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(54) **MULTI-CHANNEL HELICAL CYCLONE-ELECTROSTATIC FILTER**

(57) The multi-channel helical cyclone-electrostatic filter comprises three serially connected and complementary zones, i.e. the cyclone filter, the filter with the curvilinear elements (11, 12) and the electrostatic filter with the ionizing electrodes (18, 19) and particle deposition electrodes (19, 20), installed in one housing (4), connected by the shared tangential air flow supply duct (1) and the central air outlet duct (31). The ionizing electrode complex of the electrostatic filter comprises electrically connected electrode-rods (18) and plate-shaped ionization electrodes (19). The electrode complex of the electrostatic filter for particle deposition comprises the mechanically and electrically connected perforated cylinder (20) with the central electrode-rod (21). The deposited particles are removed through a continuous annular slot (28) in the bottom of the deposition chamber (7).

A – A

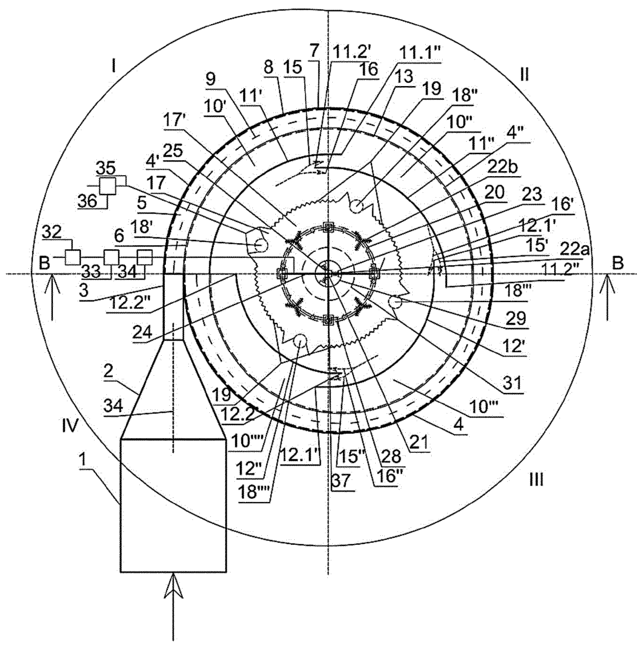

Fig. 1

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Description

Field of the Invention

[0001] The invention belongs inertial and electrostatic precipitation devices for gas cleaning, in particular to multi-channel cyclone-filter for removal of finely dispersed solid particles from gas.

Background of the invention

[0002] Multi-channel cyclones are widely used as gas cleaning devices for cleaning gas (air) by precipitating finely dispersed solid particles (KD). These devices are classified as gas treatment devices for dry cleaning and can be used in various areas of the economic practices, which are related to the emission of ordinary and sticky finely dispersed solid particles into atmosphere. In this type of devices solid particles are separated from a gas stream by: centrifugal force, air flow filtration process.

[0003] In Lithuanian patent no. LT5912 a multi-channel cyclone for cleaning air (gas) from solid particles is disclosed. The cylindrical body cyclone comprises a gas inlet, a gas outlet, and a conical hopper. The cyclone has semi-rings of different radii with adjustable gaps, and a separation chamber with segmental annular slots. The cyclone is also equipped with a partition that directs the air flow to a first channel only.

[0004] In Lithuanian patent no. LT6225 a multi-level multi-channel cylindrical cyclone-filter is disclosed. The filter comprises air tangential inlet, air outlet, curved segments of different radii with adjustable gaps at ends and forming air flow movement channels, a separation chamber with segmental slots, and a conical solid particle collection hopper. The device comprisses a number of cyclones mounted in one housing one above the other, connected by a common tangential air flow supply duct and a central air outlet duct. Cyclones also have inboard quarter rings with adjustable end gaps.

[0005] Devices as described in patents LT5912 and LT6225, can be applied to gas cleaning with medium and high particulate concentrations. The main drawback of the above devices is that the incoming gas flow is fed directly into cyclone channels where solid particles are precipitated. The entire flow of existing particles is removed by centrifugal forces and filtration in individual channels. Reduction in particle removal efficiency is due to two reasons. First, large solid particles with sizes above 10 μm are not efficiently precipitated in each of cyclone channels due to insufficiently strong centrifugal forces that can direct particles of this size to the periphery. And the second, some of finely dispersed solid particles smaller than 5 μm moving in general particle flow are carried along with the gas flow due to excessive velocity in the cyclone channels, so particles of this size cannot be precipitated with maximum efficiency. Centrifugal forces and ongoing filtration in the multichannel cyclone alone are not sufficient for precipitating.

[0006] Another drawback is that inlet of the contaminated gas flow in the disclosed devices is such that the gas flow from the inlet gas flow duct entered the first channel of the cyclone in a straight line trajectory. Such an arrangement is not effective for proper precipitating of finely dispersed solid particles, especially when the particle density is relatively low (400-800 kg/m^3), the flocculation speed of such particles is small (1-1.5 m/s), so the precipitating speed can be insufficient to remove such solid particles.

[0007] The invention does not have the above disadvantages and includes additional advantages.

Summary of the invention

[0008] The purpose of the invention is a combined gas filtration device, a filter, for removal of finely dispersed solid particles smaller than 5 μm, when pollutant concentrations are 50 mg/m^3 or higher. The multi-channel helical cyclonic electrostatic filter according to the invention comprises three, sequentially arranged, at least partially separated deposition zones in one housing of the filter. The first zone is the centrifugal deposition zone of a helical channel, the second zone is zone of centrifugal deposition - filtration channels, and the third zone is central electrostatic deposition zone. The third zone comprises continuous helical slots, ionization electrodes - rods and rebound plates, and deposition electrodes - a perforated cylinder for directing/depositing charged particles, and an electrode - a rod located along central axis of the combined gas treatment device.

[0009] The first zone is formed by the filter body wall of the filter and a helically shaped element. The helically shaped element is arranged in such a way that when making a twist angle of 2π, it is right away extended by another twist angle of $\pi/2$, thus forming a first curvilinear element.

[0010] Velocity of contaminated gas flow is decreasing as it moves towards central axis of the filter. Cross-sections of each zone are selected so that velocity of the gas flow moving in them is suitable to achieve the maximum deposition of solids, depending on the principle of solids deposition in the respective zone, even at very low solids' concentrations. In the first deposition zone of the filter, larger solid particles are most effectively removed and the concentration of solid particles is significantly reduced, while approaching the central axis of the filter deposition methods are applied for the removal of fine and ultra-fine solid particles thus achieving a very high overall degree of purification of the gas stream.

Description of drawings

[0011] Features of the invention believed to be novel and inventive are set forth with particularity in the appended claims. The invention itself, however, may be best understood by reference to the following detailed description of the invention, which describes exemplary embodiments, given in non-restrictive examples, of the invention, taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows a schematic cross-section of the multi-channel helical cyclone-electrostatic filter according to the invention across the line A-A in Fig. 4.

Fig. 2 shows a spatial schematic cross-section of the multi-channel helical cyclone-electrostatic filter according to the invention across the line A-A in Fig. 4.

Fig. 3 shows a schematic view of the deposition slotted chamber of the multi-channel helical cyclone-electrostatic filter according to the invention and a spatial view of the arrangement of the electrostatic deposition elements with a spring vibrator in the cross-section across the line B-B shown in Fig. 1.

Fig. 4 shows a profile view of the multi-channel helical cyclone-electrostatic filter according to the invention without an outer wall of a deposition chamber.

Fig. 5 shows the spatial schematic view of the cross-section of the multi-channel helical cyclone-electrostatic filter according to the invention across the line A-A in

Fig. 4, where sequentially arranged areas of the filter and their designations are shown.

[0012] Preferred embodiments of the invention are described below with reference to the drawings. Each figure has the same numbering for the same or equivalent item.

Detailed description of the invention

[0013] It should be understood that numerous specific details are presented in order to provide a complete and comprehensible description of the invention embodiment. However, the person skilled in art will understand that the embodiment examples do not limit the application of the invention which can be implemented without these specific instructions. Well-known methods, procedures and components have not been described in detail for the embodiment to avoid misleading. Furthermore, this description should not be considered to be constraining the invention to given embodiment examples but only as one of possible implementations of the invention. The multi-channel helical cyclone-electrostatic filter (CEF) for cleaning gases from solid particles comprises a duct (1) for contaminated gas flow entering the filter (CEF), a narrowing passage (2) for directing the gas flow, a gas inlet primary filter (3), the cyclonic-electrostatic filter (CEF) helical body (4), a helical channel (5), a helical element (6), a deposition chamber (7) with a bottom (7’), continuous helical slots (8) formed by the deposition chamber (7) with the bottom (7’), a peripheral centrifugal deposition zone (9), centrifugal deposition -filtration channels (10’, 10", 10‴, 10""), curved curvilinear elements (11’, 11", 12’, 12"), a continuous helical slot (13), a multichannel cyclone zone (14), a central electrostatic deposition zone (17), charge ionization rod-shaped electrodes (18’, 18", 18‴, 18″″), plate-shaped ionization electrodes (19), a perforated cylindrical deposition electrode (20) and a rod-shaped deposition electrode (21), bottom support springs (22a, 22b) of the perforated cylinder-shaped deposition electrode (20) and the rod-shaped deposition electrode (21), holding elements (23) of said springs (22a, 22b), a DC high voltage circuit (24), a vibration device (25), a motor (26), a cover (27), a continuous ring slot (28), a central opening (29), a hopper (30), an exhaust duct (31), a transformer (33), a DC unit (34), a electric current circuit (35), and a transformer (36).

[0014] The gas flow diverting narrowing passage (2) at first end is connected to the contaminated gas flow inlet to the duct (1) of the cyclone-electrostatic filter (CEF), and at second end to the primary filter (3) of the gas inlet in the helical channel (5). The area of the opening of the second end of the narrowing passage (2) for directing the gas flow is smaller than the area of the opening of the first end and fully corresponds to the area of the gas outlet of the gas inlet primary filter (3) in the helical channel (5).

[0015] The helical-shaped body (4) is formed from an outer wall (4’) and an inner wall (4"). The inner wall (4") forms a helical-shaped element (6). The outer wall (4’) extends from the first side edge (3’) of the inflow primary filter (3) to the second side edge (3") of the primary filter (3), located on opposite side to the first side edge (3’). The outer wall (4’) extends spirally from the second side edge (3") of the inflow primary filter (3) as the inner wall (3"). The inner wall (4") extends full circle at least to the area where the outer wall (4’) joins the edge of the second side (3") of the inlet primary filter (3). The inner wall (4") preferably extends approximately one full circle and one quarter circle parallel to the outer wall (4’).

[0016] In the area between the outer wall (4’) and the inner wall (4"), the channel (5) is formed extending to the end of the inner wall (4"). The channel (5) is a helical channel (5) forming a first particle deposition zone (5’). In this zone, largest particles are deposited, the diameter of which may vary but is not smaller than 20 μm (efficiency of the deposition of smaller particles is strongly reduced). The helical channel (5) is covered from above by a cover of the cyclone-electrostatic filter (CEF), and from below by the bottom (7’) of the deposition chamber (7). The continuous helical slot (8) is formed in the area of the bottom (7’) of the deposition chamber (7) of the first particle deposition zone (5’), where the continuous helical slot (8) is a peripheral centrifugal deposition zone (9) that extends from the beginning of the first particle deposition zone (5’) to the inflow into the first centrifugal deposition -filtration channel (10’). The width of the continuous helical slot (8) may not exceed 1/10 of the width of the channel (10’), but it must be ensured that suction of solids from the hopper back into the deposition chamber does not occur.

[0017] The multi-channel helical cyclone-electrostatic filter (CEF) comprises four centrifugal deposition-filtration channels (10’, 10", 10‴, 10″″).

[0018] The first centrifugal deposition-filtration channel (10’) extends between the first quarter (I) of the inner wall (4"), which begins at the end of the primary filter (3) and extends from the second cross-sectional (B-B) plane (B) to the first cross-sectional (A-A) plane (A), in a clockwise view, of the first part and the first quarter (I) of the second part, which is the first curved curvilinear element (11’) which extends parallel to the first part, but closer to the center of the filter (CEF), by width of the first deposition-filtration channel (10’).

[0019] The second centrifugal deposition-filtration channel (10") extends between the inner wall (4") of the second quarter (II) beginning at the end of the primary quarter (I) and extending from the first cross-sectional (A-A) plane (A) to the second cross-sectional (B-B) plane (B) viewed clockwise, and adjacent to the inner wall second quarter (II) of the second curved curvilinear element (11"), which is located closer to the center of the filter (CEF) than the inner wall second quarter (II), by width of the second deposition-filtration channel (10"). The beginning (11.2’) of the second curved curvilinear element (11") overlaps by a certain length with the end (11.1") of the first curved curvilinear element, so that the beginning (11.2’) of the second curved curvilinear element (11") is closer to the filter (CEF) center than the end (11.1") of the first curved curvilinear element (11’).

[0020] The third centrifugal deposition-filtration channel (10‴) extends between the third quarter (III) of the inner wall (4"), beginning at the end of the second quarter (II) and extending from the second cross-sectional (B-B) plane (B) to the first cross-section (A-A) plane (A), viewed clockwise, and adjacent to the inner wall (4") third quarter (III) of the third curved curvilinear element (12’), which is located closer to the center of the filter (CEF) than the inner wall third quarter (III), by width of the third deposition-filtration channel (10‴). The beginning (12.1’) of the third curved curvilinear element (12’) overlaps by a certain length with the end (11.2") of the second curved curvilinear element, so that the beginning (12.1’) of the third curved curvilinear element (12’) is closer to the filter (CEF) center than the end (11.2") of the second curved curvilinear element (11").

[0021] The fourth centrifugal deposition-filtration channel (10"") extends between the inner wall (4") of the fourth quarter (IV) beginning at the end of the third quarter (III) and extending from the plane (A) of the first cross-section (A-A) to the second cross-section (B-B)) plane (B), viewed clockwise, and the fourth curved curvilinear element (12") located adjacent to the inner wall fourth quarter (IV), which is located closer to the center of the filter (CEF) than the inner wall fourth quarter (IV), by width of the fourth deposition-filtration channel (10""). The beginning (12.2’) of the fourth curved curvilinear element (12") overlaps by a certain length with the end (12.1") of the third curved curvilinear element, so that the beginning (12.2’) of the fourth curved curvilinear element (12") is closer to the filter (CEF) center than the end (12.1") of the third curved curvilinear element (12’).

[0022] The zone of the multi-channel cyclone, which comprises the centrifugal deposition-filtration channels (10’, 10", 10‴, 10""), is a centrifugal deposition-filtration zone (14) at the bottom (7’) of the deposition chamber (7) and comprises a continuously extending continuous spiral slot (13).

[0023] The multi-channel helical cyclone-electrostatic filter (CEF) also comprises the central electrostatic deposition zone (17) located behind the multi-channel cyclone zone (14) in the direction of gas flow. The central electrostatic deposition zone (17) comprises four uniformly spaced single charge rod-shaped ionization electrodes (18’, 18", 18‴, 18"") arranged in a ring around the central part of the filter (CEF). Said single charge rod-shaped ionization electrodes (18’, 18", 18‴, 18"") extend through the channel (17’) of the central electrostatic deposition zone (17), in which, between the single charge rod-shaped ionization electrodes (18’, 18", 18‴, 18"") the plate-shaped ionization electrodes (19) of the same charge are arranged. The central electrostatic deposition zone (17) also comprises the central deposition electrode (20) which is in the shape of a perforated cylinder, and the central rod-shaped deposition electrode (21) surrounded by the perforated cylindrical deposition electrode (20).

[0024] The electrostatic deposition zone (17), deposition electrodes (20, 21) are connected to each other by the electrical circuit (24) from the electrical source (32) through the transformer (33) to the high voltage DC unit (34), an opposite charge to the ionization electrodes (18’, 18", 18‴, 18"", 19). The perforated cylindrical deposition electrode (20) and the rod-shaped deposition electrode (21) are mounted on springs (22a, 22b) at the bottom (7) of the deposition chamber (7). The springs (22a) of the rod-shaped deposition electrode (21) are equipped with retaining elements (23). The springs (22a, 22b) enable the deposition electrodes (20, 21) to vibrate, thus shaking off the deposited particles from the surface. Thus, the electrodes (20, 21) are regenerated.

[0025] The deposition electrodes (20, 21) are structurally connected to each other and form the common DC high voltage circuit (24). Vibration device (25) is installed on the axis-mounted rod-shaped deposition electrode (21) and is connected to the motor (26) and its control unit, which are installed on the filter cover (27). The deposited solid particles pass through the helical slots (8, 13) provided in the bottom (7’) of the deposition chamber (7), through the continuous annular slot (28) provided in the bottom (7’) of the deposition chamber (7), which extends both from the outer, and both from the inner side of the perforated cylindrical electrode (20) and enters the hopper (30) connected to the filter (CEF) body (4) through the central opening (29). At the central axis of the filter (CEF), above the perforated cylindrical deposition electrode (20) and the rod-shaped deposition electrode (21), vertically upward, the duct (31) for removing the gas flow from the filter (CEF) is installed.

[0026] The principle of operation of the multi-channel helical cyclone-electrostatic filter (CEF) is based on the fact that the dusty gas flow is sequentially directed through the solid particles deposition channels (5, 10', 10", 10‴, 10"", 17') through zones of different deposition types (5', 14, 17), where not only the concentration of solid particles is reduced to the smallest, but also the size of the particles remaining in the gas stream is reduced to ultrafine. Thus, in the course of multi-stage cleaning, in each zone (5', 14, 17) different methods of deposition of solid particles are applied, which mutually complement each other, achieving an extremely high overall cleaning efficiency.

[0027] Dusty air, gas, is supplied through the contaminated gas flow duct (1). Passing through the diverting narrowing passage (2) the velocity of the gas flow increases, for example, by more than 5 times, for example, up to ~ 15-20 m/s. Centrifugal deposition occurs due to the increase in centrifugal forces at a higher gas flow rates due to the reduced cross-sectional area of the helical channel (5) of the centrifugal deposition cyclone compared to the cross-section of the contaminated gas flow duct (1). The cross-sectional area of the cyclone helical channel (5) is, for example, approximately 5.5 times smaller compared to the cross-sectional area of the contaminated gas flow duct (1). Depending on the length and the height of the peripheral centrifugal deposition helical channel (5), the diverting narrowing passage (2) is arranged to be inclined downwards so that its axial line (34) forms an angle of 10-15° with the horizontal plane of the bottom of the deposition chamber (7'). In this case, fine solids, such as 10 μm and larger, with a low density such as 400-800 kg/m^3 are directed downward, enough to cause them to deposit after passing through the slots (8, 13).

[0028] The largest solid particles, for example, larger than 10 μm, are deposited in this peripheral centrifugal deposition zone (9) under the action of centrifugal force, which directs the particles towards the periphery of the channel (5), where they slide along the surface (4.1) of the inner side of the filter housing (4) downwards under the action of gravity and directed to the hopper (30) through the continuous helical slot (8) in the bottom of the deposition chamber (7') in the centrifugal deposition helical channel (5).

[0029] The gas from the first centrifugal deposition-filtration channel (10') enters the second centrifugal deposition-filtration channel (10"), further into the third centrifugal deposition-filtration channel (10‴), and further into the fourth centrifugal deposition-filtration channel (10″″). The gas flowing through the fourth centrifugal deposition-filtration channel (10″″) is divided and separated at the overlap zone of the end (11.1") of the first curved curvilinear element (11') with the beginning (11.2') of the second curvilinear element (11") to the first peripheral flow (15) and the first transit flow (16). At the same time, a new gas flow from the first centrifugal deposition-filtration channel (10') is introduced into the first transit flow. The first peripheral flow (15) flows at the outer wall of the second curvilinear element (11"), and the first transit flow (16) flows at the inner wall of the second curvilinear element (11"). Next, divided in this way and separated gas flow reaches the overlap zone of the end (11.2") of the second curved curvilinear element (11") with the beginning (12.1') of the third curvilinear element (12'), where the first transit gas flow (16) is additionally divided and separated into a second peripheral flow (15') and a second transit flow (16'). The second peripheral flow (15') flows at the outer wall of the third curvilinear element (12'), and the second transit flow (16') flows at the inner wall of the third curvilinear element (12'). At the same time, the first peripheral flow (15) merges with the second peripheral flow (15'). Next, divided in this way and separated gas flow reaches the overlap zone of the end (12.1') of the third curved curvilinear element (12') with the beginning (12.2") of the fourth curvilinear element (12"), where the second transit gas flow (16') is additionally divided and separated into a third peripheral flow (15") and a third transit flow (16"). The third peripheral flow (15") flows at the outer wall of the fourth curvilinear element (12") and the third transit flow (16") flows at the inner wall of the fourth curvilinear element (12"). At the same time, the second peripheral flow (15') merges with the third peripheral flow (15"). The cycle then repeats beyond the end (12.2") of the fourth curvilinear element (12") after the third peripheral flow (15") merges with the third transit flow (16"), wherein such a merged gas flow, in the zone where the end (11.1") of the first curved curvilinear element (11') overlaps with the beginning (11.2') of the second curvilinear element (11"), is divided and separated into the first peripheral flow (15) and the first transit flow (16), where a new gas stream is introduced from the first centrifugal deposition-filtration channel (10') into the first transit flow again.

[0030] Finely dispersed solid particles in the zone, which includes four centrifugal deposition-filtration channels (10', 10", 10‴, 10""), are deposited under the action of centrifugal force, which is lower than in the previous zone (5), and also during the filtering. In each centrifugal deposition-filtration channel (10', 10", 10‴, 10"") with each pass through the said channels, the gas is increasingly purified.

[0031] During multiple filtration, finely dispersed solid particles are directed into the continuous helical slot (13) of the centrifugal deposition-filtration zone, which comprises centrifugal deposition-filtration channels (10', 10", 10", 10""). The radius of the first and the second curvilinear elements (11', 11") is the same and is 1.125 times greater than the radii of the third and the fourth curvilinear elements (12) located below. The inner wall (4"), the curved curvilinear elements (11', 11", 12', 12") are arranged in the inner structure of the multi-channel helical cyclone-electrostatic filter (CEF) in such a way as to create the least possible variation of the gas flow velocity in each of the centrifugal deposition-filtration channels (10’, 10‴, 10‴, 10"").

[0032] The average cross-sectional area of each centrifugal deposition-filtration channel (10’, 10", 10‴, 10"") is larger compared to the cross-sectional area of the cyclone helical channel (5), but smaller compared to the cross-sectional area of the contaminated gas stream duct (1). Thus, after leaving the helical channel of the cyclone (5), the gas flow to the centrifugal deposition-filtration channels (10’, 10", 10‴, 10"") is decelerating. Thus, the filtration of the polluted gas flow and the deposition of finely dispersed solid particles through the continuous helical slot (8) of the centrifugal deposition-filtration channels (10’, 10", 10‴, 10""), the width of which is smaller than the width of the channel (5), installed at the bottom of the deposition chamber (7’), is increased.

[0033] In a specific embodiment of the invention, the average cross-sectional area of each centrifugal deposition-filtration channel (10’, 10", 10‴, 10"") is 1.6 times larger compared to the cross-sectional area of the cyclone helical channel (5), and approximately 3.5 times smaller compared to the cross-sectional area of the contaminated gas flow duct (1). Thus, after leaving the cyclone helical channel (5), the gas flow to the centrifugal deposition-filtration channels (10’, 10", 10‴, 10"") is decelerating and reaches, for example, about 8-10 m/s. In this way, the filtration of the polluted gas flow and the deposition of finely dispersed solid particles through the continuous helical slot of the centrifugal deposition-filtration channels (10’, 10", 10‴, 10″″), the width of which is, for example, approximately 25 times smaller than the width of the channel (5), installed at the bottom of the deposition chamber (7’), is increased (8).

[0034] Contaminated gas cleaning, by removing solid particles with a diameter of less than 2.5 μm, when the particle density in the gas flow is relatively low, 400-800 kg/m^3, is carried out by centrifugal deposition-filtration channels (10’, 10", 10‴, 10"") in the central electrostatic deposition zone (17) installed in the system. The remaining extremely fine solid particles in the partially cleaned gas flow entering the central electrostatic deposition zone (17) are charged by a charge of one sign from the fixed ionization rod-shaped electrodes (18’, 18", 18‴, 18″″) and plate-shaped ionization electrodes (19) arranged every 90° and oriented in such a way that each transit flow (16, 16’, 16") moving from each centrifugal deposition-filtration channel (10’, 10", 10‴, 10"") would be directed to these deposition electrodes (18, 19) to charge the solid particles. The ionization electrodes (18’, 18", 18‴, 18"", 19) are connected to the high voltage DC unit. Rod-shaped ionization electrodes (18’, 18", 18‴, 18"") are connected to the electric circuit (35) together with the plate-shaped ionization electrodes (19), which are supplied with an electric current of equal charge through the transformer (36). The cross-sectional area of this zone (17) is increased approximately 3 times compared to the centrifugal deposition-filtration zone (14) and is the largest among all zones (5’, 14, 17), thus the gas flow rate in this zone (14) is especially decreased and reaches no more than, for example, 1 m/s.

[0035] In order to increase the efficiency of deposition of solid particles, the perforated cylinder-shaped deposition electrode (20) is installed, which has the opposite charge to the ionization electrodes (18’, 18", 18‴, 18"", 19) for the deposition of charged particles. The two-phase gas flow can enter towards the axis of the device (37) only through the provided perforation holes (20’), so the particles in the gas flow are diverted directly towards the perforated cylindrical deposition electrode (20), where they remain attached. Ultrafine particles, having entered through the perforation holes (20’) together with the flow, move towards the rod-shaped deposition electrode (21) installed in the axis of the device, which also has the opposite charge to the ionization electrodes (18’, 18", 18‴, 18"", 19), where some of the smallest particles are deposited. To increase the probability of particle charging, plate-shaped ionization electrodes (19) are installed between the fixed rod-shaped ionization electrodes (18’, 18", 18‴, 18""), which form an obstacle to the escape of particles. These plates (19) prevent the particles from being carried away with the air flow from outside this zone, and also if they hit these plates - they bounce back and return to the initial deposition zone. Also, since these plate-shaped ionization electrodes (19) are connected to the same charge 12000 V DC high-voltage electric circuit, they can additionally charge some of the solid particles that were not charged from the rod-shaped ionization electrodes (18’, 18", 18‴, 18""). In both the perforated cylinder-shaped deposition electrode (20) and the rod-shaped deposition electrode (21), the shared voltage circuit (24) maintains the DC voltage equal to 2/3 of the voltage of the ionization electrodes (18), i.e. 8000 V compared to ionization electrodes (18’, 18", 18‴, 18″″, 19).

[0036] A time relay is installed on the cover (27) of the multi-channel helical cyclone-electrostatic filter, which, after the set filter operation time, turns on the electric motor (26), which starts the system for the removal of deposited particles (for the regeneration of the deposition electrodes). In order to remove the deposited particles, the vibration device (25) is installed on the rod-shaped deposition electrode (21) at the lid of the deposition chamber (27). Both deposition electrodes (20, 21) are mounted on springs (22a, 22b). The springs (22a) of the rod-shaped electrode (21) are attached to the retaining elements (23). Finally, all the holding elements (23) are fixed at the bottom (7’) of the deposition chamber (7). The vibration device (25) is installed above the axial electrode (21); when the vibration device is activated, the vibration affects the axial electrode (21) and the perforated cylindrical deposition electrode (20) that are structurally connected to each other with the axial electrode (21). The response to the vibration is additionally increased by the springs (22a, 22b) on which these deposition electrodes

(20, 21) are installed. During this process, deposited extremely fine solid particles fall from the deposition electrodes (20, 21), which enter the hopper (30) through the continuous annular slot (28) and the central hole (29) of the deposited particles.

[0037] The cleaned gas flow at the axis of the device (37) moves vertically upwards and is removed to the atmosphere through the gas flow removal duct (31).

[0038] Although present description includes numerous characteristics and advantages of the invention together with structural details and features, the description is given as an example of the invention embodiment. There may be changes in details, especially in the form, size and layout of materials without departing from the principles of the invention, in accordance with the widely understood definition of terms used in claims.

Claims

1. Multi-channel helical cyclone-electrostatic filter, comprising a narrowing passage for directing gas flow, a gas outlet, a cylindrical body with curved elements of different radii, a separation chamber with segmental annular slots, a conical hopper for collecting the solid particles, **characterized in that** further comprises

- ionization electrodes (18, 19) having a charge,
- particle deposition electrodes (20, 21) having the opposite charge to ionization electrodes (18, 19),
- a vibration device (25) for shaking off solid particles stuck to the deposition electrodes (20, 21),
- a slot (28) and a central hole (29) for the removal of solid particles into a filter collection hopper (30),
- where the multi-channel helical cyclone-electrostatic filter is installed in a helical filter body (4) in a electrostatic deposition zone (17) and is connected to a shared tangential air flow supply duct (1), a central air outlet duct (31) and a hopper for collecting the deposited particles (30).

2. The filter according to claim 1, **characterized in that** the ionization electrodes (18, 19) are rods (18) and plates (19).

3. The filter according to claim 1 or 2, **characterized in that** the ionization electrodes (18, 19) are arranged in a circle every 90° at the beginning of transit air flow (16).

4. The filter according to any one of the preceding claims, **characterized in that** the deposition electrodes comprise a perforated cylinder (20) with an axial electrode (21), wherein the perforated cylinder (20) and the axial electrode (21) are connected by a common voltage circuit (24) and attached to the vibration device (25), connected to a motor and its control unit (26), installed on a filter cover (27).

5. The filter according to any one of the preceding claims, **characterized in that** the vibration device (25) is mounted on the deposition electrode (21) at the filter cover (27).

6. The filter according to claims 4 or 5, **characterized in that** the perforated particle deposition cylinder (20) together with the axial electrode (21) are attached via springs (22a, 22b) to the bottom of the filter (7') where the joint allows vibrations.

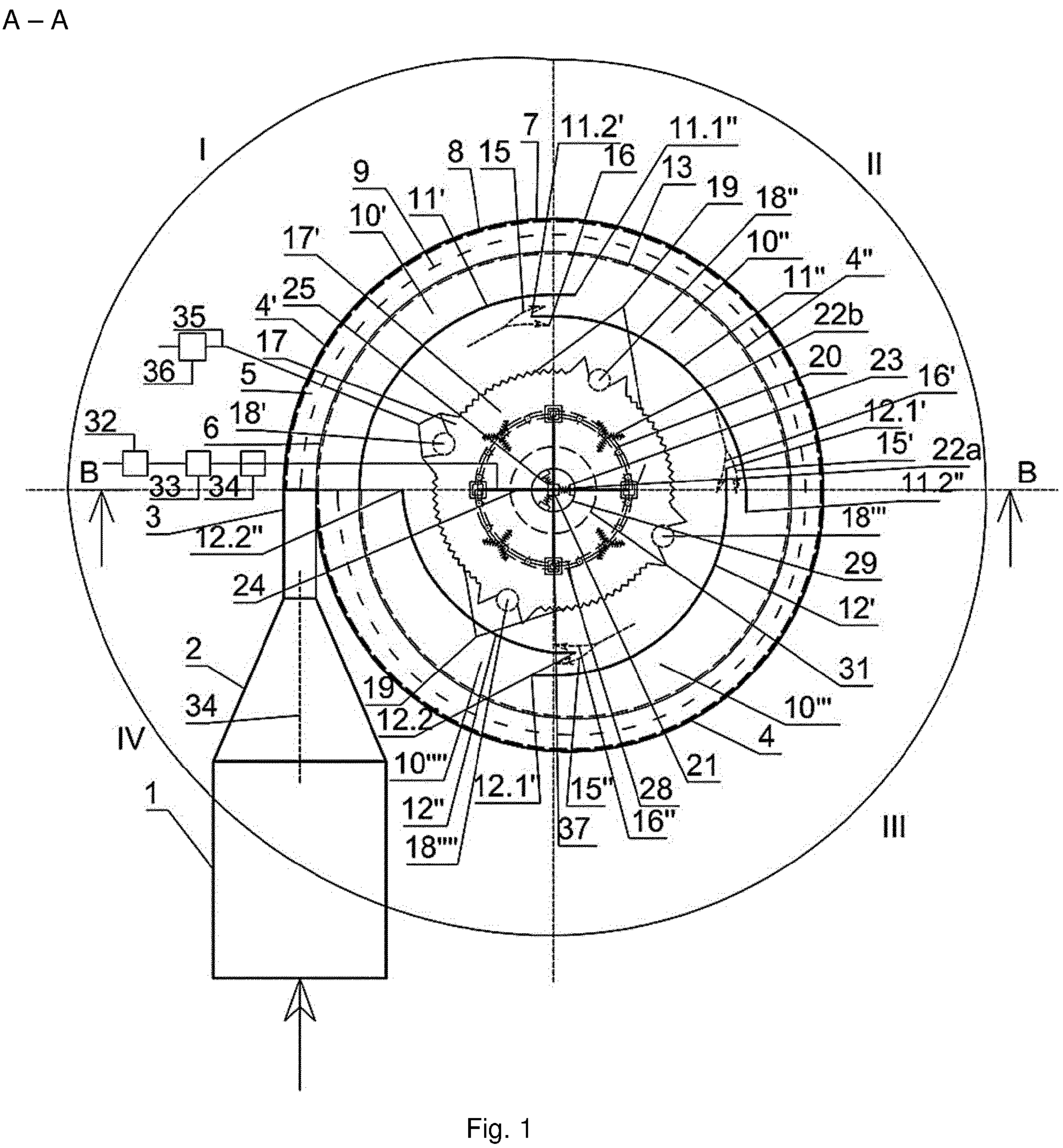
A – A
I
II
III
IV
B
B
1
2
3
4
4'
4"
5
6
7
8
9
10'
10"
10'''
10''''
11'
11"
11.1"
11.2'
11.2"
12'
12"
12.1'
12.2
12.2"
13
15
15'
15"
16
16'
16"
17
17'
18'
18"
18'''
18''''
19
20
21
22a
22b
23
24
25
28
29
31
32
33
34
35
36
37

Fig. 1

A – A

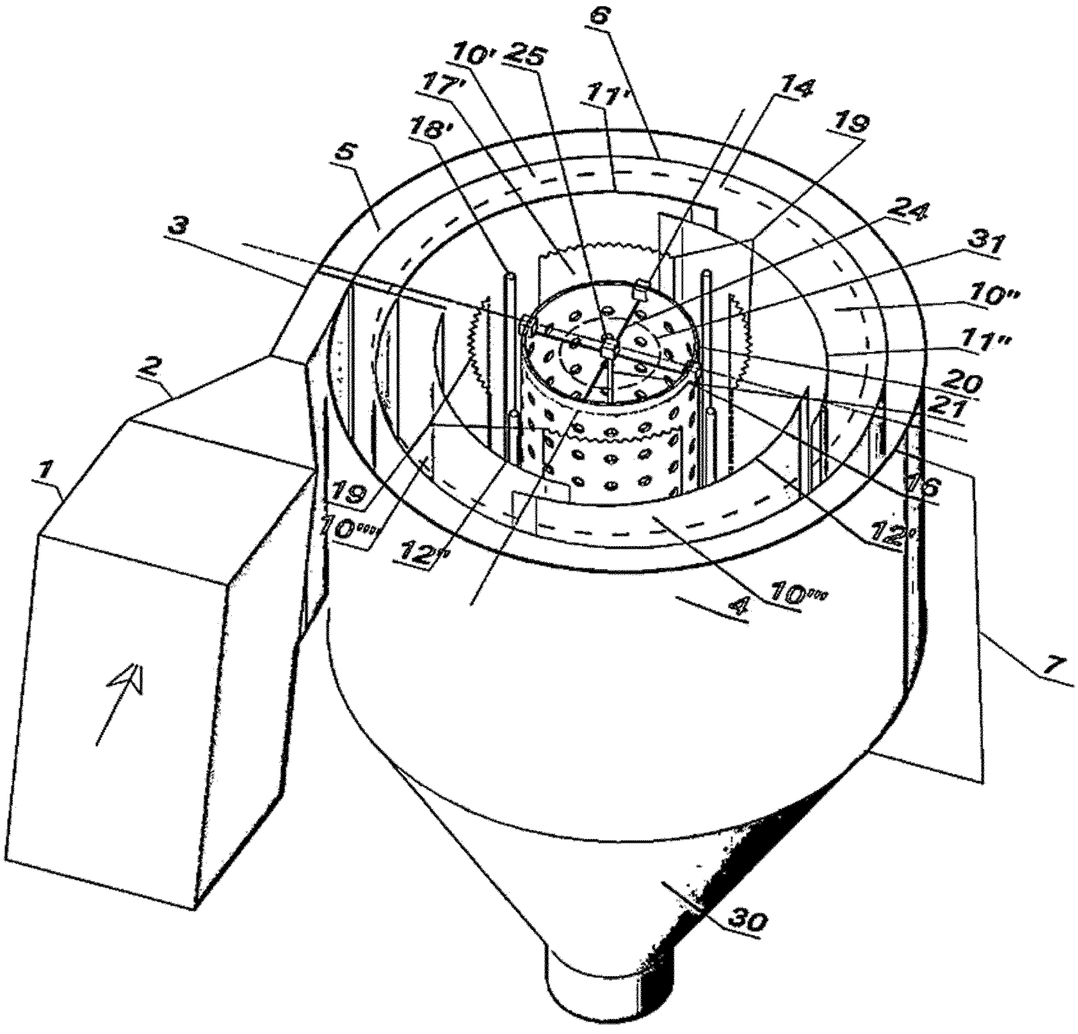

Fig. 2

B – B

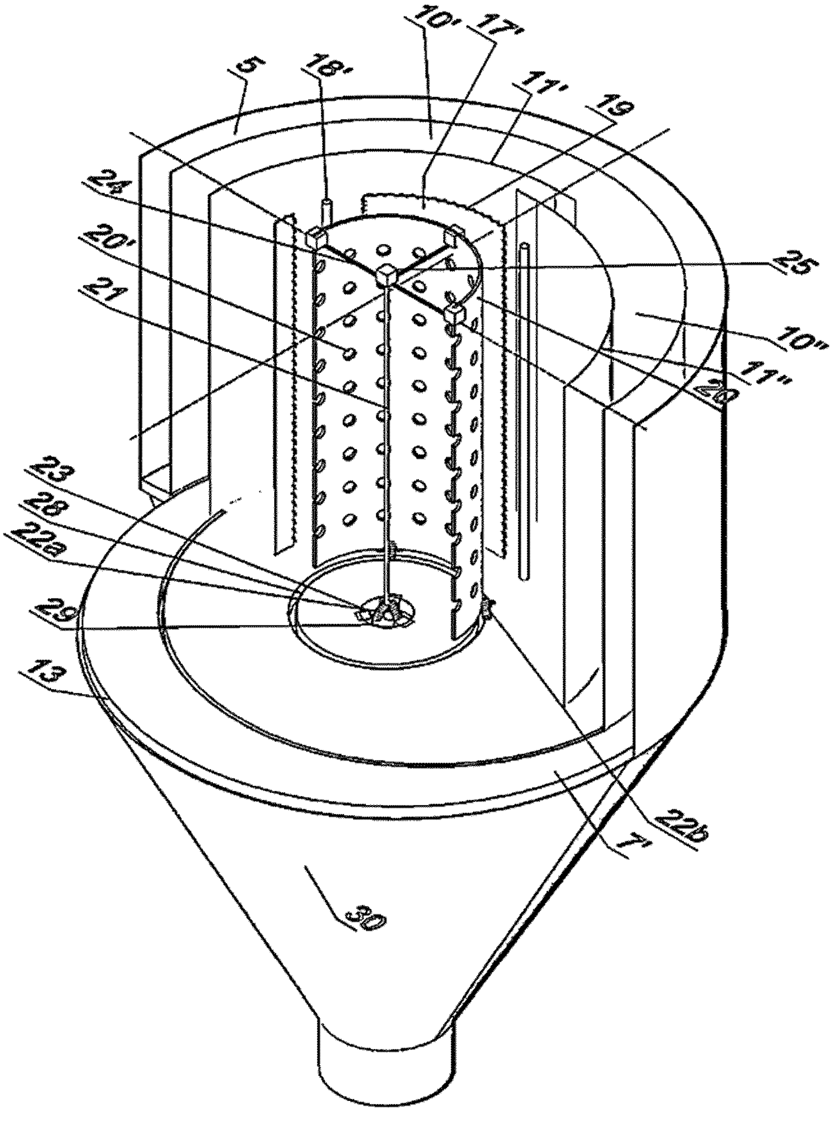

Fig. 3

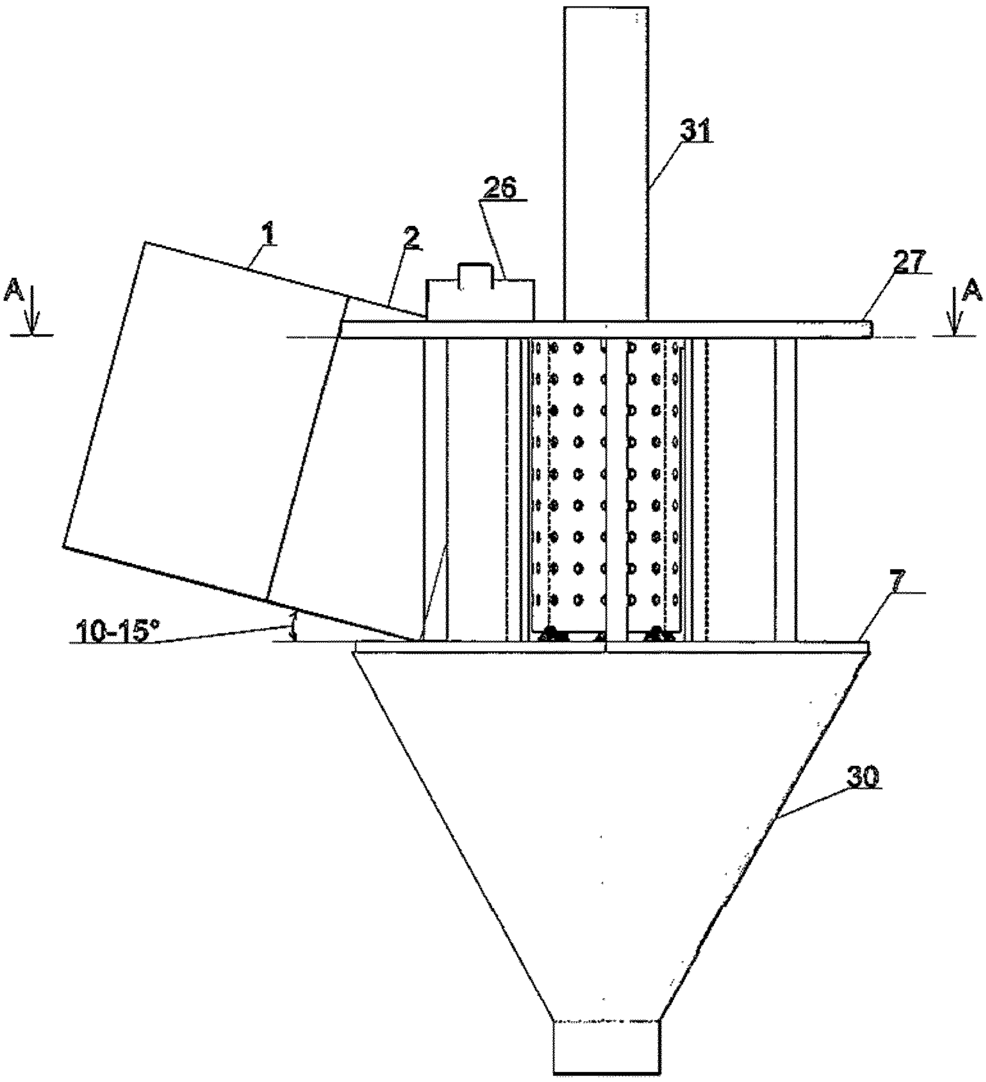

Fig. 4

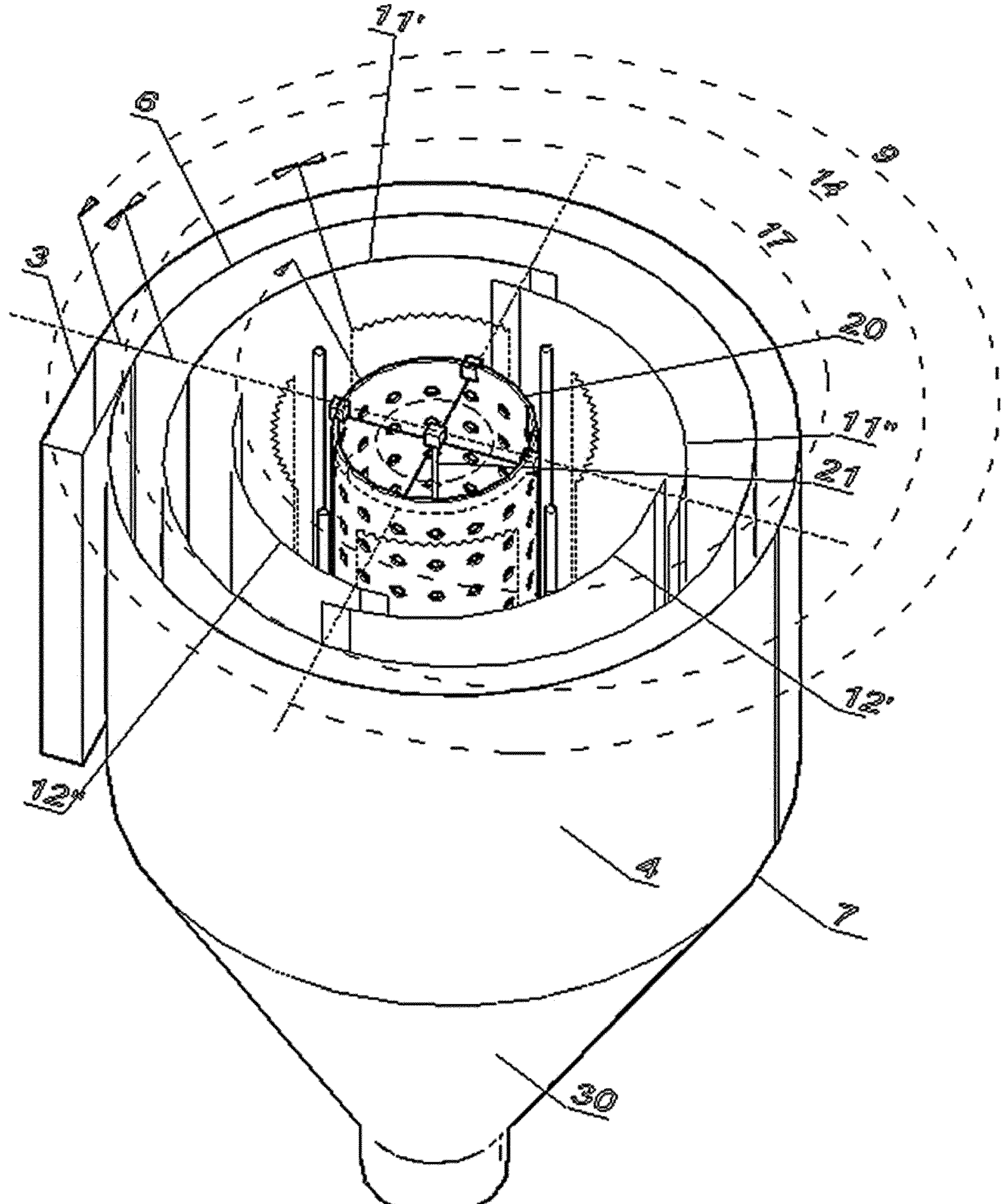

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 1335

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	RU 2 077 952 C1 (NI I PK I OKHRANY OKRUZHAYUSHC [SU]) 27 April 1997 (1997-04-27) * paragraphs [0001], [0013] - [0019], [0006] - [0008]; figures 1,2 * -----	1-6	INV. B04C5/103
Y	US 4 478 613 A (BRETTSCHNEIDER JOHANNES [DE] ET AL) 23 October 1984 (1984-10-23) * column 1, line 61 - column 2, line 4; figures 1,2a,2b,3,4 * * column 3, lines 33-37,51 - column 4, line 16 * -----	1-6	

TECHNICAL FIELDS SEARCHED (IPC)

B04C
B03C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 February 2024	Iuliano, Emanuela

CATEGORY OF CITED DOCUMENTS

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11-02-2024

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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