de particules carboniques contenues dans la poussière transportée par les gaz de combustion.
7. Procédé selon la revendication 1, **caractérisé par**: l'élimination de l'oxyde nitrique provenant des sources stationnaires d'émission.
8. Réacteur catalytique pour l'élimination de NO et de particules carboniques et de poussière inorganique des gaz de combustion, contenant les tranches du catalyseur monolithique pour l'élimination directe d'oxyde nitrique ayant une forme au moins partiellement cylindrique avec isolation thermique, avec entrée située dans la partie supérieure et générant introduction tangentielle de gaz poussiéreux dans le réacteur, est **caractérisé par**: la chambre cylindrique avec une surface interne ondulée (3), avec un phase active du catalyseur, située dans la partie supérieure du réacteur et à l'intérieur de la chambre (3) avec surface interne ondulée, se trouve une bande de (4) en spirale tombant vers la partie inférieure avec application du composant actif du catalyseur sur sa surface, tandis que dans l'axe géométrique de la chambre cylindrique du réacteur avec surface interne ondulée (3) se trouve une chambre avec des tranches monolithiques de catalyseur (9), chauffée par un dispositif de chauffage de chambre (12) et les tranches de catalyseur monolithique (10) et/ou (16) sont placées dans la chambre chauffée de tranches monolithiques de catalyseur (9), de plus, le réacteur est équipé d'un boîtier avec deux parois coaxiales (6a) et (6b) et un matériau résistant à la chaleur est placé entre les parois (6a) et (6b), mais un chauffage (7) est en contact avec au moins une partie de la paroi de la paroi interne (6b) du boîtier tandis que dans la partie inférieure du réacteur se trouve une fermeture étanche (8) et c'est à la fois un réservoir à poussière.
9. Le réacteur selon la revendication 8 est **caractérisé par**: la présence du composant actif du catalyseur sur la paroi extérieure de la chambre chauffée (9).
10. Le réacteur selon la revendication 8 est **caractérisé par**: les tranches de catalyseur monolithique (10) sont situées parallèlement à elles-mêmes et verticalement par rapport à l'axe du réacteur.
11. Le réacteur selon la revendication 8 ou 10 est **caractérisé par**: les espaces (11) de direction sont situés entre les tranches de catalyseur monolithique (10).
12. Le réacteur selon la revendication 11 est **caractérisé par**: la forme des espaces (11) de direction qui force le flux en rotation du jet des gaz de combustion.
13. Le réacteur selon la revendication 12 est **caractérisé par**: la forme des espaces (11) de direction est semblable à une hélice.
14. Le réacteur selon la revendication 8 est **caractérisé par**: le chauffage axial (13) situé dans l'axe de la chambre chauffée des tranches monolithiques de catalyseur (9).

15. Le réacteur selon la revendication 8 est **caractérisé**  
**par:** l'espacer (11) de direction situé en avant de  
l'entrée à la tranche du catalyseur monolithique (10)  
lorsque l'avant de la tranche du catalyseur monoli-  
thique (10) est dans la position où le rapport L/d > 5  
50, mais lorsque le rapport L/d < 50, l'espacer (11)  
de direction n'est pas situé avant l'entrée de la tran-  
che de catalyseur monolithique (10).

16. Le réacteur selon la revendication 8 est **caractérisé** 10  
**par:** les tranches de catalyseur monolithique (10)  
sont positionnées angulairement les unes par rap-  
port aux autres et vers à l'axe du réacteur.

17. Le réacteur selon la revendication 8 est **caractérisé** 15  
**par:** la paroi intérieure (6b) du boîtier est en contact  
avec la chambre cylindrique du réacteur avec surfa-  
ce interne ondulée (3).

18. Le réacteur selon la revendication 8 est **caractérisé** 20  
**par :** la partie cylindrique dans laquelle est située la  
chambre cylindrique du réacteur avec surface inter-  
ne ondulée (3) et la partie restante est conique.

19. Le réacteur selon la revendication 8 est **caractérisé** 25  
**par :** l'utilisation pour l'élimination simultanée de  
l'oxyde nitrique des gaz de combustion, la combus-  
tion de particules carboniques contenues dans la  
poussière transportée par les gaz de combustion et  
l'élimination de poussière inorganique. 30

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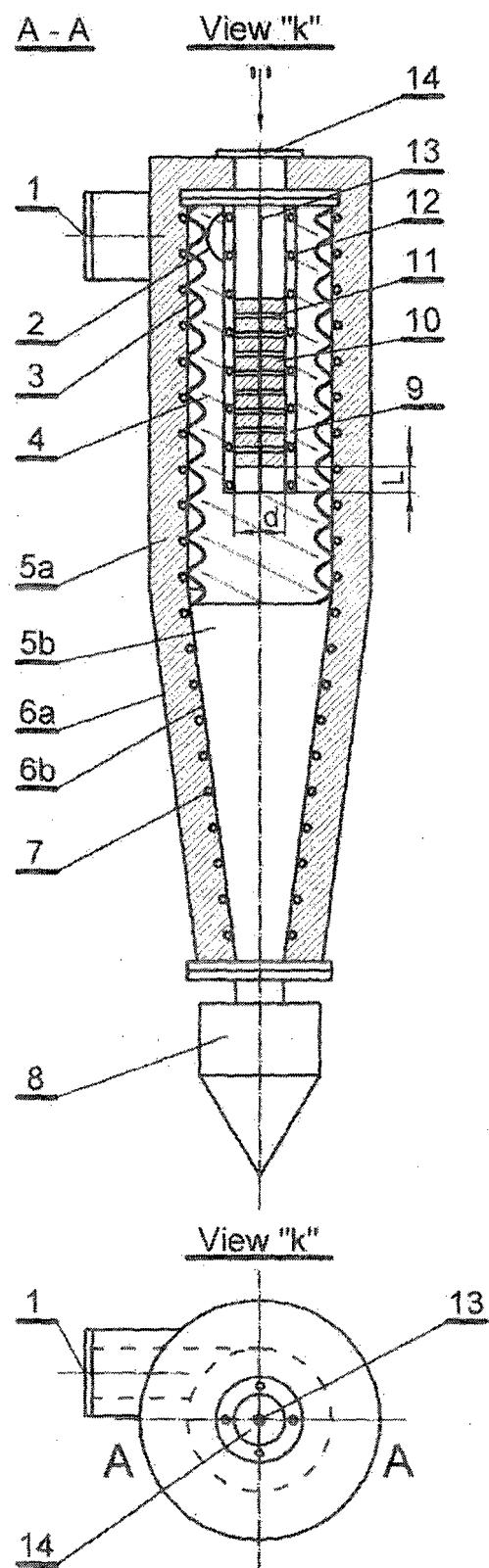


Fig. 1

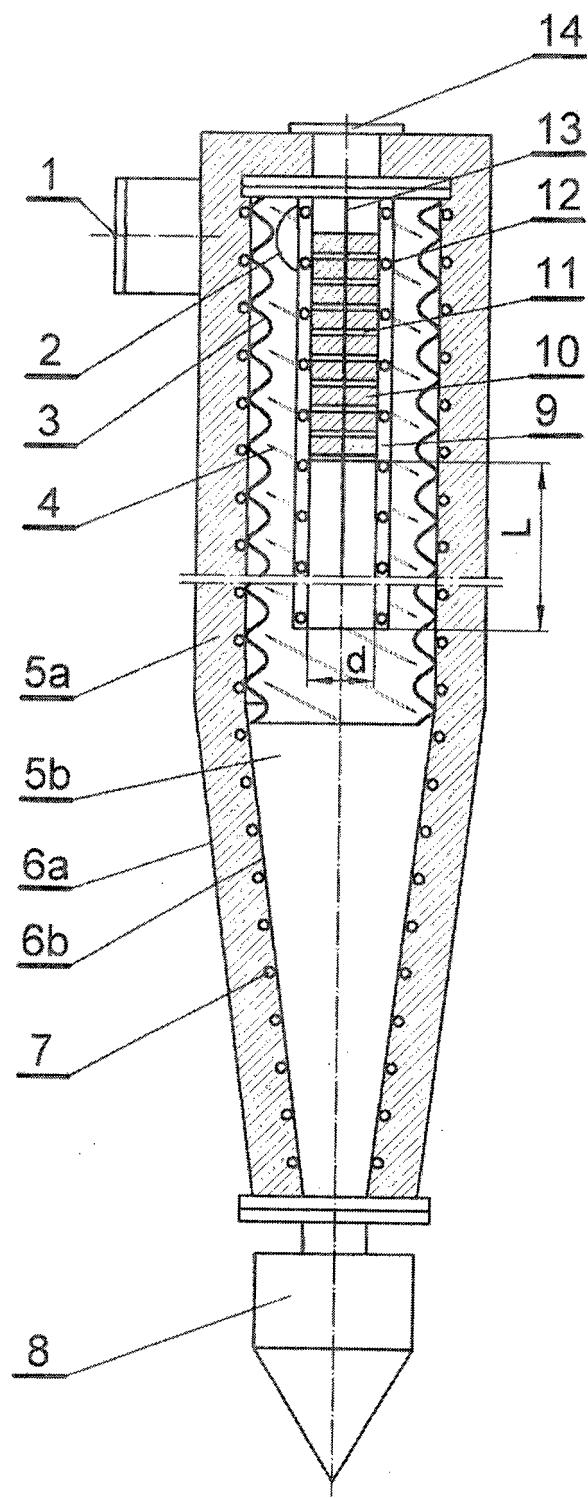


Fig. 2

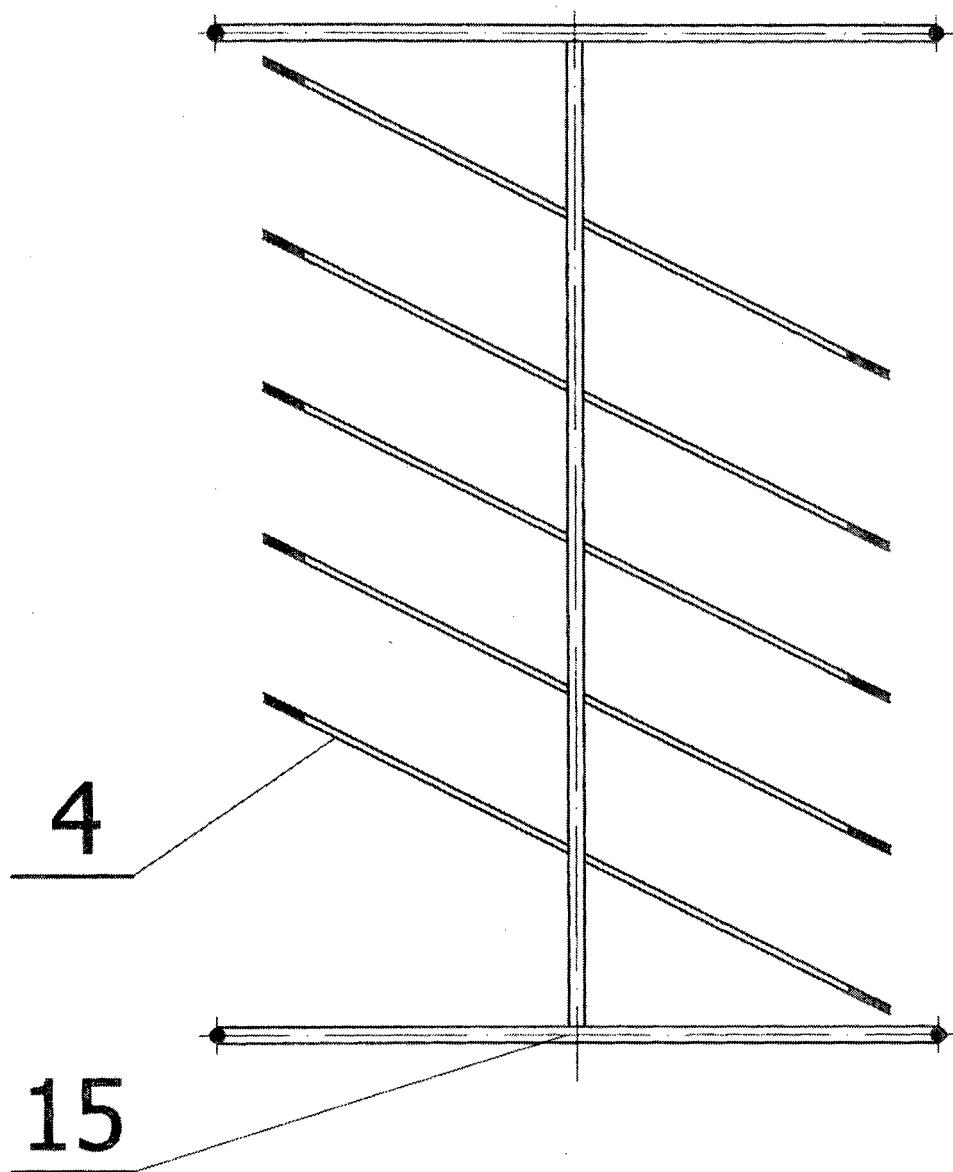


Fig. 3

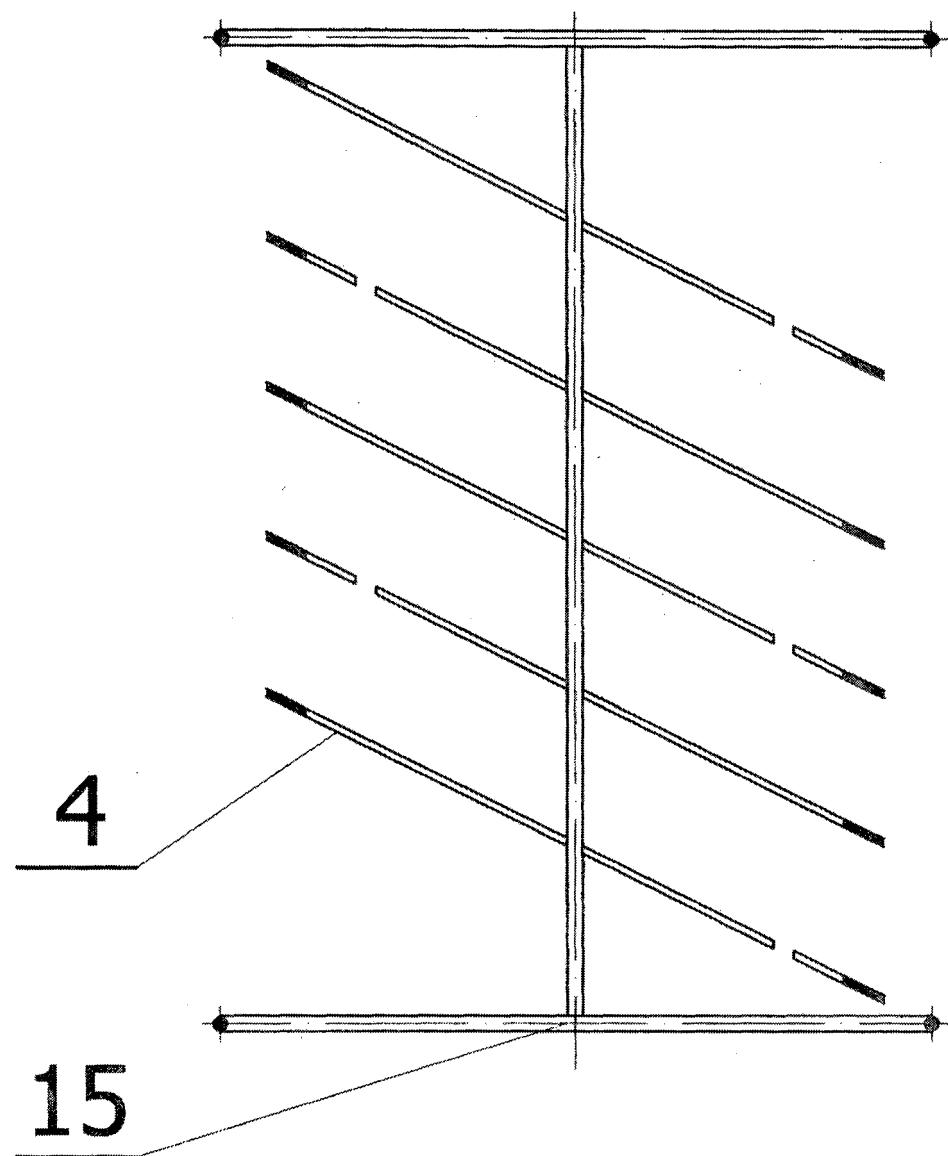


Fig. 4

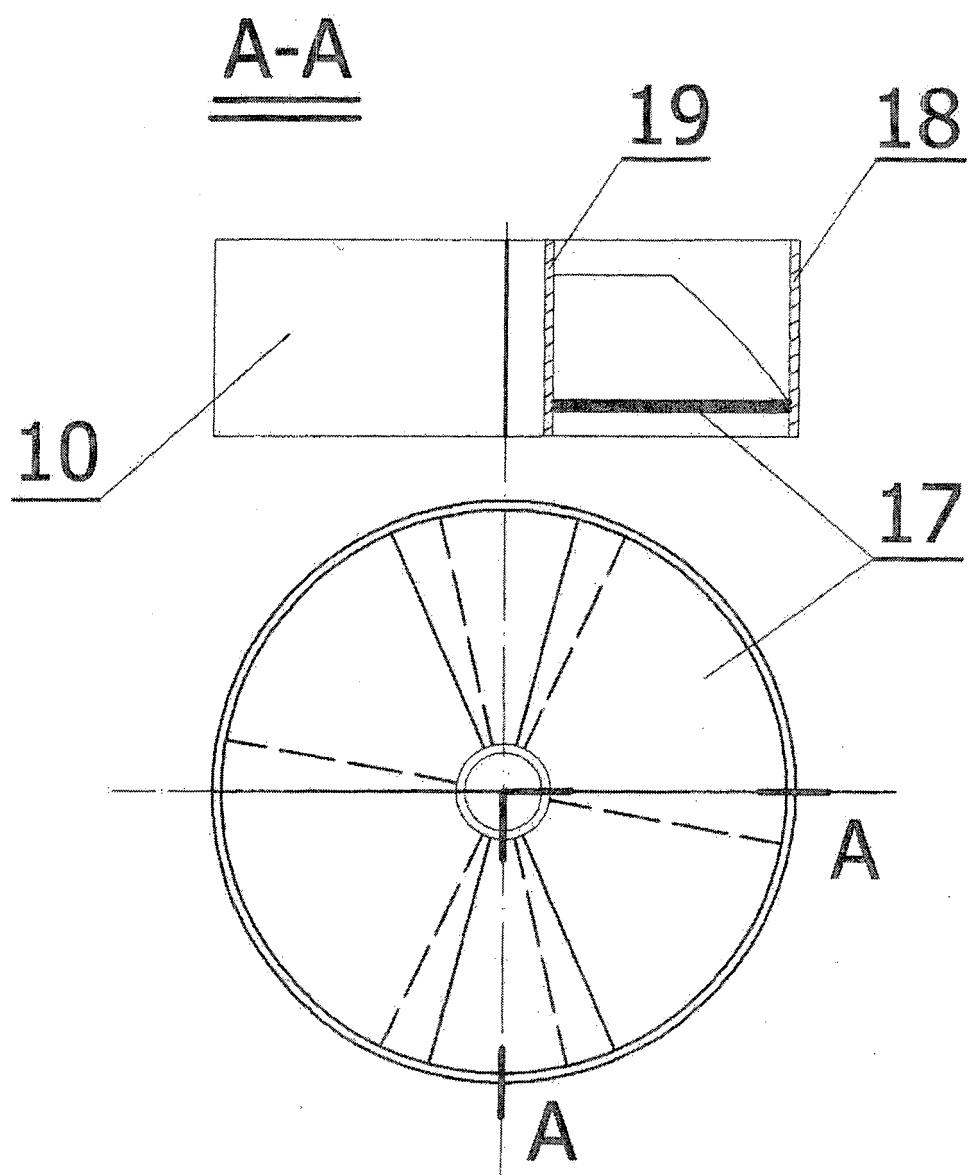


Fig.5

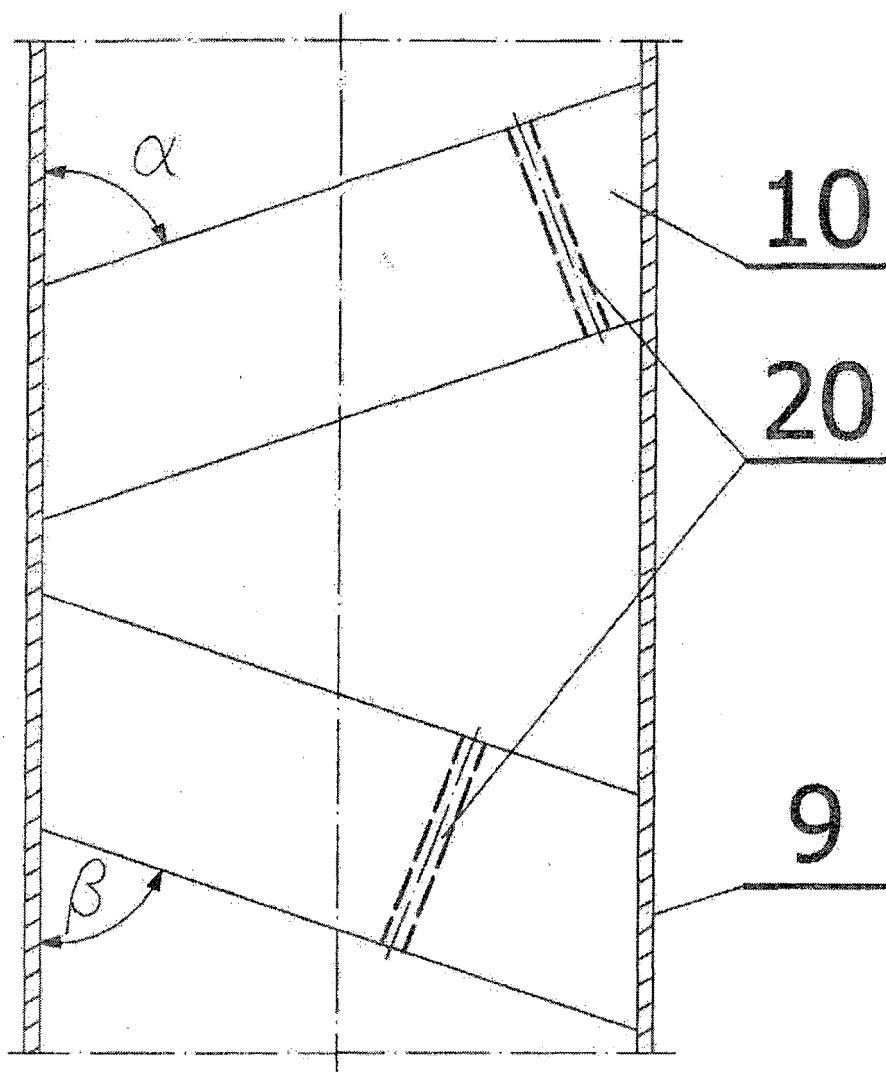


Fig. 6

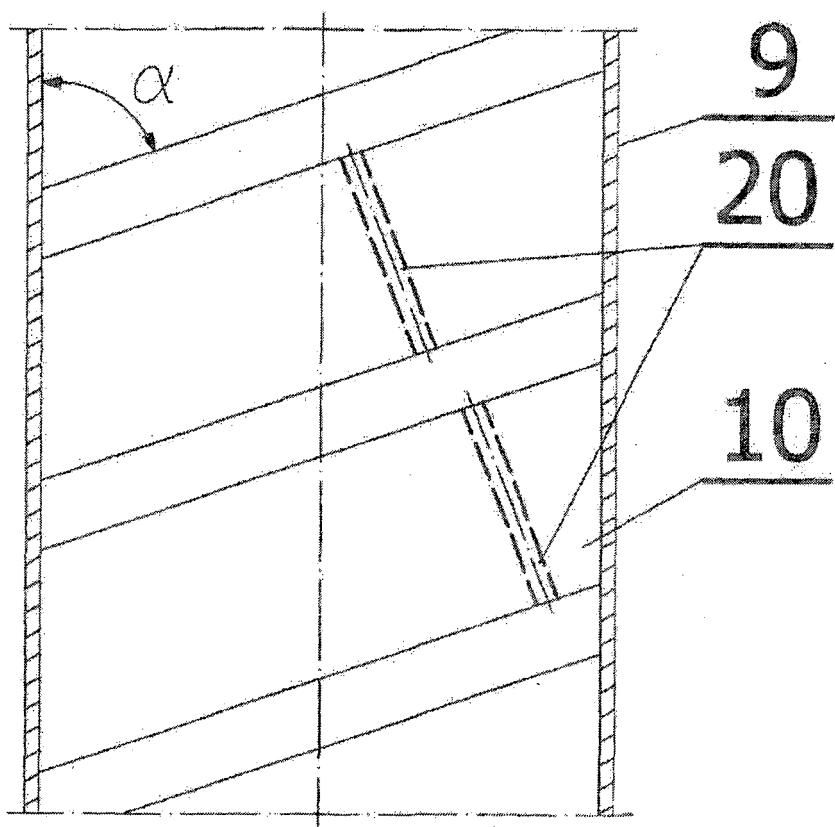


Fig. 7

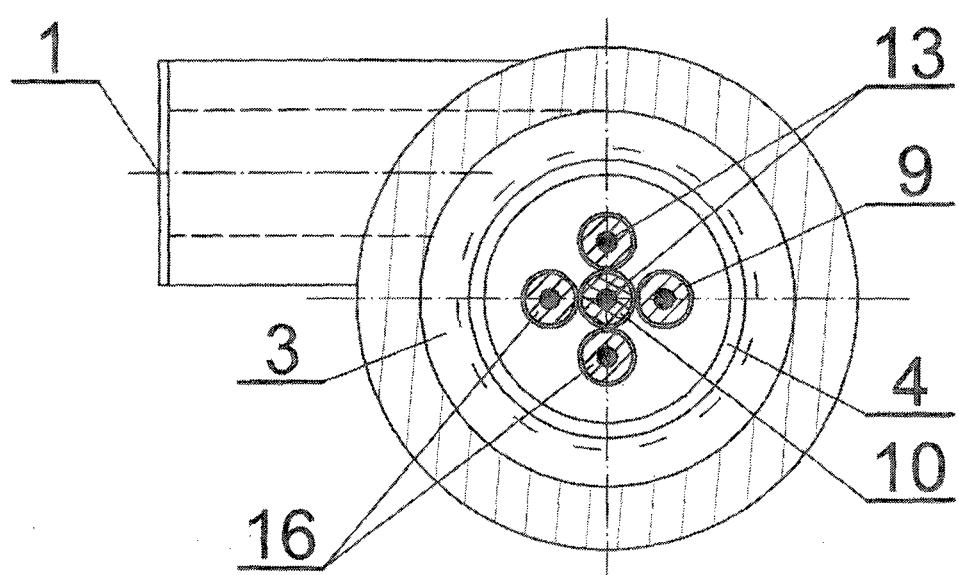


Fig. 8

**REFERENCES CITED IN THE DESCRIPTION**

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