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(56) Documents Cited:
GB 2374305 A **GB 1039485 A**
US 5720306 A **US 20050223589 A1**

(58) Field of Search:
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Other: **WPI,EPODOC**

(54) Title of the Invention: **Flow division apparatus**
Abstract Title: **Flow division apparatus**

(57) A flow division apparatus comprises a process gas inlet 5 communicating with a process gas outlet by means of a fluid flow path, a separation apparatus comprising two or more separators 3 and 4 arranged downstream of the process gas outlet and a divider apparatus 6 arranged in the fluid flow path. A divider plate 10 is provided downstream from a process gas inlet, for dividing the process gas flow and such that the process gas flow is divided between the two or more gas solids separators 4. The divider apparatus may comprise a rotatable bar 8 and a scraper 12 allowing multiple separators to be used whilst avoiding accumulation of the product on a leading edge of the divider apparatus. The bar may be cooled by circulation of cooling water to a temperature less than the dew point of the process gas. The process gas may comprise gas exhausted from a drying process. The particulate product may be tobacco, herbs or tea.

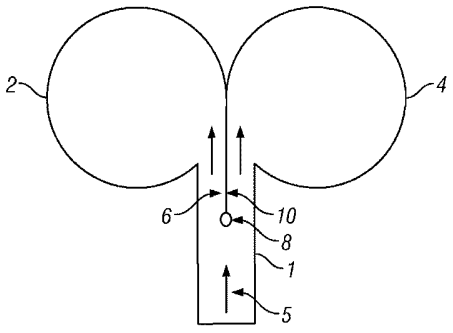

FIG. 3

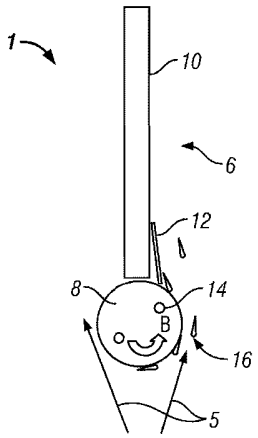

FIG. 4

GB 2481429 A

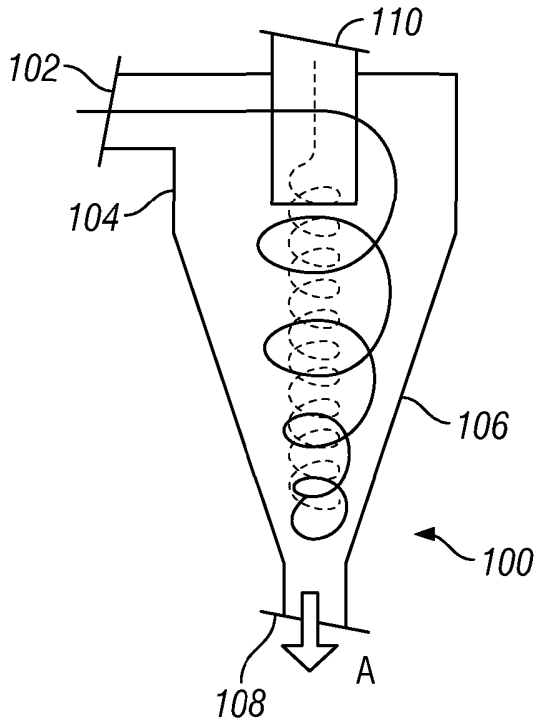

FIG. 1

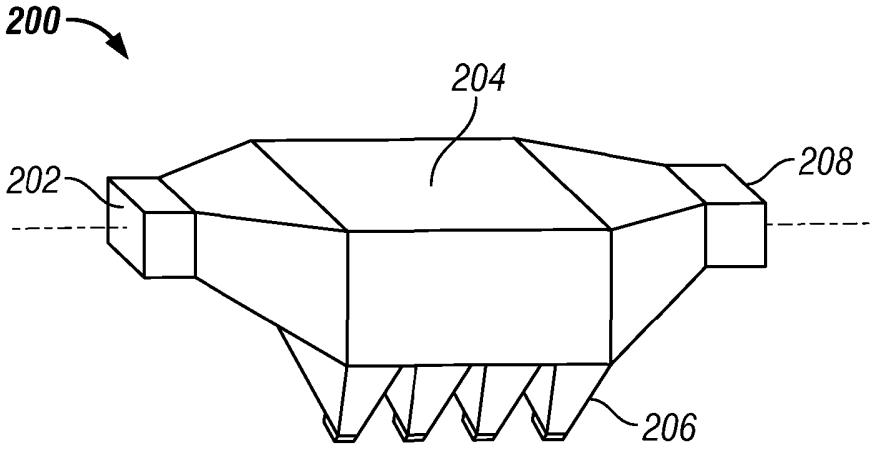

FIG. 2

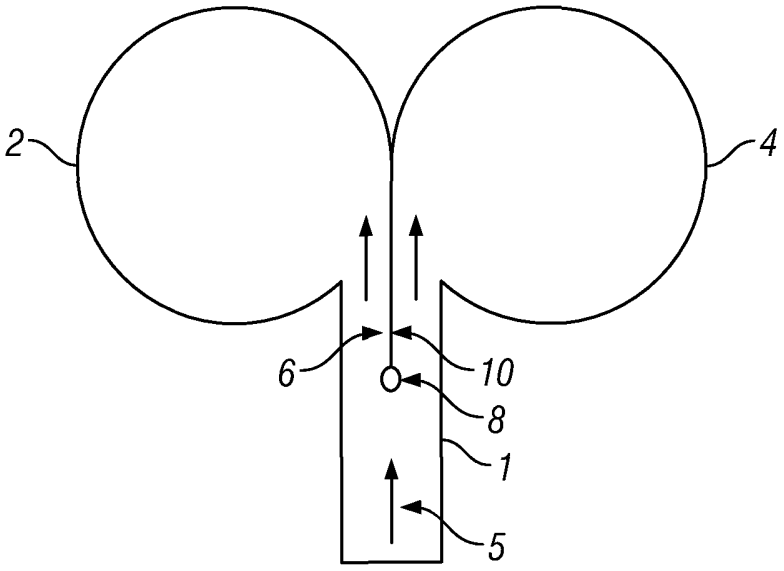

FIG. 3

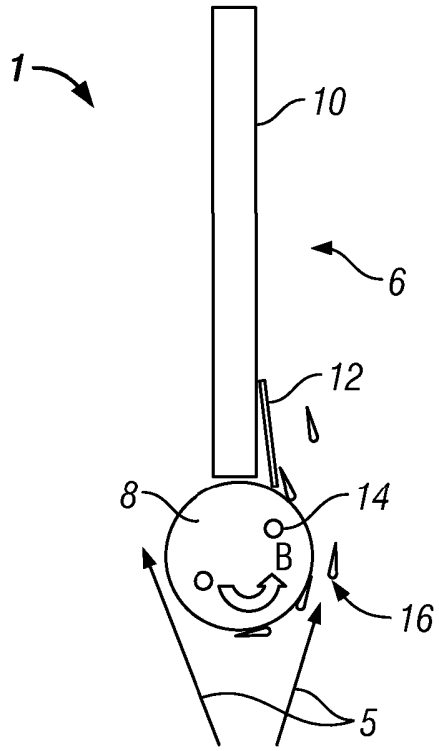

FIG. 4

FLOW DIVISION APPARATUS

The present invention relates to a dividing apparatus for dividing a process gas flow such that the process gas is directed to different portions of a separating apparatus, particularly but not exclusively to an apparatus and a method for dividing gas flow in a pneumatic conveying dryer including two cyclonic separation units, where a product to be dried is conveyed through a dryer duct by a flow of process gas.

Tobacco leaves are processed for cigarette manufacture in a primary tobacco process. The laminate portions of the tobacco leaves are compressed and then cut in a cutting machine to create tobacco particles suitable for cigarette manufacturers. Other examples of similar products with a laminar form in a processing stage could be herb leaves for culinary purposes and tea leaves for loose leaf tea. Separation and processing of the laminate portions requires a drying step. Drying can be achieved with a pneumatic conveying dryer.

In a conventional pneumatic conveying drying process the process gas is often air, superheated steam, nitrogen, or a mixture of these or similar gases. The product is dried in the gas stream and conveyed along in the gas flow. The dried product is then separated from the process gas stream by a gas/product separator.

Commonly a cyclone separator is used for the purpose of separation, other types of separator such as a tangential separator may also be used. Figure 1 illustrates a conventional cyclone 100 in use in a pneumatic conveying drying process. The cyclone 100 comprises inlet 102 located at an upper (as illustrated) cylindrical portion 104 and a lower (as illustrated) conical portion 106 including cyclone opening 108. The cylindrical portion 104 further comprises an exhaust outlet 110. In use, process gas and particulate matter from the drying process enters the cyclone inlet 102 and the path of the fluid flow in the cyclone

100 is illustrated in Figure 1 by the solid line. The solid line represents high speed rotating flow, known as the outer vortex, established within the upper (as illustrated) cylindrical section 104 of the cyclone and extending in a spiral manner into the lower (as illustrated) conical portion 106 of the cyclone. Separation occurs due to vortex separation created by the spiral flow of the gas. Particles in the rotating fluid flow, particularly large and dense particles cannot follow the path of the confined spiral due to their inertia, and instead strike the walls of the cyclone 100 before falling towards opening 108 and thus becoming separated from the process gas stream, shown falling in the direction of solid arrow A in Figure 1. The tighter radius of the spiral in the conical portion 106 of the cyclone 100 has the effect of separating lighter and smaller particles. The process gas exits the cyclone 100 through the centre of the cyclone 100 as an inner vortex flow illustrated in Figure 1 with dashed lines. The exiting process gas flow, now separated from some particulate matter, is exhausted at clean gas exhaust outlet 110. The process gas is exhausted as a cleaner gas with less entrained particulate matter.

Figure 2 illustrates a tangential separator 200 of a conventional type, comprising inlet 202, settling chamber 204, openings 206 and exhaust outlet 208. In use, process gas and particulate matter from a drying process enter the tangential separator 200 and flow through the settling chamber 204 in a manner as illustrated with a solid line in Figure 2. The settling chamber 204 is arranged tangentially to the fluid flow. Large, dense particles cease to be entrained in the fluid flow as the flow path extends across the chamber 204, the particles are settle and drop out of the fluid flow path through openings 206. The exiting process gas flow, now separated from some particulate matter, is exhausted at clean gas exhaust outlet 208. The process gas is exhausted as a cleaner gas with less entrained particulate matter.

The dryer dimensions, drying qualities and performance should be matched to the requirements for the drying process flow rate required. Therefore, one of the

practical problems with pneumatic conveying dryers is that their size is such that it is often necessary to substantially modify or extend locally a building housing the dryer in order to accommodate the dryer. Often such building provisions are costly and inconvenient and the drying system becomes height or width limited.

It is desirable to provide an apparatus to allow other methods of separating product from the process gas flow which avoids the aforementioned problems.

According to a first aspect, the present invention provides a flow division apparatus comprising a process gas inlet communicating with a process gas outlet by means of a fluid flow path, and a divider apparatus, a separation apparatus comprising two or more separators being arranged downstream of the process gas outlet and the divider apparatus being arranged in the fluid flow path such that, in use, process gas flowing along the fluid flow path from the process gas inlet to the process gas outlet and to the said separation apparatus passes through the divider apparatus, wherein a divider plate is provided, downstream of the process gas inlet, for dividing the process gas flow between the said two or more separators.

By providing a flow division apparatus enabling use of two or more separators higher separation efficiency for the particulate matter is achieved than compared with a single separator due to the smaller individual size of each of a plurality of separators for the same process gas flow.

Preferably the divider plate is mounted in a static arrangement in the fluid flow path. More preferably the divider apparatus further comprises a rotatable member, preferably a cooled bar, provided upstream of the divider plate and close to the divider plate such that, in use, process gas divides and passes around the rotatable member and passes either side of the divider plate.

In some situations particulate product may accumulate on the leading edge of the divider plate. Advantageously the rotatable bar avoids such accumulation as any particulate product matter which may become stuck to the divider plate impinges first instead on the rotatable member or bar. Particulate matter is then removed due to the relative velocity between the process gas flow around the divider apparatus and the rotation of the surface of the bar, thus avoiding the need to undertake a cleaning operation, which may require process downtime and be expensive. Accumulation of the product within a dryer is undesirable, since the product may degrade due to the effect of heating and overdrying with the additional time spent within the process chamber apparatus. The present invention seeks to eliminate these problems by preventing accumulation of product on the division of the process duct.

The bar may comprise one or more internal passageways in fluid connection with a water supply such that, in use, circulation of cooling water flowing along the internal passageways cools the bar. Preferably, the bar is cooled to a temperature less than or equal to the dew point of the process gas. In this way the cooling results in a film of condensation forming on the surface of the cooled bar, and this condensation prevents product material from sticking to the surface of the bar and accumulating thereon. In an extreme any accumulated, degraded, product material can interfere with the process gas flow. In addition the accumulated material may randomly break away and contaminate the final product as it leaves the cyclone. The cooled bar can alleviate this problem.

The divider apparatus may further comprise a scraper for cleaning the rotatable member. In this way as the bar rotates, the scraper removes and releases any product which has adhered to the bar, before it has had time to become degraded by exposure to the process gas for an excessive length of time. Preferably the process gas flow comprises gas exhausted from a drying process and particulate material, more preferably the particulate product is

tobacco and the drying process gas is one of the group of air, superheated steam, nitrogen and a mixture of the gases.

In an embodiment, the separation apparatus being arranged downstream of the process gas outlet comprises at least two cyclones arranged in parallel in the fluid flow. Advantageously, by using two or more cyclones in parallel, the overall height required for the drying apparatus equipment can be reduced as the same process gas flow for a single large (single) cyclone can now be achieved with two smaller, parallel cyclones. This can avoid the need to adapt or modify existing buildings housing the dryer.

In an embodiment, the separating apparatus being arranged downstream of the process gas outlet comprises at least two cyclones arranged sequentially in the fluid flow path. The use of cyclonic separating apparatus having at least two cyclones means that the system can take advantage of the higher separation efficiency afforded by smaller diameter cyclones as the two or more cyclones can be of smaller diameter than a single cyclone and still achieve the same process gas flow as a single, larger cyclone.

Preferably, a divider apparatus is provided at each of a set of two or more cyclones so as to route the fluid flow into each of the two, or more, cyclones. When dividing the gas flow between multiple cyclones the dividing apparatus can be a dividing plate or a shaped inlet piece with a 'Y' division.

According to a second aspect, the present invention therefore provides, for use in a pneumatic conveying drying process, a flow division apparatus mounted across an incoming fluid flow, the fluid flow conveying gas and particulate product towards a separating apparatus for separating product from the fluid flow, wherein the flow division apparatus comprises a rotatable member.

By this arrangement the accumulation of particulate product on the divider apparatus of the process duct can be reduced and in some cases avoided altogether. Also a greater degree of process uniformity is achieved in the drying processes with a pneumatic conveying dryer. Preferably the rotatable member is a cooled rod, more preferably the dividision apparatus further comprises a scraper for cleaning the rotatable member. In an embodiment the separating apparatus is a cyclonic separating apparatus.

According to a third aspect, the present invention therefore provides, a method of dividing particulate product and drying process gas from a process gas fluid flow in a pneumatic conveying drying process, the process gas fluid flow conveying gas and particulate product towards a separating apparatus for separating particulate product from the process gas fluid flow, the method comprising the steps of;

dividing the process gas downstream of a process gas inlet with a flow divider apparatus; and

rotating a rotatable member upstream of the divider apparatus so as to avoid accumulation of the product on a leading edge of the rotatable member.

Preferably, the method further comprises the step of cooling the rotatable member to less than or equal to the dew point of the process. The cooling creates a film of condensation on the rotatable member and reduces the particulate material accumulating on the rotatable member

Preferably, the method further comprises the step of cleaning the surface of the rotatable member with a scraper. This removes any particulate matter that may have built up on the surface.

The present invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a cross sectional view of a conventional cyclone separation apparatus;

Figure 2 is a perspective view of a tangential separation apparatus;;

Figure 3 is a plan view of a drying duct incorporating the separating apparatus and the divider apparatus of the present invention; and

Figure 4 is a plan view of the flow divider apparatus of Figure 3, in further detail.

A type of conventional separating apparatus will now be described with reference to the apparatus of Figures 1 and 2. Some details of the structure and operation of the separating apparatus have been set out above and summary details are as follows. In both the cyclone 100 shown in Figure 1 and in the conventional tangential separator 200 of Figure 2 process gas and particulate matter from the drying process enters at an inlet 102, 202 and separation occurs, with the exhaust or cleaned gas exiting at outlet 110, 208. In this way the exiting process gas flow, now separated from some particulate matter, is exhausted as a cleaner gas with less entrained particulate matter.

In one embodiment of the invention illustrated in Figure 3 a drying duct 1 is located upstream of the separating apparatus and is arranged in communication with two cyclones 2, 4. The cyclones 2, 4 are configured in parallel. A flow divider 6 is located in the drying duct 1. The flow divider 6 includes a rotatable bar 8 located upstream of a fixed, static divider plate 10 within the drying duct 1. Figure 4 illustrates the preferred embodiment of the flow divider 6 in more detail. The direction of rotation of the rotatable bar 8, arrow B, is in an anticlockwise direction. The rotatable bar is driven by a motor and drive means (not shown). In the preferred embodiment a scraper 12 is fixedly connected to the divider plate 10 and arranged to extend towards the rotatable bar 12 impinge thereon. The scraper 12 shown in Figure 4 is brought into engagement by the frictional force of its connection to the divider plate 10, the scraper 12 however could be urged into engagement with the rotatable bar 8 under the resilient biasing force of a spring or a weight bearing means or other means. Cooling ducts 14 are

located within the rotatable bar 8 and connected to cooling water circulation means (not shown). In alternative embodiments (not shown, but that would be understood by the skilled person from the foregoing description) the divider 6 may include rotatable bar 8 alone and with or without cooling.

In operation, process gas flow 5 entering the drying duct 1 from a pneumatic conveying drying process is divided such that it discharges into the two cyclones 2, 4. The process gas flow 5 from the dryer approaches the flow divider 6 and the gas flow 5 passes either side of the rotating bar 8 and divider plate 10 and continues as two separate flows to each of the two cyclones 2, 4. Figure 4 shows the scenario where some particles of product 16 adhere to the face of the rotating bar 8. Although this may happen, as the bar 8 rotates the gas flow around the bar 8 tends to detach these particles 16. As the bar 8 continues to rotate, any particles 16 remaining stuck to its surface are removed and released by the action of the scraper 12 at the surface of the rotatable bar 8 and conveyed towards the cyclones 2, 4 by the gas stream 5. In the embodiment illustrated the scraped particles 16 are released predominantly towards cyclone 4. The particles 16 released are added to the overall process flow and material entering cyclone 4.

Thus as the bar 8 rotates, any product particle 16 which has stuck to it is removed, firstly due to the relative velocity between the gas stream 5 and the surface of the bar 8 and secondly by the scraper 12. Therefore in use the apparatus enables the removal and release of any product which has adhered to the bar, before it has had time to become degraded by exposure to the process gas for an excessive length of time.

The rotational speed of the bar in use in the embodiment is around 10 rpm. Rotational speeds of 5-500 rpm may be used. Several hundred rpm are possible in the system. The most effective removal of particulate material from the bar would involve a speed of rotation comparable to the speed of the

process gas, at 10,000 rpm. Such speeds are impractical to achieve in this separation and dividing system and scraper 12 assists instead.

Furthermore, in use in the embodiment with the cooling water ducts 14 the particulate material is further prevented from sticking to the rotatable bar 8 as cooling the bar by circulating cold water though it enables temperature of the surface of the bar 8 to be controlled to a temperature close to, at, or below the dew point of the process gas. As a consequence a film of condensation occurs on the surface of the bar 8, and this condensation prevents product material from sticking to the surface of the bar. In the case of dryers using superheated steam as the drying gas at atmospheric pressure, the dew point is between around 98 and 100 degrees C.

The embodiment provides a flow division apparatus comprising a process gas inlet communicating with the inlet to a plurality of gas/solids separators. The flow divider does not necessarily separate product from the process gas but allows multiple separators to be used, and equally divides the flow to each cyclone or other type of separator. The flow divider discourages the build up of product on the leading edge of the divider, the apparatus in the form of a cooled bar may be used with or without the feature of rotation.

Various modifications may be made to the described embodiment without departing from the scope of the present invention. There may be a different number of cyclones or separating apparatus units, or more than one scraper or cooling device. Alternative forms or construction of a divider plate are possible, a divider plate can, for example, comprise a number of component parts joined together.

CLAIMS

1. A flow division apparatus comprising a process gas inlet communicating with a process gas outlet by means of a fluid flow path, and a divider apparatus, a separation apparatus comprising two or more separators being arranged downstream of the process gas outlet and the divider apparatus being arranged in the fluid flow path such that, in use, process gas flowing along the fluid flow path from the process gas inlet to the process gas outlet and to the said separation apparatus passes through the divider apparatus, wherein a divider plate is provided, downstream of the process gas inlet, for dividing the process gas flow between the said two or more separators.

2. A flow division apparatus as claimed in Claim 1, wherein the divider plate is mounted in a static arrangement in the fluid flow path.

3. A flow division apparatus as claimed in Claim 2, wherein the divider apparatus further comprises a rotatable member provided upstream of the divider plate and close to the divider plate such that, in use, process gas divides and passes around the rotatable member and passes either side of the divider plate.

4. A flow division apparatus as claimed in Claim 3, wherein the rotatable member is a cooled bar.

5. A flow division apparatus as claimed in Claim 4, wherein the bar comprises one or more internal passageways in fluid connection with a water supply such that, in use, circulation of cooling water flowing along the internal passageways cools the bar.

6. A flow division apparatus as claimed in Claim 4 or Claim 5, wherein the bar is cooled to a temperature less than or equal to the dew point of the process gas.

7. A flow division apparatus as claimed in any one of Claims 3 to 6, wherein the divider apparatus further comprises a scraper for cleaning the rotatable member.

8. A flow division apparatus as claimed in any preceding claim, wherein the process gas flow comprises gas exhausted from a drying process and particulate product.

9. A flow division apparatus as claimed in Claim 8, wherein the particulate product comprises tobacco and the drying process gas is one of the group of air, superheated steam, nitrogen and a mixture of the gases.

10. A flow division apparatus as claimed in any preceding claim, wherein the separating apparatus comprises at least two cyclones arranged in parallel in the fluid flow path.

11. A flow division apparatus as claimed in any one of claims 1 to 9, wherein the separating apparatus comprises at least two cyclones arranged sequentially in the fluid flow path.

12. A flow division apparatus as claimed in Claim 10 or Claim 11, wherein a divider apparatus is provided at each of a set of two or more cyclones.

13. A flow division apparatus as claimed in any preceding claim, wherein the process gas outlet is co-located with the inlet to the separation apparatus.

14. For use in a pneumatic conveying drying process, a flow division apparatus mounted across an incoming fluid flow, the fluid flow conveying gas and particulate product towards a separating apparatus for separating product from the fluid flow, wherein the flow division apparatus comprises a rotatable member.

15. Use as claimed in Claim 14, wherein the flow division apparatus further comprises a scraper for cleaning the rotatable member.

16. Use as claimed in any one of claims 13 to 15, wherein the separation means comprises a cyclonic separation system.

17. A method of dividing particulate product and drying process gas from a process gas fluid flow in a pneumatic conveying drying process, the process gas fluid flow conveying gas and particulate product towards a separating apparatus for separating particulate product from the process gas fluid flow, the method comprising the steps of;

dividing the process gas downstream of a process gas inlet with a flow divider apparatus; and

rotating a rotatable member upstream of the divider apparatus so as to avoid accumulation of the product on a leading edge of the rotatable member.

18. A method as claimed in Claim 17, further comprising the step of cooling the rotatable member to less than or equal to the dew point of the process gas.

19. A method as claimed in Claim 17 or Claim 18, further comprising the step of cleaning the surface of the rotatable member with a scraper.

20. A flow division apparatus substantially as herein described and with reference to the accompanying drawings.

21. A method substantially as herein described and with reference to the accompanying drawings.

Application No:	GB1010596.3	**Examiner:**	Mr Robert Mirams
Claims searched:	1 to 13	**Date of search:**	22 September 2010

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	at least 1, 2, 10 and 12	GB2374305 A (DYSON) whole document
X	at least 1, 2, 10 and 12	GB1039485 A (SOCIETE FIVES LILLE-CAIL) whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A24B; B04C; F26B

The following online and other databases have been used in the preparation of this search report

WPI,EPODOC

International Classification:

Subclass	Subgroup	Valid From
A24B	0003/04	01/01/2006
B04C	0005/24	01/01/2006

Application No:	GB1010596.3	**Examiner:**	Mr Robert Mirams
Claims searched:	14 to 21	**Date of search:**	16 February 2011

Patents Act 1977
Further Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	at least 14, 17 and 18	US5720306 A (KORTE) e.g. column 5 line 45 to column 6 line 43
A	N/A	US2005/0223589 A1 (FUNKE) whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Worldwide search of patent documents classified in the following areas of the IPC

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International Classification:

Subclass	Subgroup	Valid From
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B04C	0005/24	01/01/2006