United States Patent [19]

Evans

[11] **3,792,816**

[45] **Feb. 19, 1974**

[54] **GAS DISTRIBUTORS FOR FLUIDIZED BEDS**

[75] Inventor: **Bruce Ronald Evans,** North Lambton, Australia

[73] Assignee: **The Broken Hill Proprietary Company Limited,** Melbourne, Victoria, Australia

[22] Filed: **Nov. 8, 1971**

[21] Appl. No.: **196,578**

[30] **Foreign Application Priority Data**

Nov. 10, 1970 Australia............................ 3152/70

[52] **U.S. Cl.**.................. **239/553,** 239/562, 239/567

[51] **Int. Cl.**... **B05b 1/14**

[58] **Field of Search**.... 239/566, 553, 560, 558, 567

[56] **References Cited**

UNITED STATES PATENTS

3,531,053	9/1970	Miller et al.	239/566 X
1,596,452	8/1926	Reeves et al.	239/553
1,729,149	9/1929	Brown et al.	239/558
3,347,473	10/1967	Steck	239/560
3,599,877	8/1971	Goldschmied	239/562

Primary Examiner—Lloyd L. King

Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

A fluidized bed gas distributor is disclosed, wherein the gas distributor allows the fluidized bed to operate with intermittant fluidization, with substantial elimination of natural backflow of fluidized particles. The gas distributor comprises a pair of horizontal pipes disposed within one another, having an annular space thereinbetween. Holes are located in the inner pipe and the outer pipe for the passage of gas therethrough. The holes in the outer pipe are located in the lowermost one-third of the circumference of the pipe and are staggered in a circumferential and/or longitudinal direction relative to the holes in the inner pipe.

13 Claims, 5 Drawing Figures

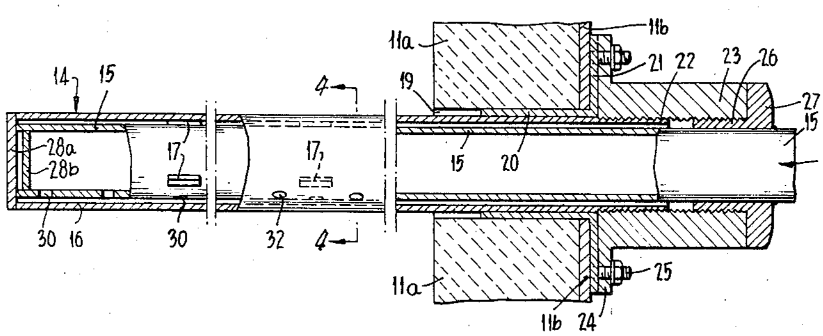
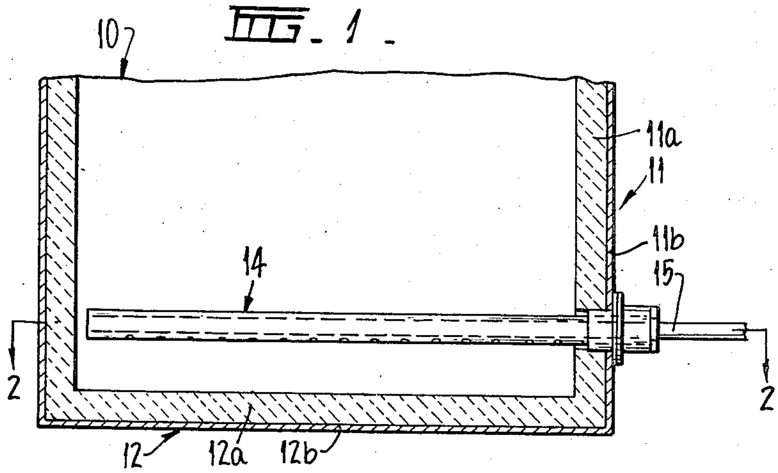


FIG. 1.



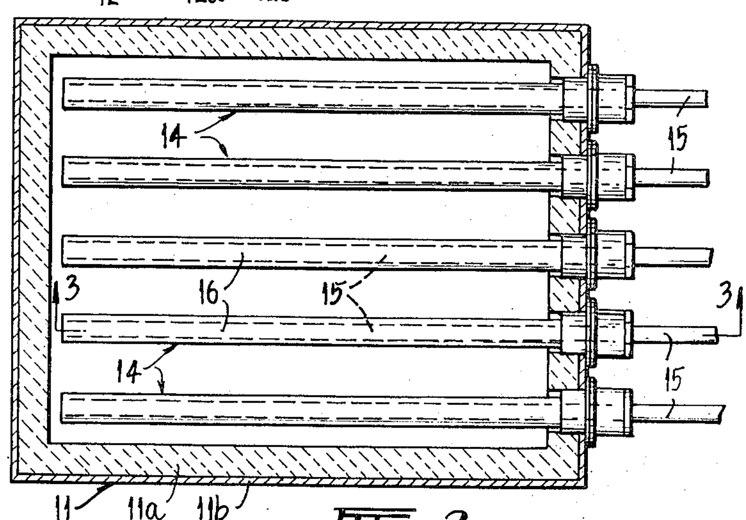


FIG. 2.

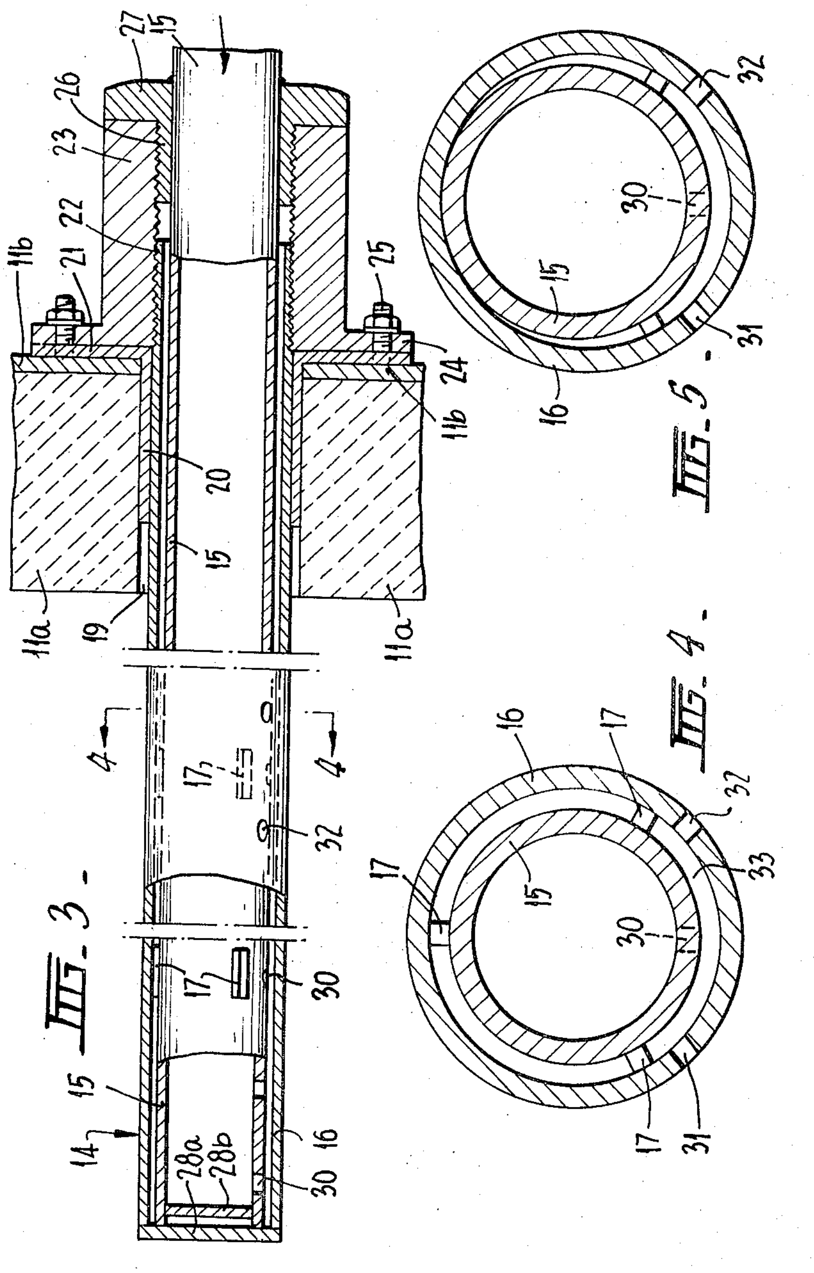


FIG. 3
FIG. 4
FIG. 5
11a
11b
14
15
16
17
19
20
21
22
23
24
25
26
27
28a
28b
30
31
32
33
4

GAS DISTRIBUTORS FOR FLUIDIZED BEDS

This invention relates to gas distributors for fluidized bed apparatus and is particularly, although by no means exclusively, concerned with distributors for fluidizing beds of hot particulate material suitable for for the carbonization of green briquettes of coal immersed in the bed.

To be suitable for intermittent fluidization processes a gas distributor must be designed to prevent such backflow of the particulate material defining the bed as would choke and prevent operation of the distributor. An object of this invention is to provide a gas distributor for fluidized bed apparatus which operates satisfactorily to fluidize particulate material, while a more specific object is to prevent undesirable backflow of bed material which would tend to block the gas distributor.

In this specification the term "gas" includes air or other fluidizing gas, or vapour such as steam or LPG.

According to the invention a gas distributor for fluidized bed apparatus is provided which comprises a pair of pipes disposed one within the other, a space between at least a substantial part of the adjacent surfaces of said pipes, holes in the inner pipe for admitting gas from the inner pipe to said space, and holes in the outer pipe for discharging gas from said space to the fluidized bed.

The pipes may be of cylindrical, polygonal or other suitable shape in cross-section, and are preferably cylindrical. The inner pipe may be disposed concentrically or eccentrically within the outer pipe.

The term "holes" in this specification includes apertures of circular, polygonal or any other suitable shape.

In order to minimise or prevent backflow of particulate material into the space between the pipes, the holes in the outer pipe are preferably arranged to face downwardly, i.e., are positioned in the lowermost one-third of the circumference of the outer pipe and are preferably above the lowermost portion of the said pipe by a circumferential distance not exceeding one-eighth of the circumference of the said pipe.

In order to enable the gas flow in the inner pipe to sweep particulate material out through the holes in the inner pipe, such holes are preferably positioned in the lowermost portion of the said pipe, and desirably are located in the lowermost one-third of its circumference.

Preferably, the holes in the inner and outer pipes are spaced in a substantially regular pattern along the length of the pipes so that the flow of gas from the holes in the inner pipe to the holes in the outer pipe is substantially uniform along the length of the pipes.

In a preferred arrangement, the pipes are concentric and there is a single row of regularly spaced holes in the lowermost portion of the inner pipe, and two rows of regularly spaced holes in the outer pipe, one row on one side of the outer pipe and the other row on the other side of the outer pipe, each row being above the lowermost portion of the outer pipe by a circumferential distance equivalent to about one-eighth of the circumference of the outer pipe, there being at each longitudinal position midway between the holes in the inner pipe either a pair of holes or a single hole alternately on one side and then the other of the outer pipe.

However, the invention is not confined to the foregoing arrangements since other workable possibilities exist. For example, backflow into the space between the pipes during non-fluidization periods can be tolerated providing the gas flow during the next fluidization period can sweep material out of the space to an extent sufficient to allow the desired gas discharge through the holes in the outer pipe. Thus, the holes in the outer pipe can be arranged to face horizontally or even upwardly providing the gas flow from the holes in the lower portion of the inner pipe is strong enough to adequately clear the space between the pipes. Similarly, the holes in the inner pipe can be in positions higher than those preferred providing the amount of material that might accumulate inside the lower portion of the pipe does not interfere with satisfactory operation of the distributor.

A combination that should obviously be avoided is one having coincident holes in the uppermost portion of both pipes, which would enable a direct flow of particulate material into the inner pipe, and into the space, during non-fluidization periods. However, an arrangement in which there are holes in the uppermost portion of the outer pipe is workable providing these holes are not coincident with holes in the inner pipe, and especially if the distance between the adjacent surfaces of the pipes at this location is sufficiently small in relation to the hole size that the backflow of material is arrested by the formation of small heaps supported by the inner pipe.

In order to minimise the accumulation of material in the extreme ends of the space between the pipes, the end holes in the inner pipe are preferably located outwardly of the end holes in the outer pipe, i.e., there is one less longitudinal hole position in the outer pipe than there is in the inner pipe.

The inner and outer pipes may be spaced apart and connected together by means of spacers secured to the inner pipe and arranged at circumferential and longitudinal intervals. Such spacers are not necessary if the pipes are relatively short.

The gas distributor preferably comprises a series of double pipes arranged horizontally in parallel relationship and spaced apart by a suitable distance. The pipes forming the gas distributor extend across the area of the fluidizing chamber, e.g., across the lower area or base thereof, and are connected to a source of fluidizing gas under pressure.

When intermittent gas supply is used, if any particulate material (e.g., sand) flows back into the space between the pipes it is blown back into the bed with the next fluidization cycle. Also any small particles in the gas supply are completely blown through the double pipe diffuser system.

In order to achieve substantially uniform flow of gas through the holes in the outer pipe, the pressure drop of the gas in flowing through the holes in the inner pipe is large compared with the pressure drop along the length of the inner pipe, and the pressure drop of the gas in flowing through the holes in the outer pipe is large compared with the pressure drop of the gas in flowing through the space between the pipes.

The fluidizing gas velocities in the inner pipe should be such as to achieve horizontal transport of suspended solids (e.g., sand) that may have back-filled into the pipes.

The gas distributor of this invention has the following advantages:

1. No moving parts.

2. The distributor can be started up or shut down without the necessity for first cleaning the solids from the system i.e., it is suitable for intermittent fluidization processes in addition to continuous processes.
3. "Natural" back-flow of the fluidized particles which takes place in existing plate-type distributors, is substantially eliminated.
4. If "unnatural" back-flow of the fluidized particles takes place, the system is self cleaning when fluidizing medium again flows through the distributor into the fluidized bed. This fluid flow forces the particles back into the bed.
5. The distributor can be made from pipe of any suitable cross-sectional configuration and from any suitable material depending on the service conditions, particularly temperature.
6. THe distributor operates satisfactorily up to high temperatures without buckling or warping. Buckling severely limits the operating conditions for existing perforated plate distributors.
7. The distributors are easier to manufacture and install than existing perforated plate or bubble cap type distributors. They can be installed at various levels in a fluidized bed for injecting different fluids; e.g., a lower row of double pipe distributors could supply air or oxygen and an upper row could supply gas for fluidized bed combustion. Alternatively, gases could be injected at various levels for chemical reactions to take place.

Reference will now be made to the preferred embodiments of the invention illustrated in the accompanying drawings, wherein:

FIG. **1** is a view in sectional elevation, partly broken away, of a fluidized bed apparatus incorporating a gas distributor according to this invention,

FIG. **2** is a view in sectional plan taken on the line **2—2** of FIG. **1**.

FIG. **3** is a view in enlarged sectional elevation taken on the line **3—3** of FIG. **2**,

FIG. **4** is a view in sectional elevation taken on the line **4—4** of FIG. **3**, and

FIG. **5** is a view in sectional elevation, similar to FIG. **4**, showing a modified arrangement in which the inner pipe is disposed eccentrically within the outer pipe.

Referring to the drawings, the reference numeral **10** indicates a fluidizing chamber or vessel having vertical side walls **11** and a bottom wall or floor **12**. The walls **11** and **12** comprise a refractory lining **11**a, **12***a* and an outer metal casing **11***b*, **12***b*.

A series of double pipes **14** are arranged in parallel relationship in the lower part of the fluidized bed chamber **10**, the said double pipes **14** being horizontal. The double pipes **14**, which constitute the distribtuor for the fluidizing gas, may be located at any desired level in the fluidizing chamber **10** and if desired a plurality of gas distributors each comprising a series of double pipes **14** may be arranged at different levels in the fluidizing chamber **10**.

Each double pipe, which is shown in greater detail in FIGS. **3** and **4**, is arranged so that one end projects through an aperture in the wall **11** of the chamber **10**, and the inner pipe of each double pipe **14** is connected externally of the chamber **10** to a source of fluidizing gas, such as air, under pressure.

Referring particularly to FIGS. **3** and **4**, each double pipe **14** comprises an inner pipe **15** and an outer pipe **16**, the inner pipe **15** being concentrically disposed within the outer pipe **16** in the form of the invention shown in FIGS. **1** to **4**. The pipes are held in their relative positions by spacers **17** which are conveniently located at 120° apart and at intervals along the pipes **15**, **16** and which are normally secured to the inner pipe **15**.

The end of each double pipe **14** projects through an aperture **19** in the side wall **11** of the chamber **10** and the outer pipe **16** fits through a sleeve **20** having an outer flange **21** which engages the outer face of the casing **11***b*. The outer end **22** of the outer pipe **16** is externally threaded and an internally threaded bush **23** is screwed onto the end **22** of the outer pipe **16**. An inner flange **24** on the bush **23** is secured to the flange **21** of the sleeve **20** by studs **25**. A plug **26** is fitted over and welded to the projecting outer end of the inner pipe **15** and is screwed into the outer end of the bush **23**. A flange **27** on the plug **26** abuts against the outer end of the bush **23**. The inner ends of the pipes **15** and **16** within the chamber **10** are closed by plates **28***b* and **28***a* respectively.

By this arrangement the inner pipe **15** and outer pipe **16** are held in their correct positions relative to one another, the said pipes are also held securely in position in the fluidization chamber **10**, and the distributor may be readily dis-assembled when required.

The outer ends of the inner pipes **15** are connected to a source (not shown) of fluidizing gas under pressure.

Each inner pipe **15** is provided with a series of gas apertures **30** which are directed downwardly and are conveniently located along the lowermost edge of the pipe **15** at spaced intervals therealong.

Each outer pipe **16** is provided with a series of gas outlet apertures **31, 32** which may be at any point on the periphery of the pipe **16** and are preferably arranged in pairs located at points spaced by about one-eighth of the circumference of the pipe **16** above the lowermost edge of said pipe, as shown in FIG. **4**. The apertures **31, 32** in the pipe **16** are offset or staggered both circumferentially and longitudinally relative to the apertures **30** in the pipe **15**. The apertures **30, 31, 32** may be of any suitable configuration and are preferably circular.

In operation, fluidizing gas under pressure is supplied to the outer ends of the inner pipes **15** and is caused to flow through the apertures **30** in each inner pipe into the annular space **33** between each inner pipe **15** and its outer pipe **16**. The fluidizing gas then flows through said annular space **33** to the apertures **31, 32** in the outer pipe **16** and then outwardly through the apertures **31, 32** into the fluidization chamber **10** where it is distributed into and maintains the fluidized bed (not shown).

In the double pipe arrangement shown in FIG. **5**, the inner pipe **15** is arranged eccentrically within the outer pipe **16** and the said pipes **15, 16** are in contact at their uppermost points, the maximum distance between the said pipes being at their lowermost points. The apertures **30** in the pipe **15** and the apertures **31, 32** in the pipe **16** are located similarly to the corresponding apertures in the double pipe arrangement shown in FIG. **4**.

To obtain satisfactory gas distribution the flow of gas through the apertures **31, 32** along the pipes **16** should be substantially equal, and this may be achieved by ensuring that the pressure drops across the gas distributor are maintained as previously specified.

It is found that in the operation of the gas distributor of this invention, any backflow of the particulate fluidizing medium (such as sand) into the inner pipes **15** is substantially prevented, and that any of such medium which may back-flow into the outer pipes **16**, when the flow of gas is interrupted, is effectively removed therefrom when the gas supply is re-applied.

Gas distributors for fluidizing a given bed using a given gas may be designed by the following procedure, which makes use of known technology:

a. the required fluidizing gas flow rate in m^3/h per 1m^2 of bed is determined experimentally or by calculation;
b. a reasonable spacing for, and hence the number of, gas distributors, is selected from known fluidization practice relating to the desirable number of gas discharge holes per 1m^2 of fluidized bed, and hence the flow rate per distributor in m^3/h is found;
c. the inside diameter of the inner pipe in mm is determined from the formula 11.8 × flow rate, which assures a gas velocity of 30 m/s, this velocity being sufficient to entrain and thus discharge particulate material such as sand from the inner pipe;
d. an available pipe size having as near as possible the calculated inside diameter is selected, the material of the pipe and wall thickness being selected having regard to service conditions;
e. an outer pipe is selected with an inside diameter that gives sufficient clearance for easy assembly and disassembly, even if the pipes should have warped as a result of high temperature service. In practice, in satisfying the foregoing requirement, the other requirement of a low pressure drop in the space between the pipes is also met;
f. a suitable pitch for the holes is selected and whether a pair of holes or only one hole is to be used in the outer pipe at each longitudinal position is decided;
g. from (*b*) and (*f*), the gas flow rate per hole is determined;
h. the pressure drop across the holes in the outer pipe is determined using equation 34, page 87, "Fluidization Engineering," published by John Wiley (Sons, 1969. The pressure drop across the holes in the inner pipe is usually selected to be about three-quarters of the pressure drop across the holes in the outer pipe;
i. from the results of (*g*) and (*h*), the hole sizes in the pipes is calculated using equations 34 to 37, pages 87 to 89 of the above reference, or equation 98, page 129, "North American Combustion Handbook," first edition. The calculated holes sizes in the inner and outer pipes may be so nearly equal that in practice the same size holes are used in both pipes.

The procedure outlined above was used to design the distributors in the following three practical Examples. These Examples show the specifications of gas distributors constructed in accordance with this invention which have been found to operate satisfactorily in practice.

In each Example, the holes in the inner pipe were regularly spaced along the length of the lowermost portion of the said pipe. The holes in the outer pipe were located longitudinally midway between the holes in the inner pipe and circumferentially one-eighth part of the circumference above the lowermost portion of the outer pipe, there being one hole at each longitudinal position, the said holes being placed alternately on one side and then on the other side of the lowermost portion of the outer pipe. The holes in both pipes were of the same diameter.

EXAMPLE 1

Dimensions of fluidization chamber	1m × 0.6m × 2m high
Fluid bed	Sand, 0.7m deep, bulk density 1400 kg/m^3, i.e. 600 kg of sand in bed.
Temperature	850°C
Fluidizing gas	Air, supplied through six stainless steel distributors at base of bed at a rate of 340 m^3/h
Fuel gas burnt in the fluidized bed	14 m^3/h of LPG supplied through one stainless steel distributor located above the air distributors
Air distributors	Inner pipe 28 mm ID × 32 mm O, with 36 holes, 4 mm dia at 25 mm pitch Outer pipe 38 mm ID × 42 mm OD, with 35 holes, 4 mm dia at 25 mm pitch

EXAMPLE 2

Fluid bed	3m × 1m × 1m deep, having an incipient fluidization velocity of 110 m^3/h per 1m^2 of bed
Temperature	Ambient
Fluidizing gas	Air supplied through 24 mild steel distributors at base of bed parallel to the 1m side of chamber at a rate four-times the incipient fluidization velocity, i.e. 55 m^3/h per distributor
Distributors	Inner pipe 12 mm ID × 18 mm OD with 35 holes, 3 mm dia at 25 mm pitch. Outer pipe 25 mm ID × 31 mm OD with 34 holes, 3 mm dia at 25 mm pitch

EXAMPLE 3

Dimensions of fluidization chamber	5m × 1m ×2.3m high
Fluid bed	Sand, 1.5 m deep with incipient fluidization velocity of 30 kg/h of steam per 1m^2 of bed
Fluidizing gas	Superheated steam at 35 kPa gauge pressure and 550°C, supplied through 49 stainless steel distributors at base of bed
Distributors	Inner pipe 18.8 mm ID × 26.8 mm OD with 18 holes, 2.4 mm dia at 50 mm pitch. Outer pipe 32.5 mm ID × 42.5 mm OD with 17 holes, 2.4 mm dia at 50 mm pitch

In this specification the following abbreviations have the following meanings:

m = metres
mm = millimetres
m^3/h = cubic metres per hour
m/s = metres per second
1m^2 = one square metre
kg = kilogram

LPG = liquid petroleum gas
ID = inside diameter
OD = outside diameter
kPa = kilopascals

I claim:

1. Gas distributor means for use in a fluidizing vessel to fluidize particles contained in said vessel to permit operation with, if desired, intermittent fluidization, with substantial elimination of natural backflow of fluidized particles, said means comprising a pair of horizontal pipes disposed within one another and having a space between the inner pipe and the outer pipe, means for admitting fluidizing gas to the inner pipe, hole means in the inner pipe for admitting fluidizing gas from the inner pipe to the said space, hole means in the outer pipe for discharging fluidizing gas from the said space, the hole means in the outer pipe being located in the lowermost one-third of the circumference of said pipe and being staggered in a circumferential and/or longitudinal direction relative to the hole means in the inner pipe.

2. Gas distributor means according to claim **1**, wherein said hole means are holes, and the end holes in the inner pipe are located outwardly of the end holes in the outer pipe.

3. Gas distributor means according to claim **1** wherein the hole means in the pipes are spaced in a substantially regular pattern along the length of the pipes, and are arranged symmetrically along the length of the pipes.

4. A gas distributor according to claim **1** wherein the hole means in the outer pipe are located above the lowermost portion of the pipe by a circumferential distance substantially equivalent to one-eight of the circumference of the pipe.

5. A gas distributor according to claim **1** wherein the inner pipe is disposed substantially concentrically within the outer pipe.

6. A gas distributor according to claim **1** wherein the inner pipe is disposed eccentrically within the outer pipe, the greatest distance between the adjacent surfaces of the pipes occurring substantially at the lowermost portion of these surfaces.

7. Gas distributor means according to claim **1** wherein the pressure drop of the gas in flowing through the hole means in the inner pipe is large compared with the pressure drop along the length of the inner pipe, and the pressure drop of the gas in flowing through the hole means in the outer pipe is large compared with the pressure drop of the gas in flowing through the space between the pipes, so that the flow of gas through the hole means in the outer pipe is substantially uniform along its length.

8. Gas distributor means according to claim **1** wherein each pair of inner and outer pipes are held in their relative positions by spacers secured to the inner pipe and spaced at intervals therearound and at intervals therealong.

9. In a fluidized bed apparatus comprising a fluidizing vessel and means for distributing a fluidizing gas in said fluidizing vessel, the improvement comprising using, as said means for distributing said gas, a plurality of pairs of horizontal pipes disposed within one another and having a space between the inner pipe and the outer pipe, means for admitting fluidizing gas to the inner pipe, first hole means in the inner pipe for admitting fluidizing gas from the inner pipe to said space, second hole means in the outer pipe for discharging fluidizing gas from said space to the fluidized bed, said second hole means being located in the lowermost one-third of the circumference of said outer pipe and being staggered in a circumferential and/or longitudinal direction relative to said first hole means, whereby said fluidized bed may be operated, with, if desired, intermittant fluidization, with substantial elimination of natural backflow of fluidized particles.

10. The fluidized bed apparatus according to claim **9** wherein a series of said inner and outer pipes are connected together in parallel relationship and are arranged to extend over the area of a fluidized bed chamber.

11. The fluidized bed apparatus as claimed in claim **9** wherein said first hole means are positioned in the lowermost portion of said inner pipe.

12. The fluidized bed apparatus as claimed in claim **11**, wherein said first hole means are in the lowermost one-third of the circumference of said inner pipe.

13. The fluidized bed apparatus as claimed in claim **9**, wherein the pressure drop of said fluidizing gas flowing through said first hole means is large compared to the pressure drop along the length of said inner pipe, and the pressure drop of said fluidizing gas flowing through said second hole means is large compared to the pressure drop of the gas flowing through said space.

* * * * *