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54 **Ash removal apparatus for fluidized bed gasifier.**

57 A fluidized bed gasifier (10) and process wherein the gasifier comprises a vertically disposed elongated vessel (12) defining an internal ash annulus region (22) disposed within a lower section of the vessel (12), a steeply sloping floor (28) disposed within the vessel (12) in the ash annulus region (22) and having orifices, process medium injection means (14) disposed upwardly through the floor (28) and into the ash annulus region (22), ash discharge means (44) for discharging ash from the vessel (12), and fluid injection means (26) disposed within the ash annulus region (22) for injection of a fluid downwardly into the ash annulus region (22).

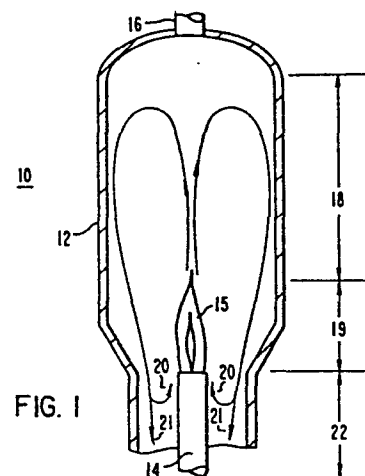


FIG. 1

ASH REMOVAL APPARATUS FOR
FLUIDIZED BED GASIFIER

This invention relates to gasification of carbonaceous materials and more particularly to a method and apparatus for separation, cooling and removal of ash from fluidized bed gasifiers.

5 In reactors for the gasification of carbonaceous materials, such as coal, a combustible product gas is produced as well as solid waste products such as agglomerated ash. In a typical fluidized bed gasifier, coal particles are pneumatically transported by a gas into the
10 hot gasifier. Process mediums such as steam, coal in particle form, and a gaseous source of oxygen, such as air or pure oxygen, are injected, as well as, perhaps, a clean recycled product gas. This process results in fluidization of the coal particles in a bed above the nozzle.
15 Further, the injection of coal and oxygen into the hot gasifier results in combustion of a portion of the coal, and the heat thereby released maintains the temperature in the gasifier. As the non-combusted coal particles are heated, rapid evaporation, or devolatilization, of volatiles in the coal occurs. The average temperature within
20 the vessel typically runs between 870°C and 1100°C or higher and this high temperature ensures that the products of devolatilization, such as tars and oils, etc., are broken down, or cracked, and gasified to form methane,
25 carbon monoxide and hydrogen. As the coal continues to

heat, devolatilization is completed and particles of coal become pieces predominantly of ungasified carbon, or char. As this char circulates throughout the fluidized bed, the carbon in the char is gradually consumed by combustion and gasification, leaving ash-rich particles that have a high ash content. The ash-rich particles contain mineral compounds and eutectics that melt at temperatures of between 540°C to 1100°C and typically consist of compounds of any or all of S, Fe, Na, Al, K and Si, which compounds are typically denser than carbon compounds. These liquid compounds within the particles extrude through pores to the surfaces where they cause the particles to stick to each other, or agglomerate. In this way, ash agglomerates are formed that are larger and denser than the particles of char in the bed. As their density and size increases, the fluidized bed is unable to support them. Gradually, the density of the ash agglomerates becomes high enough that they can no longer be supported in the fluidized bed, and the ash agglomerates defluidize. It is then necessary to remove these ash agglomerates from the vessel.

The ash withdrawal means of the prior art has taken several forms. The first of these is one in which the ash settles at the bottom of the vessel and gradually builds up to some physical level above the bottom. A fixed outlet acts as an overflow discharge to withdraw the ash. This is a satisfactory solution where the gasifier in use uses entrained limestone or some other type of material which is intended to remain within the bed as a relatively fixed inventory. It is unsatisfactory, however, where no residual ash is desired.

A second form of ash withdrawal means consists of a device which mechanically sifts the ash to separate the ash particles by size. This means is unsatisfactory because it does not take advantage of the difference in density between particles of char and particles of agglomerated ash. This may result in premature removal of char (which has residual carbon value) and a corresponding reduction in carbon conversion efficiency.

A third form of ash withdrawal means consists of a floor disposed at a very slight angle with respect to the horizontal, leading downwardly towards an ash removal plenum. A fluidizing gas is discharged through nozzles in the floor to provide a fluidizing means for particles of agglomerated ash. A disadvantage of this means is that ash removal may take place very slowly and as a result might not be effective for a large scale gasifier. A further disadvantage is that large particles of ash which are too large or too dense to be fluidized by the floor nozzles may not be discharged, and could build up in the vessel. This can distort the gas distribution from the floor nozzles, further hindering solids removal.

Another form of ash removal means consists of an apparatus for removing ash agglomerates preferentially through a venturi throat using a high velocity jet of incoming gas made up of the process mediums, against which only the agglomerates having sufficient downward momentum may fall. Unfortunately, any withdrawal of ash through the venturi throat may cause a momentary blockage in the throat, and could result in a perturbation in the fluidized bed which is supported by the gas.

All of the above means have further disadvantages. Progressively larger particles of agglomerated ash are formed because the ash will remain sticky until it is cooled enough to solidify. None of the above ash withdrawal means has the capability to cool the ash as it defluidizes, before it contacts the bottom of the vessel. If ash is allowed to contact the bottom of the vessel prior to solidification, the ash may stick to the bottom, fouling it, and could eventually plug the bottom of the gasifier. Direct discharge with insufficient cooling could also result in damage to downstream components which may be heat sensitive, such as gasket material in gas tight lockhopper valves.

It is therefore the principal object of the present invention to provide gasifier vessels with ash

discharge means which will efficiently separate char particles from ash particles and allow the char particles to be recycled back into the fluidized bed and to provide an ash discharge means which will allow cooling of the ash prior to withdrawal to minimize fouling of internal gasifier surfaces and to minimize the exposure to heat of downstream ash discharge and to accomplish this in a manner which discourages perturbations in the dynamics of the fluidized bed.

With this object in view, the present invention resides in a fluidized bed gasifier for the gasification of carbonaceous material, comprising a vertically disposed elongated vessel defining an internal ash annulus region disposed within a lower section of said vessel said vessel having a sloping floor, disposed within said vessel in said ash annulus region, having a slope angle of between 80° and 45° upwards from a horizontal reference, said floor having orifices, extending therethrough, means for the injection of process mediums into said vessel, said injection means extending upwardly through said floor and into said ash annulus region, and means for discharging ash from said vessel, said discharge means penetrating said floor at the lower edge thereof, characterized in that gas injection means are provided in the area of said ash annulus region for the injection of a gas downwardly into said ash annulus region and said floor has a slope angle of between 80° and 45° upwards from a horizontal reference.

The invention will become more readily apparent from the following description of a preferred embodiment thereof shown, by way of example only, in the accompanying drawings, in which

Fig. 1 is a sectional elevational view of a fluidized bed gasifier;

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Fig. 2 is a sectional elevational view of the annulus section of a fluidized bed gasifier in accordance with the invention;

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Figure 3 is a sectional elevational view of a portion of the annulus region of the fluidized bed gasifier in accordance with the invention;

Figure 4 is a plan view of the annulus region of a fluidized bed gasifier in accordance with the invention; and

Figure 5 is a sectional elevational view of a portion of the annulus region of the fluidized bed gasifier in accordance with the invention.

Referring now to Figure 1 there is shown a fluidized bed gasifier 10 comprising a generally elongated vessel 12, the bottom of which is penetrated by a nozzle 14, which extends upwardly into the vessel 12. Penetrating the top of the vessel 12 is a product gas outlet 16. The vessel 12 has three major horizontal regions: 1) the bed region 18 in the uppermost portion of the vessel 12 and extending downwardly to approximately the top of the combustion flame 15 formed at the top of the nozzle 14; 2) the combustor region 19 below the bed region 18 and above the top of the nozzle 14; and 3) the annulus region 22 extending from the top of the nozzle 14 downward. There is also shown the char particles flow pattern 20 and the agglomerated ash flow pattern 21. It can be seen that particles flow upwardly from the nozzle 14, through the flame 15, circulate into and through the bed region 18, downwardly through the combustor region 19 and into the annulus region 22. In the annulus region 22, the char and ash are separated, char recirculating upward, and ash defluidizing downward.

Referring now to Figure 2, there can be seen the annulus region 22 of the vessel 12. Concentric to the nozzle 14 from a point below the top of the nozzle 14 and downwardly may be an inner booster 24. An outer booster 26 may be embedded or attached to the vessel 12 at a position which is approximately at the same elevation as the top of the inner booster 24. Only one of the boosters 24, 26 is necessary, but preferably both are used. The

gas injected by the boosters 24, 26 may be any gas, but is preferably steam or clean recycled product gas. A steeply-slanted floor 28, preferably symmetric on either side of the nozzle 14, is situated at the bottom of the annulus 22, the center of which floor 28 extends upwardly towards the top of the nozzle 14. A gas, typically clean recycled product gas, is injected through inlet 30 into a floor gas plenum 31 beneath the floor 28. Beneath the floor gas plenum 31 is an ash plenum 32.

Looking now to Figures 3 and 4, there can be seen a more detailed view of the annulus 22 showing the nozzle 14 surrounded by the inner booster 24 and showing additional detail of the floor 28. The floor 28 may be a single plate, or may be comprised of multiple plates such as 34, 36, 38 and 40. Also shown are holes 42 through which a gas, typically clean recycled product gas, is injected into the annulus region 22. Penetrating the floor 28 is one or more ash discharge openings 44.

Looking now at Figure 5 there can be seen a more detailed view of the vessel 12 showing the annulus region 22 inside of which is the nozzle 14 which is surrounded by the inner booster 24. Attached to, or embedded in, the vessel 12 is the outer booster 26 which may be comprised of a singular coiled tube 46. Penetrating the tube 46 may be outer booster discharge holes 48 situated in a manner to provide discharge of a process medium into the vessel 12. Penetrating the inner booster 24 may be a series of inner booster discharge holes 50 to inject a process medium into the vessel 12.

It has been determined that injection of a gas into a fluidized bed will result in the formation of a void, or bubble, in the bed in a manner similar to the injection of a gas into a liquid. It has also been observed that the injection of gas from a number of uniformly distributed horizontal locations in a vertical fluidized bed will break up large bubbles by disruption of the bubble boundary, and thereby minimize perturbations in

the overall dynamics of the fluidized bed. Consequently, both boosters 24, 26 are disposed uniformly around the ash annulus in such a manner that large bubbles rising from the floor 28 of the vessel 12 will be effected by the gas injected by the boosters 24, 26 and thereby broken up.

This system operates in the following manner. Referring now to Figure 1, various process mediums are injected through nozzle 14 into gasifier vessel 12. A portion of the coal particles combust to provide high temperatures for the process. The remaining particles of coal are heated and fluidized into a bed in the bed region 18. As coal is gasified to leave particles of agglomerated ash, the ash, being more dense, and of larger particle size, than char, gradually defluidizes.

Referring now to Figure 2, as the agglomerated ash defluidizes into the annulus region 22, rather than falling directly to the floor 28, the ash is defluidized gradually, because the recycled gas, which is injected into the vessel 12 through the floor 28, and the steam, or recycled product gas which is injected into the vessel 12 through the boosters 24, 26 provides a fluidizing force to resist gravity. This flow of fluidizing gas permits gradual defluidization of the heavier, larger ash agglomerates (which descend with a velocity of between 1 and 2 feet per minute), but more vigorously fluidizes the lighter char particles such that they are separated from the heavier ash particles. These separated char particles are transported up from the annulus region 22 into the combustor region 19 and into the bed region 18 where the carbon contained in the char is further consumed. Thus, the fluidization flow serves to both slow the descent of the ash agglomerates and transport char back up to the bed region 18 for further gasification.

The extended time spent in the annulus region 22 defluidizing also provides the ash with the opportunity to cool from the temperature of the fluidized bed. The recycled gas, typically injected at a temperature between

38°C and 370°C, and the steam, typically injected at a temperature between 100°C and 480°C cool the ash significantly, from above 870°C when it leaves the bed, to a range of 38°C to 427°C when it is discharged. Eventually, the ash passes through the floor 28 through ash discharge openings 44 (see Figure 4) and into the ash discharge plenum 32 where it can be further disposed of, such as through large diameter piping and lockhoppers.

Referring now to Figure 3, it can be seen that the floor 28 has grid gas discharge penetrations 42 through which a gas such as recycled product gas passes from the floor gas plenum 31 into the annulus region 22 of the vessel 12. Preferably, these grid gas discharge penetrations 42 will be designed and sized such that the pressure drop across the penetrations 42 is greater than 30% of the bed pressure drop. It has been determined that this pressure drop will prevent flow imbalances through the penetrations 42 at different locations. Such flow imbalances could result in loss of fluidizing action on the ash agglomerates and char in the annulus region 22. Obviously, the bed pressure drop will depend upon several variables such as the vessel operating pressure and the vessel height. It is further desirable that the total flow from these grid gas discharge penetrations 42 will be approximately one-half of the total gas fed to the annulus region 22 including the boosters 24, 26. This will help to insure that the distribution of gas within the annulus region 22 is uniform.

When seen in cross section, the floor 28 may typically have an angle of between 80° and 45°, and preferably, approximately 70°, upwards from the horizontal. This angle helps to assure the removal of large agglomerated ash particles formed in the bed. The angle of internal friction is that angle of a surface for which a particle of a particular material will roll regardless of its shape. For coal that angle is 60°; for ash agglomerates 45°; and for char fines 65°. Because the angle of 70° is

larger than the angle of internal friction for most coal-derived solid materials, no large particles of agglomerated ash are expected to accumulate even with the loss of fluidizing gas. Obviously, it would be acceptable to
5 use an angle of between 70° and 45° if no coal or char fines were expected to find their way into the annulus region.

Looking now at Figure 4, it can be seen that the floor 28 is penetrated by the nozzle 14 and the inner
10 booster 24 and at least one ash discharge opening 44. Preferably, the penetration for the nozzle 14 and the inner booster 24 will be in the center and there will be two ash discharge openings 44 on opposite sides of the vessel 12 from each other and tangent to the wall of the
15 vessel 12 at the lowest point of the floor 28. The recycled gas discharged through the floor 28, through the floor gas discharges 42, will be at angles which will direct the ash towards the ash discharge openings 44 and away from the wall of the vessel 12. In a preferred
20 embodiment, these floor gas discharges 42 will discharge floor gas generally towards the ash discharge opening 44 and specifically at an angle θ which is between 30° to 45° from a line that passes through the centers of both ash discharge openings 44.

25 Referring now to Figure 5 there is seen a more detailed view of the inner booster 24 and the outer booster 26. The inner booster 24 may consist of a capped pipe concentric to the nozzle 14 with a series of holes 50 which penetrate the inner booster 24. These holes 50 may
30 be made such that gas discharged from them will be discharged generally downward, and in the preferred embodiment, at an angle approximately 60° downward from the horizontal. The outer booster 26 may generally consist of a coiled hollow pipe 46 with outer booster discharge pene-
35 trations 48 made such that the discharge of a gas would be generally downward, and in the preferred embodiment, at an angle approximately 60° downward from the horizontal.

These penetrations 48 and holes 50 may typically be of a diameter between 1.6 mm and 12.7 mm, but preferably about 6.35 mm in diameter.

5 The inner and outer boosters 24, 26 provide several functions. First, the boosters 24, 26 provide cooling of the agglomerated ash which is defluidizing inside the annulus 22. Second, the boosters 24 and 26 provide additional fluidizing gas in the annulus 22, particularly in that space above the boosters 24, 26 and
10 below the top of the nozzle 14. Third, the boosters provide a mechanism generating bubbles uniformly across the annulus region 22 to facilitate particle separation.

 It should be noted that the removal of ash from the system 10 after its passage through the annulus 22,
15 out the ash discharge openings 44, and through the ash plenum 32 is typically conducted without the loss from the vessel 12 of a significant quantity of gas. This is generally accomplished through the use of, for instance, lock hopper valves, which are well known in the art and
20 serves several purposes. First, obviously, is the prevention of loss of valuable product gas. Second, it provides that the general flow of gas in the annulus 22 is upwardly and therefore conducive to the slow defluidization and cooling of agglomerated ash from the bed.

CLAIMS:

1. A fluidized bed gasifier for the gasification of carbonaceous material, comprising a vertically disposed elongated vessel (12) defining an internal ash annulus region (22) disposed within a lower section of said vessel (12), said vessel having a sloping floor (28), disposed within said vessel (12) in said ash annulus region (22), having a slope angle of between 80° and 45° upwards from a horizontal reference, said floor (28) having orifices, extending therethrough, means (14) for the injection of process mediums into said vessel, said injection means (14) extending upwardly through said floor (28) and into said ash annulus region (22), and means (44) for discharging ash from said vessel (12), said discharge means (44) penetrating said floor (28) at the lower edge thereof, characterized in that gas injection means (26) are provided in the area of said ash annulus region (22) for the injection of a gas downwardly into said ash annulus region and said floor (25) has a slope angle of between 80° and 45° upwards from a horizontal reference.
2. A fluidized bed gasifier in accordance with claim 1, characterized in that said floor (28) comprises first and second sloped surface areas which intersect to form an upper edge in the center section of said ash annulus region (22) and said first and second surfaces are disposed symmetrically to each other about said upper edge.

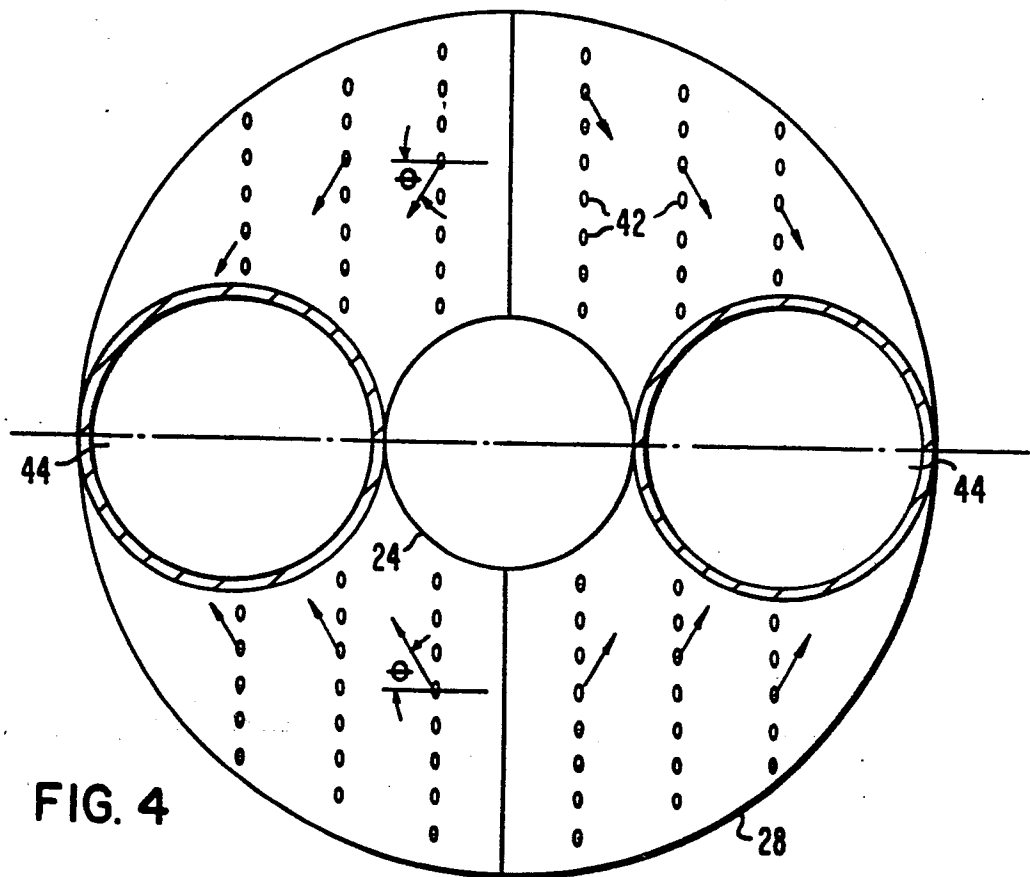
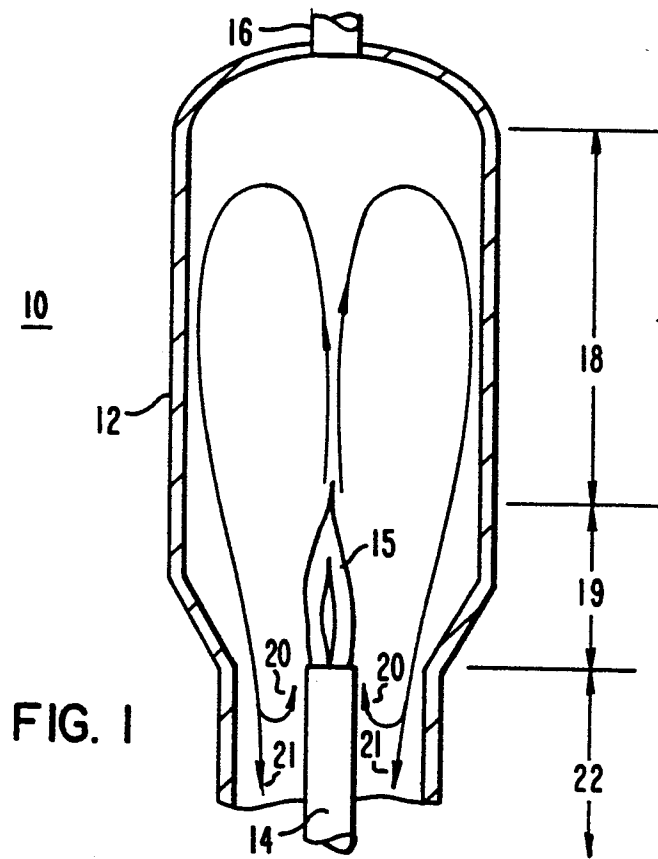
3. A fluidized bed gasifier in accordance with claim 1 or 2, wherein said vessel (12) further comprises a wall characterized in that said gas injection means comprises a pipe provided with orifices and attached to said wall and disposed within said ash annulus.

4. A fluidized bed gasifier in accordance with claim 3, characterized in that said gas injection means (26) is disposed concentrically to said process medium injection means (14).

5. A process for cooling and discharging ash from a fluidized bed gasifier as claimed in any of claims 1 to 4, wherein the fluidized bed of said gasifier comprises particles of a carbonaceous material, particles of partially oxidized carbonaceous material, and particles comprised substantially of noncarbonaceous ash and wherein said ash particles are separated from said carbonaceous material particles by subjecting said fluidized bed to fluidizing gas which is sufficient to fluidize said carbonaceous material particles and insufficient to fluidize said ash particles and said ash particles are defluidized and cooled in an ash annulus of said vessel and are finally impacted on the slanted floor of said vessel and discharged through discharge openings, characterized in that a gas is injected into said annulus region of said vessel in a direction which is generally downward and towards said discharge openings which are adjacent to said vessel wall at a lower edge of said floor to cool said ash particles in the lower part of said annulus region.

6. A process according to claim 5, characterized in that steam is injected into said annulus region at a temperature of between 315°C and 427°C and said steam and said gas are utilized to cool said ash agglomerates to a temperature of between 93°C and 150°C as said ash agglomerates defluidize through said annulus region; and additionally, gas at a temperature of between 93°C and 150°C is injected through the floor of said annulus fluidizing said ash agglomerates toward said ash discharge

opening through which said ash agglomerates from said vessel are discharged.



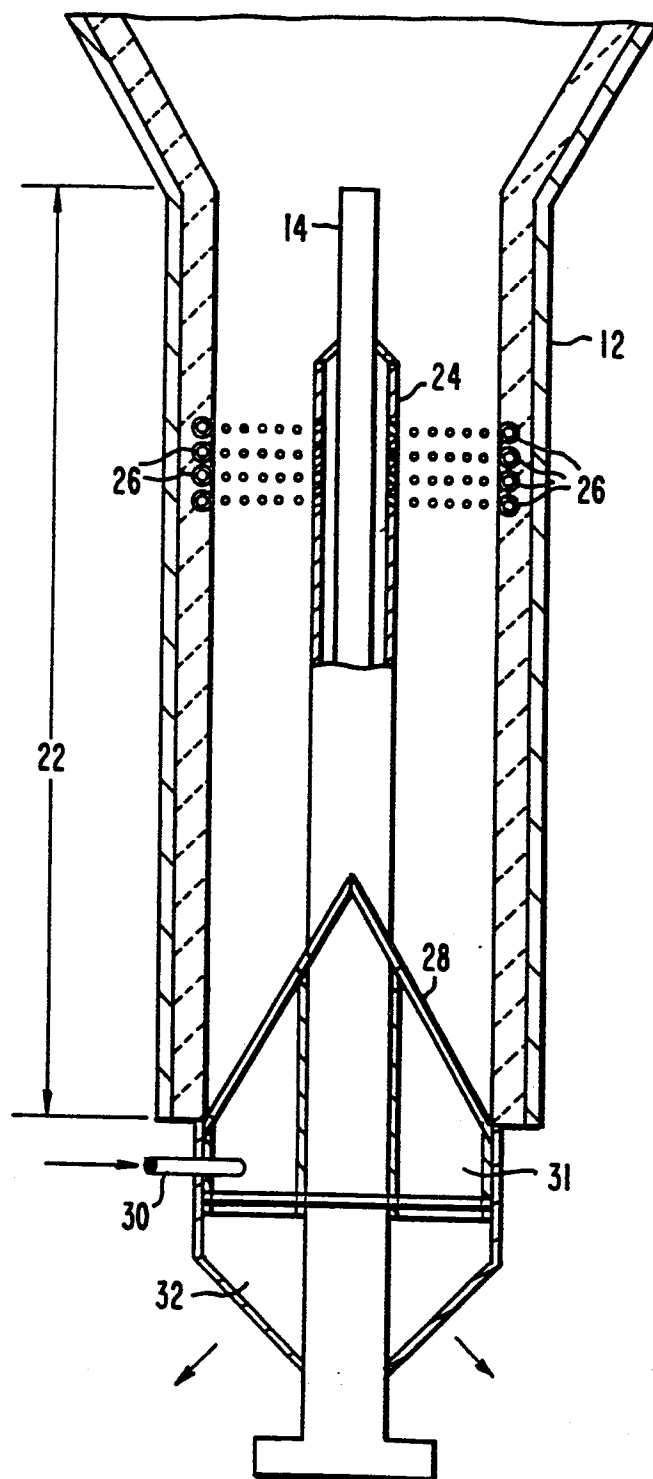


FIG. 2

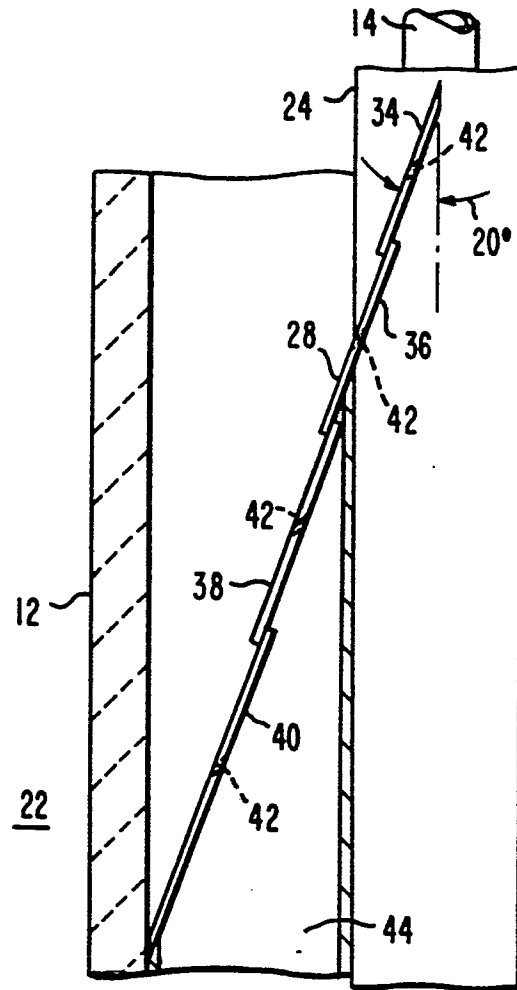


FIG. 3

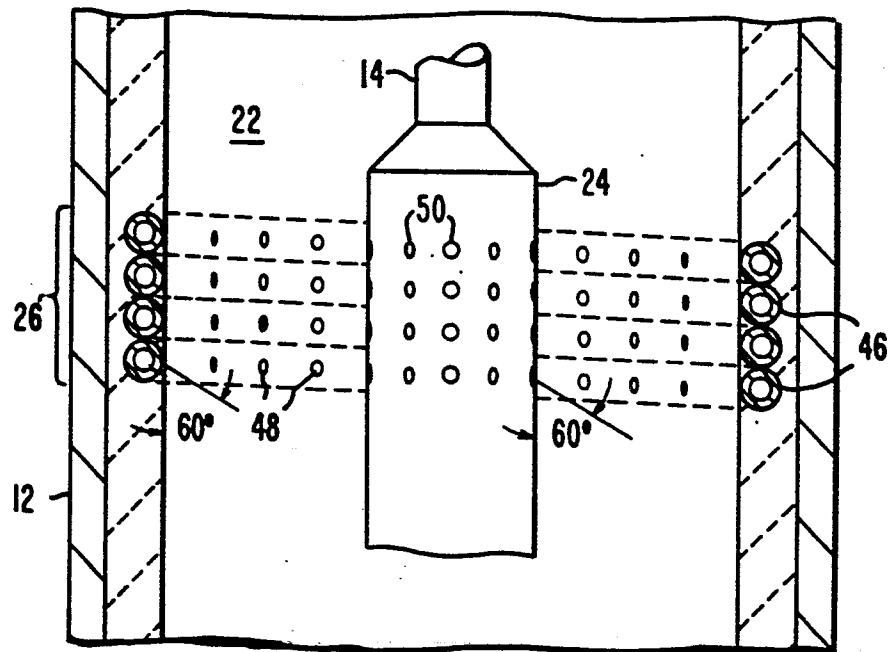


FIG. 5



DOCUMENTS CONSIDERED TO BE RELEVANT			EP 84107712.6
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US - A - 4 372 228 (KORENBERG) * Fig. 3 * --	1	F 23 C 11/02 F 23 J 1/00
A	EP - A1 - 0 031 098 (COMBUSTION ENGINEERING) * Fig. 2 * --	1	
A	DE - A - 1 526 108 (TADA MITSURA) * Fig. 5 * --	1	
A	EP - A1 - 0 041 094 (WESTINGHOUSE ELECTRIC CORPORATION) -----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
Place of search VIENNA			Date of completion of the search 27-12-1984
			Examiner TSCHÖLLITSCH
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			