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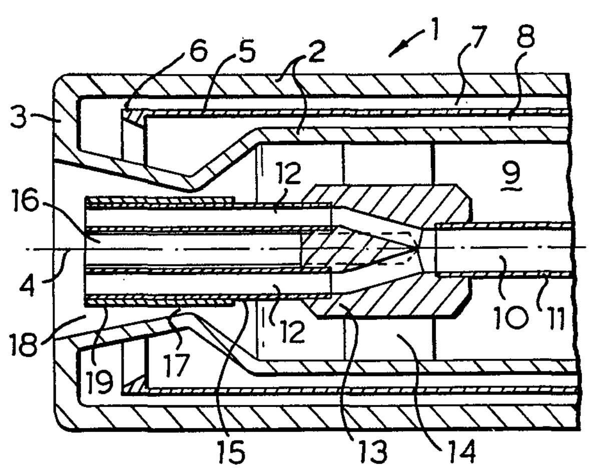
(54) Burner and process for gasifying solid fuel.

(57) Burner for the gasification of a finely divided solid fuel, which burner has an oxygen supply passage 9 and a solid fuel supply passage 10, the oxygen supply passage 9 debouching into a central high velocity oxygen outlet passage 16 and via a constricted passage 17 into a low velocity oxygen outlet passage 18, while the solid fuel supply passage 10 is connected to a solid fuel outlet passage 12 substantially arranged between the oxygen passages 16 and 18.



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BURNER AND PROCESS FOR GASIFYING SOLID FUEL

The present invention relates to a burner for the gasification of a finely divided solid fuel and to a gasification process in which such a burner is used.

Gasification of a solid fuel may be defined as a process wherein solid fuel is partially combusted with a substoichiometric amount of pure oxygen or an oxygen containing gas, such as air, to form product gas consisting mainly of carbon monoxide and hydrogen. Depending on the composition of the combustion medium the product-gas further contains other substances which may be useful or may be considered as pollutants.

Although the present invention will primarily be described with reference to pulverized coal, it should be noted that the burner and process according to the invention are also suitable for other types of solid fuels which can be gasified, such as lignite, wood, bitumen, soot and petroleum coke.

According to a well known gasification process solid fuel in a finely divided state is passed with a carrier gas to a reactorzone via a burner, while the combustion medium is either added to the solid fuel flow inside the burner or is separately introduced into said reactorzone. Great care must be taken that the reactants are effectively mixed with one another. If the reactants are not brought into intimate contact with each other, the oxygen and solid fuel flow will follow at least partially independent trajectories inside the reactor. Since the reactor zone is filled with mainly hot carbon monoxide and hydrogen, the oxygen will rapidly react with these gases instead of with the solid fuel. The so formed very hot combustion products carbon dioxide and steam will also follow independent trajectories having poor contact with the relatively cold solid fuel flow. This behaviour of the oxygen will result in local hot spots in the reactor, thereby possibly causing damage to the reactor refractory lining and increased heat fluxes to the burner(s) applied.

Sufficient mixing of the solid fuel and the oxygen can be attained by adding the oxygen to the solid fuel flow in the burner itself. A disadvantage of this method consists, however, therein that - especially at high pressure gasification - the design and operation of the burner are highly critical. The reason for this is that the time elapsing between the moment of mixing and the moment the fuel/oxygen mixture enters into the reactor zone should be invariably shorter than the combustion induction time of the mixture. Moreover, the velocity of the mixture inside the burner should be higher than the flame propagation velocity in order to avoid flashback. However, the combustion induction time shortens and the flame propagation velocity increases at a rise in gasification pressure. Further, if the burner is operated at a low fuel load or, in other words, if the velocity of the fuel/oxygen mixture in the burner is low, the combustion induction time or flashback condition might easily be reached in the burner itself, resulting in overheating and possibly severe damage to the burner.

The above problem of premature combustion does not occur if the fuel and oxygen are mixed outside the burner in the reactor zone. In this case special measures are to be taken to ensure a sufficient mixing necessary for an effective gasification of the fuel as discussed in the above. A drawback of mixing fuel and oxygen in the reactor zone outside the burner is the risk of overheating the burnerfront due to the hot flame generated by premature contact of oxygen with product gas, viz. carbon monoxide and hydrogen, present in the reactor zone. To promote an intimate mixing of fuel and oxygen, it has already been proposed to introduce the oxygen as high velocity jets into the fuel flow. Such high velocity jets, however, cause an easy entrainment of reactor gases, with the risk of the formation of zones of overheating in the reactor space. As already mentioned in the above such zones of overheating may easily cause damage to the refractory lining of the reactor and the front part of the burner.

An object of the present invention is to provide an improved burner for gasifying a solid fuel, with which a proper mixing of fuel and oxygen outside the burner can be achieved without the above disadvantage attended with fuel/oxygen mixing when using known burners.

The burner for gasifying a finely divided solid fuel thereto comprises according to the invention an oxygen supply passage, a solid fuel supply passage coaxially arranged inside the oxygen supply passage, the oxygen supply passage debouching into a central high velocity oxygen outlet passage and via a constricted passage into a separate annular low velocity oxygen outlet passage, said constricted passage being arranged at or downstream of the upstream end of the central high velocity oxygen outlet passage, the solid fuel supply passage debouching into a solid fuel outlet passage arranged between the central high velocity oxygen outlet passage and the annular low velocity oxygen outlet passage.

The constricted passage between the central oxygen supply passage and the annular low velocity oxygen outlet passage may be formed in different ways. In order to promote a uniform outflow of oxygen this constricted passage is suitably formed by either a plurality of channels uniformly distributed over the annular low velocity oxygen outlet passage or by an annulus coaxially arranged with the annular low velocity oxygen outlet passage.

To further reduce the outflow velocity of the oxygen from the low velocity oxygen outlet passage, the annular low velocity oxygen outlet passage preferably widens gradually in downstream direction. In this manner the oxygen velocity in the central oxygen supply passage can be chosen relatively high without affecting the shielding action of the low velocity oxygen issuing from the low velocity oxygen outlet passage during operation of a burner according to the invention.

During operation the low velocity oxygen issuing from the low velocity oxygen outlet passage forms a shield around the high velocity oxygen and the solid fuel flow, thereby preventing excessive suction of hot reactor gases by the high velocity oxygen flow. The suction of hot reactor gases along the burner front might cause overheating and even damage to the burner itself. Apart from forming a protection shield preventing overheating of the burner front, the low velocity oxygen flow further serves to supply additional oxygen for completion of the solid fuel gasification.

The quality of the solid fuel to be gasified sets requirements to the mixing intensity necessary for a proper contact of the solid fuel with the gasification medium, formed by pure oxygen or oxygen containing gas. Depending on the mixing intensity required, the solid fuel outlet passage may be arranged parallel to the central high velocity oxygen outlet passage or in a position tapering in downstream direction towards said high velocity oxygen outlet passage.

To attain an optimum effect of the low velocity oxygen shield, the shield should preferably be formed closely around the solid fuel flow. This means that the annular low velocity oxygen outlet passage and the solid fuel outlet passage should be arranged so as to follow parallel trajectories, or in other words both passages should be either parallel to the central high velocity oxygen outlet passage or tapering in downstream direction.

If the proposed burner is intended for relatively low throughputs of solid fuel, the solid fuel outlet passage may advantageously be formed by an annular conduit separating the central high velocity oxygen outlet passage from the annular low velocity oxygen outlet passage. The annular conduit should have a rather limited thickness in order to enable all the solid fuel particles to be contacted with oxygen.

For accomplishing relatively large throughputs, it is advisable to refrain from application of an annular outlet passage since such an annulus would necessarily have a rather large thickness, not suitable for a proper contact of all the solid fuel particles with oxygen.

If the proposed burner is intended for high throughputs it is therefore advisable to form the solid fuel outlet passage by a plurality of spaced apart, relatively small, outlet conduits. An advantage of this arrangement consists herein that relatively thin solid fuel flows can be generated which are each fully surrounded by oxygen. These conduits are suitably uniformly distributed over a tubular element separating the central high velocity oxygen outlet passage from the annular low velocity oxygen outlet passage. The solid fuel outlet conduits may be arranged outside the tubular element or at the inner surface thereof.

In a variant of the above burner according to the invention the wall of the tubular member is provided with holes for the passage of solid fuel.

The solid fuel supply passage is formed by a channel, preferably with a cylindrical shape, which channel is centrally arranged inside the oxygen supply passage to obtain a symmetric arrangement of the burner internals which is favourabe for reducing vibration during operation. As known in the art, the cross-sectional area of the solid fuel outlet passage should preferably be chosen equal to the cross-sectional area of the solid fuel outlet passage to reduce the risk of stagnant zones in the solid fuel passages.

The oxygen velocity in the central outlet passage should be chosen sufficiently high to enable an easy breaking-up of the solid fuel flow. Suitable velocities for the central oxygen are chosen at least 60 m/sec, even more suitable are oxygen velocities of at least 90 m/sec. In order to maintain the oxygen flow velocities in the oxygen supply passage at an admissable level without affecting the required minimum velocity of the oxygen in the central outlet passage, the total cross-sectional area of the central high velocity oxygen outlet passage and the constricted passage is preferably substantially equal to and even more preferably smaller than the cross-sectional area of the oxygen supply passage.

The present invention further relates to a process for the gasification of a finely divided solid fuel, which process comprises using one or more burners of the above-mentioned type according to the invention. When using such a burner the solid fuel to be gasified is introduced into a reactor space downstream of the burner as an annulus around a flow of high velocity oxygen, while the solid fuel annular flow itself is surrounded by a protecting shield of low velocity oxygen.

The oxygen leaving the annulus around the solid fuel and central oxygen passages serves amongst other things as further combustion medium for completing the gasification of the solid fuel. As already mentioned in the above the annular low velocity oxygen flow has a further function in that it forms a shield around the solid fuel flow and central high velocity oxygen flow, thereby suppressing suction of hot reactor gases along the burner-front towards the high velocity oxygen flow. The low velocity oxygen shield further suppresses escape of solid fuel thereby advantageously influencing the conversion rate, i.e. the quantity of solid fuel which is converted into valuable product gas versus the quantity of solid fuel supplied.

In order to attain a sufficient suppression of suction of hot reactor gases along the burner front, the velocity of the annular low velocity oxygen flow is preferably at most about 50 m/sec, and even more preferably at most about 30 m/sec.

Apart from the purpose of gasification the central oxygen flow has a primary function in that it serves to break up the solid fuel flow. The velocity of the central oxygen should preferably be in the order of magnitude of at least about 60 m/sec to provide sufficient momentum for breaking up the solid fuel flow. Even more preferably, the central oxygen flow has a velocity of at least about 90 m/sec.

For maintaining the reactor temperature at an admissable level a moderator gas may be added to the oxygen passing through the oxygen supply passage. The moderator gas may be formed by for example steam, carbon dioxide, nitrogen and cold reactor gas.

The invention will now be further illustrated with reference to the accompanying drawings, in which

Figure 1 shows a longitudinal section of the front part of a first burner according to the invention;

Figure 2 is a front view of the burner shown in Figure 1;

Figure 3 shows a longitudinal section of the front part of a second burner according to the invention; and

Figure 4 shows section IV-IV of the burner shown in Figure 3.

It should be noted that the invention is by no means limited to the description based on these drawings.

Figures 1 and 2 of the drawings represent a first embodiment of a burner according to the invention, which burner, generally indicated with reference numeral 1, is intended for the gasification of a finely divided solid fuel, such as pulverised coal. The said burner 1 comprises a substantially cylindrical hollow, internally cooled, wall member 2, having an enlarged endpart forming the burner front face 3 which extends substantially normal to the longitudinal axis 4 of the burner. The interior of the hollow wall member 2 is provided with a substantially concentric partition wall 5 having an enlarged endpart 6 arranged near the burner front face 3. The partition wall 5 divides the interior of the hollow wall member 2 into passages 7 and 8 for the circulation of a cooling fluid therethrough. The hollow wall member 2 encloses a virtually centrally arranged oxygen supply passage 9, in which passage a substantially concentrically arranged solid fuel supply passage 10 is positioned. This solid fuel supply passage 10 is separated from the oxygen supply passage 9 by a substantially cylindrical wall 11.

In the embodiment according to Figure 1 the solid fuel supply passage 10 is near the burner front face 3 splitted up into four separate solid fuel outlet passages 12 spaced apart from one another. To guarantee a smooth outflow of solid fuel from the solid fuel supply passage 10 into the solid fuel outlet passages 12, the upper parts of the latter passages are only slightly outwardly inclined. As shown in Figure 1, the upper parts of the solid fuel outlet passages 12 are formed by holes provided in a solid block 13, substantially centrally mounted in the oxygen supply passage 9 via a plurality of spacer elements 14. The major parts of the solid fuel outlet passages 12 are formed by tubular elements 15, firmly secured to the solid block 13. To further suppress the occurrence of stagnant zones in the solid fuel passages the total cross-sectional area of the solid fuel outlet passages 12 is chosen substantially equal to the cross-sectional area of the solid fuel supply passage 10.

The oxygen supply passage 9 debouches near the burner front face 3 into a central high velocity oxygen outlet passage 16 and via a substantially annular constricted passage 17 into a substantially annular low velocity outlet passage 18. As clearly shown in Figure 1, the passages 17 and 18 form in fact part of a venturi-shaped substantially annular opening. The rate of widening of the low velocity oxygen outlet passage 18 depends on the required velocity of the oxygen issuing from said passage.

The annular low velocity oxygen outlet passage 18 is separated from the central high velocity oxygen outlet passage 16 by means of a substantially concentrically arranged hollow tubular element 19 surrounding the tubular elements 15 for the passage of solid fuel.

Reference is now made to Figures 3 and 4, showing a further embodiment of a burner according to the present invention.

It should be noted that identical elements of the two shown burners have been indicated with the same reference numeral.

In this further embodiment the oxygen supply passage 9 debouches via a plurality of separate channels 20 into an annular low velocity oxygen outlet passage 21, widening in downstream direction. The channels 20 are substantially uniformly distributed around the longitudinal burner axis 4. The solid fuel outlet passages, indicated with reference numeral 22, in this further embodiment are formed by holes arranged in the wall of a tubular element 23. Said passages are each formed by a first outwardly inclined upper part, an intermediate substantially parallel to the longitudinal burner axis 4, and an inwardly inclined lower part. The inwardly inclined lower parts of the solid fuel outlet passages cause during operation the solid fuel to flow towards the high velocity oxygen issuing from the central high velocity oxygen outlet passage 16, thereby promoting intense mixing of the fuel with oxygen. To closely surround the solid fuel and high velocity oxygen with a protective shield of low velocity oxygen, the annular low velocity outlet passage 21 and the end parts of the solid fuel outlet passages follow substantially parallel trajectories.

The central high velocity oxygen outlet passage 16 is in fluid communication with the oxygen supply passage via a plurality of channels 24 formed in the wall of tubular element 23 between adjacent solid fuel outlet passages 22. It should be noted that the total cross-sectional area of the channels 24 is preferably at least equal to the cross-sectional area of the high velocity oxygen outlet passage 16 to promote a uniform high velocity outflow of oxygen during operation of the burner.

As shown in Figures 1 and 3, the constricted passage formed by annulus 17 and channels 20, respectively, is arranged downstream of the upstream end of the central high velocity oxygen outlet passage 16. The constricted passage may, however, also be arranged at the upstream end of the central oxygen outlet passage, to obtain a central high velocity oxygen flow and an annular low velocity oxygen flow. Although in the Figures shown the low velocity oxygen outlet passage is formed by an annulus, it is noted that said passage may also be formed by a plurality of separate channels forming together, at least at their downstream end, a substantially annulus.

C L A I M S

1. Burner for the gasification of a finely divided solid fuel, comprising an oxygen supply passage (9) and a solid fuel supply passage (10) coaxially arranged inside the oxygen supply passage, the oxygen supply passage debouching into a central high velocity oxygen outlet passage (16) and via a constricted passage (17) into a separate annular low velocity oxygen outlet passage (18), said constricted passage being arranged at or downstream of the up-stream end of the central high velocity oxygen outlet passage, the solid fuel supply passage debouching into a solid fuel outlet passage (12) arranged between the central high velocity oxygen outlet passage and the annular low velocity oxygen outlet passage.

2. Burner according to claim 1, wherein the constricted passage is concentrically arranged with the oxygen supply passage.

3. Burner according to claim 2, wherein the constricted passage is formed by a plurality of uniformly spaced apart channels.

4. Burner according to claim 2, wherein the constricted passage is formed by an annular slit.

5. Burner according to any one of the claims 1-4, wherein the annular low velocity oxygen outlet passage gradually widens in downstream direction.

6. Burner according to any one of the claims 1-5, wherein the annular low velocity outlet passage and the solid fuel outlet passage each have a cylindrical shape.

7. Burner according to any one of the claims 1-5, wherein the annular low velocity oxygen outlet passage and the solid fuel out-let passage each taper in downstream direction.

8. Burner according to any one of the claims 1-7, wherein the solid fuel outlet passage is formed by an annular conduit separat-ing the central high velocity oxygen outlet passage from the annu-lar low velocity oxygen outlet passage.

9. Burner according to any one of the claims 1-7, wherein the solid fuel outlet passage is formed by a plurality of spaced apart conduits uniformly distributed over a tubular element separating the central high velocity oxygen outlet passage from the annular low velocity oxygen outlet passage.

10. Burner according to any one of the claims 1-9, wherein the solid fuel supply passage is formed by a cylindrical channel centrally arranged inside the oxygen supply passage.

11. Process for the gasification of a finely divided solid fuel with oxygen, which process comprises using one or more burners according to any one of the claims 1-10.

FIG. 1

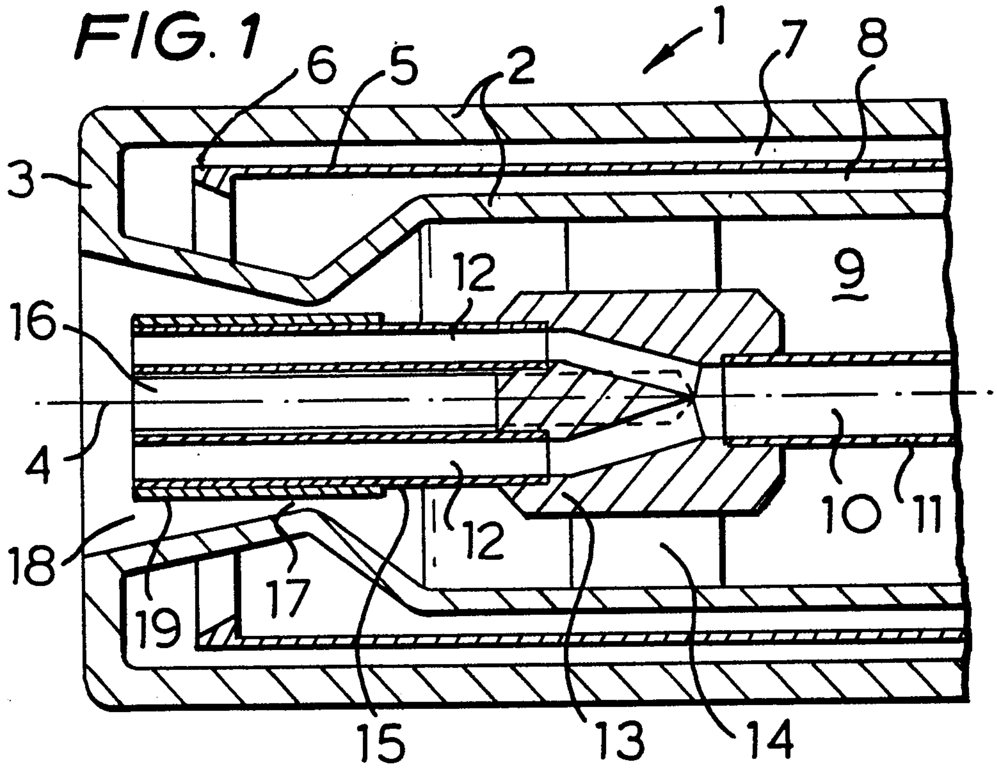

FIG. 2

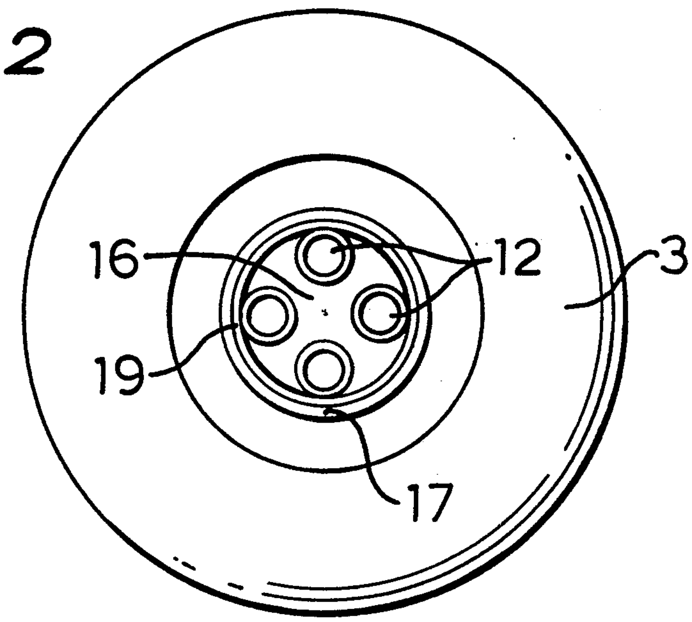

FIG. 3

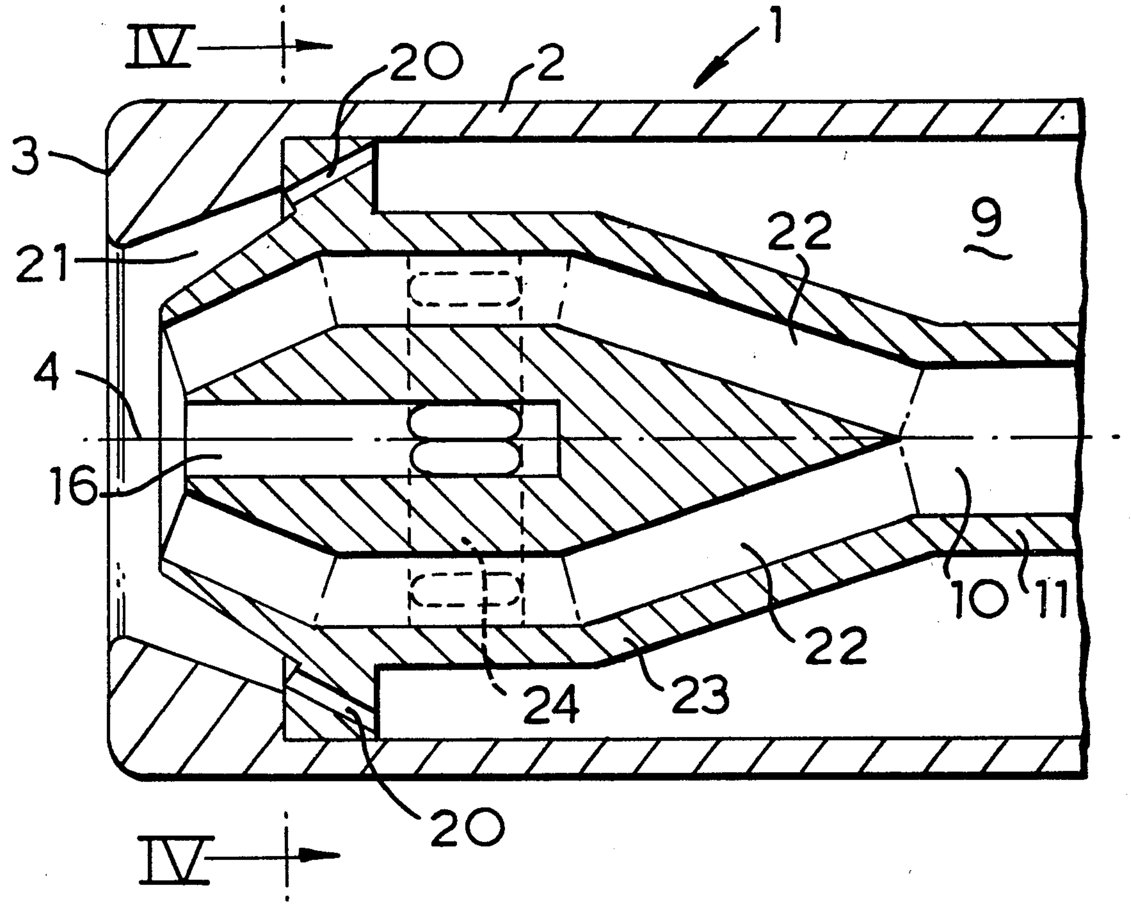

FIG. 4