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

(11) EP 0 931 981 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.07.1999 Bulletin 1999/30

(51) Int. Cl.[6]: **F23J 1/00**, F23B 5/00

(21) Application number: **99200062.0**

(22) Date of filing: **12.01.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **15.01.1998 IT MI980051**

(71) Applicant:
Magaldi Ricerche E Brevetti S.R.L.
84135 Salerno (IT)

(72) Inventors:
- **Magaldi, Mario**
  84100 Salerno (IT)
- **Carrea, Alberto**
  16145 Genova (IT)

(74) Representative: **Riccardi, Sergio**
Riccardi & Co.
Via Macedonio Melloni, 32
20129 Milano (IT)

(54) **Apparatus and method for postcombustion of heavy ash with high contents of unburnt matter**

(57) An apparatus and method to promote the completion of the combustion of unburnt matter contained in ash arising from the combustion of solid fuel are described. The apparatus for the postcombustion of ash arising from the combustion of solid fuel comprises a combustion chamber (14) and an extractor (16) arranged so as to receive ash falling from the combustion chamber, the unburnt matter of said ash having to be burnt, said extractor comprising in turn a metallic belt (18) for ash transportation, said apparatus being characterized in that said conveyor belt is provided with parts or openings for the passage of combustion feeding air, said air thus passing through said ash during at least a part of the forward advancing stretch of said belt.

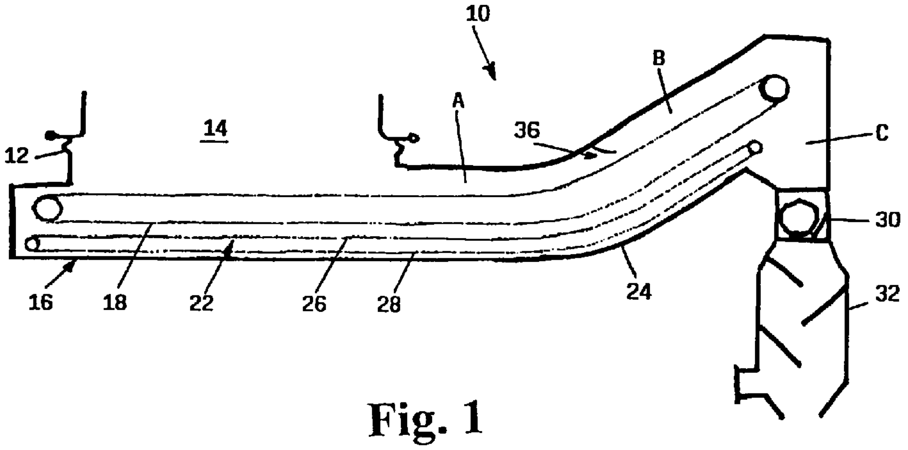

Fig. 1

EP 0 931 981 A2

Description

[0001] The present invention relates to an apparatus and a method promoting the combustion completion or postcombustion of unburnt matter still contained in heavy ash arising from combustion of solid fuel of any kind in combustion chambers for powdered fuel, when said ash fall out from the combustion chamber. This invention will produce the greater advantages the higher is the contents of unburnt matter in the ash.

[0002] The present invention can be considered a development of the invention disclosed in EP- 0 259 967 B1, applicable in those cases where the contents of unburnt matter is high and/or the postcombustion degree that can be attained with the apparatus disclosed in said prior document is not satisfactory.

[0003] The apparatus disclosed in said document claimed the increase of efficiency arising from the reduction of unburnt matter in heavy ash because of the introduction through suitable openings of air that travelled in countercurrent to the ash flow and promoted the combustion completion in view of the consequent oxidising ambient.

[0004] This result was experimentally verified in many applications of said prior invention, for example in the usual boilers using fine coal powder, as a substitution for the wet extraction systems like the so-called flooded hopper, where it gave a reduction of the unburnt matter to about three-quarters of the conventional amount. However the reduction in other cases was not equally significant, for instance this happened in an application for extraction of ash from a boiler using lignite, where the reduction of the ash unburnt matter was about 10 - 20%.

[0005] The reasons of this different behaviour are mainly due to two interrelated factors: ash reactivity (or postcombustion velocity) and temperature sinking. Indeed in case of lignite and generally of poor fuel, low heating power and high ash contents cause the ash leaving the combustion chamber to undergo a decrease of temperature.

[0006] In the light of the above drawbacks, the main object of the present invention is to provide for an apparatus and a method solving these problems so as to allow

1. to keep the ash carried by the conveyor belt for the required amount of time at such a temperature to allow a significant reduction of unburnt matter still contained in the ash; and
2. to carry out subsequently the cooling of said ash in order to discharge it from the system at a temperature compatible with the usual transportation systems to the final storage bin.

[0007] The above mentioned and other objects are brilliantly attained by the apparatus recited in independent claim 1 and the method set forth in independent claim 13. Further advantageous features of the apparatus and the method are indicated in the corresponding dependent claims. Now follows a detailed description of the apparatus and the method according to the present invention, given as an explicative non-limiting example to be read in connection with the accompanying sheets of illustrative drawings in which:

Figure 1 is a diagrammatic general view of one embodiment of the apparatus;
Figure 2 is a diagrammatic partial view of a possible embodiment of an ash measuring device;
Figure 3 is a cross-sectional view of the postcombustor arranged under the combustion chamber;
Figure 4 is a partial top plan view of a known system of plate conveyor belt;
Figure 5 is a diagrammatic detail of the air inlet ports;
Figure 6 shows diagrammatically how the ash thickness limits the lateral penetrations through the areas above and under the belt;
Figure 7 shows diagrammatically the postcombustion zone;
Figure 8 is a partial diagrammatic view of the ash discharge zone; and
Figure 9 is a diagram of the air circulation in the final extraction part.

[0008] Like or equal reference numerals in the various figures of the drawings indicate equal or functionally equivalent elements.

[0009] Figure 1 of the drawings shows in a diagrammatic way one embodiment of the apparatus according to the present invention, comprising:

a) a seal 12 between boiler 14 and extractor 16, said seal expanding downwards in view of thermal expansion. Said seal can be mechanical (as shown in Figure 1) or hydraulic. As said seal is known, it will not be described in detail, but it is sufficient to state that the seal avoids introduction of improper air between boiler and postcombustion belt;
b) the extractor 16, comprising a metallic belt 18 continuously running and allowing postcombustion of ash 34. Along the path of the extraction belt 18 one can recognize two zones having different functions: a first postcombustion hot zone A and a second ash cooling cold zone B;
c) a system 22 of recovery of fine material depositing on the bottom of container 24 in which the belt extractor 18 is arranged. Said system 22 consists of a chain 26 provided with doctor blades 28 so as to collect the fine material and carry it to the ash discharge point C;
d) a crusher 30 arranging to crush possible ash lumps formed in the combustion chamber or on said postcombustion belt; and
e) a final ash cooler 32 carrying out the final cooling

to a temperature compatible with the downstream transportation systems.

[0010] The postcombustion belt 18 is arranged directly below the combustion chamber 14 and receives ash 34 continuously falling from said combustion chamber. The belt is moved to such a speed to obtain the optimal combination of thickness of the ash layer and ash residence time on the belt as a function of the amount of ash produced. Indeed if on the one hand an increase of the residence time promotes a postcombustion increase, on the other hand it causes an increase of the ash layer thickness on the belt that reduces diffusion of air necessary for the combustion inside the ash layer. The regulation of the optimal combination may be effected only once, when the operative conditions are so stable to allow it, or more frequently in a continuous way by means of a continuous measurement of the actual thickness of ash 34 on the belt 18 for instance through a device 36 shown in Figure 2. Said measuring device 36 comprises a blade 38 shaped so as not to hinder substantially the advancement of ash 34, said blade 38 being hinged to the top of the container 24. From the value of angle α formed by said blade lying on the ash bed, it is possible to know the thickness of said bed. Said blade 38 has also another function of great relevance in the method of the invention, that will be described hereinafter.

[0011] The belt postcombustion zone A is extended farther the belt stretch under the boiler, so as to give a suitable residence time also to ash deposited on the belt in proximity of the outlet. The extension of the postcombustion zone outside the boiler will be determined for each single plant as a function of the general configuration of the boiler area and the desired postcombustion degree. As it was stated hereinbefore, it is fundamental to keep the temperature at high values, but harmonized with the necessity of safeguarding the mechanical characteristics of the components involved in the high temperature zone, namely the belt and the support rollers. To this purpose, as shown in Figure 3, the lateral walls 40 of the postcombustion zone A, as well as the cover of said zone at the outlet of the postcombustion chamber, are thermally insulated.

[0012] This configuration allows to limit thermal dispersion sidewards and upwards, but it is not sufficient to obtain the desired thermal behaviour. In this connection it is of fundamental importance the amount of air introduced to the system: said amount must obviously be sufficient to assure a good oxidizing ambient, thus in a large excess of the stoichiometric quantity, but at the same time limited so as not to cool excessively the relevant zone as it is to be noted that air enters the postcombustion zone at a temperature which is considerable lower than that desired in the postcombustion zone. The correct amount of postcombustion air moreover must be introduced in the postcombustion zone in such a way to promote air diffusion from below to the interior of the ash layer. This can be obtained by making suitable air inlet ports 42 (Figure 5) between the plates 44 without modifying the geometry of the plate conveyor belt shown in Figure 4.

[0013] The air inlet ports 42 must be of limited size in the belt advancement direction so as to limit ash fall through said ports. By keeping a positive pressure differential between the area below the belt and the area above the belt, air will be forced to pass through said inlet ports. To obtain said positive pressure difference, taking into account that the combustion chambers normally operate under a light vacuum, it will be necessary to seal as far as possible the area above the belt. In this way the area above the belt will be at the said vacuum level of the combustion chamber, while the area under the belt will be at the pressure close to the atmospheric one. To this end, it will be the thickness of the ash 34 layer to limit the lateral penetrations through the area under the belt 18 and the area above the belt 18 for the whole length of said belt.

[0014] The postcombustion zone A may be divided, during belt advancement, as follows (see Figure 7):

- a start area A1: in this area a slope 46 will convey ash 34 on the belt 18. The purpose of the slope is to restrict as far as possible the belt position where the ash layer is not significant. Between slope 46 and belt 18 it is possible to place a pad 48 fixed to said slope 46 to limit the inevitable reentry of air between the stationary slope and moving belt plates. In this area the lateral air penetration to the postcombustion zone (air that would not come in intimate contact with ash) must be limited by pads fixed to the transition duct. The slope geometry will be suitable to optimize ash distribution on the belt: for instance, if ash would tend to accumulate in the belt middle portion, the slope can be shaped to increase ash distribution to the belt sides or viceversa. Moreover a dam 50 is provided in the area under the belt, so as to create a loss of head at the air passage and limit air penetration through the belt slots in this area.
- an intermediate area A2: in this area the ash layer, even if it is not yet at the maximum height, reached already such a thickness to oblige the postcombustion air 52 to pass through ash so as to be attracted by the vacuum existing in the combustion chamber. Therefore in this area the differential pressure between outer and inner postcombustion area will be greater than in the first area, even if not yet at the maximum value. If required, an additional air shield may be inserted;
- and a final area A3: this area is now outside the combustion chamber and the thickness of the ash layer is constant at the maximum value. The differential pressure between the outer area under the belt and the postcombustion area is at the maximum level and is about equal to the difference

between the atmospheric pressure and the vacuum in the combustion chamber. The final area A3 ends with the above mentioned blade 38, which has also the task of avoiding direct passage of air from the cooling zone to the postcombustion zone so as to force air to pass from below through the ash layer and at the same time allow ash to go out from the postcombustion zone.

[0015] Both in the intermediate and the final zone, if the amount of air required for the combustion exceeds that succeeding to pass through the ash pushed by the differential pressure, it is advisable to provide for a supplemental inlet through the lateral channels 70 shown in Figure 6.

[0016] At the outlet of the combustion zone, ash is hit by cold air introduced into the apparatus through a suitable opening so as to start the cooling process. Said cooling process is completed when discharging the material from the belt to the free atmosphere, at the area where it falls toward the primary crusher 30 as well as at the subsequent contact heat exchanger 32. In the latter device hot ash are cooled both by the direct contact with cold air and contact with metal plates 54 in turn hit by upwards ascendent cold air; these plates may be provided with lower fins (not shown) so as to increase the thermal exchange with the air and keep their temperature at minimal values.

[0017] Air ascending from the cooler to the postcombustor, forming totally or partially the combustion air, will be delivered to the zone where ash is discharged from the belt through a duct of suitable size in order to minimize loss of head. This feature is shown in Figure 8.

[0018] At last in Figure 9 the diagram of air circulation in the final part of the extractor is shown, and it is to be noted that the air is guided to the lateral channels and under the belt, where it will then pass through the ash layer and above it, as described hereinbefore, in view of the vacuum existing in the combustion chamber.

[0019] In said diagram one can see the following elements: a cold air inlet 56, through the opening at the end of the postcombustion zone; an air inlet 58 from the final cooler 32; a drum 60 driving the belt; said belt 18; the ash layer 34 on the belt; the lateral channels or troughs 62 in which air is forced to move so as to enter again the combustion chamber, being attracted by the vacuum; and the lower trough 64 having the double function of deviating the possible fall of ash particles at the sides of the extractor container, so as to avoid said fall on the return stretch of the belt and the consequent erosion, and of forming together with the lateral channels a duct distributing hot air under the belt for the subsequent passage through the plate slots.

[0020] From this diagram of air circulation one can see also that in the cooling zone there will be a positive differential pressure, even if it is minimal, between the area above the ash bed and that under the belt in the cooling zone: this fact will prevent air passage in this zone from below through the ash bed, thus stopping continuation of the combustion.

[0021] A variant of the illustrated situation may occur in case air passing through the ash layer is insufficient to obtain a good combustion. In this case one may use air under positive pressure coming from an air heater, namely at a temperature adequate for a good combustion. Said air will be conveyed under the belt, where it will be forced to pass through the ash layer in view of a confinement obtained through the belt, the lower trough (that must be arranged as close as possible to the container) and two vertical diaphragms between trough and belt, placed one at the beginning and the other at the end of the postcombustion zone, so as to limit air escape.

[0022] With such a configuration, air coming from the final cooler will be taken without hindrance from the vacuum of the combustion chamber, and to this end the blade of Figure 2 should be modified so as to maintain its function of measuring the ash level on the belt, but not the function to form a division between the two ambients of the postcombustion zone and the cooling zone.

[0023] Although the invention was described hereinbefore in a very detailed way, it will be apparent to a man skilled in the art that many modifications, variations and substitutions of elements with other functionally equivalent ones may be resorted to the invention, without departing however from its scope of protection as defined in the appended claims.

Claims

1. Apparatus for postcombustion of ash from combustion of solid fuels comprising a combustion chamber under vacuum and an extractor arranged for receiving from said combustion chamber the fall of ash, whose unburnt matter must be burnt, said extractor comprising in turn an ash carrying metal belt, characterized in that said conveyor belt is provided with ports or slots for the passage of postcombustion air, said postcombustion air passing through the ash during at least a part of the advancement stretch of the belt.

2. Apparatus according to Claim 1, characterized in that means are provided on at least a part of said advancement stretch of the belt, to make a negative differential pressure between the area above the belt and that under the belt.

3. Apparatus according to Claim 2, characterized in that said means to make a negative differential pressure comprise the ash bed on said belt.

4. Apparatus according to any of the preceding claims, characterized in that it further comprises air heating means to create air under positive pres-

sure, said air being conveyed under the belt and forced to pass through the ash.

5. Apparatus according to any of the preceding claims, characterized in that it further comprises lateral channels in which said ash postcombustion or combustion feeding air is guided, in addition to the air under the belt, said additional air then passing through and above the ash bed in view of the vacuum existing in the combustion chamber.

6. Apparatus according to any of the preceding claims, characterized in that said extractor comprises a postcombustion zone and an ash cooling zone, said zones being preferably divided by separating means such as moving blades.

7. Apparatus according to Claim 6, characterized in that the swinging or rotation angle of the blade is related to the thickness of the ash bed on the belt.

8. Apparatus according to any of the preceding claims, characterized in that it comprises cold air inlet means at the end of the postcombustion zone, or at the beginning of the cooling zone and air inlet means from a final cooler, the air so introduced in the cooling zone making a positive differential pressure preventing air to pass through the ash bed on the belt.

9. Apparatus according to any of the preceding claims, characterized in that it comprises means to recover fine ash fallen from the belt, said recovery means comprising a chain provided with doctor blades or the like, said blades being arranged under the belt.

10. Apparatus according to any of the preceding claims, characterized in that it comprises distribution means adapted to make a uniform ash distribution on the belt.

11. Apparatus according to claim 10, characterized in that the space between said distribution means and said conveyor belt is sealed by yieldable means such as pads.

12. Apparatus according to any of the preceding claims, characterized in that it further comprises crushing means for crushing any possible ash lumps.

13. Method of postcombustion of heavy ash with high contents of unburnt matter, arising from a combustion chamber, comprising the steps of: depositing said ash on the conveyor belt of an extractor; providing along the forward run of said belt an ash postcombustion zone and an ash cooling zone; and taking at least a part of the air used for ash cooling, characterized by the steps of causing at least a part of the air taken from the cooling zone to pass through said ash, by means of ports or openings in said belt, and drawing again the postcombustion air into the combustion chamber.

14. Method according to claim 13, characterized in that there is a negative differential pressure between the area above the belt and the area under the belt.

15. Method according to claim 13 or 14, characterized in that it further comprises the step of limiting the lateral penetrations of air through the area under the belt and the area above the belt by the thickness of the ash bed.

16. Method according to any of claims 13 to 15, characterized in that the belt is moved at a speed related to the thickness of the ash bed.

17. Method according to any of claims 13 to 16, characterized in that said postcombustion air comes from a cooler.

18. Method according to any of claims 13 to 17, characterized in that said postcombution air is air at a positive pressure coming from a heater.

19. Method according to any of claims 13 to 18, characterized in that the step of causing air to pass through said ash bed is carried out by conveying air under the belt and through lateral channels.

20. Method according to any of claims 13 to 19, characterized by the step of conveying ash from the combustion chamber to the belt through distribution means for the uniform ash distribution on the belt.

21. Method according to claim 20, characterized by comprising the step of sealing the area between said distribution means and the belt plates by means of a pad.

22. Method according to any of claims 13 to 20, characterized by providing a separation between the postcombustion zone and the cooling zone.

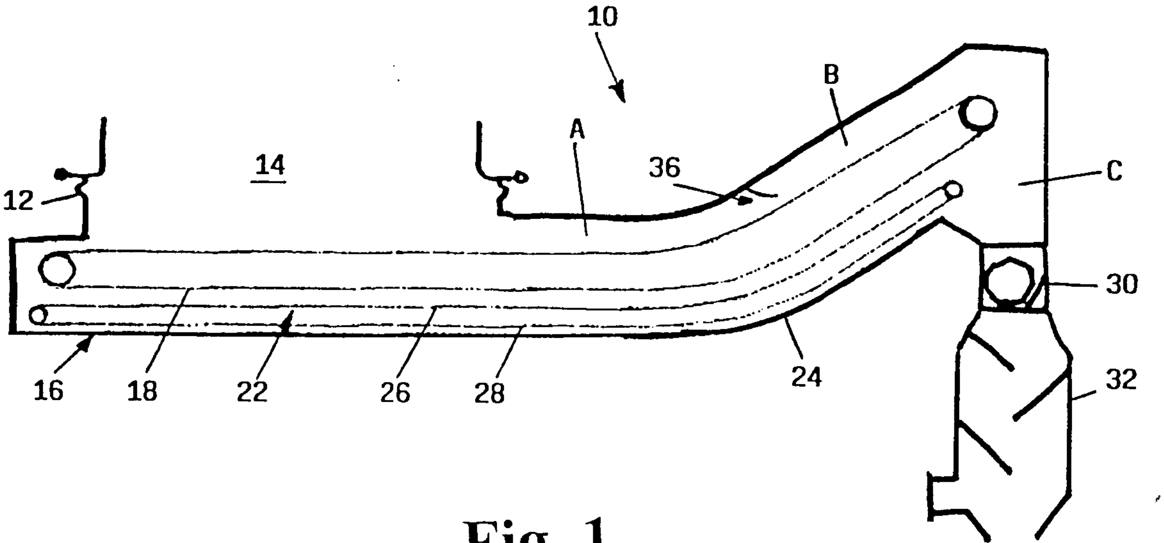

Fig. 1

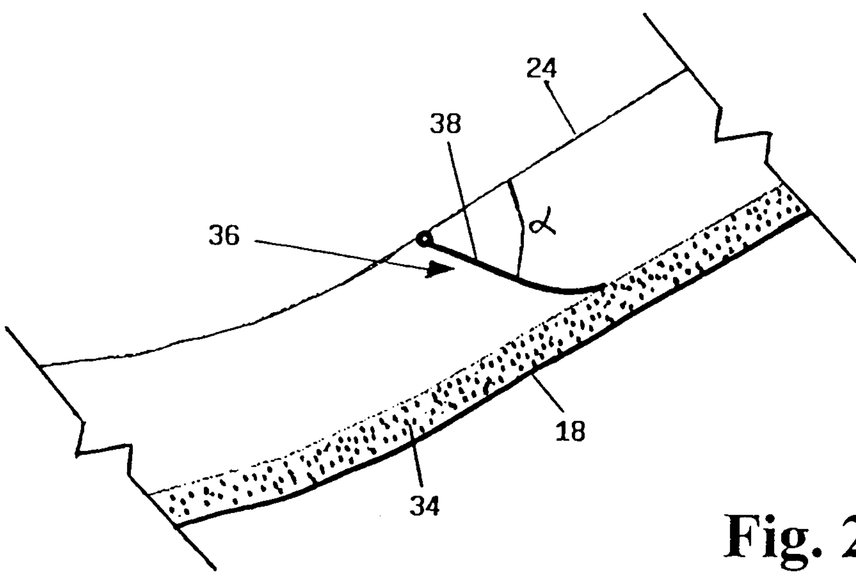

Fig. 2

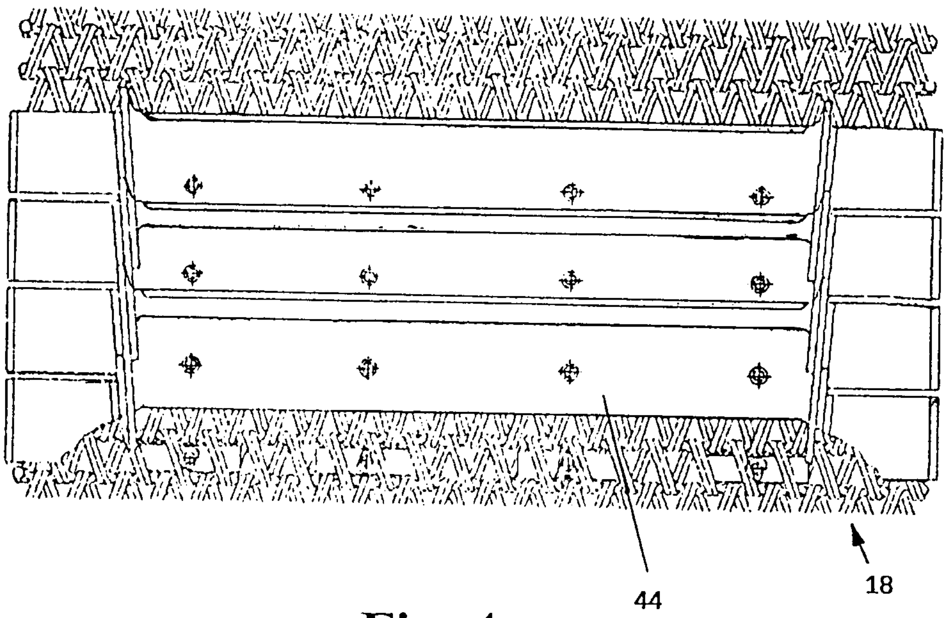

Fig. 4

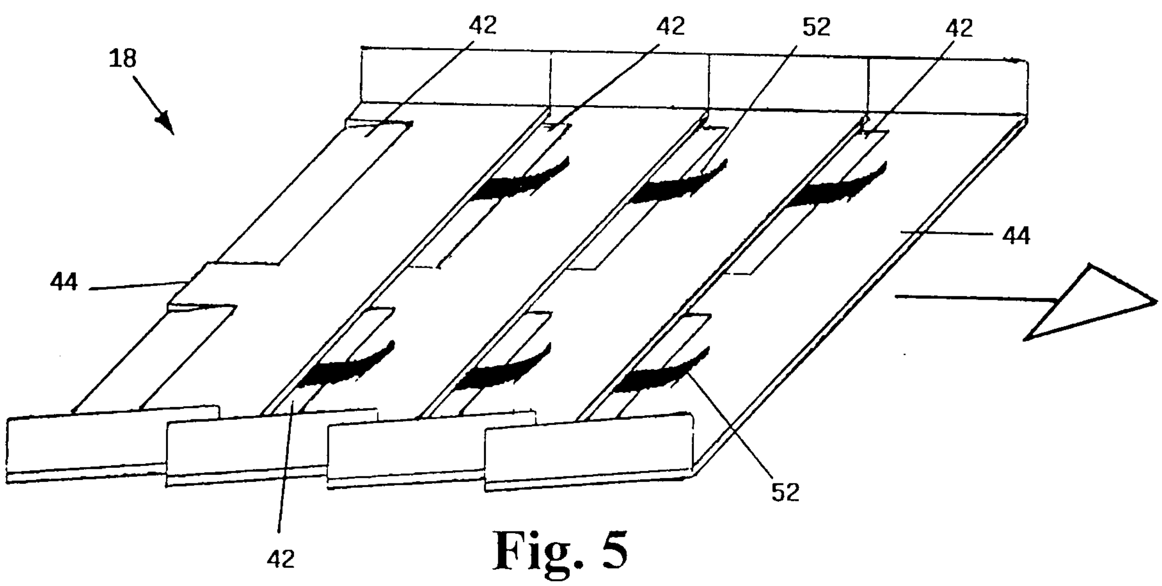

Fig. 5

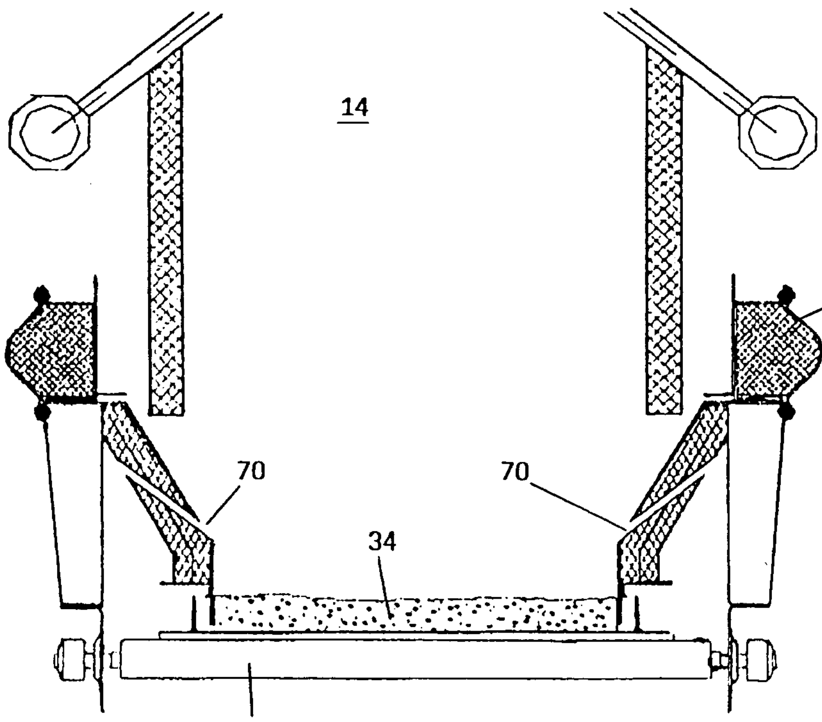

Fig.6

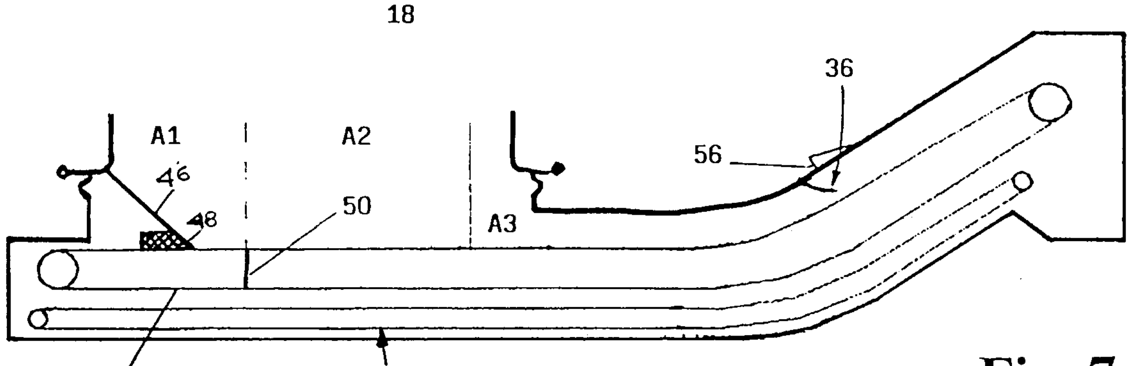

Fig. 7

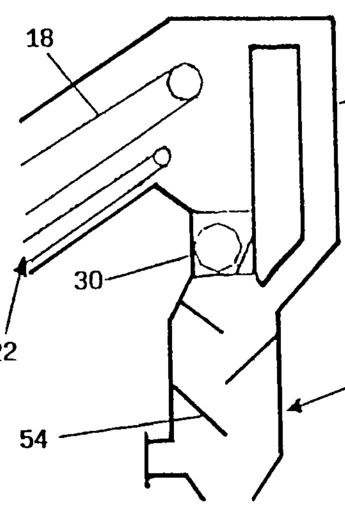

Fig. 8

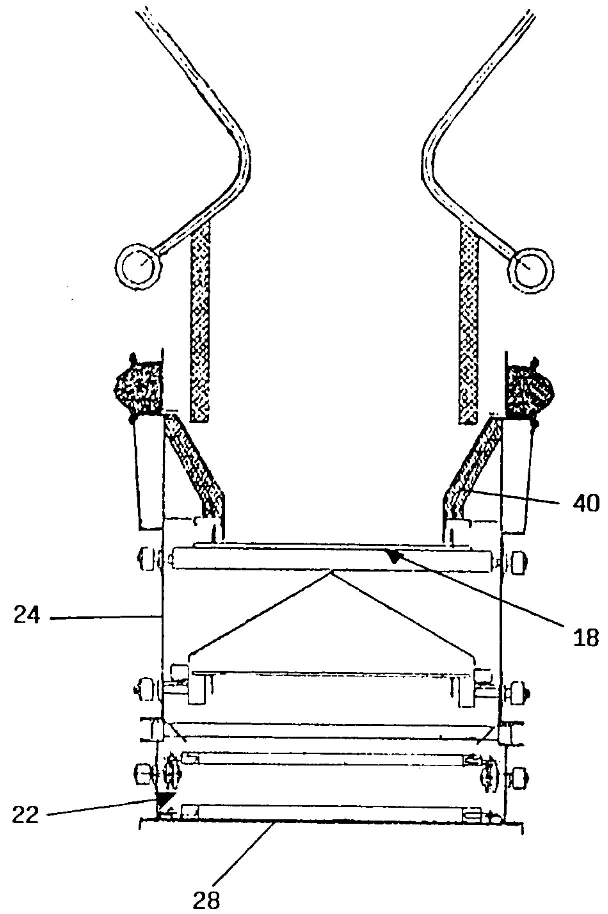

Fig. 3

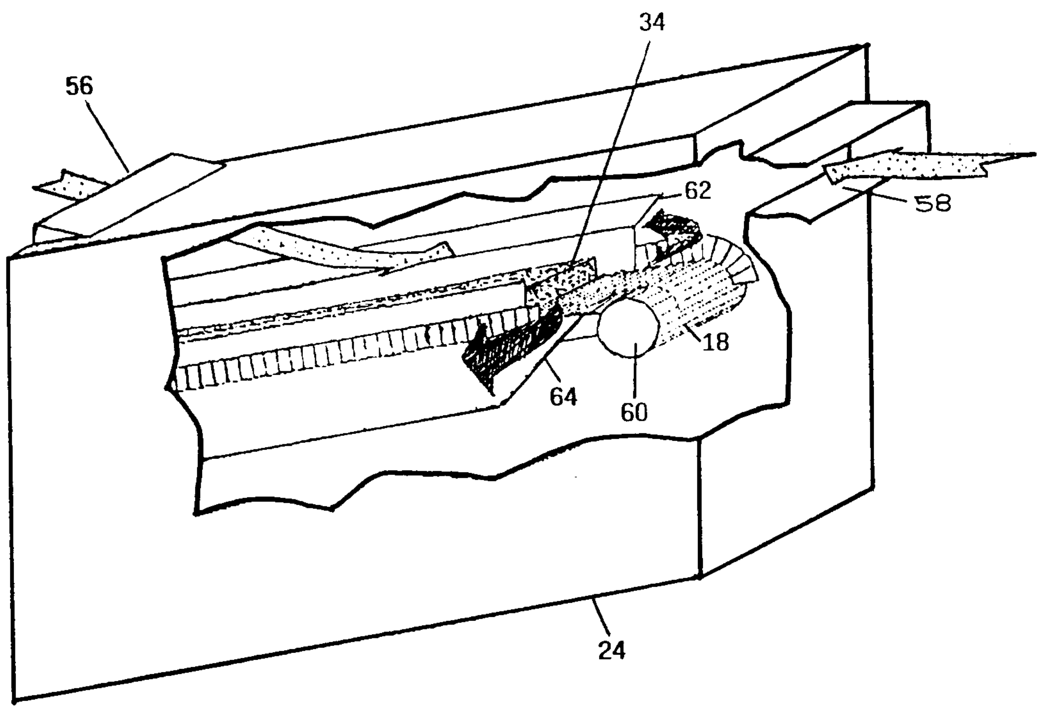

Fig. 9