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(54) PRESSURE VESSEL AND METHOD OF HEATING A FLOWING PRESSURISED GAS

DRUCKBEHÄLTER UND VERFAHREN ZUM HEIZEN EINES UNTER DRUCK STEHENDEN GASES

RÉCIPIENT À PRESSION ET PROCÉDÉ DE CHAUFFAGE D'UN GAZ SOUS PRESSION

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EP 2 941 600 B1

Description

Scope of the invention

[0001] The invention relates to a pressure vessel intended to be fitted as part of a pressurised gas pipe and arranged for heating the flowing pressurised gas, comprising two concentric tubes inside the pressure vessel, an inlet for pressurised gas to the gap between the tubes, and an outlet from the pressure vessel, wherein the gap between the tubes has its outlet in the pressure vessel and the inner tube has a heating unit for heating the tube from inside.

[0002] The invention also relates to a method of heating a flowing pressurised gas in a pipe to a high temperature by leading the gas through a small gap between two tubes fitted in a pressure vessel, wherein the inner tube is heated from the inside and the heated gas is allowed to flow from the gap freely out into the pressure vessel and on to the outlet of the pressure vessel.

Prior art

[0003] US 2,797,297 shows a heater that can heat pressurised gas to a high temperature. The gas flows between the walls of an outer pressure vessel and an inner tube and then back through this inner tube along heating coils. EP 089 998 shows a heater that has an annular gap between two tubes and a burner in the inner tube that must thus be pressure-classified. Yet another heater adapted to heat pressurized gas to a high temperature is known from US 1 985 280. Further fluid heaters are known from patent applications US2527013A and DE19610593A1.

Object of the invention

[0004] An object of the invention is to provide at relatively low cost a gas heater for high pressure and high temperatures that is easily constructed, easy to maintain and easy to adapt to different conditions.

Brief description of the invention

[0005] The object of the invention is achieved by the method as claimed in claim 1 and the pressure vessel as claimed in claim 4. According to the invention the inner tube is open towards the flow path of the gas in the pressure vessel for pressure equalisation between the inside and the outside of the inner tube without the inner tube being part of the flow path of the gas, and the inner tube has an electric element for heating the tube from inside by radiant heat. The two tubes will thereby have roughly the same pressure on their outside and their inside and they do not need to be pressure-approved. The tubes are therefore interchangeable without this affecting the pressure vessel approval. It is only the outer pressure vessel that has to be approved. The electric element is simply interchangeable and is separated from the flow path of the gas. For the process industry, the tube quality can therefore be selected freely and the tubes adapted to the process gas in question. For example, powder-metallurgically manufactured tubes or ceramic tubes that do not tolerate high pressures can be used. With normal tubes, a catalytic effect on the gas can be obtained and carbon deposition occure, for example, if the gas is a reduced gas containing an H_2 and/or CO. The Sandvik Kanthal APM tube (ferritic iron-chromium-aluminium tube) is an example of a tube that can be used. The invention is defined by the claims.

Brief description of the drawings

[0006]

Figure 1 shows a section through a gas heater as an example of the invention.

Figure 2 shows an enlarged inlet part of the heater shown in figure 1.

Figure 3 shows an enlarged outlet part of the heater shown in figure 1.

Figure 4 corresponds to figure 2, but shows an alternative embodiment.

Figure 5 corresponds to figure 2 and shows another alternative embodiment.

Description of the illustrated example of the invention

[0007] Figures 1-3 show a gas heater in the form of a pressure vessel, the outer casing of which consists of a tube 11 with ends 12, 13. The end 12 can be bolted firmly to a pipe, for example, or directly to a reactor vessel in a process industry in order to supply heated gas at a high pressure. The entering process gas at a high pressure, for example 100 bar, that is to be heated to a high temperature, for example 1000 degrees Celsius, is supplied through the end 13. The tube 11 is insulated internally by an insulation 14 that is adapted to the high temperature that shall be reached. The insulation can be a ceramic insulation or a fibre insulation, for example. Different sections of the tube 11 can have different insulations adapted according to the temperature, which increases towards the outlet. The insulation can be created in layers with different properties.

[0008] Inside the insulation's cavity 15, two concentric tubes 16, 17 are put in as is best shown by figures 2 and 3. The upper ends of the tubes are joined together in a sealing manner, for example welded together or bolted together, and the gap 18 formed between the tubes has an inlet 19 through the end 13 for the gas that is to be heated, which is clearest from figure 2. The gap 18 is maintained by control projections, which are not shown, on the inner tube. The gap is open towards the cavity 15 in the insulation and towards the tapering outlet 20 from the pressure vessel that is formed by this cavity, which

is shown best by figure 3. The inner tube 17 has a closed end 21 at the outlet 22 of the gap 18. The tubes 16, 17 are kept in place at the inlet 19 and the tubes can expand freely in a longitudinal direction upon heating.

[0009] The inner tube 17 is open towards the end 13 and has electric elements in the form of heating coils 23, 24 along its length. The electric elements have their electric leads 25-28 led in a sealing manner through the end 13. The inner tube 17 is thus heated only by radiant heat from inside and the inner tube does not participate in the flow through the gas heater, which means that the electric coils are not exposed to chemical or catalytic reactions to such an extent. The reaction risk can be reduced further by having a small continuous supply of buffer gas to the inside of the inner tube. In figures 2 and 3, a supply line 30 for buffer gas is shown that extends down towards the closed end 21 of the inner tube 17.

[0010] Between the insulation 14 and the outer tube 16 is a gap 31 that provides pressure equalisation between the inside and outside of the inner tube 17, since the inside of the inner tube here remains open towards the gap outlet 22 and thereby towards the part 32 of the insulation cavity 15, i.e. open towards the outlet 20 of the pressure vessel. The part 32 takes up the longitudinal expansion of the tubes 16, 17.

[0011] The first coil 23 seen in the flow direction has a tighter winding and greater power than the second coil 24 and the power of the coils can be varied respectively so that the power supplied per unit of length of tube reduces when the gas becomes hotter. The first part of the flow path can have power that is three times as great per unit of length as the last part, for example. The temperature of the electric coils is limited thereby. It is possible to have more than two zones with different power. The gas that flows through the gap 18 acquires a large increase in volume due to heating and pressure reduction. The pressure gradient and heat transfer can be optimised by having a varying gap along the length of the tubes.

[0012] Figure 4 shows an alternative embodiment in which a separating wall 34 seals between the pressure vessel tube 11 and the tube 16. Instead of the inner tube 17 communicating with the outlet side of the flow path of the gas in the pressure vessel, it communicates with the inlet side through an opening 35. The embodiments are otherwise the same.

[0013] Figure 5 shows another alternative embodiment in which the pressure vessel tube 11 has a flange 36 that is directly bolted to a flange 37 on the inlet tube 38 for the pressurised gas that is to be heated. The inner tube 17 is thus open towards the pressurised inlet side of the flow path of the gas in the pressure vessel. The gap 18 has its inlet 39. Only one, 25, of the electric connections is shown.

[0014] The pressure vessel/gas heater can be manufactured in various sizes and as an example of a typical size it can be said that the outer tube 16 can have a length of 3.5 m and a diameter of 140 mm, and the pressure vessel tube 11 can have an outer diameter of 600 mm.

Claims

1. Method of heating a flowing pressurised gas in a pipe to a high temperature, said pipe being fitted in a pressure vessel (11, 12, 13) and comprising an inner tube (17) being concentrically arranged inside an outer tube (16) whereby a narrow gap (18) is formed between the inner tube (17) and the outer tube (16), and wherein the inner tube (17) is heated from the inside by an electric element (23, 24) being arranged inside the inner tube (17), said method involving the steps of freely leading the pressurised gas through the narrow gap (18) between the two tubes (16, 17) whereby the pressurized gas is heated by radiant heat from the inside of the inner tube (17), and wherein the heated pressurised gas is allowed to flow freely from the narrow gap (18) out into the pressure vessel (11, 12, 13) and on to an outlet (20) of the pressure vessel (11, 12, 13), and wherein the inner tube (17) is kept open towards the flow path of the pressurized gas thereby allowing pressure equalisation between the inside and the outside of the inner tube (17) without the inner tube (17) forming part of the flow path of the pressurised gas.

2. Method according to claim 1, **characterised in that** a first part of the inner tube (17) seen in the flow direction is heated by a higher power per unit of length than a following part of the inner tube (17) is heated.

3. Method according to claim 1 or 2, **characterised in that** one end (21) of the inner tube (17) is kept closed and a buffer gas is led in towards the closed end.

4. Pressure vessel (11, 12, 13) intended to be fitted as part of a pressurised gas pipe and arranged to heat pressurised flowing gas to a high temperature, the pressure vessel (11, 12, 13) comprising:

   an inner tube (17) and an outer tube (16), the inner and outer tubes (16, 17) being concentrically arranged inside the pressure vessel (11, 12, 13), and wherein a narrow gap (18) is formed between the inner tube (17) and the outer tube (16),
   an inlet (19, 39) allowing a supply of pressurised gas into the narrow gap (18) formed between the inner and outer tubes (17, 16), and
   an outlet (20) from the pressure vessel (11, 12, 13), and wherein the narrow gap (18) between the inner and outer tubes (17, 16) has its outlet (22) in the pressure vessel (11, 12, 13) **characterised in that**
   the inner tube (17) has a heating unit formed by an electric element (23, 24) for heating the inner tube (17) from its inside by radiant heat, and that the inner tube (17) is open towards the flow path

of the pressurized gas in the pressure vessel for pressure equalisation between the inside and outside of the inner tube (17) without the inner tube (17) being part of the flow path of the pressurized gas.

5. Pressure vessel according to claim 4, **characterised by** insulation material (14) being arranged in the pressure vessel (11, 12, 13) for protecting the walls (11) of the pressure vessel (11, 12, 13)against high temperature.

6. Pressure vessel according to claim 4 or 5, **characterised in that** the end (21) of the inner tube (17) towards an outlet (20) of the pressure vessel (11, 12, 13) is closed and that an end of the inner tube (17) towards its inlet is open.

7. Pressure vessel according to claim 6, **characterised by** a conduit (30) for buffer gas that leads into the inner tube (17).

8. Pressure vessel according to claim 5, **characterised in that** a passage (31) along the outer tube (16) of the concentric tubes holds the inner tube (17) open towards the outlet (20) in the pressure vessel (11,12, 13).

9. Pressure vessel according to claim 5, **characterised in that** the passage (31) is a gap arranged between the insulation (14) and the outer tube (16).

Patentansprüche

1. Verfahren zum Erwärmen eines strömenden Druckgases in einer Leitung auf eine hohe Temperatur, wobei die Leitung in einen Druckbehälter (11, 12, 13) eingebracht ist und ein inneres Rohr (17) umfasst, das im Inneren eines äußeren Rohrs (16) konzentrisch angeordnet ist,
wodurch ein enger Spalt (18) zwischen dem inneren Rohr (17) und dem äußeren Rohr (16) gebildet ist und wobei das innere Rohr (17) von innen durch ein elektrisches Element (23, 24) erwärmt wird, das im Inneren des inneren Rohrs (17) angeordnet ist, wobei das Verfahren die Schritte des freien Führen des Druckgases durch den engen Spalt (18) zwischen den zwei Rohren (16, 17) einbezieht, wodurch das Druckgas durch Strahlungswärme von dem Inneren des inneren Rohrs (17) erwärmt wird, und wobei dem erwärmten Druckgas erlaubt wird, frei aus dem engen Spalt (18) heraus in den Druckbehälter (11, 12, 13) und weiter zu einem Auslass (20) des Druckbehälters (11, 12, 13) zu strömen, und wobei das innere Rohr (17) hin zu dem Strömungsweg des Druckgases offen gehalten wird, wodurch ein Druckausgleich zwischen dem Inneren und dem Äußeren des inneren Rohrs (17) erlaubt wird, ohne dass das innere Rohr (17) Teil des Strömungswegs des Druckgases bildet.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** ein erster Teil des inneren Rohrs (17), wenn in der Strömungsrichtung betrachtet, durch eine höhere Energie pro Längeneinheit erwärmt wird als ein nachfolgender Teil des inneren Rohrs (17) erwärmt wird.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** ein Ende (21) des inneren Rohrs (17) geschlossen gehalten wird und ein Puffergas hin zu dem geschlossenen Ende eingelassen wird.

4. Druckbehälter (11, 12, 13), der ausgelegt ist, um als Teil einer Druckgasleitung angebracht zu sein, und angeordnet ist, um strömendes Druckgas auf eine hohe Temperatur zu erwärmen, wobei der Druckbehälter (11, 12, 13) Folgendes umfasst:

ein inneres Rohr (17) und ein äußeres Rohr (16), wobei das innere und äußere Rohr (16, 17) im Inneren des Druckbehälters (11, 12, 13) konzentrisch angeordnet sind und wobei ein enger Spalt (18) zwischen dem inneren Rohr (17) und dem äußeren Rohr (16) gebildet ist,
einen Einlass (19, 39), der eine Zufuhr von Druckgas in den engen Spalt (18) erlaubt, der zwischen dem inneren und äußeren Rohr (17, 16) gebildet ist, und
einen Auslass (20) von dem Druckbehälter (11, 12, 13), und wobei der enge Spalt (18) zwischen dem inneren und äußeren Rohr (17, 16) seinen Auslass (22) in dem Druckbehälter (11, 12, 13) hat, **dadurch gekennzeichnet, dass**
das innere Rohr (17) eine Erwärmungseinheit hat, die durch ein elektrisches Element (23, 24) zum Erwärmen des inneren Rohrs (17) von seinem Inneren durch Strahlungswärme gebildet ist, und dass
das innere Rohr (17) hin zu dem Strömungsweg des Druckgases in dem Druckbehälter zum Druckausgleich zwischen dem Inneren und Äußeren des inneren Rohrs (17) offen ist, ohne dass das innere Rohr (17) Teil des Strömungswegs des Druckgases ist.

5. Druckbehälter nach Anspruch 4, **gekennzeichnet durch** Isoliermaterial (14), das in dem Druckbehälter (11, 12, 13) zum Schützen der Wände (11) des Druckbehälters (11, 12, 13) vor hohen Temperaturen angeordnet ist.

6. Druckbehälter nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** das Ende (21) des inneren

Rohrs (17) hin zu einem Auslass (20) des Druckbehälters (11, 12, 13) geschlossen ist und dass ein Ende des inneren Rohrs (17) hin zu seinem Einlass offen ist.

7. Druckbehälter nach Anspruch 6, **gekennzeichnet durch** einen Kanal (30) für Puffergas, der in das innere Rohr (17) führt.

8. Druckbehälter nach Anspruch 5, **dadurch gekennzeichnet, dass** ein Durchgang (31) entlang des äußeren Rohrs (16) der konzentrischen Rohre das innere Rohr (17) hin zu dem Auslass (20) in dem Druckbehälter (11, 12, 13) offen hält.

9. Druckbehälter nach Anspruch 5, **dadurch gekennzeichnet, dass** der Durchgang (31) ein Spalt ist, der zwischen der Isolierung (14) und dem äußeren Rohr (16) angeordnet ist.

Revendications

1. Procédé de chauffage d'un gaz sous pression s'écoulant dans un tuyau à une haute température, ledit tuyau étant inséré dans une cuve sous pression (11, 12, 13) et comprenant un tube intérieur (17) étant disposé concentriquement à l'intérieur d'un tube extérieur (16), moyennant quoi un interstice étroit (18) est formé entre le tube intérieur (17) et le tube extérieur (16), et dans lequel le tube intérieur (17) est chauffé de l'intérieur par un élément électrique (23, 24) étant disposé à l'intérieur du tube intérieur (17), ledit procédé impliquant les étapes consistant à guider librement le gaz sous pression à travers l'interstice étroit (18) entre les deux tubes (16, 17), moyennant quoi le gaz pressurisé est chauffé par chaleur rayonnante à partir de l'intérieur du tube intérieur (17), et dans lequel le gaz sous pression chauffé est autorisé à s'écouler librement à partir de l'interstice étroit (18) dans la cuve sous pression (11, 12, 13) et vers une sortie (20) de la cuve sous pression (11, 12, 13) et dans lequel le tube intérieur (17) est gardé ouvert dans la direction du trajet d'écoulement du gaz sous pression en permettant ainsi une égalisation de pression entre l'intérieur et l'extérieur du tube extérieur (17) sans que le tube intérieur (17) fasse partie du trajet d'écoulement du gaz sous pression.

2. Procédé selon la revendication 1, **caractérisé en ce que** une première partie du tube intérieur (17) vue dans la direction d'écoulement est chauffée par une puissance plus élevée par unité de longueur qu'une partie suivante du tube intérieur (17) est chauffée.

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce qu'**une extrémité (21) du tube intérieur (17) est gardée fermée et un gaz tampon est guidé dans la direction de l'extrémité fermée.

4. Cuve sous pression (11, 12, 13) encline à être montée comme un tuyau de gaz sous pression et disposée afin de chauffer le gaz sous pression s'écoulant à une haute température, la cuve sous pression (11, 12, 13) comprenant :

un tube intérieur (17) et un tube extérieur (16), les tubes intérieur et extérieur (16, 17) étant disposés concentriquement à l'intérieur de la cuve sous pression (11, 12, 13) et dans lequel un interstice étroit (18) est formé entre le tube intérieur (17) et le tube extérieur (16),
une entrée (19, 39) permettant une alimentation de gaz sous pression dans l'interstice étroit (18) formé entre les tubes intérieur et extérieur (17, 16), et
une sortie (20) de la cuve sous pression (11, 12, 13) et dans laquelle l'interstice étroit (18) entre les tubes intérieur et extérieur (17, 16) a sa sortie (22) dans la cuve sous pression (11, 12, 13), **caractérisée en ce que**
le tube intérieur (17) a une unité de chauffage formée par un élément électrique (23, 24) pour chauffer le tube intérieur (17) à partir de son intérieur par chaleur rayonnante, et **en ce que**
le tube intérieur (17) est ouvert dans la direction du trajet d'écoulement du gaz sous pression dans la cuve sous pression en vue d'une égalisation de pression entre l'intérieur et l'extérieur du tube intérieur (17) sans que le tube intérieur (17) fasse partie du trajet d'écoulement du gaz sous pression.

5. Cuve sous pression selon la revendication 4, **caractérisée par** un matériau isolant (14) étant disposé dans la cuve sous pression (11, 12, 13) pour protéger les parois (11) de la cuve sous pression (11, 12, 13) contre des hautes températures.

6. Cuve sous pression selon la revendication 4 ou 5, **caractérisée en ce que** l'extrémité (21) du tube intérieur (17) dans la direction d'une sortie (20) de la cuve sous pression (11, 12, 13) est fermée et qu'une extrémité du tube intérieur (17) est ouvert dans la direction de son entrée.

7. Cuve sous pression selon la revendication 6, **caractérisée par** un conduit (30) pour gaz tampon qui mène au tube intérieur (17).

8. Cuve sous pression selon la revendication 5, **caractérisée en ce qu'**un passage (31) le long du tube extérieur (16) des tubes concentriques maintient le tube intérieur (17) ouvert dans la direction de la sortie (20) dans la cuve sous pression (11, 12, 13).

9. Cuve sous pression selon la revendication 5, **caractérisée en ce que** le passage (31) est un interstice ménagé entre l'isolation (14) et le tube extérieur (16).

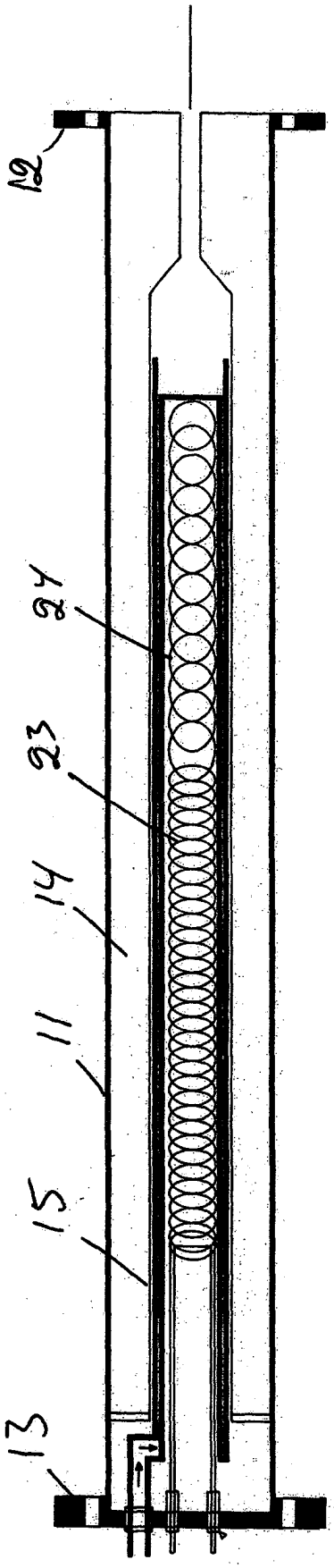


Fig 1

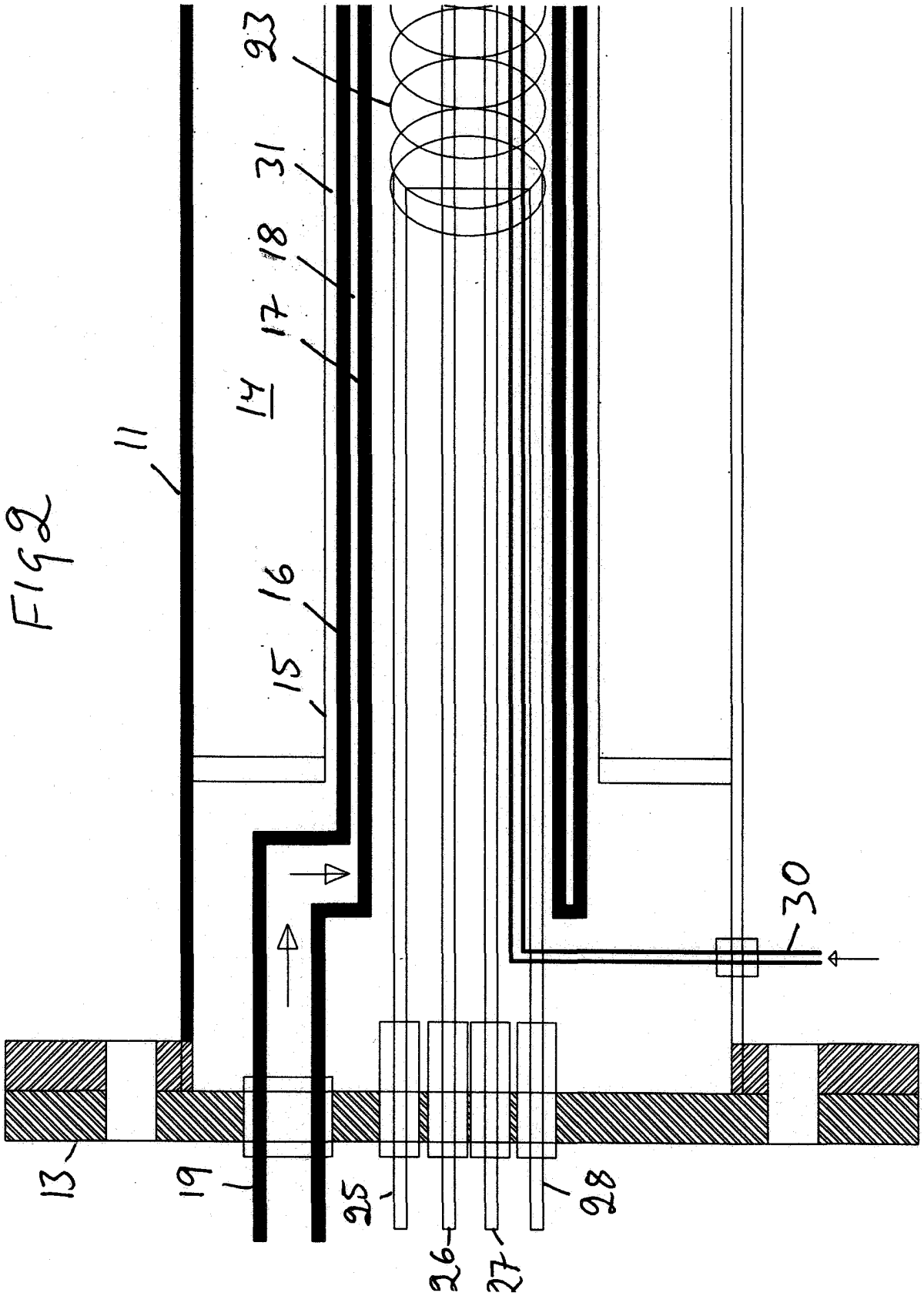


Fig 2

FIG 3

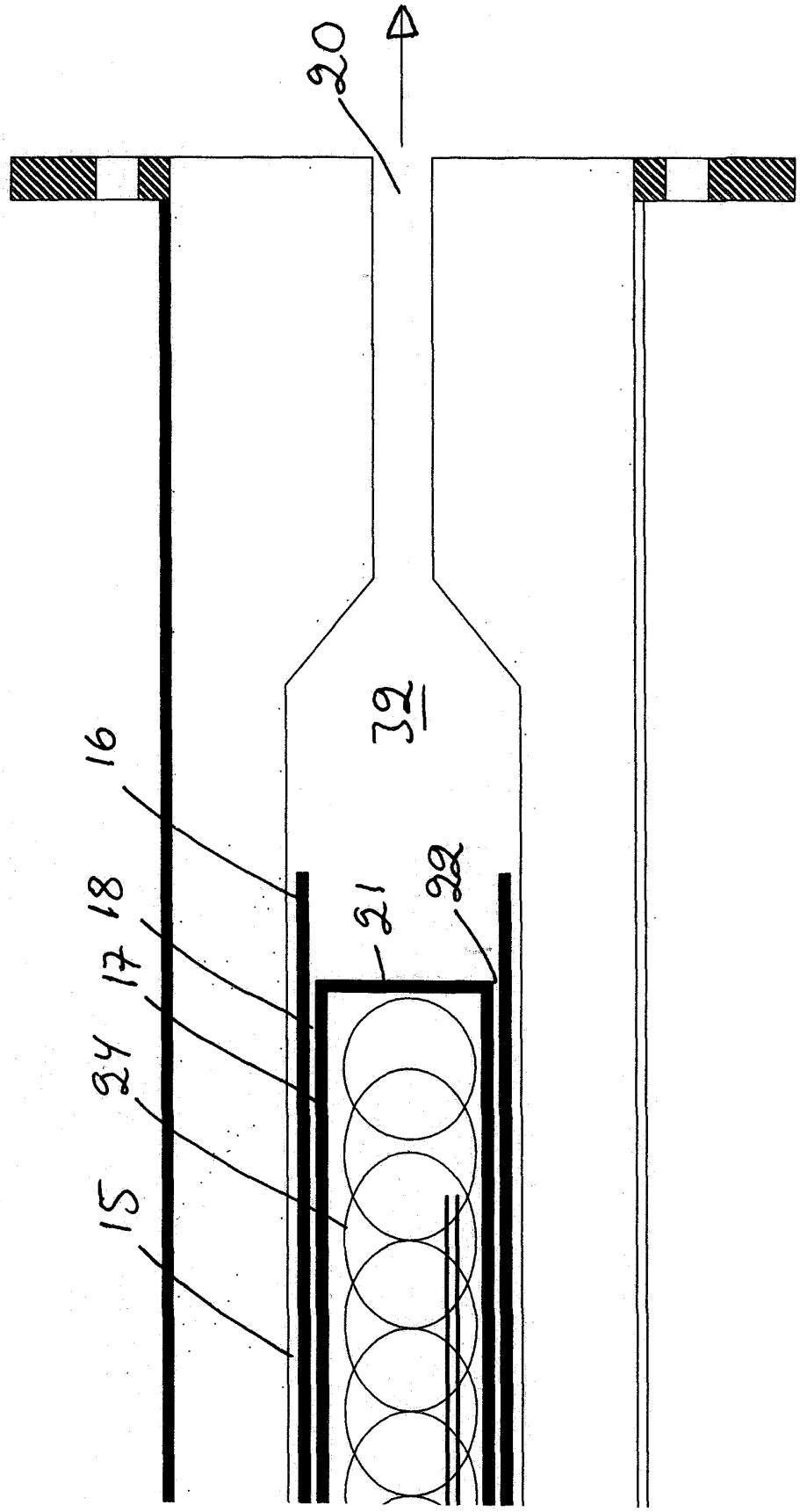


FIG 4

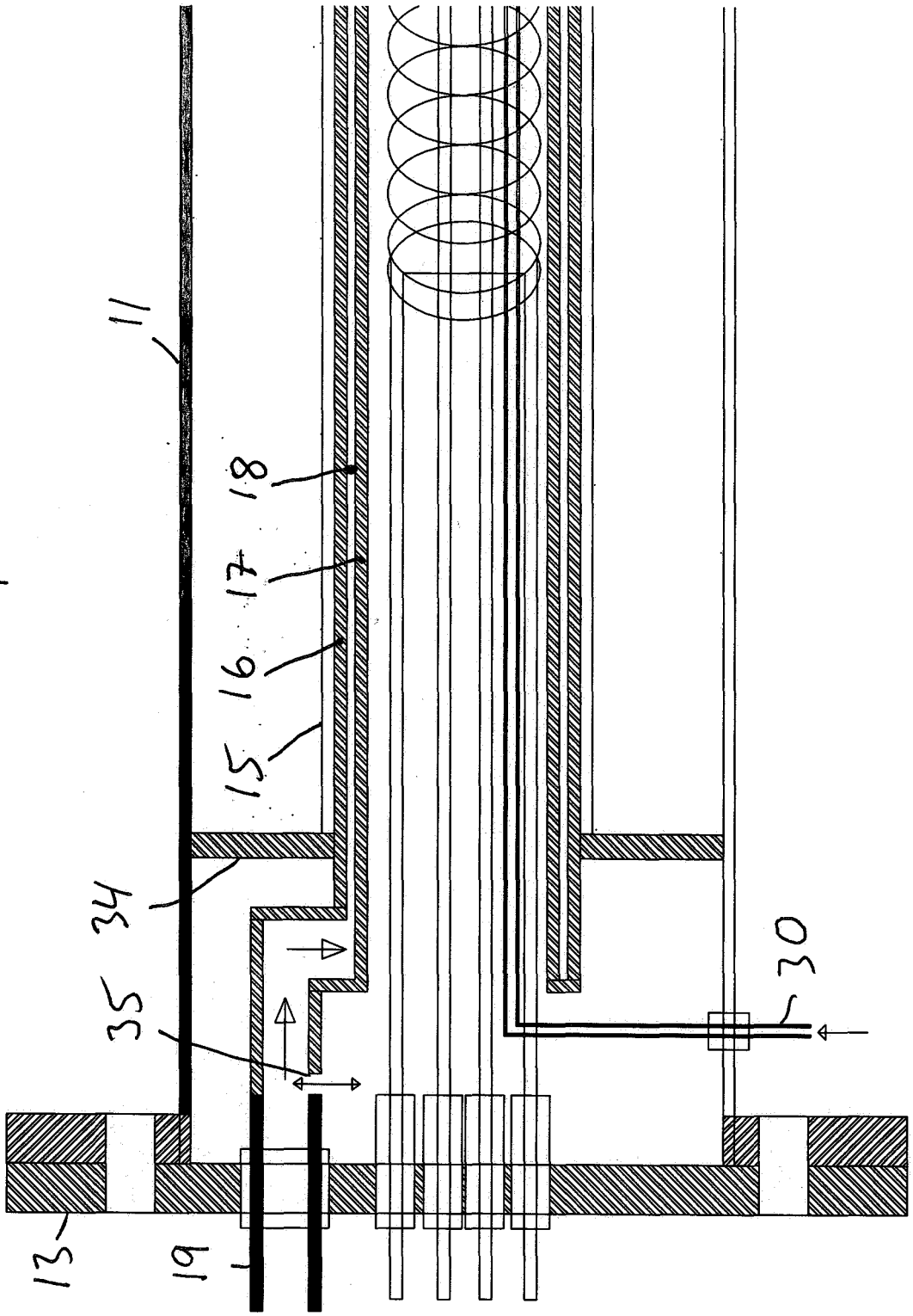
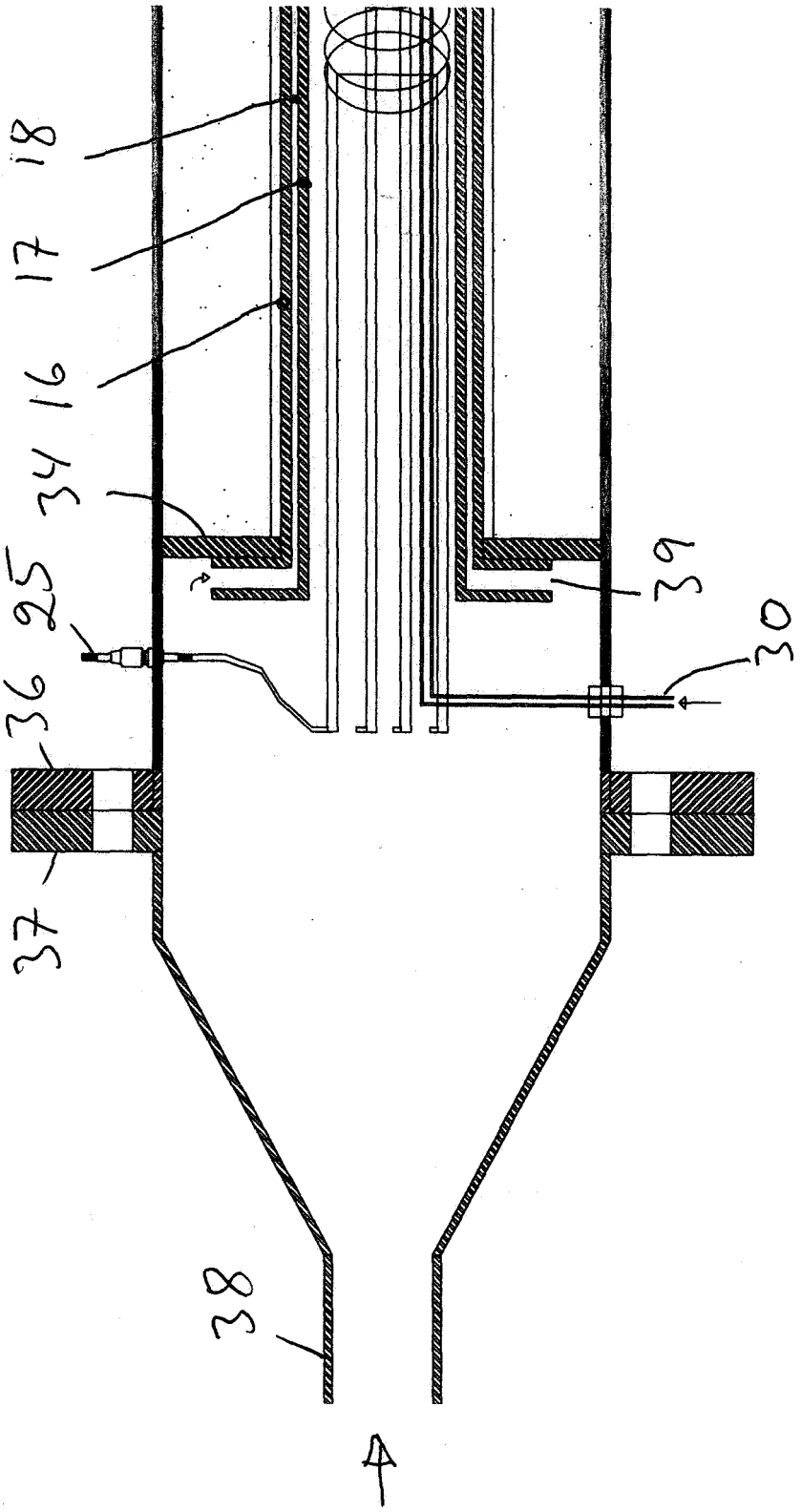


FIG 5



REFERENCES CITED IN THE DESCRIPTION

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