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(73) Patenthaver: **Enotec GmbH Prozess und Umweltmesstechnik, Höher Birken 6, 51709 Marienheide, Tyskland**

(72) Opfinder: **Gumprecht, Fred, Höher Birken 6, 51709 Marienheide, Tyskland**

(74) Fuldmægtig i Danmark: **NORDIC PATENT SERVICE A/S, Bredgade 30, 1260 København K, Danmark**

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Description

The invention relates to a liquid-cooled gas sampling probe comprising:

- a probe tube through which cooling liquid flows and having an outer jacket and an inner jacket which are connected to one another in a sealed manner and form an enclosure of a flow space,
- at least one tubular filter made of sintered material, which is arranged inside the inner jacket of the probe tube, wherein measuring gas entering the inner jacket of the probe tube through the free end of the probe tube flows through the tubular filter from the outside to the inside,
- at least one measuring chamber with at least one measuring sensor, into which the sample gas enters after flowing through the tubular filter,
- an ejection plate which is arranged in the region of the free end of the probe tube and is axially displaceable within the inner jacket, wherein during the measurement operation, a narrow annular gap between the exterior of the ejection plate and the inner jacket of the probe tube allows measuring gas to flow into the probe tube.

Such a gas sampling probe is known from WO 95/28628 A1 or EP 1 371 976 B1. The gas sampling probe from EP 1 371 976 B1 is intended to ensure proper combustion for the operators of the firing systems of power plants, waste incineration plants, glass smelters, cement rotary kilns and similar plants by controlling the firing. In order to be able to comply with the prescribed limit values for the flue gas composition, the composition and, in particular, the oxygen concentration in the flue gas must be constantly monitored. As a rule, water is used as the coolant, possibly with an antifreeze or other additives. For this reason, the term water cooling is used in the following. However, it is also possible to use another cooling liquid, e.g. oil, which has a different boiling point than water. An intermediate jacket between the outer jacket and the inner jacket divides the flow space for the cooling liquid into an outer inflow space with an annular cross-section, in which cooling liquid flows from a cold end of the probe tube to its free end inside the flue gas, and into an inner outflow space with an annular cross-section, in which the cooling liquid flows back from the free end to the cold end of the probe tube. However, other structures for guiding the flow of the cooling liquid between the outer jacket and the inner jacket are also possible, for example small diameter pipes.

Earlier measuring methods and measuring arrangements for determining the gaseous flue gas components suggested drawing the sample gas from the combustion chamber by means of water-cooled gas sampling probes and feeding it to a gas analyser via temperature-controlled hoses and long distances. The flue gas needed several minutes to get from the combustion chamber to the analyser. The changed gas composition could therefore only be measured with a long time delay. In heavily dust-laden furnaces, e.g. cement rotary kilns, there was a risk of dust caking inside the measuring chamber (raw meal build-up) with the previously known probes.

These disadvantages have been reduced or eliminated by the gas sampling probe according to EP 1 371 976 B1. The measuring sensor is located inside an inner jacket of the water-cooled probe tube near the sampling point. The extracted gas flows through a tubular filter made of a sintered material, which encloses a measuring chamber so that dust particles are filtered out of the flue gas before reaching the measuring sensor. Connected to the measuring chamber is an ejection plate located within the inner shell near the free end of the probe tube. The ejection plate is axially movable within the inner jacket. An annular gap is provided between the ejection plate and the inner jacket through which the sample gas flows into the probe tube and flows towards the filter. The measuring chamber with the filter and the ejection plate is arranged axially movable within the inner jacket. It is pushed axially forward at regular intervals so that the ejection plate eliminates any accumulation of particles at the free end of the probe tube inside the combustion chamber. The probe tube itself is rotated through an angle of 90° at regular intervals. This is to ensure that deposits of particles on the probe tube fall down and that the probe tube is not firmly connected by such deposits to the inlet opening of the combustion chamber through which the probe tube protrudes.

GB 1 340 918 A discloses a gas analysis device in which a filter is arranged in a cooling tube. A number of bowl-shaped metal parts or brushes are arranged at the tip of a dust removal rod 3 for scraping off dust deposited on the filter. US 4 772 454 A describes a probe for extracting dusty gas with a cooling jacket and a duct leading to a chamber with a filter. The duct inlet is convergent to reduce the gas velocity at the inlet opening and thus the dust load. As the gas flows into the duct inlet, it is accelerated to a higher velocity. In contrast, US 4 161 883 A discloses a gas sampling probe with a collection tube that draws sample gas from a hood-shaped filter inside a cylindrical protective tube and transports it to an inner filter.

The gas sampling probe of EP 1 371 976 B1 has proven itself in practice. However, problems due to particle deposits were observed during its operation, which are to be eliminated by the present invention. In particular, after a certain period of operation, the tubular filter could clog up. Also, the caking of particles could not always be reliably avoided by rotating the probe tube.

The present invention is intended to eliminate these problems.

For this purpose, it is proposed to arrange a connecting element between the filter and the ejection plate, the diameter of the connecting element being several millimetres smaller than the inner diameter of the inner jacket, so that an annular space is formed between the connecting element and the inner jacket, the radial extent of the annular space corresponding to a multiple of the radial extent of the annular gap between the ejection plate and the inner jacket.

As is already the case with the known measuring probe of EP 1 371 976 B1, the annular inlet opening for the measuring gas in the region of the free end of the probe tube keeps a large part of the particles outside the probe tube. In the present development, however, there is a connecting element between the ejection plate and the filter, which has a significantly smaller diameter than the inner jacket of the probe tube. This forms a large-volume annular space adjacent to the annular gap, in which the flow velocity of the sample gas entering through the annular gap is considerably slowed down. While flowing through the annular space, particles present in the sample gas are deposited in the annular space due to gravity, so that they do not reach the filter. If the design of the annular gap imposes a velocity component on the sample gas in the circumferential direction of the probe tube, in addition to the deposition due to gravity, deposition due to a cyclone effect also takes place in the annular space, i.e. the particles are moved towards the wall of the annular space by centrifugal force of the gas flow rotating about the axis of the probe tube. Only a very small fraction of the particles reach the filter. Consequently, the risk of a clog up of the filter surface by particles is considerably reduced.

As with the known measuring probe, the flow path of the sample gas is regularly backwashed. For this purpose, a flushing gas is passed through the inner jacket, which flows over the filter surface at high flow velocity and out of the free end of the probe tube through the annular space and the annular gap. As it flows over the filter surface and through the annular space and annular gap, the flushing gas entrains deposited particles.

During backwashing, the ejection plate is moved out of the free end of the probe tube so that particles deposited on the face of the probe tube in the area of the annular gap are loosened and repelled. The outlet opening for the flushing gas is much larger than the annular gap when the ejection plate is completely moved out. Due to the annular space with a large cross-section, the volume flow of flushing gas during backwashing is much greater than with the known probe with a small annular gap. Due to the large volume flow of flushing gas, all particles on the filter surface and in the annular space are blown out. In addition, a pressure surge is created at the beginning of the flushing process, which also promotes the loosening of deposits. The increased volume flow of flushing gas that flows out over the filter surface and the reduced deposition of particles on the filter itself prevent permanent deposits from forming on the filter surface and reducing its permeability.

The measuring probe according to the invention can be operated over a period of years without disturbances of the sample gas extraction and without the need for manual cleaning work. It reliably provides the required in-situ measurement results of the flue gas composition without the need to interrupt the operation of the combustion plant for maintenance or cleaning work on the gas sampling probe.

Compared to the previously known probe, the measuring chamber is displaced backwards in the axial direction by the connecting element with the smaller inner diameter. The measuring chamber can still be located inside the probe tube. However, it can also be arranged near the cold end of the probe tube, which is outside the combustion chamber, in a flanged housing.

It should be noted that the features of the invention preferably but not exclusively refer to circular elements with a constant diameter value in all directions. Both the diameter of the inner jacket and the diameter of the connecting element may vary. For example, the inner shell and the connecting element may have a quadrangular or triangular cross-section. The annular space need not be a circular ring with homogeneous extension along the entire circumference. It can also be an angular ring or otherwise inhomogeneous ring. However, the annular space has a larger cross-sectional area than the annular gap between the ejection plate and the inner jacket, so that the sample gas flow slows down considerably in the annular space. The radial extension of the annular space does not have to correspond to a multiple of the radial extension of the annular gap at all points. In particular, if the cross-section of the annular space deviates from the annular ring shape, it is sufficient that the mean radial extension of the annular space corresponds to a multiple of the mean radial extension of the annular gap, so that the total cross-sectional area of the annular space is considerably larger than that of the annular gap.

In practice, the following features have proven to be advantageous, which individually or in combination with each other advantageously further form the gas sampling probe described above.

The length of the annular space can be greater than the outer diameter of the probe tube. The longer the annular space, the longer the particle-laden gas flows at a slower speed before reaching the filter, and the more particles can be deposited in the annular space so that they do not foul the filter surface.

The connecting element can extend over at least one third of the length of the probe tube. For a 2 m long probe tube, the length of the connector would therefore be at least 60 cm. In practice, the length of the connecting element may even be greater than half the length of the probe tube.

The filter can extend over at least a quarter of the length of the probe tube. With a 2 m long probe tube, the filter would therefore have a minimum length of 50 cm. Several filters can also be arranged in series.

The measuring chamber is axially adjacent to the end of the filter facing away from the connecting element. In particular, the following movable elements are then arranged successively in the axial direction inside the inner jacket of the probe tube, starting from its free end:

- ejection plate
- Connecting element
- Filter (one or more).

In a practical embodiment, the measuring chamber is directly adjacent to the cold end of the probe tube, but can also be arranged inside the probe tube in the area of the cold end. The measuring chamber is firmly coupled to the movable elements in the probe tube.

In practice, these movable elements are accommodated in the inner jacket of the probe tube so that they can be moved in the axial direction and are connected to a drive unit. The drive unit pushes the elements forward in axial direction at regular intervals so that the ejection plate exits through the free end of the probe tube. At the same time, flushing gas is directed inside the inner jacket over the filter and past the connecting element out of the free end of the probe tube. For this purpose, the flushing gas is contained in a flushing gas tank with considerable overpressure. The flushing gas removes deposits from the outer surface of the filter and flushes them through the annular space between the connecting element and the inner jacket of the probe tube to the free end of the probe tube and then back into the flue gas. Deposits on the face of the probe tube are removed by the ejection plate. Due to the large volume flow of flushing gas, such deposits are prevented from getting into the annular space between the connecting element and the inner jacket. The flushing gas flow emerging at the free end of the probe tube prevents particles from the flue gas flow from entering the probe tube.

As mentioned above, the measurement chamber may be located inside the probe tube. In particular, the measuring chamber may be located near the cold end of the probe tube, which is opposite the free end of the probe tube that projects into the flue gas flow.

In practice, the length of the probe tube can be between 2,000 and 4,000 mm (2 m and 4 m).

The diameter of the probe tube can be between 80 and 200 mm in particular.

The width of the annular gap can be smaller than 1 mm in practice. In particular, an annular gap with a width of about 0.5 mm has proven itself.

The width of the annular space between the connecting element and the inner jacket of the probe tube can be greater than 5 mm. In this way, the speed of the flow of the sample gas towards the filter inside the inner jacket of the probe tube is considerably reduced and the deposition of particles present in the sample gas is made possible.

In practice, the at least one tubular filter can have a pressure pipe projecting through it, which has at least one passage opening and whose interior is in fluid communication with the measuring chamber. Consequently, the sample gas can flow not only through the annular space between the filter and the pressure pipe to the measuring chamber, but also through the inner cross-section of the pressure pipe.

In practice, the ejection plate may further be connected to centring bodies which are supported against the wall of the inner shell. In particular, the ejection plate may be attached to a guide element which has pins extending in the radial direction. The pins rest against the inner jacket of the probe tube. The inner jacket of the probe tube is usually made of stainless steel. The pins can be made of a softer metal, for example brass. In this way, the ejection plate is precisely guided in the probe tube while maintaining the annular gap. Preferably, 3 brass pins are arranged as centring bodies in the guide element. The three brass pins extend in a radial direction and are each offset from each other by an angle of 120°. However, more centring bodies can also be provided.

The ejection plate and the guide element with the centring bodies can be detachably connected to the other movable elements in the probe tube (connecting element, filter). The exterior of the ejection plate is in direct contact with the flue gas. The brass pins that form the guide elements for the ejection plate can wear out because they are made of a softer metal than the inner jacket. The possibility of replacing the heavily loaded elements and the elements subject to wear means that the probe according to the invention can be operated very reliably over a very long period of time.

The invention further relates to a method for measuring the composition of particle-laden gases in which

- measuring gas is extracted from a gas flow by means of a probe tube with an outer jacket and an inner jacket through which cooling liquid flows,
- the sample gas flows into the probe tube through a narrow annular gap between an ejection plate arranged in the inner jacket and the inner jacket in the region of the free end of the probe tube, and

- the sample gas is passed through a tubular filter made of sintered material to a measuring chamber with a measuring sensor.

Again with the aim of avoiding clogging of the filter, the sample gas, before flowing into the filter, is passed through an annular space arranged between the filter and the ejection plate, the radial extent of which corresponds to the multiple of the radial extent of the annular gap between the ejection plate and the inner jacket.

In practice, the ejection plate can be moved axially through the free end out of the probe tube at predetermined time intervals, whereby a flushing gas with overpressure is fed into the inner jacket and flows over the filter surface and through the annular space and out of the free end of the probe tube. Due to the enlarged flow cross-section in the annular space, the volume flow of the flushing gas in the probe is considerably much greater than in the previously known probe, in which only a very small annular gap existed between the inner jacket and the parts of the probe that move therein. Due to the increased amount of flushing gas, a much higher flow volume is achieved, which removes any deposits from the filter surface. Furthermore, all deposits are reliably blown out of the annular space. The flushing gas is stored in a large tank (e.g. 30 L) at a considerable overpressure, so that a pressure surge is created in the inner jacket at the beginning of the backwash process. This pressure surge entrains deposits on the filter surface and on other surfaces inside the inner jacket. There is enough flushing gas to maintain a flow for a continuous period of several seconds until the ejection plate is moved back into the probe tube and closes the gas inlet opening except for the annular gap.

In practice, the probe tube is connected to a drive device that moves the probe tube in axial direction at predetermined time intervals. This movement takes place over a fraction of the length of the probe tube. A 2 - 4 m long probe tube can, for example, be pulled axially out of the combustion chamber by 0.5 m or 1 m and then pushed in again. The axial displacement ensures that no unacceptably large deposits form on the probe tube near the inlet opening in the wall of the combustion chamber. By pulling out in the axial direction, deposits formed on the probe tube near the wall of the combustion chamber are wiped off by the edge of the inlet opening for the probe tube.

Furthermore, the probe tube can be rotated as in the previously known embodiment. The rotation ensures that successively different surface areas of the probe tube are exposed to the flow, so that the debris is distributed to different areas of the probe tube and loose particles fall from the surface of the probe tube.

Further practical embodiments and advantages of the invention are described below in connection with the drawings.

Figure 1 shows a three-dimensional view of a gas sampling probe according to the invention.

Figure 2 shows a sectional view of the probe tube of the gas sampling probe from Figure 1.

Figure 3 shows an enlarged view of detail A from figure 2.

Figure 4 shows an enlarged view of detail B from figure 2.

Figure 5 shows a cutaway side view of the successive movable elements within the probe tube.

Figure 6 shows an enlarged view of detail C from figure 5.

Figure 7 shows an enlarged view of detail D from figure 5.

Figure 8 shows an enlarged view of detail E from figure 5.

Figure 9 shows an enlarged view of the detail F from Figure 5.

Figure 10 shows a side view of the moving parts from Figure 5.

Figure 11 shows an enlarged sectional view along section line XI-XI in Figure 10.

Figure 12 shows a three-dimensional view of the probe tube with adjoining measuring chamber in partial section.

Figure 13 shows an enlarged view of the detail G from Figure 12.

Figure 1 shows a three-dimensional top view of a gas sampling probe 1 cooled by a cooling liquid according to the development described here. Water is usually used as the cooling liquid. The gas sampling probe 1 essentially consists of a probe tube 2 with a connection box 3, which is attached to the rear end of the probe tube 2. The connection box 3 is connected via an energy chain 4 to stationary devices (not shown) such as a pump and a heat exchanger for the cooling water, an analysis cabinet, a supply for flushing gas, a power supply, etc. The energy chain 4 consists of several links and accommodates all cables and hoses through which the connection box 3 is connected to stationary equipment. The connection box 3 mainly comprises valves for pneumatic and hydraulic lines, since the drives of the gas sampling probe are preferably pneumatically actuated. The links of the energy chain 4 enable damage-free movement of the cables and hoses during displacement of the probe tube 2. In the present case, the probe tube 2 has a length of 4 m and a diameter of 120 mm. The probe tube 2 is attached to a support rail 5 so that it can be moved in the axial direction. The carrier rail 5 consists of two I-shaped steel beams which are connected to each other at their ends by suitable connecting elements. The support rail 5 can have toothed racks which interact with toothed wheels of a drive motor 10 for the gas sampling probe. Movement stops and movement detectors for controlling the movement of the gas sampling probe 1 may also be provided on the support rail 5. A closure box 6 is arranged at the front end of the mounting rail 5. This is flange-mounted on a wall of the flue gas-conducting space, for example a combustion chamber of a rotary cement kiln. The closure box 6 ensures that the opening to the combustion chamber is closed in the best possible way both when the probe tube 2 is pushed in and when the probe tube 2 is pulled out, as shown in Figure 1.

In the front area of the support rail 5, a support roller 7 is attached, which supports the probe tube 2. The rear area of the probe tube 2 is connected via pedestal bearings 8, 9 to a moving carriage which moves on the two supports of the carrier rail 5. The pedestal bearings 8, 9 are part of the movable unit. The drive motor 10 is connected to the connection box 3. The drive motor is a pneumatic motor and moves the unit consisting of the moving carriage with probe tube 2 with connection box 3 and drive motor 10 in the axial direction along the carrier rail 5. A gas container 11 is attached to the moving carriage. This serves to hold flushing gas which is used during the cleaning process of the gas sampling probe 1 described further below.

For measuring operation, the probe tube 2 is displaced by the drive motor 10 in axial direction towards its free end 12. In the process, the free end 12 of the probe tube 2 enters the combustion chamber through the closure box 6 and is moved more than one metre into the flue gas flow.

The flue gas in the combustion chamber has a temperature of up to 1,400°C, for example in the case of a cement rotary kiln. For this reason, the probe tube 2 is cooled, in this case water-cooled.

Figures 2 to 11 explain the structure of the probe tube 2 and the elements movable therein, which as can be seen in Fig. 5 form a movable unit also called a plunger. As can be seen in Figs. 2 to 4, the probe tube 2 comprises an outer jacket 13, an intermediate jacket 36 and an inner jacket 14. The inner jacket 14 is composed of an inner jacket tube 14' and a sleeve-shaped section 14" of an end piece 37, which tightly connects the outer jacket 13 to the inner jacket 14 in the region of the free end 12 of the probe tube 2. A flow space 15 for the cooling liquid is formed between the outer jacket 13 and the inner jacket 14. The flow space 15 is divided by the intermediate jacket 36 into two elongated spaces with an annular cross-section. In the outer inflow space, relatively cold water is directed from the cold end of the probe tube 2 to the free end 12 of the probe tube 2 in the flue gas. In the inner outflow space, the water flows back to the cold end of the probe tube 2. Further guide devices, in particular guide plates (not shown), can be provided in the flow space 15, which influence the water flow within the flow space 15. The water inlet and outlet are both arranged in a known manner at the end of the cold end of the probe tube near the plenum box 3 (see Fig. 1). The circulating water flow within the flow chamber 15 ensures effective cooling of the probe tube 2 and the elements located therein.

The elements inside the inner jacket 14 of the probe tube 2, which are successive in the axial direction, can be seen in particular in Figures 2 to 13. They comprise

- an ejection plate 16 positioned closest to the free end 12 of the probe tube 2;
- a guide element 17 to which the ejection plate 16 is attached;
- a tubular connecting element or connecting tube 18;
- a first tubular filter 19 made of sintered metal;
- a second tubular filter 20 made of sintered metal, which is connected to the first filter 19 via a connecting sleeve 21;
- an extension member 22 having a sealing ring 23 at its end remote from the ejection plate 16 opposite a measuring chamber 33; and
- a connector 24, via which the movable elements are connected to the measuring chamber 33.

The measuring chamber 33 is located behind the cold end of the probe tube 2 behind a casing 25 (see Figures 1 and 13). Sensors known from the state of the art are arranged in the measuring chamber 33, in particular an oxygen sensor and a sensor for measuring the carbon monoxide content (CO).

In contrast to the prior art, the measuring chamber in the present gas sampling probe is located near the cold end of the probe tube 2, which is opposite the free end 12. The sensors are thus not located within the flue gas flow but in a relatively cool area. This considerably increases the reliability and service life of the sensors, while still ensuring their proximity to the location of the gas extraction, i.e. to the free end 12 of the probe tube 2 in the flue gas.

Detail A in Figure 3 shows how the ejection plate 16 is attached to the guide element 17 and the latter to the connecting tube 18. The connecting tube 18 is welded to the end of the guide element 17 facing away from the free end 12 of the probe tube 2. On the opposite side, the ejection plate 16 is attached to the guide element 17 with a screw connection. The ejection plate 16 is in direct contact with the flue gas and is pushed out of the probe tube 2 at regular intervals in the direction of movement shown by the arrow in Figure 3 until it protrudes several millimetres from the probe tube 2. The ejection plate 16 is therefore susceptible to wear and can be easily detached from the guide element 17 by means of the screw connection. The guide element 17 has three centring bodies 26 (see figures 10 and 11). The centring bodies 26 consist of cylindrical brass pins. They are inserted into radial bores in the guide element 17, the bore axis of each of which is offset by 120° to the next bore. The surfaces of the brass centring bodies 26 lie against the inner jacket 14 of the steel probe tube 2 (see Figure 3). When assembling the probe, the guide element 17 with the ejection plate 16 is pushed inside the inner jacket 14 through the entire length of the inner jacket tube 14' into the sleeve-shaped section 14" of the end piece 37. During operation, the guide member 17 with the ejection plate 16 is moved within and out of the sleeve-shaped section 14" of the end piece 37. The centring members 26 ensure that a narrow annular gap is maintained between the periphery of the ejection plate 16 and the inner sleeve 14. The annular gap is so small relative to the diameter of the ejection plate 16 that it is barely visible in Figure 3. The gap width may be in the order of 0.5 mm, for example. Since the material of the centring bodies 26 (brass) is softer than the material of the inner jacket 14 (steel), the inner jacket 14 is not worn out during the relative movement of the guide element 17 to the probe tube 2. The centring bodies 26, on the other hand, can be replaced relatively easily.

It can be seen in Figure 3 or Figure 5, for example, that the movable arrangement located in the inner jacket 14 has a reduced diameter shortly behind the ejection plate 16. The guide element 17 already has a smaller diameter than the ejection plate 16. The connecting element (connecting tube 18) adjoining the guide element 17 has a diameter several millimetres smaller than the ejection plate 16. The diameter of the ejection plate is in the order of more than 40 mm. The diameter of the connecting tube 18 is less than 30 mm.

At its end facing away from the ejection plate 16, the connecting tube 18 has a closure body 27 and a threaded sleeve 28. The threaded sleeve 28 can be connected to a complementary threaded sleeve 29 which is welded to the first tubular filter 19 made of sintered metal. The first tubular filter 19 has a length of approximately 0.5 m. It is followed by a second tubular filter 20, which has a length of 1 m. The total length of the tubular filters 19, 20 allows a sufficiently large volume flow of sample gas to pass through during the measurement.

The two tubular filters 19, 20 are connected to each other by a connecting sleeve 21, which is shown in particular in Figure 7. The filter 20 is connected to a tubular extension element 22 made of stainless steel via a corresponding connecting sleeve 21. The end of the tubular extension element 22 is connected to a structural element in which the measuring chamber is located and sealed by a sealing ring 23.

Within the filters 19, 20 and within the tubular extension element 22 a pressure tube 30 extends. The pressure tube 30 is tightly closed at its front end with the closure body 27 and coupled in axial direction with the tubular connection element 18 (see Fig. 6). At the opposite end, the pressure pipe 30 has the connection piece 24, which can be connected to the measuring chamber 33. The pressure pipe 30 has, in particular in the area of the tubular filter 19, 20, passage openings 31 which allow gas to flow through the wall of the pressure pipe 30. In this way, sample gas can flow not only through the annular space between the pressure tube 30 and the extension element 22 or the filters 19, 20, but in particular through the interior of the pressure tube 30.

During the measuring operation, the ejection plate with the adjoining axially displaceable elements is completely inside the probe tube 2 as shown in Figures 2, 3 and 4. In particular, it can be seen in Figure 3 that a very narrow gap remains between the ejection plate 16 and the front end of the inner jacket 14. The gap is precisely adjusted due to the guidance of the ejection plate 16 by means of the centring bodies 26 in the inner jacket 14 of the probe tube 2. The area of the ejection plate 16 with the largest diameter extends only over a few millimetres. After that, the diameter of the ejection plate 16 and the adjoining guide element 17 is reduced. The guide element 17 itself is attached to the tubular connecting element 18, also called connecting tube, whose diameter is several millimetres smaller than the diameter of the inner jacket 14.

In the measuring chamber 33, a negative pressure prevails during measuring operation, caused by a suction pump to be connected externally, so that a certain amount of measuring gas is taken from the flue gas flow through the opening in the free end 12 of the probe tube 2. Initially, the sample gas flows through the annular narrow gap between the ejection plate 16 and the inner jacket 14. Then the gap widens and merges into the annular space 32, which is located between the connecting tube 18 and the inner jacket 14. In this annular space 32, the flow velocity is much lower than in the gap between the ejection plate 16 and the inner jacket 14. Particles that have passed through said gap settle in the annular space 32 due to the slow flow velocity. The annular space 32 extends over a longer distance, e.g. 0.6 to 1 m. Most of the particles will sink out of the sample gas as it flows through the annular space 32 due to gravity and will not move up to the surface of the filters 19 or 20. By means of spiral grooves in the outer surface of the ejection plate 16 or on the inner wall of the inner jacket 14, a rotational movement can also be imposed on the sample gas flow, which creates a vortex effect and additionally separates particles from the sample gas flow by centrifugal force.

On the surface of the tubular filters 19 and 20, the sample gas hardly has any particles. The sample gas flows through the tubular filters 19, 20 from their outside to their inside. Here the sample gas can flow either outside the pressure tube 30 or through the passage openings 31 in the pressure tube 30 and inside the pressure tube 30 in axial direction further to the measuring chamber. Connected to the second filter 20 made of sintered material is a connecting element 22 made of stainless steel tube, the end of which is sealed by means of the sealing ring 23 and leads to the measuring chamber. The end of the pressure pipe 30 is also connected to the measuring chamber 33 via the connecting piece 24 (see Fig. 13). The extracted sample gas flows between the pressure pipe 30 and the tubular extension element 22 and inside the pressure pipe 30 to the measuring chamber 33. The actual measuring probe 34 for the gas analysis with the sensors required for this is located in the measuring chamber.

To clean the device described here, the pressure tube 30, the filters 19, 20 and the connecting tube 18 are pushed forward towards the free end 12 of the probe tube by means of a drive. This causes the guide element 17 with the ejection plate 16 to move out of the free end 12 of the probe tube 2 in the direction shown by the arrow in Figure 3. At the same time, flushing gas at a high pressure is supplied to the inner jacket 14 from the gas container 11. The flushing gas first flows with a pressure surge and then continuously through the inner jacket 14 along the surfaces of the filters 19, 20. In the process, the flushing gas carries away any dirt that has deposited on the filters 19, 20. Further, the flushing gas flows parallel to the connecting tube 18 in the direction of the free end 12 of the probe tube 2 and here out of the probe tube 2. All impurities and particles inside the probe tube 2 are thereby blown out of the probe tube 2. While the flushing gas is still flowing, the movable elements inside the probe tube 2 are retracted again, so that the ejection plate 16 moves back into the probe tube 2 into the position shown in Figure 3. The flushing gas supply to the probe tube is then interrupted and the measuring chamber is subjected to a negative pressure with respect to the flue gas, so that flue gas again flows through the probe tube 2 and the filters 19, 20 arranged therein to the measuring chamber 33 at the cold end of the probe tube 2.

The features of the invention disclosed in the present description, in the drawings as well as in the claims may be essential, both individually and in any combination, for the realisation of the invention in its various embodiments. The invention is not limited to the embodiments described. It may be varied within the scope of the claims and taking into account the knowledge of the person skilled in the art.

List of reference signs

1	gas sampling probe
2	probe tube
3	connection box
4	energy chain
5	support rail
6	closure box
7	support roller
8	pedestal bearing
9	pedestal bearing
10	drive device
11	gas container
12	free end
13	outer jacket
14	inner jacket
15	flow space
16	ejection plate
17	guide element
18	connecting tube, tubular connecting element
19	tubular filter
20	tubular filter
21	connecting sleeve

22	extension member
23	sealing ring
24	connector
25	casing
26	centering bodies
27	closure body
28	threaded sleeve
29	threaded sleeve
30	pressure tube
31	passage opening
32	annular space
33	measuring chamber
34	measuring probe
35	Sealing element
36	intermediate jacket

Patentkrav

1. Væskekølet gasprøvetagningssonde (1) med:

- et sonderør (2), som gennemstrømmes af en kølevæske, med en yderkappe (13) og en inderkappe (14), som er tæt forbundet med hinanden og udgør begrænsningen af et strømningsrum (15),
- mindst et rørformet filter (19,20) af sintermateriale, som er anbragt inde i sonderørets (2) inderkappe (14), hvor målegas, der kommer ind i sonderørets (2) inderkappe (14) gennem sonderørets (2) frie ende (12), strømmer gennem det rørformede filter (19,20) udefra og ind,
- mindst et målekammer (33) med mindst en målesensor, som målegassen kommer ind i efter at have strømmet gennem det rørformede filter (19,20),
- en ejektorplade (16), som er anbragt i området med den frie ende (12) af sonderøret (2) og kan flyttes aksialt inde i inderkappen (14), hvor en smal ringspalte mellem ydersiden af ejektorpladen (16) og inderkappen (14) af sonderøret (2) i måledrift muliggør indstrømning af målegas i sonderøret (2),

kendetegnet ved, at der mellem filteret (19,20) og ejektorpladen (16) er anbragt et forbindelseselement (18), hvis diameter er flere millimeter mindre end inderkappens (14) indvendige diameter, sådan at der mellem forbindelseselementet (18) og inderkappen (14) opstår et ringrum (32), hvis radiale udstrækning svarer til en multipel af den radiale udstrækning af ringspalten mellem ejektorpladen (16) og inderkappen (14).

2. Gasprøvetagningssonde (1) ifølge krav 1, **kendetegnet ved, at** den har mindst et af følgende kendetegn:

- længden af forbindelseselementet (18) er større end den udvendige diameter af sonderøret (2);
- forbindelseselementet (18) strækker sig over mindst en tredjedel af længden af sonderøret (2);
- filteret (19,20) strækker sig over mindst en fjerdedel af længden af sonderøret (2);
- der er anbragt flere filtre (19,20) efter hinanden;
- målekammeret (33) grænser i aksial retning op til den ende af filteret (19,20), som vender væk fra forbindelseselementet (18);

- målekammeret (33) befinder sig i en kold ende af sonderøret (2) modsat den frie ende (12);
- længden af sonderøret (2) udgør mellem 2000 og 4000 mm;
- diameteren af sonderøret (2) udgør mellem 80 og 200 mm;
- bredden af ringspalten er mindre end 1 mm;
- bredden af ringrummet (32) er større end 5 mm.

3. Gasprøvetagningssonde (1) ifølge et af de foregående krav, **kendetegnet ved, at** det mindst ene rørformede filter (19,20) gennembores af et trykrør (30) med mindst en gennemgangsåbning (31), og hvis indvendige rum er i fluidforbindelse med målekammeret (33).

4. Gasprøvetagningssonde (1) ifølge et af de foregående krav, **kendetegnet ved, at** ejektorpladen (16) er forbundet med centreringselementer (26), som støtter sig mod væggen af inderkappen (14).

5. Gasprøvetagningssonde (1) ifølge et af de foregående krav, **kendetegnet ved, at** ejektorpladen (16) er fastgjort aftageligt på et føringselement, i hvilket der er anbragt mindst tre centreringselementer (26), som strækker sig radialt.

6. Gasprøvetagningssonde (1) ifølge krav 4 eller 5, **kendetegnet ved, at** føringselementerne kan udskiftes og består af et blødere metal end inderkappen (14).

7. Fremgangsmåde til måling af sammensætningen af partikelladede gasser, hvor:
- målegas udtages fra en gasstrøm ved hjælp af et sonderør (2), som gennemstrømmes af en kølevæske og har en yderkappe (13) og en inderkappe (14),
- målegassen strømmer ind i sonderøret (2) gennem en smal ringspalte mellem en ejektorplade (16) anbragt i inderkappen (14) og inderkappen (14) i området med den frie ende (12) af sonderøret (2),
- målegassen ledes gennem et rørformet filter (19,20) af sintermateriale til et målekammer (33) med en målesensor, **kendetegnet ved, at** målegassen før indstrømning i filteret (19,20) strømmer gennem et ringrum (32) mellem filteret (19,20)

og ejektorpladen (16), hvilket ringrums radiale udstrækning svarer til det multiple af den radiale udstrækning af ringspalten mellem ejektorpladen (16) og inderkappen (14).

8. Fremgangsmåde ifølge krav 7, **kendetegnet ved, at** ejektorpladen (16) med forhåndsdefinerede tidsintervaller bevæges aksialt ud af sonderøret (2) gennem den frie ende (12), hvor en skyllegas ledes med overtryk over overfladen af filteret (19,20) i inderkappen og gennem ringrummet (32) og strømmer ud af sonderørets (2) frie ende (12).

9. Fremgangsmåde ifølge krav 7 eller 8, **kendetegnet ved, at** en drevanordning (10) flytter sonderøret (2) aksialt med forhåndsdefinerede tidsintervaller.

10. Fremgangsmåde ifølge krav 7, 8 eller 9, **kendetegnet ved, at** en drevanordning drejer sonderøret (2) med forhåndsdefinerede tidsintervaller.

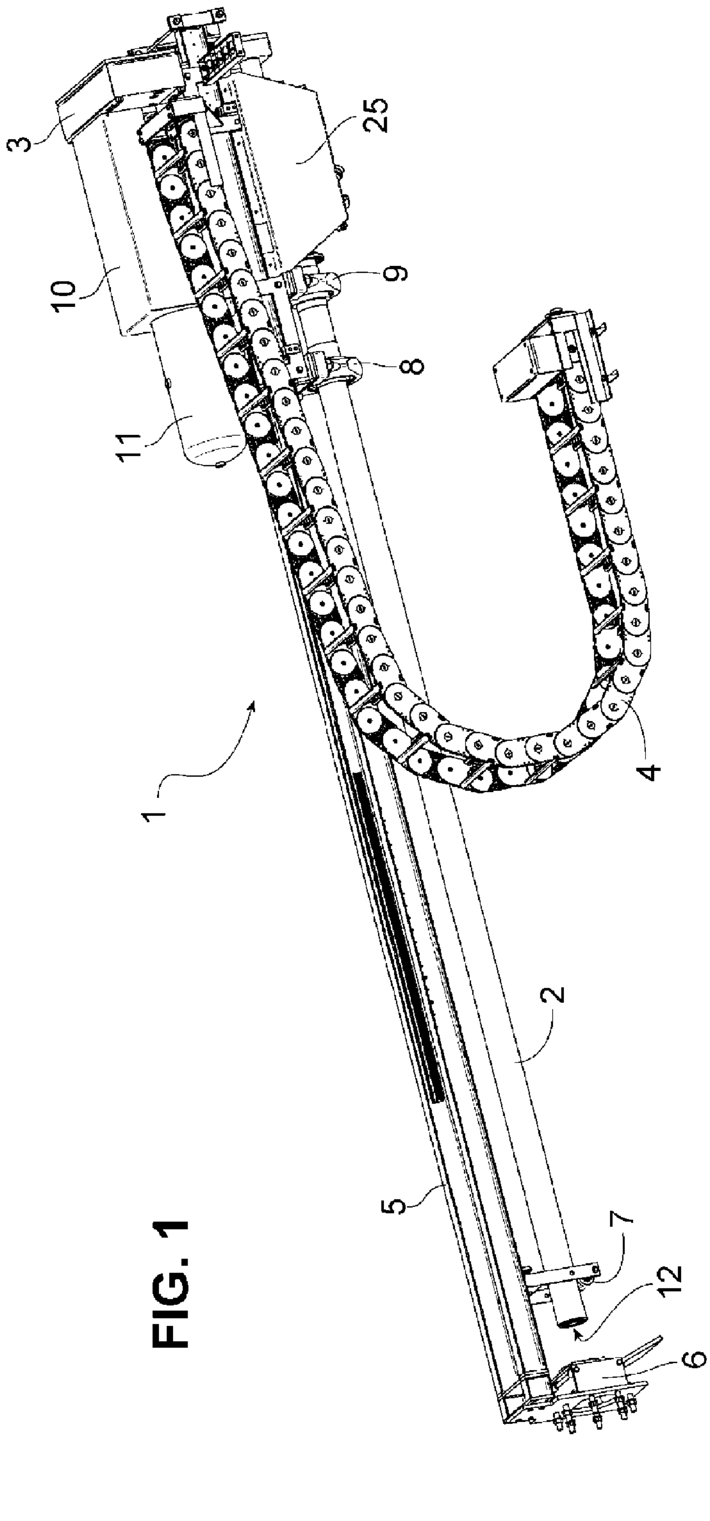

FIG. 1

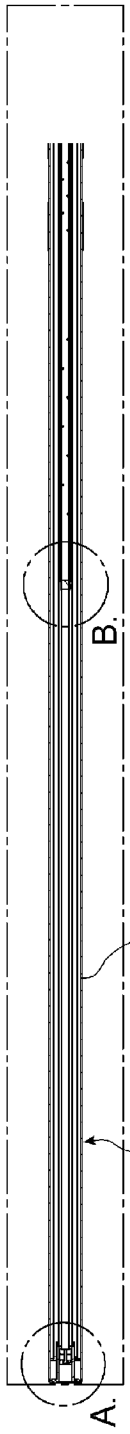

FIG. 2

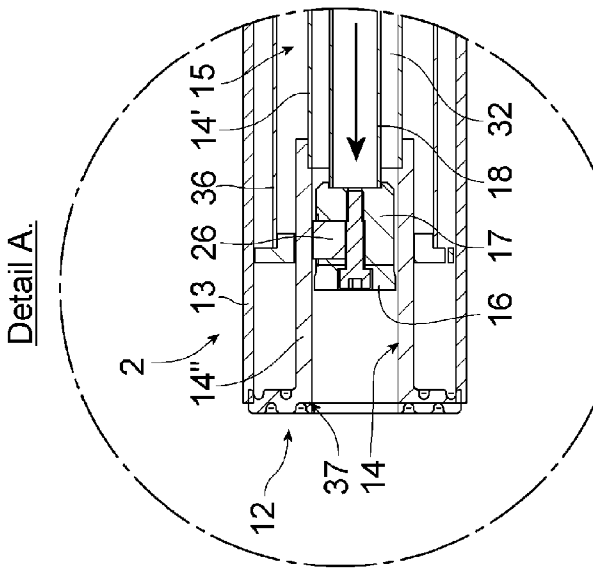

FIG. 3

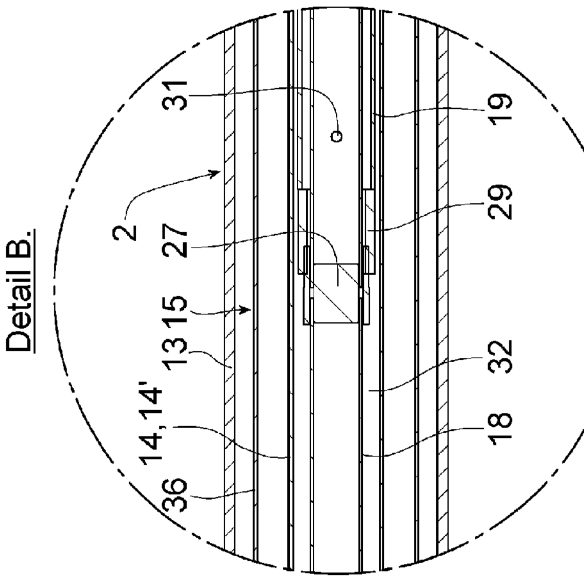

FIG. 4

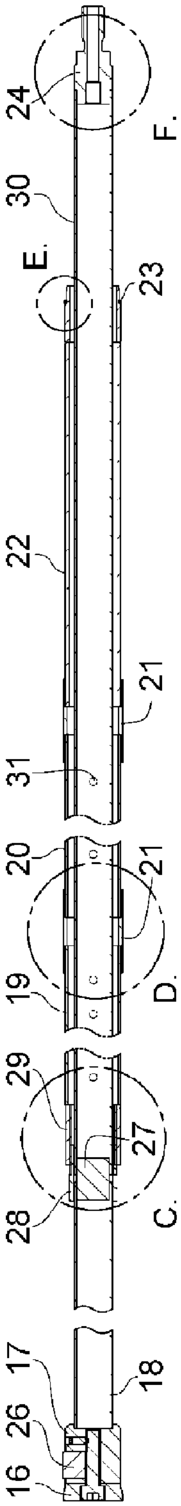

FIG. 5

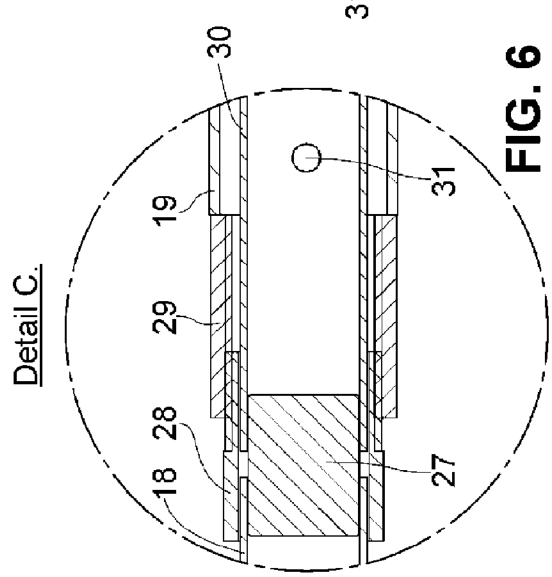

FIG. 6

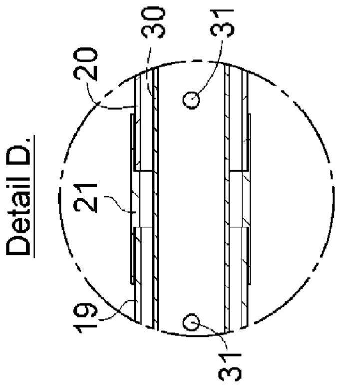

FIG. 7

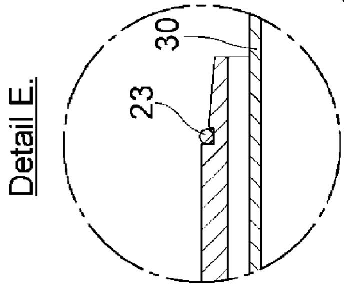

FIG. 8

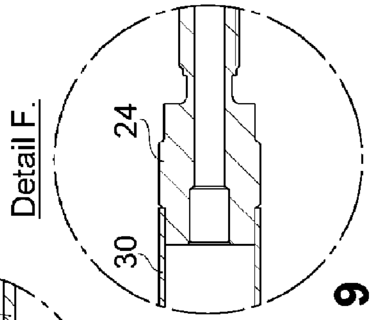

FIG. 9

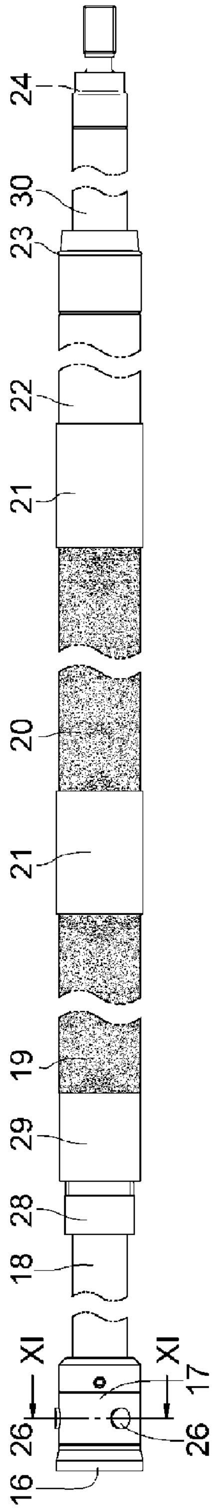

FIG. 10

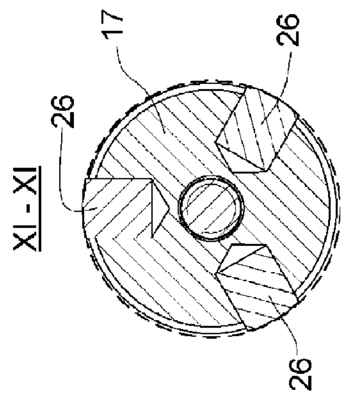

FIG. 11

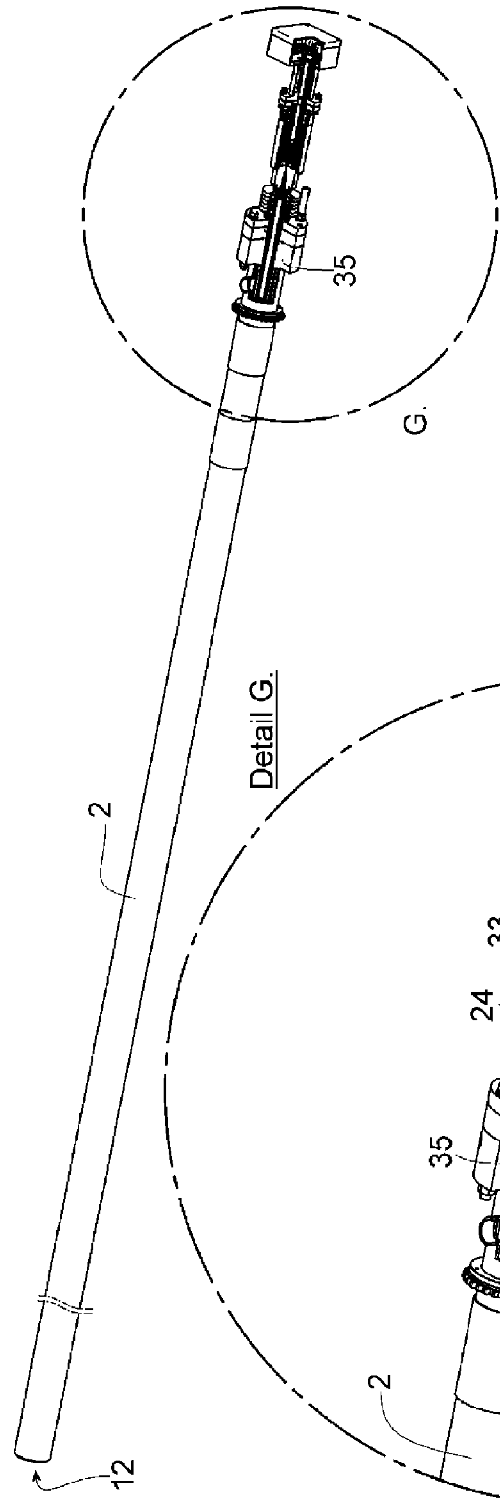

FIG. 12

Detail G.

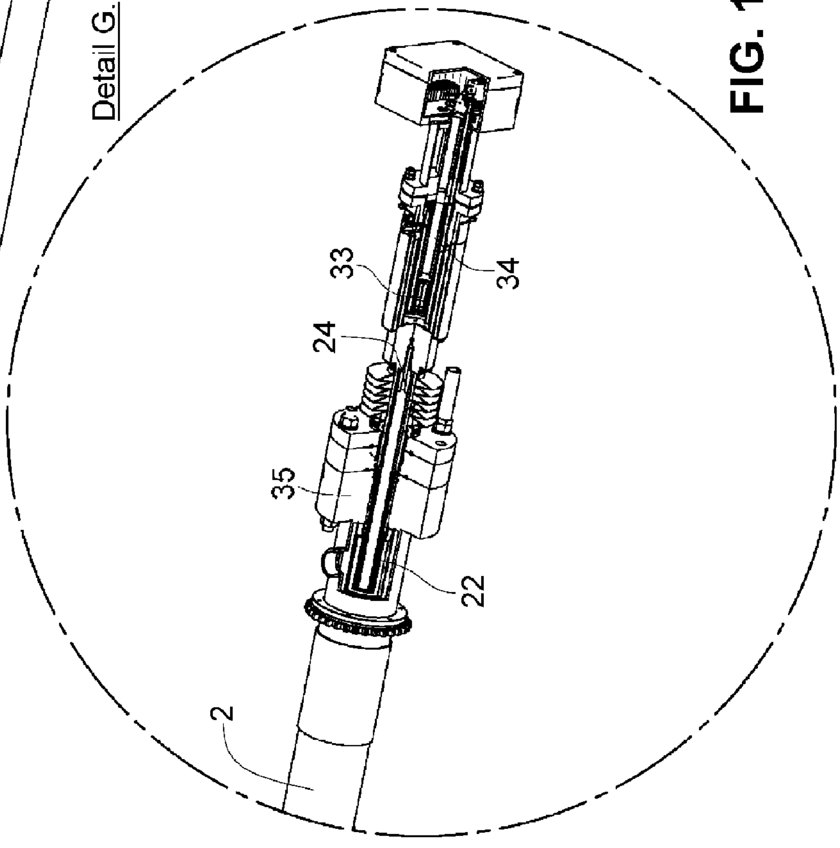

FIG. 13