(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 115 094
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 83201705.7

(22) Date of filing: 30.11.83

(51) Int. Cl.³: C 10 J 3/46
C 10 J 3/48, C 10 J 3/86

(30) Priority: 29.12.82 DE 3248551

(43) Date of publication of application:
08.08.84 Bulletin 84/32

(84) Designated Contracting States:
BE DE FR GB IT NL

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(54) **Process and apparatus for the production of synthesis gas.**

(57) Process for the production of synthesis gas comprising the steps:

a) a finely divided carbonaceous fuel is partially combusted in a gasifier,

b) liquid slag is removed from the bottom of the gasifier,

c) hot crude synthesis gas containing entrained slag droplets is removed from the top of the gasifier and passes upwards through a radiation chamber where it is cooled,

d) the gas is passed upwards through a superheater to cool it further,

e) the flow of the gas is reversed in a pipe connecting the superheater with an evaporator

f) the gas is passed downwards through the evaporator, to cool it still further,

g) slag particles are separated from the cooled crude synthesis gas.

Apparatus for carrying out the process described hereinbefore.

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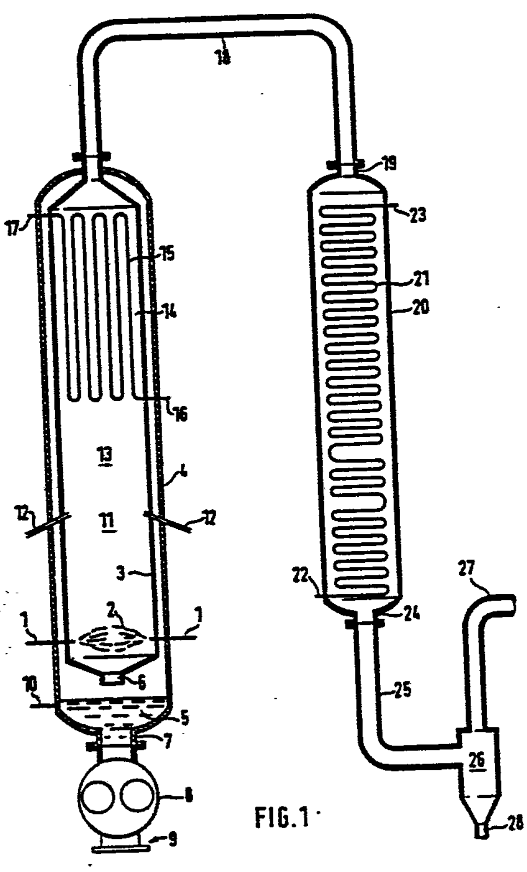

FIG.1

PROCESS AND APPARATUS FOR THE PRODUCTION OF SYNTHESIS GAS

The invention relates to a process for the production of synthesis gas characterized by the following steps:

a) a finely divided carbonaceous fuel is partially combusted with an oxygen-containing gas at elevated temperature and pressure in a gasifier,

b) liquid slag is removed from the bottom of the gasifier,

c) hot crude synthesis gas containing entrained slag droplets is removed from the top of the gasifier and passed upwards through a radiation chamber where it is cooled, the slag droplets being solidified,

d) the crude synthesis gas is passed upwards through a superheater to cool it further,

e) the flow of the crude synthesis gas is reversed in a pipe connecting the superheater with an evaporator

f) the crude synthesis gas is passed downwards through the evaporator, to cool it still further

g) slag particles are separated from the cooled crude synthesis gas.

The invention also relates to an apparatus for carrying out the process described hereinbefore, which apparatus is characterized in that it comprises the following components:

a) a vertical cylindrical outer pressure shell containing a water bath for catching and solidifying liquid slag and comprising an inlet for water and an outlet for solidified slag in water and above the water bath a water tube wall structure comprising an outlet for slag at the bottom and an outlet for crude synthesis gas at the top,

b) a gasifier defined by the lower part of the water tube wall structure,

c) a radiation chamber defined by an intermediate part of the water tube wall structure,

d) a superheater defined by the upper part of the water tube wall structure and comprising an outlet for crude synthesis gas,

e) a vertical cylindrical evaporator positioned next to the vertical cylindrical pressure shell, comprising an inlet and an outlet for crude synthesis gas and a number of tube banks for the evaporation of water,

f) a pipe connecting the top of the vertical cylindrical outer pressure shell with the top of the evaporator,

g) means for separating slag particles from the cooled crude synthesis gas, which means are connected by a pipe with the bottom of the evaporator.

As a feedstock for the present process any carbonaceous fuel can be used. In this specification "carbonaceous fuel" means any combustible material consisting of at least 50% by weight, of carbon. The fuel may contain oxygen, sulphur and/or nitrogen. Such a feedstock includes, e.g., lignite, anthracite, bituminous coal, coke, shale oil, mineral oils or oil fractions, tar sand oil or natural gas. The feedstock, if solid, should be in a powdered form so that it can readily react with oxygen in the gasifier. Preferably, the size of solid carbonaceous fuel is such that 70%, by weight, of the fuel has a particle size smaller than 200 mesh (A.S.T.M.).

The oxidant includes air and oxygen diluted with steam, carbon dioxide, nitrogen and/or argon. Advantageously, the oxidant is preheated before it is reacted with the carbonaceous fuel. The preheating of the oxidant is suitably carried out indirectly by heat exchange with any heat source, e.g., the hot product gas obtained in the present process. The oxidant is preferably preheated to a temperature in the range of 150 to 1300°C, depending on the type of oxidant. After the preheating, the hot oxidant is advantageously mixed with carbonaceous fuel and the oxidant/fuel mixture is introduced, preferably as one or more jets into the gasifier.

According to the present invention a process for the production of a hydrogen- and carbon monoxide-containing gas from a carbonaceous fuel, comprises reacting air or oxygen with the carbonaceous fuel in a gasifier which is preferably kept at an average temperature within the range 1200 to 1700°C and an average pressure within the range 2 to 200 bar, the residence time in said gasifier being preferably from 1 to 10 seconds.

Preferably, a moderator is also supplied to the gasifier. The purpose of the moderator is to exercise a moderating effect on the temperature in the gasifier. That is achieved by means of an endothermic reaction between the moderator and the reactant and/or products of the synthesis gas preparation. Suitable moderators are steam and carbon dioxide.

The gasifier in which the synthesis gas is prepared has the shape of a vertical cylinder. For preference the gasifier has substantially the shape of a circular cylinder.

The carbon-containing fuel and the oxygen-containing gas can be supplied through the bottom of the gasifier. It is also possible for one of the reactants to be supplied through the bottom of the gasifier and one or more other reactants through the side-wall of the gasifier. Preferably, however, both the fuel as well as the oxygen-containing gas and the moderator are supplied through the side-wall of the gasifier. This is advantageously effected by means of at least two burners positioned symmetrically in relation to the gasifier axis in a low-lying part of the side-wall. These burners protrude through the vertical cylindrical outer pressure shell and the water tube wall structure.

Part of the slag formed in the partial combustion reaction falls downwards and is discharged through the slag discharge in the bottom of the gasifier. A proportion of the slag, however, is entrained as small droplets by the hot crude synthesis gas leaving the gasifier flowing substantially vertically upwards via the gas discharge at the top, preferably at an average linear velocity in the range from 1 to 15 m/s. The presence of slag droplets in the gas may be inconvenient. When the gas is cooled down in a waste heat boiler, the droplets become sticky and may cause a blockage. In order to counteract this, the hot crude synthesis gas is first passed upwards through a radiation chamber where it is cooled, preferably to a temperature in the range from 600 to 1200 °C.

The average linear velocity of the hot crude synthesis gas in the radiation chamber is preferably in the range from 1 to 15 m/s.

The gasifier and the radiation chamber have both the form of cylinders, preferably circular cylinders and are positioned vertically on top of each other. Preferably the internal diameters of the gasifier and of the radiation chamber are equal. This design which does not apply an outlet nozzle at the top of the gasifier is much simpler than the conventional designs. As mentioned hereinbefore the gasifier and the radiation chamber are internally defined by the lower and an intermediate part respectively of the tube wall structure. Through this tube wall structure cooling water is passed, which is evaporated by the heat radiation from the hot crude synthesis gas generated in the gasifier. In order to cool the hot crude synthesis gas leaving the top of the gasifier even better and quicker this gas is preferably quenched. The quench is advantageously carried out by injecting cold gas, steam and/or water into the hot crude synthesis gas. Recycled cold purified synthesis gas is very suitable for this purpose since it substantially does not change the composition of the gas to be cooled.

For the purpose of quenching the present apparatus is preferably provided with two to 20 quench nozzles protruding through the vertical cylindrical outer pressure shell and the water tube wall structure. These nozzles are suitably situated leaving the gasifier flowing substantially vertically upwards via the gas discharge at the top, preferably at an average linear velocity in the range from 1 to 15 m/s. The presence of slag droplets in the gas may be inconvenient. When the gas is cooled down in a waste heat boiler, the droplets become sticky and may cause a blockage. In order to counteract this, the hot crude synthesis gas is first passed upwards through a radiation chamber where it is cooled, preferably to a temperature in the range from 600 to 1200 °C.

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For the purpose of quenching the present apparatus is preferably provided with two to 20 quench nozzles protruding through the vertical cylindrical outer pressure shell and the water tube wall structure. These nozzles are suitably situated section which is connected to the outlet of the reactor. For further cooling of the gas mixture obtained as a result of the injection of cold, clean gas into the hot, impure gas, the quench section and the radiation chamber suitably contain means by which the gas mixture can be indirectly cooled. Said means consist of the tube wall structure which is located on the inside of the quench section and radiation chamber. Through this membrane wall coolant, for example evaporating water and steam, flow.

In conventional coal gasification plants it has been usual to place a heat exchanger for cooling the generated gas above the gasification reactor. For relatively low capacities said arrangement is not unpractical, but for an apparatus in which a high rate of production of H_2- and CO-containing gas must be possible, it causes problems owing to the great structural height involved. In an apparatus of said type the reactor and the heat exchanger will, therefore, preferably be located next to each other. This means that the flow of the gas mixture must be reversed, but before doing so the temperature of the gas mixture is further reduced, advantageously to a value in the range of from 400 to 600°C, in order to facilitate the construction of the pipe connecting the top of the vertical cylindrical outer pressure shell with the top of the evaporator. The further reduction in temperature of the crude synthesis gas is achieved by passing it in an upward direction through the superheater which is situated above the radiation chamber and defined by the upper part of the water tube wall structure. The superheater has advantageously about the same internal diameter as the radiation chamber and it contains at least one tube bank in which steam produced in the evaporator and/or the radiation chamber is superheated thereby indirectly cooling the upflowing crude synthesis gas to the desired temperature in the range from 400 to 600°C. The average linear velocity of the gas in the superheater is preferably in the range from 3 to 15 m/s.

Especially when coal having a high ash content (15 to 40%wt ash) is converted in the present process it is advantageous to separate slag particles from the crude synthesis gas between the superheater and the evaporator so that the chance of slag being deposited on the internals of the evaporator is reduced. Therefore the pipe connecting the top of the vertical cylindrical outer pressure shell with the top of the evaporator preferably contains means for separating solidified slag from the crude synthesis gas.

Such means consist very suitably of one or more impingement separators, bend separators or cyclones in which at least the relatively coarse slag particles are separated from the crude synthesis gas, cyclone(s), being preferred. Slag particles are discharged from the bottom of the cyclone(s), the partially purified synthesis gas being removed from the top of the cyclone(s) and passed to the top of the evaporator.

On its route through the connecting pipe the gas mixture is advantageously further cooled, preferably by indirect heat exchange and to a temperature ranging from 200 to 350°C. In order to ensure this, the connecting pipe is suitably provided with means by which the gas can be cooled indirectly. To this end membrane walls, through which coolant, for example water and/or steam, can flow are most suitable and are therefore preferred.

The vertically arranged evaporator is preferably of a type in which the gas to be cooled is conducted substantially vertically downwards around cooling pipes through which coolant, suitably consisting of water, flows, which is to be transferred to steam.

The average linear velocity of the gas in the evaporator is preferably in the range from 3 to 15 m/s. The crude synthesis gas is advantageously cooled in the evaporator to a temperature in the range from 200 to 350°C.

After the crude synthesis gas has been cooled in the evaporator slag particles are separated therefrom in order to purify it further. This separation is carried out in means for separating slag particles from the cooled crude synthesis gas. These means suitably consist of at least one cyclone, impingement separator or bend separator and they are connected with the bottom of the evaporator by a pipe. For this purpose one or more cyclones are preferred.

As mentioned hereinbefore the pipe connecting the radiation chamber and the evaporator preferably contains means for separating relatively coarse slag particles from the crude synthesis gas. The separated slag particles are suitably caught in a receiving vessel for slag particles which is connected by a pipe with the means for separating the relatively coarse slag particles from the crude synthesis gas.

According to a preferred embodiment of the present invention the receiving vessel is connected by a pipe with the bottom of the evaporator or with the pipe connecting the bottom of the evaporator with the means for separating slag particles from the cooled crude synthesis gas coming from the evaporator. Since on its way through the evaporator the crude synthesis gas is somewhat reduced in pressure, the pressure in the pipe connecting the bottom of the evaporator with the means for separating slag particles is somewhat lower than the pressure in the receiver. Therefore the relatively coarse slag particles caught in the receiver can be easily passed from the receiver to the pipe connected to the bottom of the evaporator, a solid pump not being necessary for this purpose. The relatively coarse slag particles having been removed from the crude synthesis gas before it enters into the evaporator are thus united with this gas after it has been passed through the evaporator. In this way erosion of the evaporator by the relatively coarse particles is obviated ultimately and moreover the relatively coarse particles are very effectively cooled so that they can be sluiced out of the system in an easy way. As well the relatively coarse slag particles as the other slag particles are removed from the cooled crude synthesis gas.

According to another preferred embodiment the relatively coarse slag particles caught in the receiving vessel are taken up in water, thus forming a slurry. This can be done by spraying water over the slag particles in the receiving vessel, the receiving vessel containing means for supplying water at the top and an outlet for slurry at the bottom.

It can also be effected in another way e.g. by pumping water upwards into the receiving vessel through a pipe near its bottom.

Since the present prosess is operated at elevated pressure the slurry formed in the receiving vessel is preferably depressurized before it is discharged from the system. For this purpose the outlet for slurry at the bottom of the receiving vessel for slag particles is suitably connected with a receiving vessel for slurry, which is intermittently filled with slurry and depressurized, whereafter the depressurized slurry is passed through a pipe to a settler for slurry.

In this settler the depressurized slurry is advantageously separated into solid material and water and at least part of the water is used again for the uptake of slag particles. To this end the settler preferably comprises an outlet for wet slag particles at the bottom and an outlet for water at its upper part, the latter outlet being connected by a pipe with the means for supplying water to the receiving vessel for slag particles.

As mentioned hereinbefore hot liquid slag is removed from the bottom of the gasifier. This hot liquid slag drips down into a water bath contained in the bottom of the outer pressure shell, where it cools down rapidly and solidifies thus forming more or less big lumps of glassy material. These lumps are sometimes too big to be handled easily. For this reason the bottom of the vertical cylindrical outer pressure shell is suitably connected with a slag crusher which is joined by means of a pipe with a receiving vessel for crushed slag in water. The slag lumps are passed together with the surrounding water through the slag crusher wherein they are ground and the mixture of ground slag and water is then passed into the receiving vessel. Thereafter it is depressurized and removed from the system.

Despite all measures described hereinbefore, it is still possible that a few slag particles will adhere to the inner walls of the radiation chamber, the superheater, the connecting pipe(s) and the evaporator, as a result of which the cooling effect of said surfaces is reduced and the passage through the whole system is reduced. These effects are undesirable. Therefore, means are preferably connected to the radiation chamber, the superheater, the evaporator and/or the connecting pipe(s) to remove slag deposits from the inner walls of said components. Said means may be of various types, for example, acoustic, mechanical and/or electrical means. However, mechanical jogging means are preferably connected for said purpose. For optimum operation of the latter means the radiation chamber, superheater, connecting pipes and/or the evaporator are preferably designed in such a manner that there is some clearance between the above-mentioned membrane walls, on the inside of which slag particles can settle, and insulating layers suitably arranged against the inside of the (steel) outer walls of said components of the apparatus according to the invention, which outer walls are preferably kept relatively cool, since they must be capable of absorbing forces resulting from the high pressure, for example 30 bar, at which the process according to the invention is preferably carried out.

The invention will now be further illustrated with reference to the drawings showing diagrammatic representations of the apparatus in which the process according to the invention and its preferred embodiments are carried out, in which drawings auxiliary equipment, such as pumps, compressors, valves, cleaning devices and control instruments are not included.

However, the invention is by no means limited to the description based on these drawings.

Figure 1 of the drawings represents a simple embodiment of the process according to the invention especially suitable for the conversions of low ash coals i.e. coals having an ash content in the range from 1 to 5%wt. Through burners 1 a mixture of powderous coal, oxygen-containing gas and steam is passed into a gasifier 2 where it is converted to an H_2 and CO-containing crude synthesis gas by partial combustion. The gasifier 2 is defined by the lower part of a membrane wall 3 consisting of water tubes through which boiling water is circulated being transferred into high pressure steam. The membrane wall 3 is positioned within a vertical cylindrical outer pressure shell 4. At the bottom of the vertical cylindrical outer pressure shell 4 a water bath 5 is present for catching and solidifying liquid slag dropping down from the gasifier 2 through an outlet 6 for liquid slag at the bottom of the water tube wall 3. Liquid slag caught in the water bath 5 solidifies. This material is removed therefrom through an outlet 7 for solidified slag in water. It is passed to a slag crusher 8 where it is crushed to particles with a diameter of at most 50 mm and withdrawn from the system via an outlet 9 together with a volume of water. The proper level of the water in the slag bath 5 is maintained by supplying water to it through a line 10. The hot crude synthesis gas generated in the gasifier 2 contains liquid slag droplets. It ascends into a quench section 11 which has substantially the same internal diameter as the gasifier 2. In the quench section 11 the ascending gas is rapidly cooled down by injecting water, steam and/or cold recycle gas into it through nozzles 12. The temperature and the amount of water, steam and/or cold recycle gas are preferably chosen such that the ascending hot crude synthesis gas is cooled down to a temperature at which the entrained slag droplets solidify to slag particles. After having been cooled in the quench section 11 the crude synthesis gas is passed upwards through a radiation chamber 13, which is defined by an intermediate part of the water tube wall structure 3 and has about the same internal diameter as the quench section 11. In the radiation chamber the crude synthesis gas is further cooled because it loses heat by radiating it to the tubes of the tube wall structure 3 in which water is converted to steam. By the further cooling in the radiation chamber 13 solid slag particles which may be sticky at the entrance of the chamber 13 lose their stickyness. The crude synthesis gas is then passed through a superheater 14 in order to cool it still further. It enters the superheater 14 at its bottom and leaves it through an outlet at its top. This superheater 14 is defined by the upper part of the tube wall structure 3 and has about the same internal diameter as the radiation chamber 13.

It is provided with vertical tube banks 15 in which high pressure steam introduced via an inlet 16 is superheated and then withdrawn from the system via an outlet 17. Since the slag particles have lost their stickyness in the radiation chamber 13 they do not adhere to the tubes of the superheater 14. The crude synthesis gas leaving the top of the superheater 14 is passed via a pipe 18 connecting the top of the vertical cylindrical outer pressure shell 4 with an inlet 19 of an evaporator 20 into this vertical cylindrical evaporator 20 which is positioned next to the vertical cylindrical pressure shell 4 and which comprises a number of horizontal tube banks 21. In these tube banks cooling water is evaporated at elevated pressure to high pressure steam.

The water enters the tube banks 21 via an inlet 22 at its bottom and the steam leaves the tube banks via an outlet 23 at its top. Heat is transferred by convection to the tube banks 21, the crude synthesis gas being passed from the top to the bottom of the evaporator 20 and being further cooled during its course through the evaporator 20.

The cooled crude synthesis gas leaves the evaporator 20 via an outlet 24 which is connected by a pipe 25 to a cyclone 26. In the cyclone 26 slag particles are separated from the crude synthesis gas, cooled purified synthesis gas being discharged from the system via a line 27 and separated slag particles being withdrawn from the system via an outlet 28.

Figure 2 represents a preferred embodiment of the process and apparatus according to the invention and in the process and apparatus outlined in this figure essentially the same constructional parts are used as depicted in figure 1.

In addition the crude synthesis gas being transferred in pipe 18 from the top of superheater 14 to the inlet 19 of the evaporator 20 is firstly introduced into a relatively low efficiency cyclone 29, where relatively coarse slag particles are removed from the synthesis gas. These particles fall down through a pipe 30 into a receiving vessel 31 for slag particles, from which vessel they are discharged via an outlet 32. The synthesis gas from which the relatively coarse particles have been removed is transferred through a pipe 33 to the inlet 19 of the evaporator 20 and further treated as has been described hereinbefore with regard to figure 1.

Figure 3 represents a further extension of the preferred embodiment according to figure 2 in which the outlet 32 of the receiving vessel 31 for relatively coarse particles is connected by a line 34 with the line 25 connecting the outlet 24 of the evaporator 20 with the high efficiency cyclone 26. Therefore in this embodiment not only relatively fine slag particles but also the relatively coarse slag particles are removed from the system via the outlet 28 of cyclone 26 in which they have been separated from the synthesis gas. The advantage of the embodiment according to figure 3 over that according to figure 2 consists in the need of only one sluicing system operating at a relatively low temperature (not shown in both figures) in order to depressurize the slag particles which have been obtained from the cyclones 31 and 26 at about the relatively high pressure at which the present process is operated.

Figure 4 gives an alternative extension of the preferred embodiment according to figure 2. The receiving vessel 31 is now provided with a sprinkle installation 36 through which water being supplied through a line 35 is sprayed on the slag particles contained in the receiving vessel 31. A slurry of slag particles in water is withdrawn through the outlet 32 and passed via a line 37 to a receiving vessel 38 for slurry. Via a line 39 the slurry is transferred to a sluicing system (not shown) where it is depressurized. The depressurized slurry may be separated by settling and/or filtration into clear water and wet slag particles. The latter are withdrawn from the system. The former can be recycled via the line 35 to the sprinkle installation 36. It goes without saying that a similar installation for transporting slag particles as a slurry in water as described with reference to figure 4 (items 31, 32, 35-39) can also be applied to the slag particles separated by means of cyclone 26 as is described with reference to figures 1-4.

Dependent on the type of coal which used as a feedstock for the present process one of the embodiments described with reference to figure 1, 2, 3 or 4 can be applied. The apparatus described with reference to figure 1 can be very conveniently converted into one of the apparatuses described with reference to figure 2, 3 or 4 and vice versa. It is therefore a special advantage of the process according to the invention over the conventional coal gasification processes that the apparatus needed for a certain type of coal (e.g. low ash, high ash, low melting point ash, high melting point ash) can be easily adapted to the type of coal to be processed.

EXAMPLE

To a gasifier 2 as described with reference to Fig. 1, having a capacity of 6600 kg of coal powder per hour was supplied via the burners 1 in nitrogen, 5600 kg of oxygen-containing gas and 600 kg of steam.

The coal powder had an average particle size of 50 and, on a dry and ash-free basis, had the following composition:

C	81.5 % by wt.
H	5.3 % by wt.
N	1.6 % by wt.
O	10.8 % by wt.
S	0.8 % by wt.

The ash content was 8% by weight and the moisture content 1% by weight. The oxygen-containing gas had the following composition:

O_2	99 % by wt.
N_2 Ar	1 % by wt.

The pressure in the gasifier was 30 bar and the temperature 1450°C.

Via the top of the gasifier, 12,000 kg of synthesis gas (calculated as dry gas) was discharged per hour, having the following composition:

CO	65.6 % by vol.
H_2	31.2 % by vol.
CO_2	2.0 % by vol.
N_2 + Ar	0.9 % by vol.
COS + H_2S	0.3 % by vol.
CH_4	0.1 % by vol.

The quantity of slag drained via the slag discharge 6 was 280 kg/h.

Per hour 220 kg of slag was entrained with the crude synthesis gas. The carbon content of the slag was 15% by weight.

In the quench zone 11 the crude synthesis gas was cooled down to a temperature of 900°C by injecting 9000 kg/h cleaned synthesis gas of substantially the same gas composition as the crude gas but having a temperature of 40°C. The synthesis gas was further cooled to a temperature of 800°C in the radiation chamber 13 and still further to 500°C by passing it through the superheater 14. On its way through the evaporator 20 the gas was lowered in temperature to 300°C. It was finally passed through the cyclone 26 where 200 kg/h slag was separated from the gas. The cooled and purified gas leaving the top of the cyclone contained only 0.1%wt. slag which was removed by a water wash.

CLAIMS

1. A process for the production of synthesis gas characterized by the following steps:

a) a finely divided carbonaceous fuel is partially combusted with an oxygen-containing gas at elevated temperature and pressure in a gasifier,

b) liquid slag is removed from the bottom of the gasifier,

c) hot crude synthesis gas containing entrained slag droplets is removed from the top of the gasifier and passed upwards through a radiation chamber where it is cooled, the slag droplets being solidified,

d) the crude synthesis gas is passed upwards through a superheater to cool it further,

e) the flow of the crude synthesis gas is reversed in a pipe connecting the superheater with an evaporator,

f) the crude synthesis gas is passed downwards through the evaporator, to cool it still further,

g) slag particles are separated from the cooled crude synthesis gas.

2. A process as claimed in claim 1, characterized in that the hot crude synthesis gas leaves the top of the gasifier flowing substantially vertically upwards at an average linear velocity ranging from 1 to 15 m/s.

3. A process as claimed in any one or more of the preceding claims, characterized in that cold clean gas, steam and/or water is injected into the hot crude gas leaving the top of the gasifier.

4. A process as claimed in any one or more of the preceding claims, characterized in that the hot crude synthesis gas flows substantially vertically upwards through the radiation chamber at an average linear velocity ranging from 1 to 15 m/s.

5. A process as claimed in any one or more of the preceding claims, characterized in that the hot crude synthesis gas is cooled in the radiation chamber to a temperature in the range from 600 to 1200°C.

6. A process as claimed in any one or more of the preceding claims, characterized in that the crude synthesis gas flows substantially vertically upwards through the superheater at an average linear velocity ranging from 3 to 15 m/s.

7. A process as claimed in any one or more of the preceding claims, characterized in that the crude synthesis gas is cooled in the superheater to a temperature in the range from 400 to 600°C.

8. A process as claimed in any one or more of the preceding claims, characterized in that the crude synthesis gas flows substantially vertically downwards through the evaporator at an average linear velocity ranging from 3 to 15 m/s.

9. A process as claimed in any one or more of the preceding claims, characterized in that the crude synthesis gas is cooled in the evaporator to a temperature in the range from 200 to 350°C.

10. An apparatus for carrying out the process as claimed in any one or more of the preceding claims, characterized in that the apparatus comprises the following components:

a) a vertical cylindrical outer pressure shell containing a water bath for catching and solidifying liquid slag and comprising an inlet for water and an outlet for solidified slag in water and above the water bath a water tube wall structure comprising an outlet for slag at the bottom and an outlet for crude synthesis gas at the top,

b) a gasifier defined by the lower part of the water tube wall structure,

c) a radiation chamber defined by an intermediate part of the water tube wall structure,

d) a superheater defined by the upper part of the water tube wall structure and comprising an outlet for crude synthesis gas,

e) a vertical cylindrical evaporator positioned next to the vertical cylindrical pressure shell, comprising an inlet and an outlet for crude synthesis gas and a number of tube banks for the evaporation of water,

f) a pipe connecting the top of the vertical cylindrical outer pressure shell with the top of the evaporator,

g) means for separating slag particles from the cooled crude synthesis gas,
which means are connected by a pipe with the bottom of the evaporator.

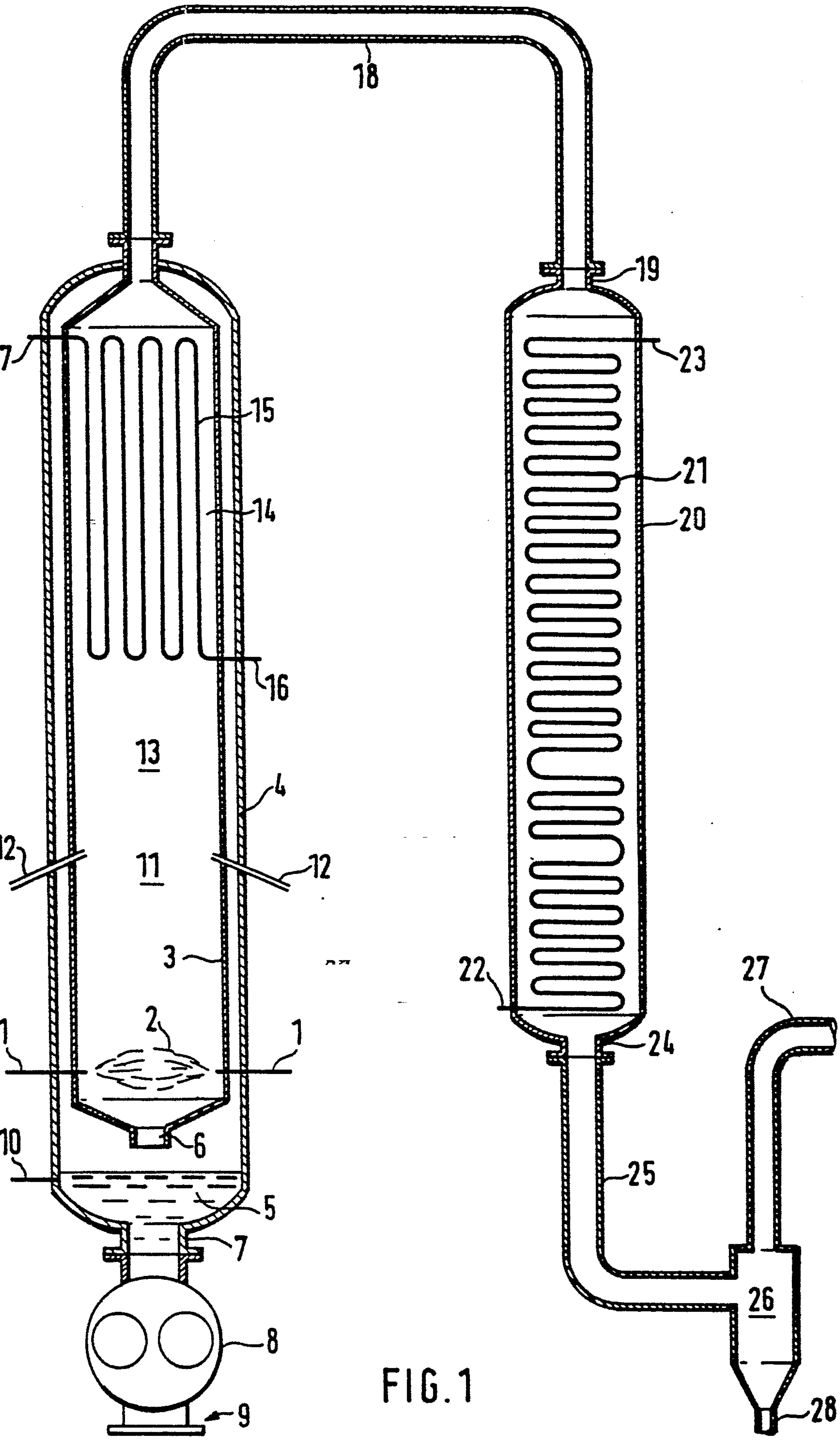
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FIG.1

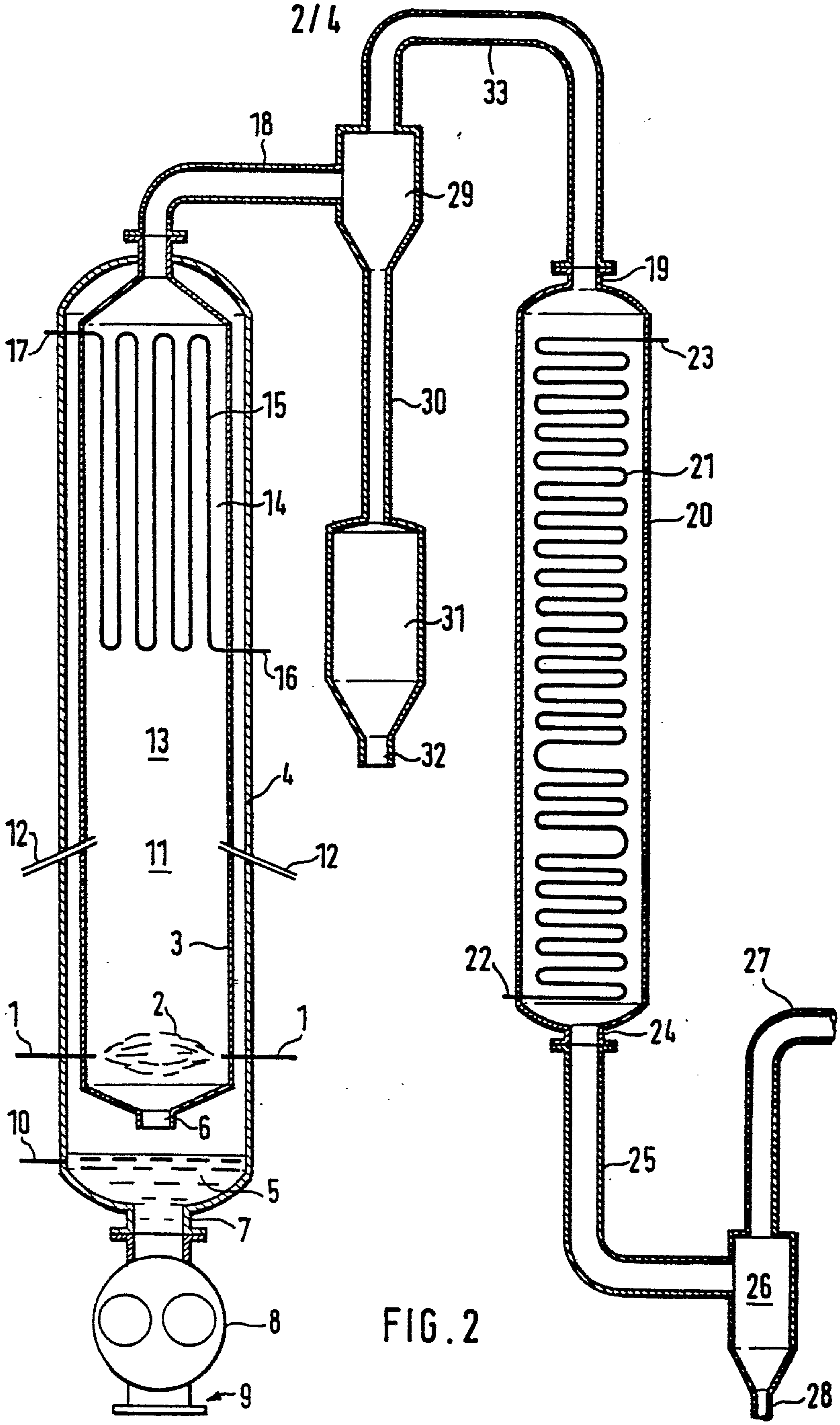

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FIG. 2

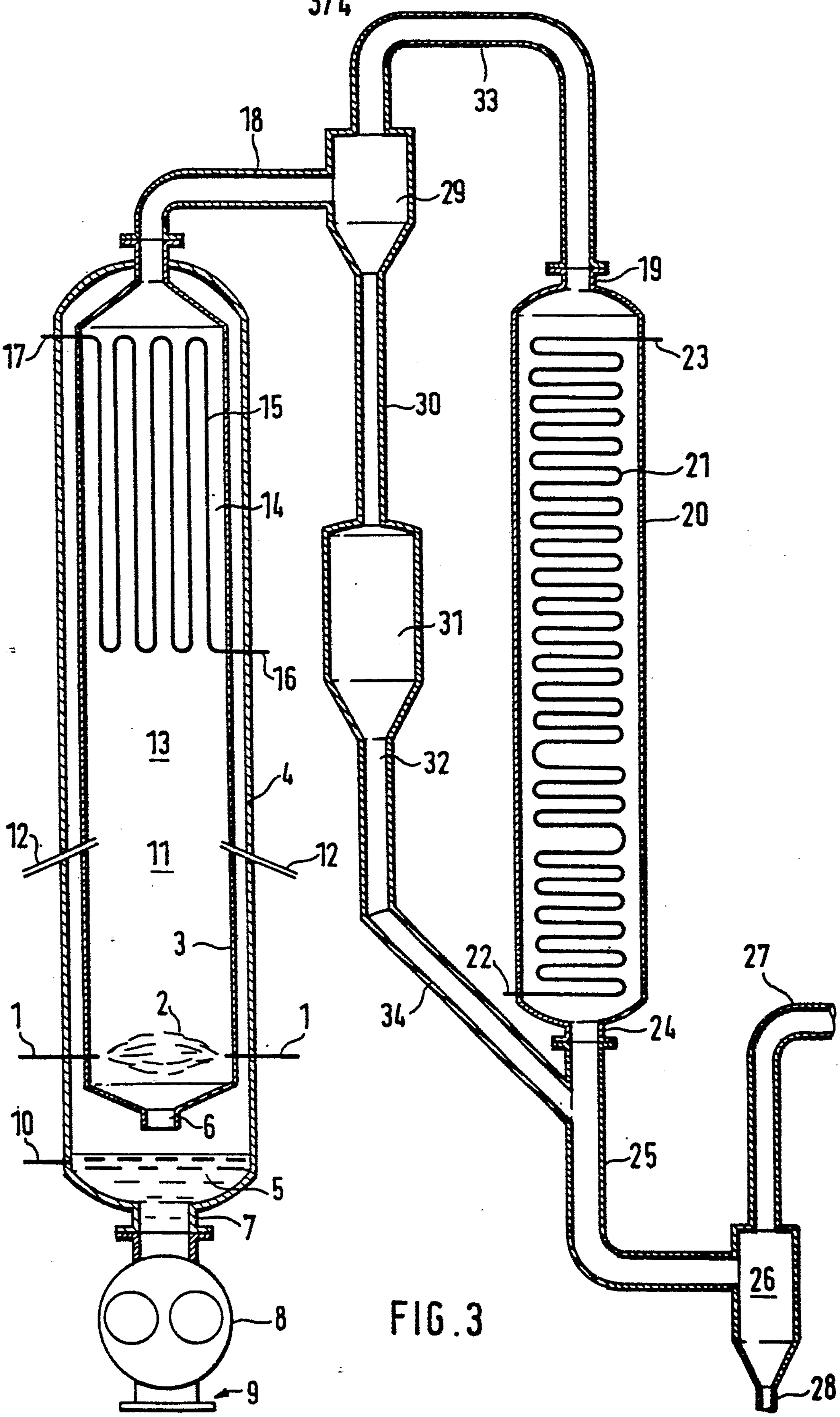

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FIG.3

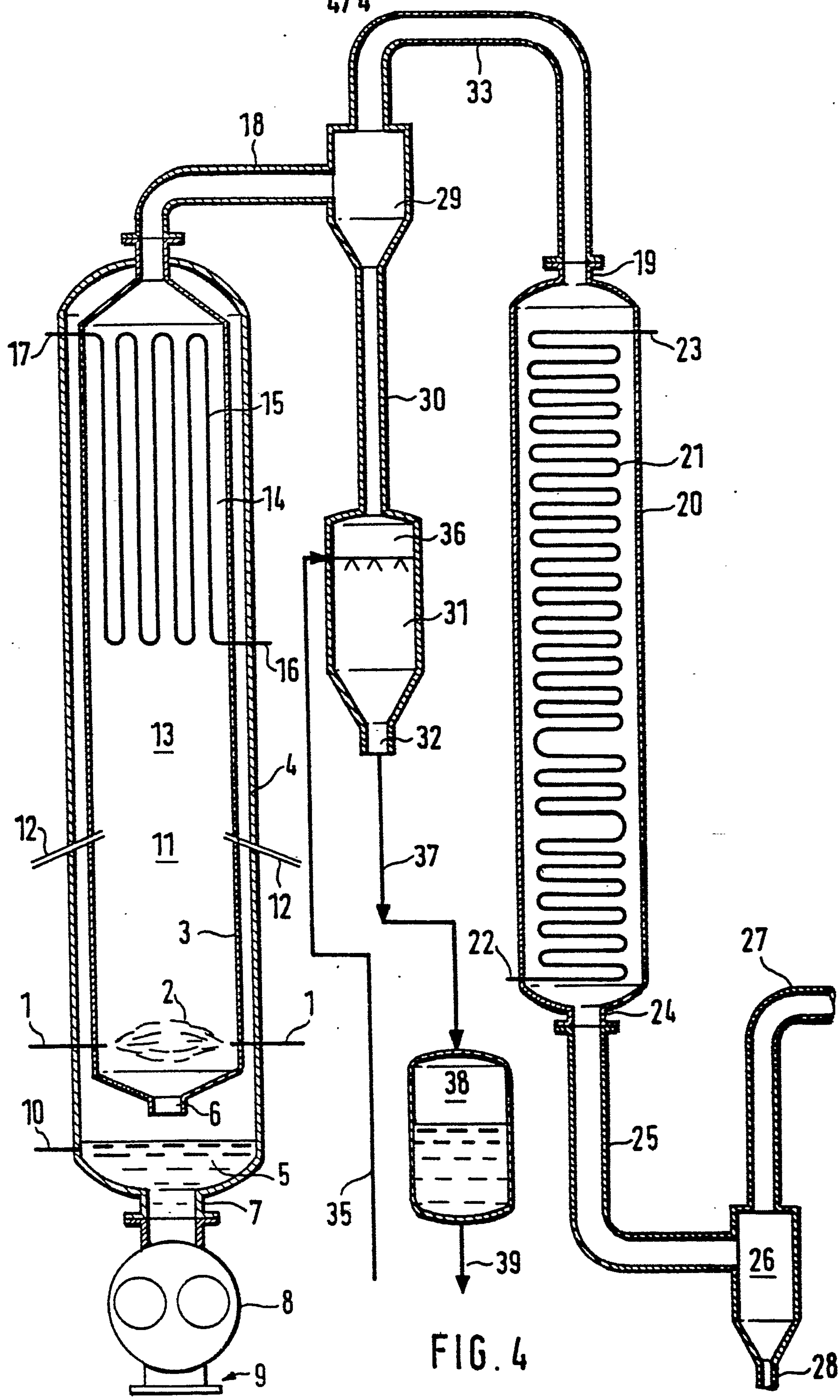
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FIG. 4