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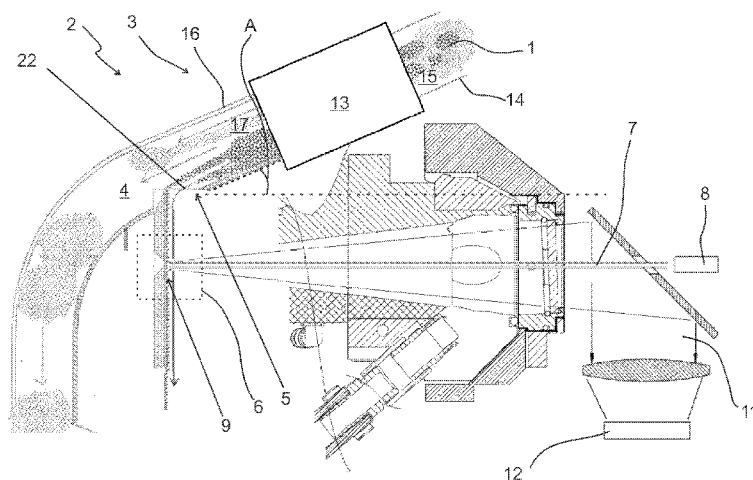


FIG 1

(57) Abstract: The invention relates to a method and to an apparatus for optical emission spectroscopy of fluids. The method comprising conducting a fluid sample flow (1) in a conduit (2) having an inclined conduit section (3), wherein the conduit (2) limits a flow channel (4) for the fluid flow, conducting at least a part of the fluid sample flow (1) vertically downwards from an outlet (5) of the inclined conduit section (3) of the conduit (2) to a flow cell (6). The method comprises providing the inclined conduit section (3) of the conduit (2) upstream of the outlet (5) with a turbulence generator (13) to change the cross section of the flow channel (4) of the conduit (2), and by providing the turbulence generator (13) at a distance from the outlet (5).



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METHOD AND APPARATUS FOR OPTICAL EMISSION SPECTROSCOPY OF FLUIDS

Field of the invention

5 The invention relates to a method for optical emission spectroscopy of fluids as defined in the preamble of independent claim 1.

The invention also relates to an apparatus for optical emission spectroscopy of fluids as defined in the preamble of independent claim 12.

10 Atomic/optical emission spectroscopy is a method to measure the presence or quantity of an element in a sample. By means of a source for electromagnetic energy such as a laser, plasma is induced in the sample and electrons in an element are excited to a higher level, and as the electrons decay back to a lower energy level they emit photons at a characteristic wavelength. Light i.e. photons emitted by the plasma are received and analyzed in a spectroscopy system. The wavelength is proportional to the energy difference between the excited state and the state it
15 decays to. The measured intensity is proportional to the concentration of the measured element in the plasma, the atomic parameters of the measured transition including the transition probability and the energy of the excited state, and parameter of the plasma including electron density and temperature.

20 Atomic/optical emission spectroscopy can for example be used for to measure the presence or quantity of an element / elements in a fluid sample flow.

A problem in electromagnetic energy assisted spectroscopy of fluids is that if the components of the fluid are not evenly distributed in the fluid when the actual measuring is performed, the performed measurement of elemental concentrations of the fluid does not represent the actual elemental concentrations of the fluid.

Objective of the invention

The object of the invention is to provide to solve the above-identified problem.

Short description of the invention

30 The method for optical emission spectroscopy of fluids of the invention is characterized by the definitions of independent claim 1.

Preferred embodiments of the method are defined in the dependent claims 2 to 11.

The apparatus for optical emission spectroscopy of fluids of the invention is correspondingly characterized by the definitions of independent claim 12.

35 Preferred embodiments of the apparatus are defined in the dependent claims 13 to 22.

The method and the apparatus make it possible to produce a representative fluid sample flow of the fluid flowing in the conduit i.e. a fluid sample flow, where components of the fluid flow are evenly distributed in the fluid sample flow.

The invention is based on changing the flow velocity of the fluid flow to create turbulence in the fluid flow to even out particle distribution in the fluid flow.

List of figures

5 In the following the invention will be described in more detail by referring to the figures, of which

Figure 1 shows in part a first embodiment of an apparatus for optical emission spectroscopy of fluids, wherein the apparatus has a conduit provided with a turbulence generator,

10 Figure 2 shows in part a second embodiment of an apparatus for optical emission spectroscopy of fluids, wherein the apparatus has a conduit provided with a turbulence generator comprising one throttling element,

Figure 3 shows in part a third embodiment of an apparatus for optical emission spectroscopy of fluids, wherein the apparatus has a conduit provided with a turbulence generator comprising two throttling elements,

15 Figure 4 shows in part a fourth embodiment of an apparatus for optical emission spectroscopy of fluids, wherein the apparatus has a conduit provided with a turbulence generator,

Figure 5 shows in part a fifth embodiment of an apparatus for optical emission spectroscopy of fluids, wherein the apparatus has a conduit provided with a turbulence generator,

20 Figure 6 shows in part a sixth embodiment of an apparatus for optical emission spectroscopy of fluids, wherein the apparatus has a conduit provided with a turbulence generator,

Figure 7 shows in part a seventh embodiment of an apparatus for optical emission spectroscopy of fluids, wherein the apparatus has a conduit provided with a turbulence generator,

Figure 8 shows the function principle of a first embodiment of a turbulence generator arranged in a conduit,

25 Figure 9 shows the function principle of a second embodiment of a turbulence generator arranged in a conduit,

Figure 10 shows the function principle of a third embodiment of a turbulence generator arranged in a conduit, and

30 Figure 11 shows the function principle of a fourth embodiment of a turbulence generator arranged in a conduit.

Detailed description of the invention

The invention relates to a method for optical emission spectroscopy of fluids and to an apparatus for optical emission spectroscopy of fluids

35 The method can for example be implemented in an Arc spark optical emission spectroscopy (OES) apparatus as shown in figure 6, in a Laser Induced Fluorescence (LIF) apparatus as shown in figures 1 to 3, and 5, in a Raman Spectroscopy apparatus as shown in figure 4, in a X-Ray Fluorescence (XRF) apparatus, and in a X-Ray Diffraction (XRD) apparatus

as shown in figure 7.

Correspondingly, the apparatus can be an Arc Spark optical emission spectroscopy (OES) apparatus as shown in figure 6, a Laser Induced Fluorescence (LIF) apparatus as shown in figures 1 to 3, and 5, a Raman Spectroscopy apparatus as shown in figure 4, a X-Ray Fluorescence (XRF) apparatus, or a X-Ray Diffraction (XRD) apparatus as shown in figure 7.

First the method for optical emission spectroscopy of fluids and some preferred embodiments and variants of the method will be described in greater detail.

The method comprises conducting a fluid sample flow 1 in a conduit 2 having an inclined conduit section 3. The conduit 2 limits a flow channel 4 for the fluid sample flow.

The method comprises conducting at least a part of the fluid sample flow 1 vertically downwards from an outlet 5 of the inclined conduit section 3 of the conduit 2 to a flow cell 6 configured to receive at least a part of the fluid sample flow 1 that flows in the inclined conduit section 3 of the conduit 2 from the inclined conduit section 3 of the conduit 2 and configured to release said at least a part of the fluid sample flow 1 so that said at least a part of the fluid sample flow 1 flows through the flow cell 6.

The method comprises applying electromagnetic energy 7 from a source 8 of electromagnetic energy onto a surface 9 of the fluid sample flow 1 that flows through the flow cell 6 to induce plasma 10 in the fluid sample flow 1 that flows through the flow cell 6.

The method comprises receiving light 11 emitted by the plasma 10 and analyzing the light 11 emitted by the plasma 10 in a spectroscopy system 12.

The method comprises providing the inclined conduit section 3 of the conduit 2 upstream of the outlet 5 with a turbulence generator 13 to change the cross section of the flow channel 4 of the conduit 2.

The method comprises providing the turbulence generator 13 at a distance from the outlet 5.

The method may comprise using in the inclined conduit section 3 of the conduit 2 upstream of the turbulence generator 13 a first conduit element 14 limiting a first flow channel section 15 forming a part of the flow channel 4, wherein the first flow channel section 15 of the flow channel 4 having an round cross section having an inner diameter between 10 and 33 mm, preferably between 15 and 25 mm.

The method may comprise using in the inclined conduit section 3 of the conduit 2 between the turbulence generator 13 and the outlet 5 a second conduit element 16 limiting a second flow channel section 17 forming a part of the flow channel 4, wherein the second flow channel section 17 of the flow channel 4 having an round cross section having an inner diameter between 10 and 40 mm, preferably between 20 and 30 mm.

The turbulence generator 13 that is provided may comprise at least one throttling element 18 limiting a third flow channel section 19 forming a part of the flow channel 4, wherein the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having a

round cross section having at a first downstream end 20 of the throttling element 18 an inner diameter that is between 5 and 18 mm, preferably about 10 mm, smaller than the round cross section of the first flow channel section 15 of the flow channel 4 upstream of the turbulence generator 13, and wherein the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having at a first upstream end 21 of the throttling element 18 an inner diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of the third flow channel section 19 of the flow channel 4 at the first downstream end 20 of the throttling element 18.

The turbulence generator 13 that is provided may comprise at least one throttling element 18 limiting a third flow channel section 19 forming a part of the flow channel 4, wherein the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having a round cross section having at a first downstream end 20 of the throttling element 18 an inner diameter that is between 5 and 18 mm, preferably about 10 mm, smaller than the round cross section of the second flow channel section 17 of the flow channel 4 between the turbulence generator 13 and the outlet 5, and wherein the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having at a first upstream end 21 of the throttling element 18 an inner diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of the third flow channel section 19 of the flow channel 4 at the first downstream end 20 of the throttling element 18.

The method may include providing the turbulence generator 13 between 25 and 300 mm from the outlet 5 as measured in the direction the fluid flow.

In the method as the source for electromagnetic energy can for example be used a laser such as a Nd:YAG laser, an arc spark generator, and a X-ray tube or source.

The method may include, as shown in figures 1, 2, 3, 4, 6, and 7, separating by means of separation element 22 that is arranged at the outlet 5 a portion of the fluid sample flow 1 flowing in the inclined conduit section 3 of the conduit 2 to generate a part of the fluid sample flow 1, and guiding said part of the fluid sample flow 1 through the outlet 5 by means of separation element 22.

The method may include, as shown in figure 5, conducting the fluid sample flow 1 vertically downwards from outlet 5 of the inclined conduit section 3 of the conduit 2 to a flow cell 6 by conducting the fluid sample flow 1 that flows in the inclined conduit section 3 of the conduit 2 from the outlet 5 against a vertical wall member 23 that is in fluid connection with the flow cell 6, and conducting the fluid sample flow 1 vertically downwards to the flow cell 6 along the vertical wall member 23.

The method includes preferably, but not necessarily, arranging the inclined conduit section 3 of the conduit 2 inclined at an inclination angle A with respect to a horizontal plane that is between 20 and 75°.

The method includes preferably, but not necessarily applying electromagnetic energy 7

from the source 8 of electromagnetic energy onto the surface 9 of the fluid sample flow 1 that flows through the flow cell 6 at a point that is located at such distance vertically below the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2, which distance is required for forming a vertical fluid sample flow 1 of the fluid sample flow flowing from the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2. This distance is in part dependent on the size of the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2.

The method includes preferably, but not necessarily applying electromagnetic energy 7 from the source 8 of electromagnetic energy onto the surface 9 of the fluid sample flow 1 that flows through the flow cell 6 at a point that is located at distance between 4 and 100 mm vertically below the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2.

The method includes preferably, but not necessarily applying electromagnetic energy 7 from the source 8 of electromagnetic energy onto the surface 9 of the fluid sample flow 1 that flows through the flow cell 6 at a point that is located at distance between 4 and 100 mm vertically below a point of the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2, which said point is the most upstream point of the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2. In other words, said point is the point in the flow channel 4 of the inclined conduit section 3 of the conduit 2, where fluid sample starts to flow out of the outlet 5 in the inclined conduit section 3 of the conduit 2

Next the apparatus for optical emission spectroscopy of fluids and some preferred embodiments and variants of the apparatus will be described in greater detail.

The apparatus comprising a conduit 2 configured to conduct a fluid sample flow 1, wherein the conduit 2 having an inclined conduit section 3, wherein the conduit 2 limits a flow channel 4 for the fluid sample flow 1.

The apparatus comprising a flow cell 6 in fluid connection with an outlet 5 the inclined conduit section 3 of the conduit 2 and configured to receive at least a part of the fluid sample flow 1 is configured to flow in the inclined conduit section 3 of the conduit 2 from the outlet 5 of the inclined conduit section 3 of the conduit 2 and configured to release said at least a part of the fluid sample flow 1 so that said at least a part of the fluid sample flow 1 flows through the flow cell 6,

The apparatus comprising a source 8 of electromagnetic energy for applying electromagnetic energy 7 onto the surface 9 of the fluid sample flow 1 that flows through the flow cell 6 to induce plasma 10 in the fluid sample flow 1 that flows through the flow cell 6, and

The apparatus comprising a spectroscopy system 12 for receiving light 11 emitted by the plasma 10 and for analyzing the light 11 emitted by the plasma 10.

The inclined conduit section 3 of the conduit 2 comprises a turbulence generator 13 upstream of the outlet 5.

The turbulence generator 13 is configured to change the cross section of the conduit 2.

The turbulence generator 13 is arranged at a distance from the outlet 5.

The inclined conduit section 3 of the conduit 2 upstream of the turbulence generator 13 may comprise a first conduit element 14 limiting a first flow channel section 15 forming a part of the flow channel 4, wherein the first flow channel section 15 of the flow channel 4 having an round cross section having an inner diameter between 10 and 33 mm, preferably between 15 and 25 mm.

The turbulence generator 13 may comprise at least one throttling element 18 limiting a third flow channel section 19 forming a part of the flow channel 4, so that the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having a round cross section having at a first downstream end 20 of the throttling element 18 an inner diameter that is between 5 and 18 mm, preferably about 10 mm, smaller than the round cross section of the first flow channel section 15 of the flow channel 4 upstream of the turbulence generator 13, and so that the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having at a first upstream end 21 of the throttling element 18 an inner diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of the third flow channel section 19 of the flow channel 4 at the first downstream end 20 of the throttling element 18.

The inclined conduit section 3 of the conduit 2 can between the turbulence generator 13 and the outlet 5 comprise a second conduit element 16 limiting a second flow channel section 17 forming a part of the flow channel 4, wherein the second flow channel section 17 of the flow channel 4 having an round cross section having an inner diameter between 10 and 40 mm, preferably between 20 and 30 mm.

The turbulence generator 13 may comprises at least one throttling element 18 limiting a third flow channel section 19 forming a part of the flow channel 4, so that the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having a round cross section having at a first downstream end 20 of the throttling element 18 an inner diameter that is between 5 and 18 mm, preferably about 10 mm, smaller than the round cross section of the second flow channel section 17 of the flow channel 4 between the turbulence generator 13 and the outlet 5, and so that the third flow channel section 19 of the flow channel 4 limited by the throttling element 18 having at a first upstream end 21 of the throttling element 18 an inner diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of the third flow channel section 19 of the flow channel 4 at the first downstream end 20 of the throttling element 18.

The distance between the turbulence generator 13 and the outlet 5 as measured in the direction the fluid flow may be between 25 and 300 mm.

The source for electromagnetic energy may comprise: a laser such as a Nd:YAG laser, an arc spark generator, and a X-ray tube or source

The apparatus may comprise, as shown in figures 1, 2, 3, 4, 6, and 6, a separation element

22 arranged at the outlet 5, wherein by the separation element 22 being configured to separate a portion of the fluid sample flow 1 from the fluid sample flow 1 and to guide said portion of the fluid sample flow 1 through the outlet 5 so that the said portion of the fluid sample flow 1 vertically downwards to the flow cell 6.

5 The apparatus may comprise, as shown in figure 5, a vertical wall member 23 arranged at the outlet 5, wherein the vertical wall member 23 being configured to conduct the fluid sample flow 1 vertically downwards from outlet 5 of the inclined conduit section 3 of the conduit 2 so that the sample flow vertically downwards to the flow cell 6 along the vertical wall member 23.

10 The inclined conduit section 3 of the conduit 2 may be inclined at an inclination angle A with respect to a horizontal plane that is between 20 and 75°.

15 The source 8 of electromagnetic energy may be arranged to apply electromagnetic energy 7 onto the surface 9 of the fluid sample flow 1 that is configured to flow through the flow cell 6 at a point that is located at distance vertically below the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2, which distance is required for forming a vertical fluid sample flow 1 of the fluid sample flow flowing from the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2. This distance is in part dependent on the size of the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2.

20 The source 8 of electromagnetic energy may be arranged to apply electromagnetic energy 7 onto the surface 9 of the fluid sample flow 1 that is configured to flow through the flow cell 6 at a point that is located at distance between 4 and 100 mm vertically below the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2.

25 The source 8 of electromagnetic energy may be arranged to apply electromagnetic energy 7 onto the surface 9 of the fluid sample flow 1 that is configured to flow through the flow cell 6 at a point that is located at distance between 4 and 100 mm vertically below the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2, which said point is the most upstream point of the outlet 5 in the flow channel 4 of the inclined conduit section 3 of the conduit 2. In other words, said point is the point in the flow channel 4 of the inclined conduit section 3 of the conduit 2, where fluid sample starts to flow out of the outlet 5 in the inclined conduit section 3 of the conduit 2.

30 It is apparent to a person skilled in the art that as technology advanced, the basic idea of the invention can be implemented in various ways. The invention and its embodiments are therefore not restricted to the above examples, but they may vary within the scope of the claims.

Claims

1. A method for optical emission spectroscopy of fluids, comprising
conducting a fluid sample flow (1) in a conduit (2) having an inclined conduit section (3),
wherein the conduit (2) limits a flow channel (4) for the fluid flow,

conducting at least a part of the fluid sample flow (1) vertically downwards from an
outlet (5) of the inclined conduit section (3) of the conduit (2) to a flow cell (6) configured to
receive at least a part of the fluid sample flow (1) that flows in the inclined conduit section (3) of
the conduit (2) from the inclined conduit section (3) of the conduit (2) and configured to release
said at least a part of the fluid sample flow (1) so that said at least a part of the fluid sample flow
(1) flows through the flow cell (6),

applying electromagnetic energy (7) from a source (8) of electromagnetic energy onto a
surface (9) of the fluid sample flow (1) that flows through the flow cell (6) to induce plasma (10)
in the fluid sample flow (1) that flows through the flow cell (6), and

receiving light (11) emitted by the plasma (10) and analyzing light (11) emitted by the
plasma (10) in a spectroscopy system (12),

characterized

by providing the inclined conduit section (3) of the conduit (2) upstream of the outlet (5)
with a turbulence generator (13) to change the cross section of the flow channel (4) of the
conduit (2), and

by providing the turbulence generator (13) at a distance from the outlet (5).

2. The method according to claim 1, **characterized**

by using in the inclined conduit section (3) of the conduit upstream of the turbulence
generator (13) a first conduit element (14) limiting a first flow channel section (15) forming a
part of the flow channel (4), wherein the first flow channel section (15) of the flow channel (4)
having an round cross section having an inner diameter between 10 and 33 mm, preferably
between 15 and 25 mm.

3. The method according to claim 2, **characterized**

by the turbulence generator (13) that is provided comprises at least one throttling element
(18) limiting a third flow channel section (19) forming a part of the flow channel (4),

wherein the third flow channel section (19) of the flow channel (4) limited by the
throttling element (18) having a round cross section having at a first downstream end (20) of the
throttling element (18) an inner diameter that is between 5 and 18 mm, preferably about 10 mm,
smaller than the round cross section of the first flow channel section (15) of the flow channel (4)
upstream of the turbulence generator (13),

and wherein the third flow channel section (19) of the flow channel (4) limited by the
throttling element (18) having at a first upstream end (21) of the throttling element (18) an inner

diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of the third flow channel section (19) of the flow channel (4) at the first downstream end (20) of the throttling element (18).

5 4. The method according to any of the claims 1 to 3, **characterized**
by using in the inclined conduit section (3) of the conduit (2) between the turbulence
generator (13) and the outlet (5) a second conduit element (16) limiting a second flow channel
section (17) forming a part of the flow channel (4), wherein the second flow channel section (17)
of the flow channel (4) having an round cross section having an inner diameter between 10 and
10 40 mm, preferably between 20 and 30 mm.

5. The method according to claim 4, **characterized**
by the turbulence generator (13) that is provided comprises at least one throttling element
(18) limiting a third flow channel section (19) forming a part of the flow channel (4),
15 wherein the third flow channel section (19) of the flow channel (4) limited by the
throttling element (18) having a round cross section having at a first downstream end (20) of the
throttling element (18) an inner diameter that is between 5 and 18 mm, preferably about 10 mm,
smaller than the round cross section of the second flow channel section (17) of the flow channel
(4) between the turbulence generator (13) and the outlet (5),
20 and wherein the third flow channel section (19) of the flow channel (4) limited by the
throttling element (18) having at a first upstream end (21) of the throttling element (18) an inner
diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of
the third flow channel section (19) of the flow channel (4) at the first downstream end (20) of the
throttling element (18).

25 6. The method according to any of the claims 1 to 5, **characterized**
by providing the turbulence generator (13) between 25 and 300 mm from the outlet (5) as
measured in the direction the fluid flow.

30 7. The method according to any of the claims 1 to 6, **characterized**
by using as the source for electromagnetic energy: a laser such as a Nd:YAG laser, an arc
spark generator, a X-ray tube or source

8. The method according to any of the claims 1 to 7, **characterized**
35 by separating by means of separation element (22) that is arranged at the outlet (5) a
portion of the fluid sample flow (1) flowing in the inclined conduit section (3) of the conduit (2)
to generate a part of the fluid sample flow (1), and
by guiding said part of the fluid sample flow (1) through the outlet (5) by means of

separation element (22).

9. The method according to any of the claims 1 to 7, **characterized**

by conducting the fluid sample flow (1) vertically downwards from outlet (5) of the inclined conduit section (3) of the conduit (2) to a flow cell (6) by conducting the fluid sample flow (1) that flows in the inclined conduit section (3) of the conduit (2) from the outlet (5) against a vertical wall member (23) that is in fluid connection with the flow cell (6), and

by conducting the fluid sample flow (1) vertically downwards to the flow cell (6) along the vertical wall member (23).

10. The method according to any of the claims 1 to 9, **characterized**

by arranging the inclined conduit section (3) of the conduit (2) inclined at an inclination angle A with respect to a horizontal plane that is between 20 and 75°.

11. The method according to any of the claims 1 to 10, **characterized**

by applying electromagnetic energy (7) from the source (8) of electromagnetic energy onto the surface (9) of the fluid sample flow (1) that flows through the flow cell (6) at a point that is located at distance between 4 and 100 mm vertically below the outlet (5) in the flow channel (4) of the inclined conduit section (3) of the conduit (2).

12. An apparatus for optical emission spectroscopy of fluids, comprising

a conduit (2) configured to conduct a fluid sample flow (1), wherein the conduit (2) having an inclined conduit section (3), wherein the conduit (2) limits a flow channel for the fluid sample flow (1),

a flow cell (6) in fluid connection with an outlet (5) the inclined conduit section (3) of the conduit (2) and configured to receive at least a part of the fluid sample flow (1) is configured to flow in the inclined conduit section (3) of the conduit (2) from the outlet (5) of the inclined conduit section (3) of the conduit (2) and configured to release said at least a part of the fluid sample flow (1) so that said at least a part of the fluid sample flow (1) flows through the flow cell (6),

a source (8) of electromagnetic energy for applying electromagnetic energy (7) onto the surface (9) of the fluid sample flow (1) that flows through the flow cell (6) to induce plasma (10) in the fluid sample flow (1) that flows through the flow cell (6), and

a spectroscopy system (12) for receiving light (11) emitted by the plasma (10) and for analyzing light (11) emitted by the plasma (10),

characterized

by the inclined conduit section (3) of the conduit (2) comprising a turbulence generator (13) upstream of the outlet (5),

by the turbulence generator (13) being configured to change the cross section of the conduit (2), and

by the turbulence generator (13) being arranged at a distance from the outlet (5).

5 13. The apparatus according to claim 12, **characterized**

by the inclined conduit section (3) of the conduit (2) upstream of the turbulence generator (13) comprise a first conduit element (14) limiting a first flow channel section (15) forming a part of the flow channel (4), wherein the first flow channel section (15) of the flow channel (4) having an round cross section having an inner diameter between 10 and 33 mm, preferably
10 between 15 and 25 mm.

14. The apparatus according to claim 13, **characterized**

by the turbulence generator (13) comprises at least one throttling element (18) limiting a third flow channel section (19) forming a part of the flow channel (4),

15 by the third flow channel section (19) of the flow channel (4) limited by the throttling element (18) having a round cross section having at a first downstream end (20) of the throttling element (18) an inner diameter that is between 5 and 18 mm, preferably about 10 mm, smaller than the round cross section of the first flow channel section (15) of the flow channel (4) upstream of the turbulence generator (13), and

20 by the third flow channel section (19) of the flow channel (4) limited by the throttling element (18) having at a first upstream end (21) of the throttling element (18) an inner diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of the third flow channel section (19) of the flow channel (4) at the first downstream end (20) of the throttling element (18).

25 15. The apparatus according to any of the claims 12 to 14, **characterized**
by the inclined conduit section (3) of the conduit (2) between the turbulence generator (13) and the outlet (5) comprise a second conduit element (16) limiting a second flow channel section (17) forming a part of the flow channel (4), wherein the second flow channel section (17)
30 of the flow channel (4) having an round cross section having an inner diameter between 10 and 40 mm, preferably between 20 and 30 mm.

16. The apparatus according to claim 15, **characterized**

35 by the turbulence generator (13) comprises at least one throttling element (18) limiting a third flow channel section (19) forming a part of the flow channel (4),

by the third flow channel section (19) of the flow channel (4) limited by the throttling element (18) having a round cross section having at a first downstream end (20) of the throttling element (18) an inner diameter that is between 5 and 18 mm, preferably about 10 mm, smaller

that the round cross section of the second flow channel section (17) of the flow channel (4) between the turbulence generator (13) (13) and the outlet (5), and

by the third flow channel section (19) of the flow channel (4) limited by the throttling element (18) having at a first upstream end (21) of the throttling element (18) an inner diameter that is between 4 and 8 mm, preferably about 5 mm, larger than the inner diameter of the third flow channel section (19) of the flow channel (4) at the first downstream end (20) of the throttling element (18).

17. The apparatus according to any of the claims 12 to 16, **characterized**

by the distance between the turbulence generator (13) and the outlet (5) as measured in the direction the fluid flow is between 25 and 300 mm.

18. The apparatus according to any of the claims 12 to 17, **characterized**

by the source for electromagnetic energy comprising: a laser such as a Nd:YAG laser, an arc spark generator, and a X-ray tube or source

19. The apparatus according to any of the claims 12 to 18, **characterized**

by a separation element (22) arranged at the outlet (5), and

by the separation element (22) being configured to separate a portion of the fluid sample flow (1) from the fluid sample flow (1) and to guide said portion of the fluid sample flow (1) through the outlet (5) so that the said portion of the fluid sample flow (1) vertically downwards to the flow cell (6).

20. The apparatus according to any of the claims 12 to 18, **characterized**

by a vertical wall member (23) arranged at the outlet (5), and

by a vertical wall member (23) being configured to conduct the fluid sample flow (1) vertically downwards from outlet (5) of the inclined conduit section (3) of the conduit (2) so that the sample flow vertically downwards to the flow cell (6) along the vertical wall member (23).

21. The apparatus according to any of the claims 12 to 20, **characterized**

by the inclined conduit section (3) of the conduit (2) being inclined at an inclination angle A with respect to a horizontal plane that is between 20 and 75°.

22. The apparatus according to any of the claims 12 to 21, **characterized**

by the source (8) of electromagnetic energy being arranged to apply electromagnetic energy (7) onto the surface (9) of the fluid sample flow (1) that is configured to flow through the flow cell (6) at a point that is located at distance between 4 and 100 mm vertically below the outlet (5) in the flow channel (4) of the inclined conduit section (3) of the conduit (2).

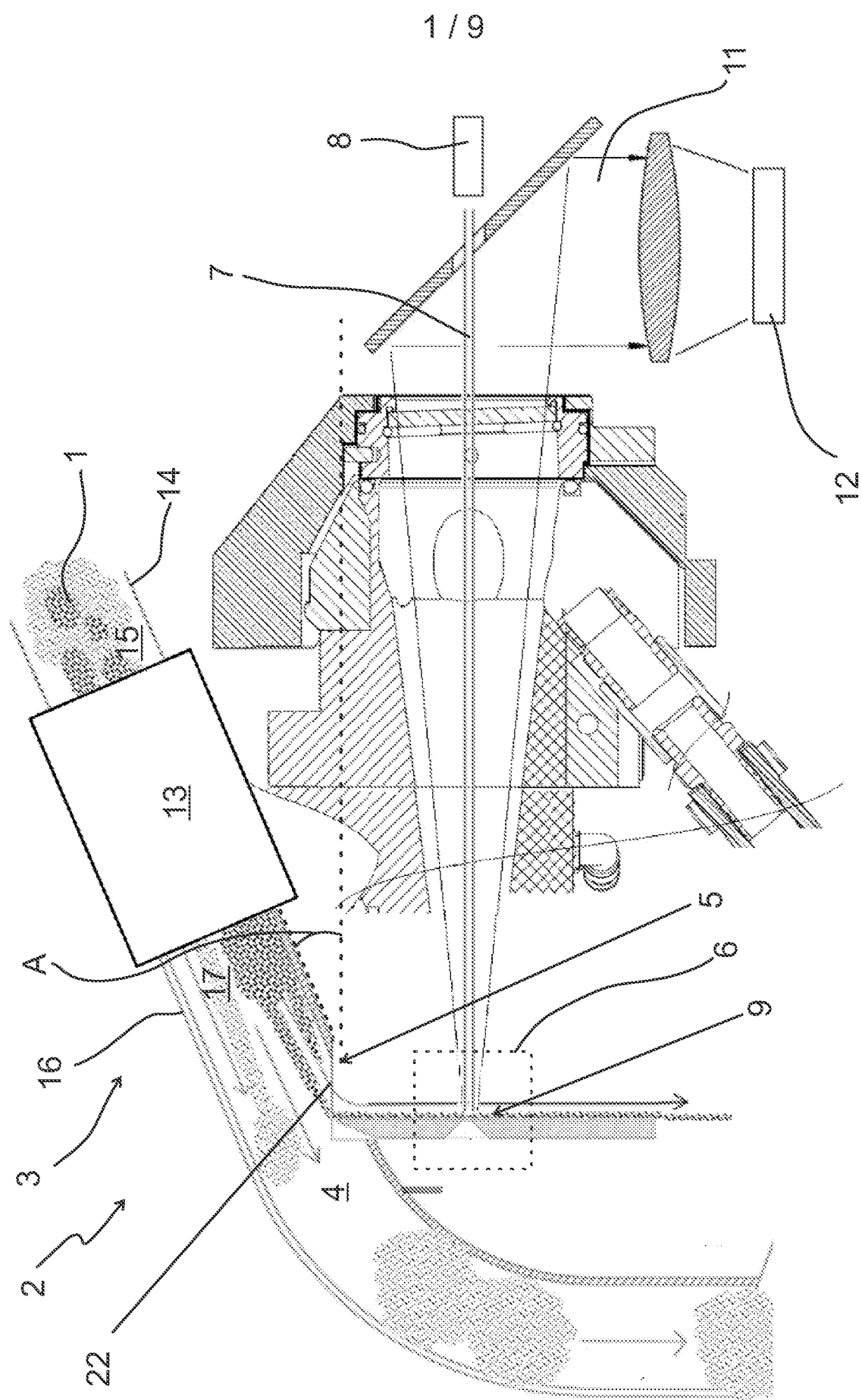
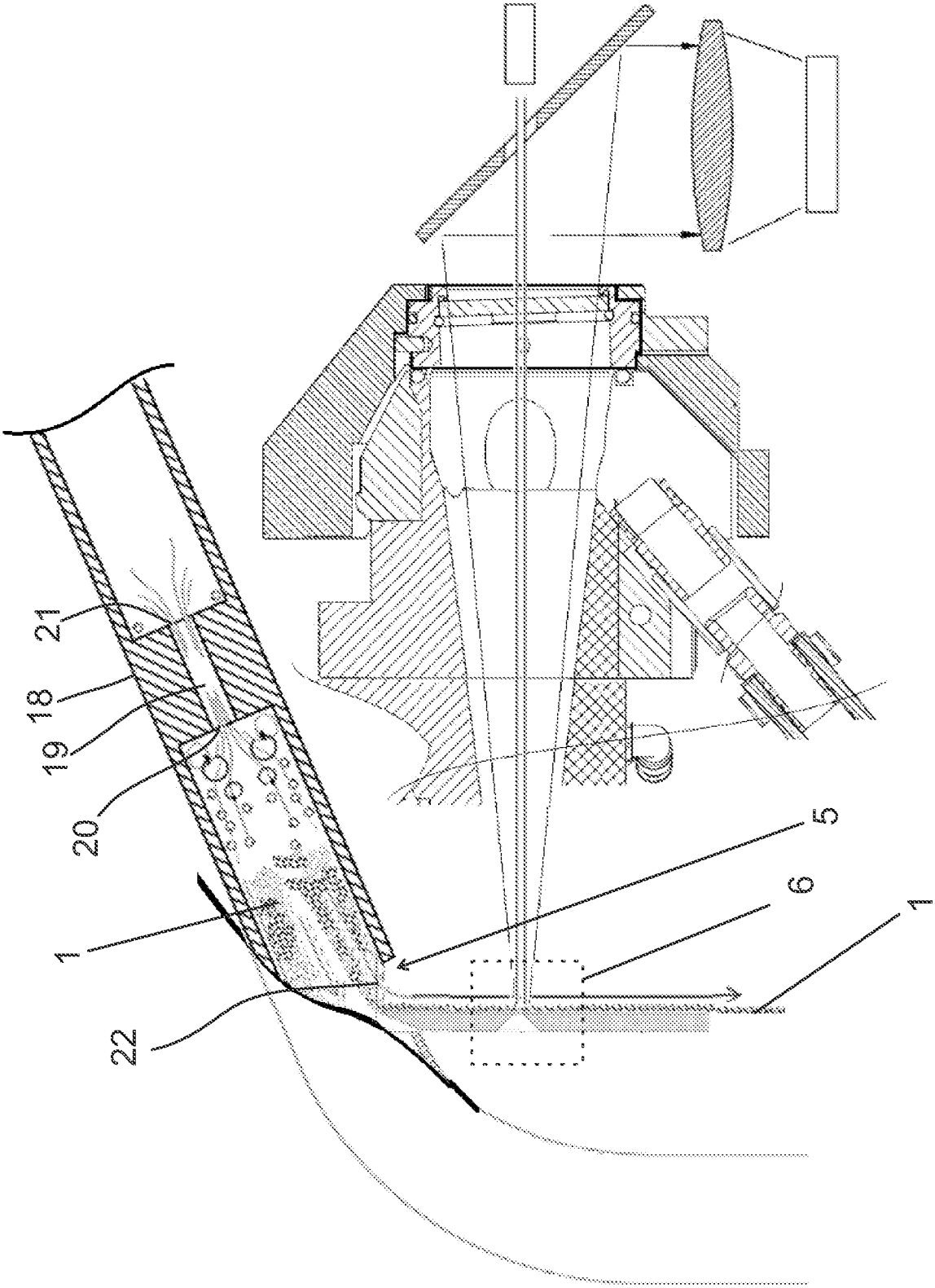




FIG 2



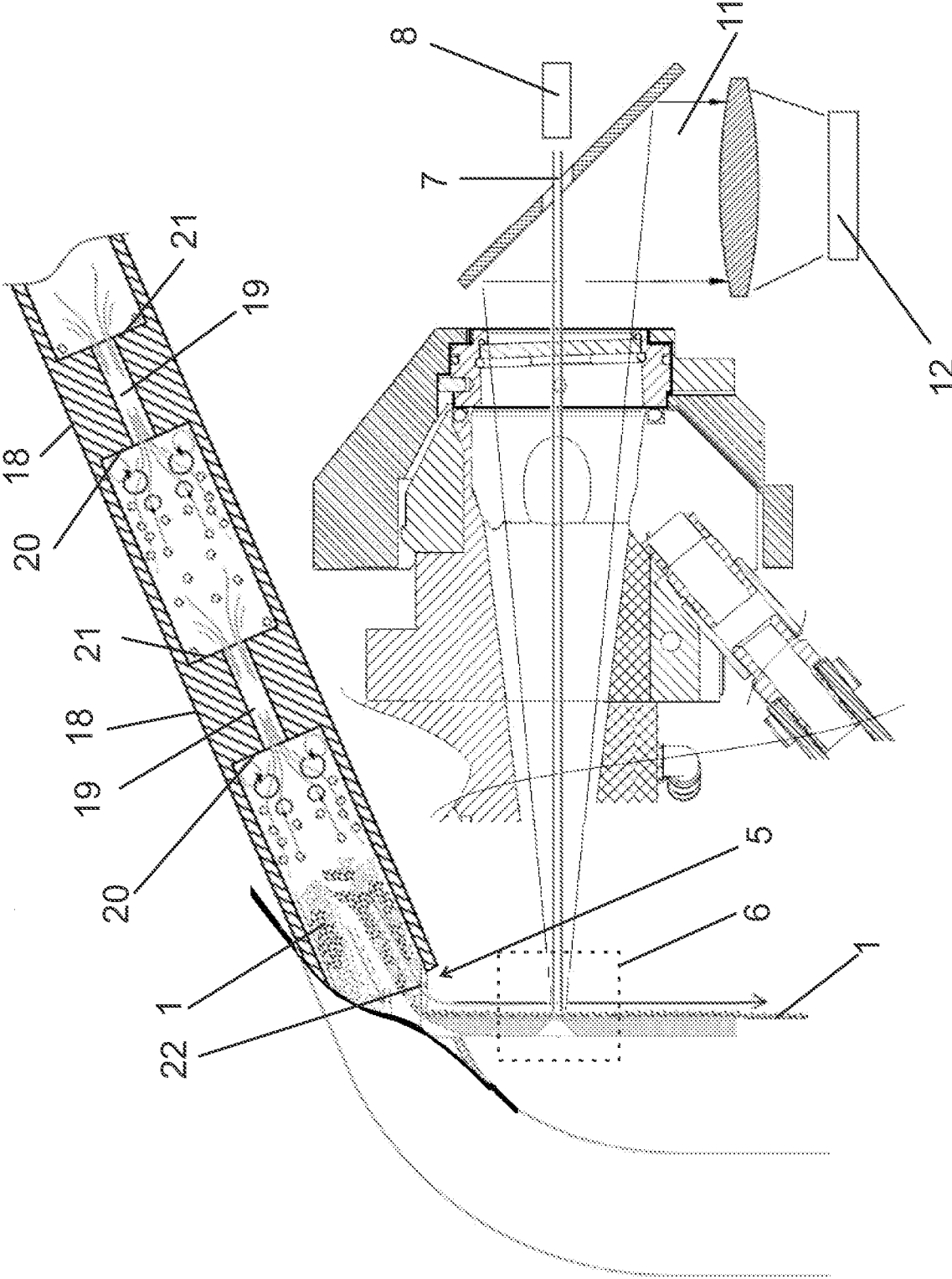
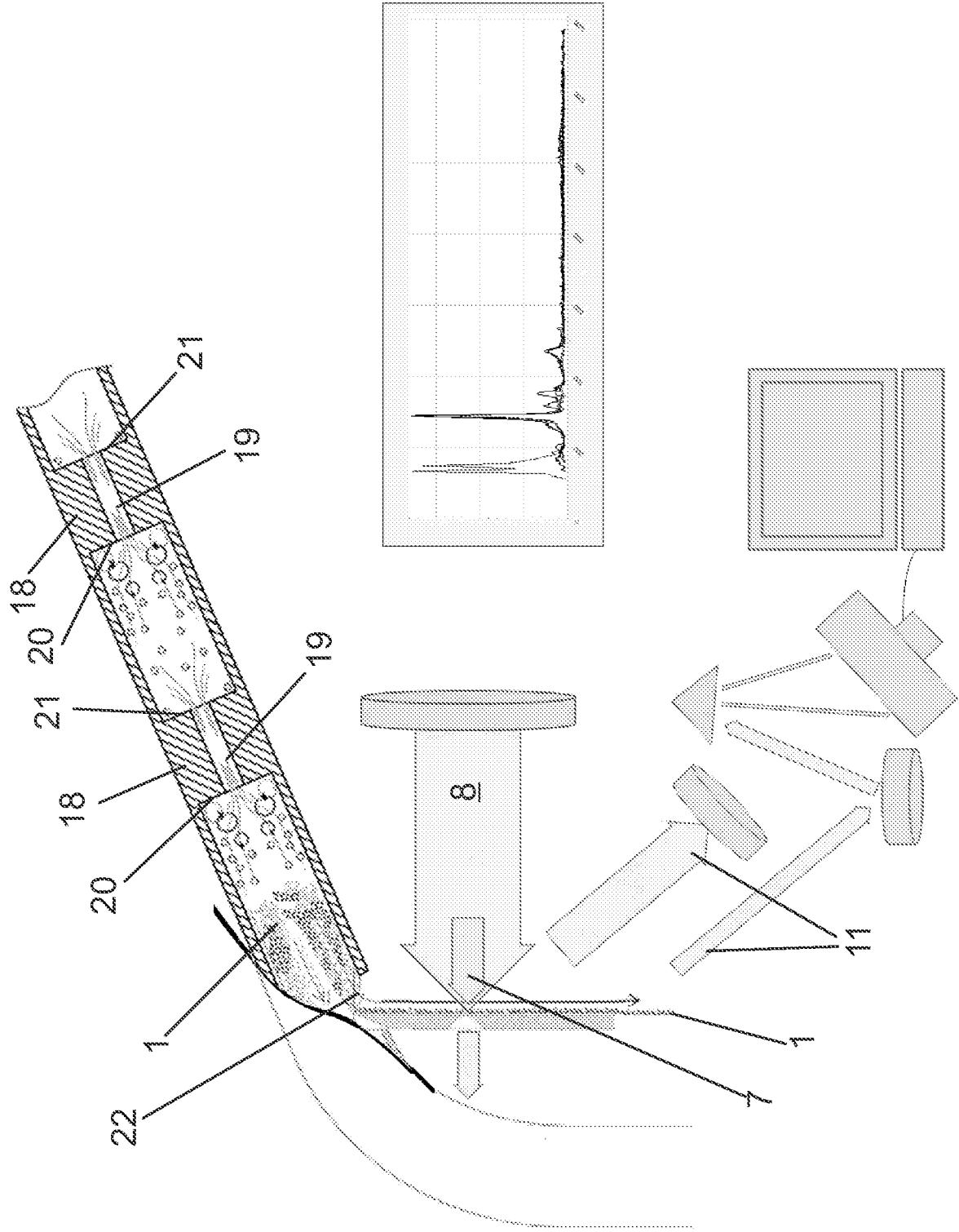


FIG 4



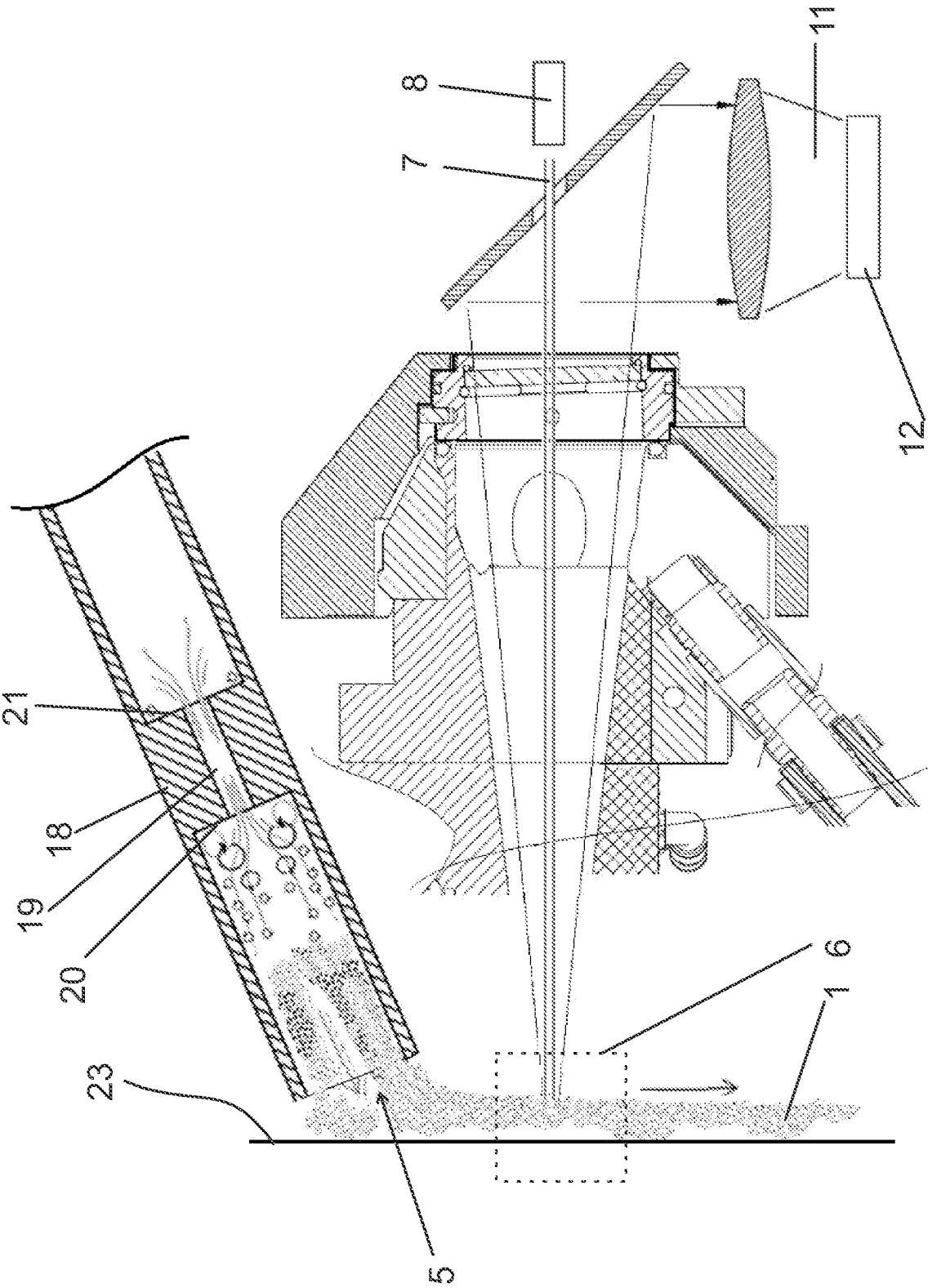
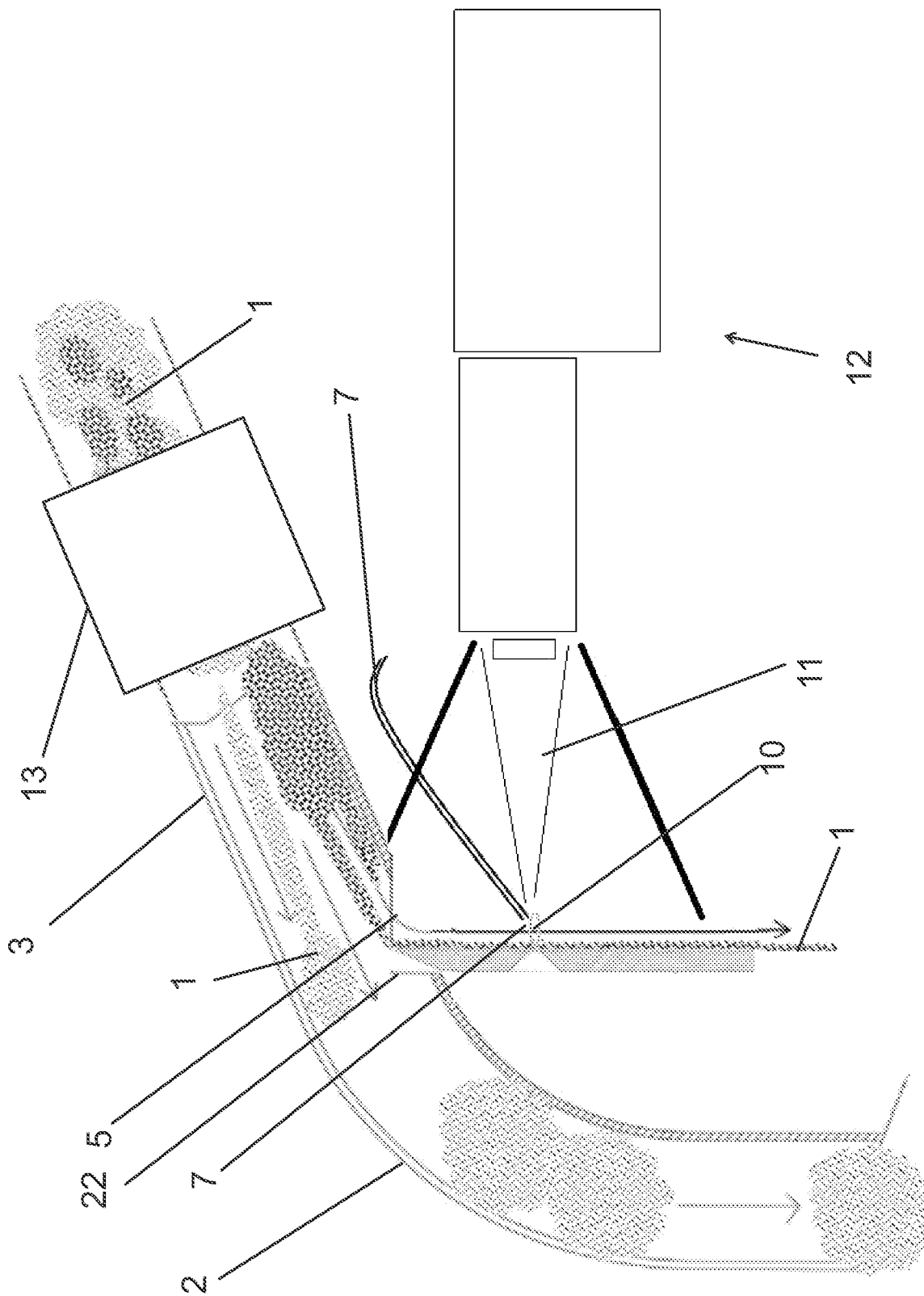
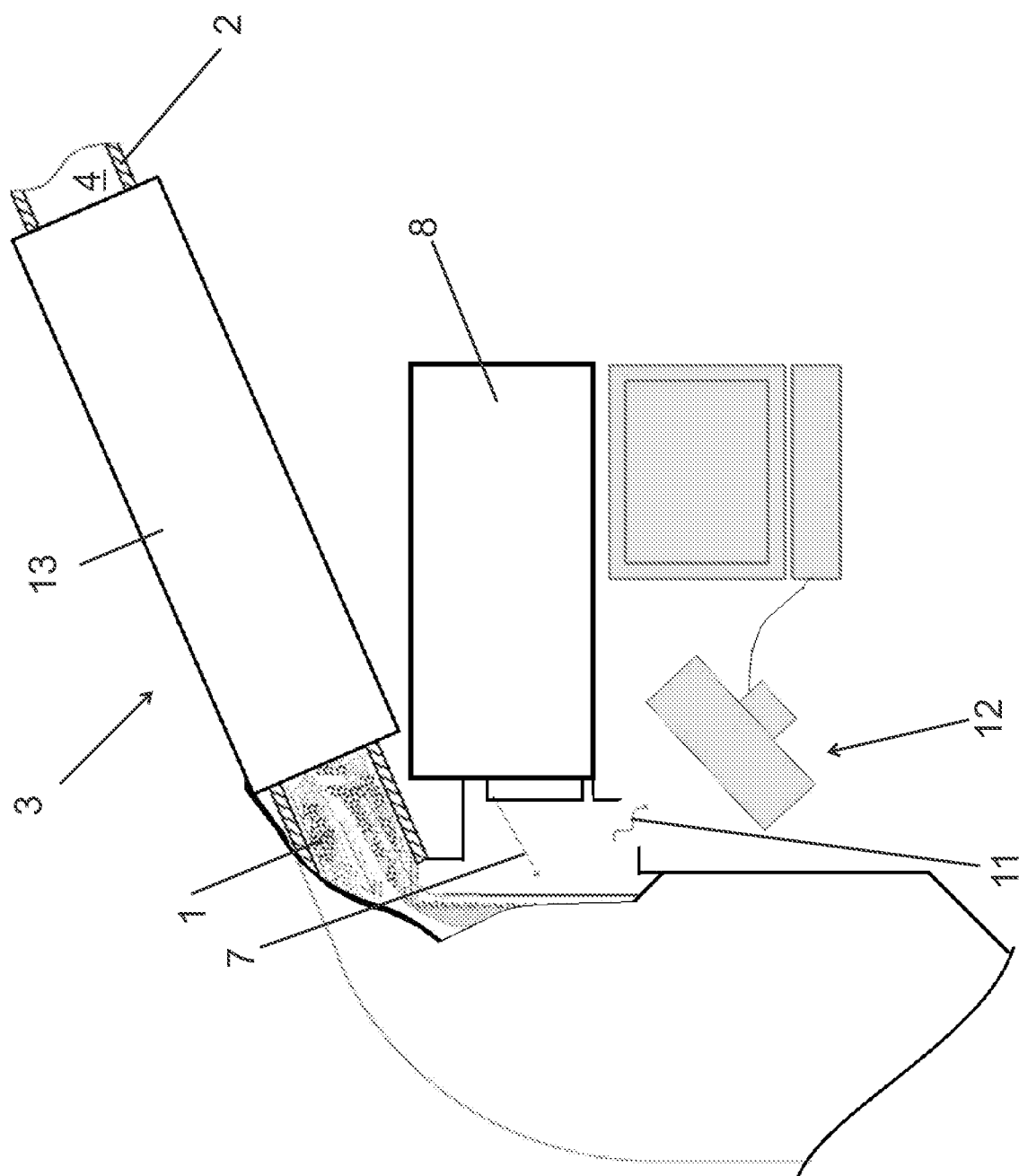


FIG 5

FIG 6



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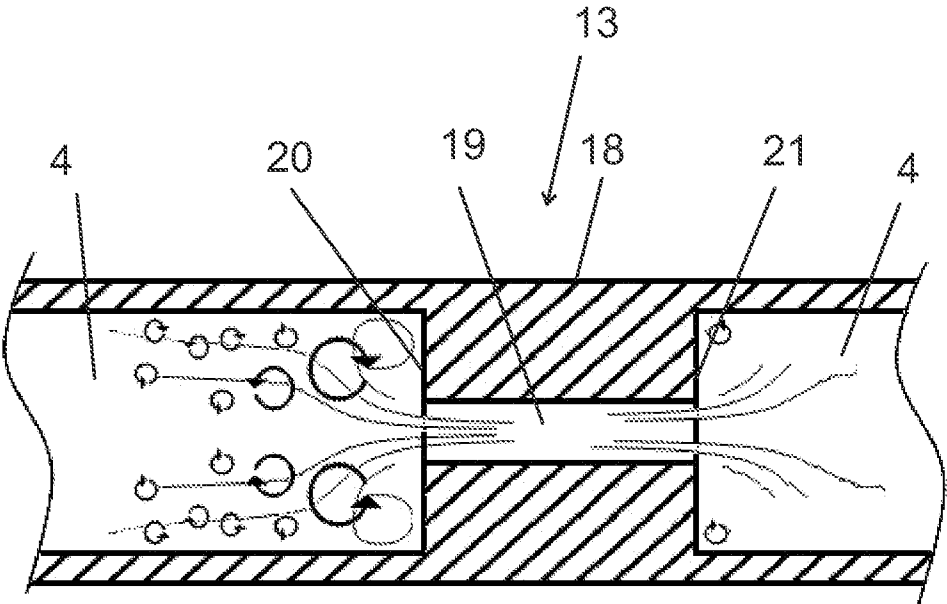


FIG 8

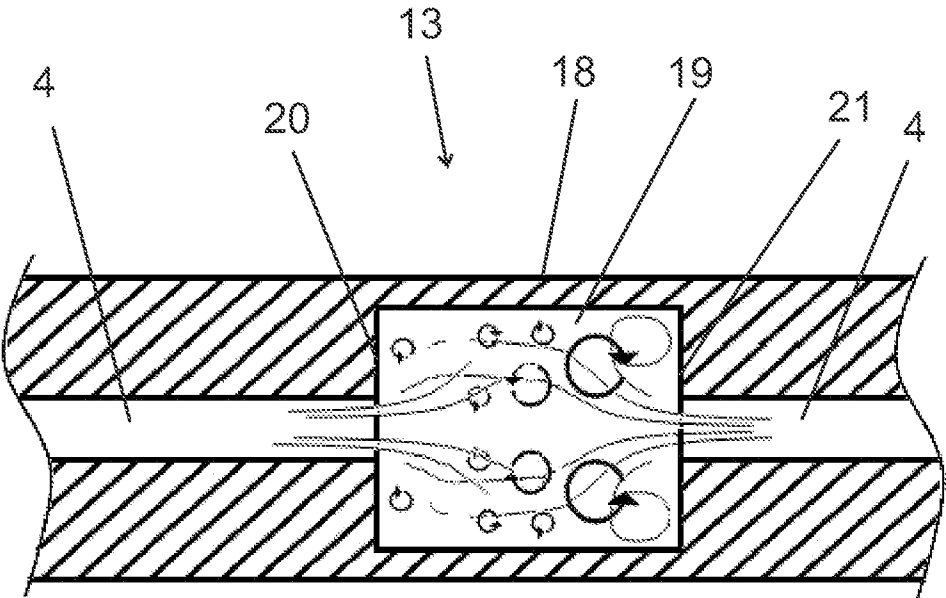


FIG 9

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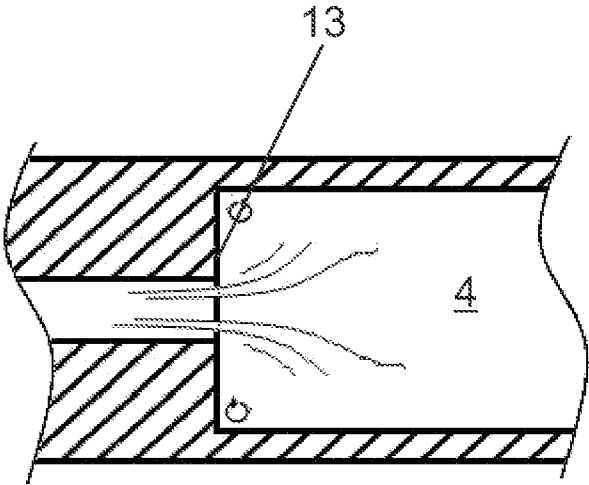


FIG 10

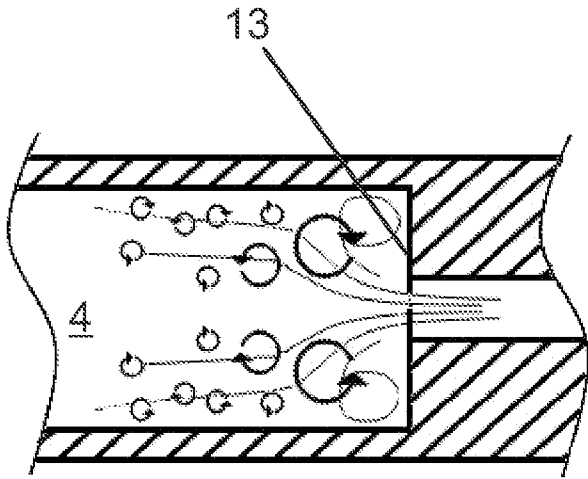


FIG 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2016/050508

A. CLASSIFICATION OF SUBJECT MATTER

INV. G01N21/71 G01N21/85 B01F5/06
ADD. G01N21/67 G01N21/69

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01N B01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/100444 A1 (CHESNER WARREN H [US] ET AL) 25 April 2013 (2013-04-25) paragraphs [0018], [0058], [0059], [0061], [0067] figures 1,2	1,7,12, 18
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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

10 October 2016

Date of mailing of the international search report

18/10/2016

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Fax: (+31-70) 340-3016

Authorized officer

D'Alessandro, Davide

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2016/050508

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

PCT/FI2016/050508

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