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(54) **Tumble dryer**

(57) A tumble dryer has a drum 1 mounted in a cabinet 2, the drum having an opening 3 through which the drum is loaded and which is closed by a door (now shown) in use. Heated air enters the drum at the rear via opening 8 under the propulsion of a blowing fan 5, and cooler moist air leaves the front of the drum and is fed to a duct 10 to be led to the rear of the dryer to be

exhausted, for example, to the atmosphere. According to the invention, a cyclone separator 11 is provided into which the drying air leaving the drum is fed tangentially. A further sucking fan 15 is provided to increase the velocity of the moist air entering the cyclone separator. Fluff build-up in the cyclone separator can be disposed of periodically by undoing a cap 14.

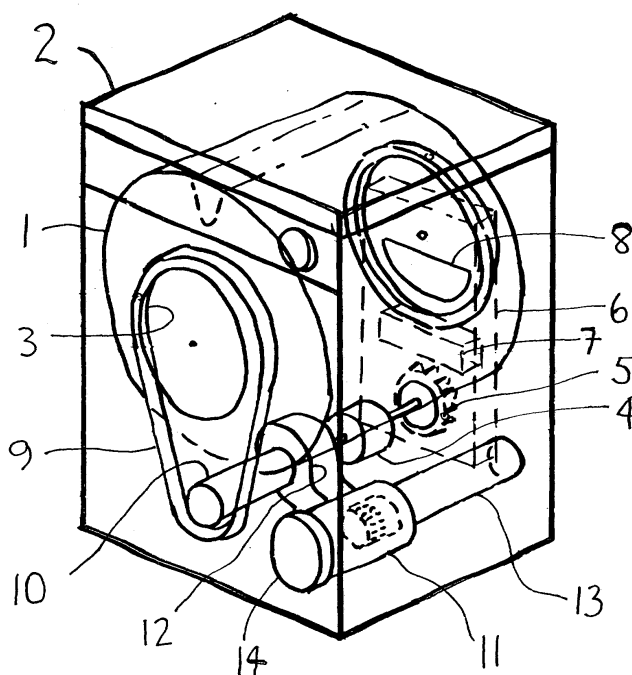


FIG 1

EP 1 380 683 A2

Description

[0001] This invention relates to tumble dryers.

[0002] A tumble dryer typically consists of a rotating drum in which a load is placed, a heater, and a fan for conveying dry heated air, which has been drawn into the dryer from outside the dryer, through the load. The cooler moist air leaving the drum may be vented directly to the outside atmosphere. Typically, the duct along which the moist air travels is provided with a mesh filter, accessible to the user of the tumble dryer. This mesh filter must be removed periodically for cleaning, or the performance of the dryer will be impaired.

[0003] An alternative proposed tumble dryer arrangement is to include a cyclonic separator, in which the fluff laden air is spiraled or swirled in some manner to centrifugally remove fluff from the stream of moist air leaving the drum. Such tumble dryers with cyclone arrangements may produce a more consistent flow of drying air than produced using a conventional mesh filter, since the latter becomes progressively impeded by fluff. Examples of such tumble dryer proposals are described in US Patents 5706588, 4118207, 6016610, 5560120 and in Japanese patent application number JP 2000329376.

[0004] In most of these prior proposals the efficiency and performance of the tumble dryer and in particular the cyclone separation is poor. This is evidenced by the fact that most of these proposals also further include mesh filters to assist in fluff / lint removal. The use of an additional mesh filter adds further complexity to the arrangement and also partially negates some of the advantages of using a cyclone filter.

[0005] Specifically a mesh filter requires the fluff trapped thereon to be scraped or otherwise removed from the filter screen and also as fluff is trapped on the filter screen airflow there through is restricted. Also whilst these arrangements produce a more consistent flow of drying air the overall performance of these proposed tumble dryers is also poor and can be improved. A further problem with some of these proposed arrangements in which a fan is provided upstream of the cyclone separator is that the fluff builds up on the fan thereby reducing the fan performance and flow of air through the drum and dryer leading to poor dryer performance. In the worst case fluff build up on the fan could possibly clog the fan entirely. The various proposed arrangements for collecting and removal of the fluff and lint are also complex and in some cases convoluted and in practical.

[0006] It is therefore desirable to provide an improved tumble dryer that address the above mentioned problems, which has improved dryer performance and in particular which has an improved separator for removing fluff / lint, and/or which provides improvements generally.

[0007] According to the present invention there is provided a tumble dryer as defined in the accompanying claims.

[0008] In an described embodiment a tumble dryer comprises a rotating drum into which a load is placed, a heater, a fan for conveying a stream of dry heated air heated by the heater through drum, and a cyclone separator for removing fluff from the stream of drying air leaving the drum. The fan is located upstream of the drum and blows a stream of dry heated air through the drum. The dryer further comprises a second fan downstream of the drum and upstream of the cyclone separator to increase the velocity of the drying air entering the cyclone separator and suck air through the drum.

[0009] The operating efficiency of this arrangement is enhanced due to the combination of the blowing fan and a sucking fan. The fluff removal in the cyclone separator is also enhanced with the second fan increasing the velocity of the air into the cyclone separator. Consequently no additional mesh filter is required which would throttle the airflow through the dryer and causes some of the above mentioned problems.

[0010] The cyclone separator preferably comprises a cylindrical outer housing, an inner tube, an inlet port, and an end cap. The inner tube is coaxially located within the outer housing and extends part way into one end of the outer tube to define an annular space there between at that one end of the cyclone separator. The inner tube also defines an outlet duct from the separator. The inlet port in the outer tube opens into the annular space between the inner tube and outer housing. The end cap assembly closes off the opposite end of the outer tube and cyclone separator.

[0011] The cyclone separator preferably has a removable portion accessible from the front of the dryer to permit disposal of fluff. In particular the end cap comprises a cylindrical portion which fits within the outer housing of the cyclone separator and within which fluff is in use collected. This end cap is removable and may comprise the removable portion of the cyclone separator accessible from the front of the dryer to permit disposal of fluff. The removable portion may be at least partially transparent so that fluff build-up is visible from outside the tumble dryer.

[0012] With such an arrangement the separated fluff can be easily seen, and removed by removing and emptying the removable portion.

[0013] The removable portion, within which the fluff is collected may have projecting surfaces to prevent the collected fluff from revolving with the cyclone air. These projecting surfaces may comprise radially projecting ribs or vanes. The outer periphery of the inner tube may include a projecting spiral vane which spirals around the circumference of and long at least part of the length of the inner tube.

[0014] The removable portion may be laterally spaced from the opening of a duct through which drying air leaving the drum is directed. The cyclone separator is arranged to receive drying air tangentially.

[0015] A barrier may be provided to shield the second fan from the flow of air from the drum. Furthermore the

second fan may be arranged to draw in and directs a further separate flow of air which is directed to entrain and combine with the air leaving the drum to thereby increase the velocity of air leaving the drum as it enters the cyclone separator as a combined air stream.

[0016] The barrier, and this arrangement of the second fan to entrain the fluff laden flow rather than the fluff laden flow passing through the second fan, reduces the likelihood of fluff build up on the second fan.

[0017] According to another aspect of an embodiment of the claimed invention, a tumble dryer comprises a rotating drum into which a load is placed, a heater, a fan for conveying a stream of dry heated air through drum, and a cyclone separator for removing fluff from the stream of drying air leaving the drum. The cyclone separator comprises a cylindrical outer housing, an inner tube coaxially located within the outer housing and extending part way into one end of the outer tube to define an annular space there between at that one end of the cyclone separator, and an inlet port in the outer tube opening into the annular space between the inner and outer tube. The outer periphery of the inner tube includes a projecting spiral vane which spirals around the circumference of and long at least part of the length of the inner tube.

[0018] In yet another aspect of an embodiment of the claimed invention a tumble dryer comprising a rotating drum into which a load is placed, a heater, a fan upstream of the drum for conveying a stream of dry heated air heated by the heater through drum, and a cyclone separator for removing fluff from the stream of drying air leaving the drum. The cyclone separator comprises a cylindrical outer housing, an inner tube coaxially located within the outer housing and extending part way into one end of the outer tube to define an annular space there between at that one end of the cyclone separator, and an inlet port in the outer tube opening into the annular space between the inner and outer tube. Within the outer housing there are inwardly projecting surfaces to prevent the collected fluff from revolving with the cyclone air. Preferably the separator further comprises a removable end cap assembly removably fitted to the outer housing and closing off an end of the outer housing tube, and within which the inwardly projecting surfaces comprise internal ribs or vanes of the end cap assembly.

[0019] Advantageously in embodiments of the invention, the cyclone separator has a removable portion accessible from the front of the dryer to enable removal of fluff. The removable portion may be laterally spaced from the opening of a duct through which the air leaving the drum is directed. In this way, the cyclone separator may be arranged to receive the drying air tangentially.

[0020] A tumble dryer constructed in accordance with the invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective, cut away, draw-

ing of the tumble dryer according to the invention;

Figure 2 is a view from underneath, partly in section, of a part of the tumble dryer including a cyclone separator;

Figure 3 is a side view of the cyclone separator shown in Figure 2, seen in the direction of the arrows 3-3;

Figure 4 is an end view of the cap 14 shown in Figures 1 to 3;

Figure 5 is an axial cross-section of the cap 14;

Figure 6 shows an alternative version of the cyclone shown in Figure 3; and

Figure 7 shows an alternative version of the fan 15 shown in Figure 2.

[0021] Referring to the drawings, the tumble dryer consists of a rotatable drum 1 mounted in a cabinet 2, the drum having an opening 3 provided with a door (not shown) through which the load to be dried, typically clothes which have been washed in a washing machine, have been inserted. A motor 4 drives a fan 5 in a heater box 6 containing a heater unit 7. The motor 4 may also be responsible for rotating the drum 1.

[0022] The heated air enters the drum at the rear via an opening 8 in the dryer box 6, and passes through the load of clothes while the drum is being rotated. The cooled moist air leaves the front of the drum via a banjo-shaped duct 9, which opens in an annular slot around the mouth of the opening 3, which is of course shielded off by means of the door which is not shown. The banjo-shaped duct 9 is secured to the front of the cabinet and channels the cooler moist air into a duct 10 which eventually leads to the rear of the dryer. The air could for example be vented via the rear of the dryer, through a pipe in an outside wall or to a window.

[0023] As is well known, the moist air leaving the front of the drum entrains a certain amount of fluff which could block the duct or cause a nuisance at the outside venting position and, for this reason, a mesh filter is usually included in known tumble dryers at some point in the path of the exhausting moist air. In accordance with the invention, a cyclone separator 11 is provided, and the moist air leaving the drum and traveling along duct 10 is diverted via volute 12 to provide a tangential input to the cyclone separator 11. The cyclone separator 11 removes the fluff from the air stream, which then exhausts from the rear of the appliance via duct 13, to be fed to an opening in an outside wall or to a window. A portion of the cyclone separator is removable to enable the fluff built up to be periodically removed, and the cyclone separator 11 has a cap 14 accessible from the front of the dryer to permit this. The cyclone separator 11 will now

be described with reference to Figures 2 and 3.

[0024] The cyclone separator 11, as shown, comprises a cylindrical hollow outer tube or housing 30. Co-axially located within the outer tube 30 is an inner cylindrical hollow tube 32 which has a outer diameter that is less than the inner diameter outer tube 30. The inner tube 30 extends part way along the length, and into one end, of the outer tube 30 with a distal end 38 of the inner tube 32 located, as shown, within the outer tube 30. An annular space 34 is thereby defined between the inner and outer tubes 30,32 at one end of the separator 11. This annular space 34 then opens out into an enlarged cylindrical chamber 40 at the other end of the separator 11 and beyond the distal end 38 of the inner tube 32. The distal end 38 of the inner tube 32 is closed off by an end wall 42. Circumferentially around the distal end 38 of the inner tube 32 there are a series of slot openings 16 through the inner tube 32 to admit a flow of air into the inner tube 32. An outlet end of the inner tube comprises an outlet port 31 of the cyclone separator 11 and is extended to directly form the exhaust duct 13, or is connected to a separate exhaust duct 13.

[0025] The end of the outer tube 30 into which the inner tube 32 is fitted, and the annular space 34 between the outer tube 30 and inner tube 32, is closed off by an annular end wall 38. Towards that end of the outer tube 30 there is also a tangential inlet port 36 that is connected to an outlet of the volute 12 and duct 10. The inlet port 36 faces and opens onto the outside of inner tube 32 with the inlet port 36 laterally spaced along the length of the separator 11 away from the distal end 38 of the inner tube 32. The inlet port is aligned to direct a flow B of moist air tangentially into the cyclone separator 11 and into the annular space 34 between the inner and outer tubes 30,32 and around the inner tube 32 as shown by arrow B and explained further below. The other end of the outer tube 30 is closed off by the end cap assembly 14 which is shown in more detail in isolation in figures 4 and 5.

[0026] The end cap assembly 14 comprises a circular end plate 46 which closes off a cylindrical main body portion 44 which is dimensioned to closely fit within the end of the outer tube 30, and into the enlarged cylindrical chamber portion 40 of the cyclone separator 11. This end cap assembly 14 is similarly laterally spaced from the inlet port 36. The outer periphery of the end plate 46 extends beyond the outer diameter of the cylindrical main body portion 44 with a peripheral circumferential lip 48 projecting from the end plate 46 to fit over the outside of the outer tube 30 when the end cap assembly 14 is fitted to the outer tube 30 to secure the end cap to the outer tube 30. An inner circumferential surface of the lip 48 and corresponding outer surface of the outer tubular body 30 may be threaded to secure the end cap assembly 14 to the outer tube 30. Alternatively a close interference fit between the lip 48 and outer tubular body, or other arrangement, can be used to secure the end cap assembly 14 to the outer tube 30. Towards the

end plate end of the end cap assembly 14 there are a series of internal ribs 17 which project radially from the inside of the cylindrical main body 44. There are also radially extending vanes 18 located and extending from the centre of the cylindrical main body 44. In this embodiment there are four internal ribs and four vanes, although it will be appreciated that different numbers of ribs and vanes and different configurations of ribs and/or vanes could be employed.

[0027] In operation to build up sufficient velocity of the moist air to form a cyclone, volute 12 is provided with a fan 15 immediately upstream of the cyclone separator 11, which is also driven by motor 4. The moist air passing down the duct 10 in the direction of arrow A is driven by the fan 15 in the tangential direction B, and sets up a cyclonic swirling motion C in the cyclone separator 11. The swirling motion passes down the cyclone separator 11 so that fluff builds up at the lefthand end as seen in Figure 3. The internal ribs 17 and vanes 18 of the end cap assembly 14 prevent the collected fluff from revolving with the cyclone air. The cap 14 is periodically removed by the user for cleaning out the fluff. The cap 14 is transparent (but need not be) to make the amount of collected fluff visible from the exterior of the dryer 2. The cyclonic airflow C passes down the outside wall of inner tube 32, which can if desired be conical, within the annular space 34 before exiting through slots 16 in the inner tubular body 32 and exhausting from the rear of the machine D to the outside atmosphere. The slots 16 are disposed circumferentially around the inner cylindrical body 32 and open out radially such that for the air to exit the separator 11 the airflow must flow radially inwardly through the slots 16 and into the inner tube 32 and thence axially (as shown towards the right) along the inner tube 32. The fluff, having a greater mass, is directed radially outwards and axially along the separator 11 (as shown towards the left) by the swirling cyclonic air flow and away from the slots 16 and outlet and in the opposite direction the exhausted air leaving the separator 11. The slots 16 are kept clear of fluff by the swirling air of the cyclone passing over its surface.

[0028] Among the advantages of the dryer described are that the operating efficiency is enhanced due to combined use of the blowing fan 5 and the sucking fan 15 and improved fluff capture. Furthermore the blowing fan 5 which is located upstream of the drum 11 and is not susceptible to fluff deposition, provides the main consistent flow of drying air through the drum whilst the sucking fan 15, whilst assisting in providing airflow through the drum, principally provides and adds an increased velocity to the moist air entering the separator 11. In this manner the main fan 5 can be optimized for maximum flow efficiency whilst the sucking fan 15 can be designed to avoid deposition of fluff with efficiency being less important since the main flow is generated by the main fan 5. Also, there is no mesh filter which would throttle the airflow. The airflow is never impeded by the fluff, resulting in more consistent lower air tem-

peratures throughout the drying cycle and consistent thermostat operations.

[0029] The vanes 18 and ribs 17 in the end cap assembly 14 also ensure that the collected fluff does not block the outlet slots 16 or downstream ducts and that collected fluff is better retained. This again improves the performance of the cyclone separator 11.

[0030] The internal configuration of the cyclone separator 11 also provides improved separator performance as compared to previous proposals. In particular the lateral spacing of the removable end cap 14 from the slots 16 of the inner tubes 32, and lateral spacing of the inlet port 36 from the slots 16, enhances cyclonic flow and reduces the possibility of fluff impeding or being entrained in the air leaving the separator through the slots 16.

[0031] The method of removing the fluff is straightforward. The fluff is easily tipped out of the cyclone separator, whereas it is less easy to peel fluff off a mesh filter. Further, the receiving space in the cap assembly 14 holds more fluff than the surface of the mesh, hence less frequent cleaning is required.

[0032] The duct 4 feeding the moist air to the cylinder 10, the banjo-shaped 9 is of simple construction.

[0033] Of course, variations may be made without departing from the scope of the invention.

[0034] Thus, referring to Figure 6, the outer periphery of the inner tube 32 may be provided with a spiral-shaped profile and a projecting spiral vane 19 to help convey the air to the front of the cyclone (at the front of the dryer) in a cyclonic manner and to promote an enhanced cyclonic air flow.

[0035] Referring to Figure 7, in an alternative version of the cyclone, a barrier 20 is provided between the flow of fluff-entrained air leaving the drum, and the fan 15, to prevent any possible fluff build-up on the blades of the fan 15. The fan is turned around compared to Figure 2 and sucks air E from inside the dryer instead of from the drum, and blows this air tangentially into the cyclone along with the air A from the drum which is propelled by the rear fan 5. This air flow E from the fan 15 entrains the air for flow A from the duct 10 increasing the velocity of the combined airflow into the separator. This serves to reduce the chances of fluff being deposited on the barrier 20 itself, or of fluff from clogging the fan 15 with the fan being protected from the fluff laden moist airflow A from the drum by the barrier 20.

[0036] Alternatively, the fan 15 may be specially chosen so that it is self-cleaning, to avoid fluff build-up.

[0037] As described the motor 4 is responsible for rotating the drum 1 and for driving the fans 5 and 15. If desired, a separate single directional motor may be used to drive the cyclone fan 15. This would be advantageous in some designs of dryer in which the drum reverses periodically to prevent the clothes tangling in the drum. A single stage cyclone separator has been described, and this may well be sufficient for dryers vented to the outside atmosphere. Nevertheless, a two or more

stage cyclonic separator could be provided, in the manner of two or more stage cyclonic separators used in vacuum cleaners such as in EP-A-0 018197 and EP-A-0 042723.

[0038] While the illustrated dryer is rear-venting, the design could be adapted to a front-venting dryer.

Claims

1. A tumble dryer comprising a rotating drum (1) into which a load is placed, a heater (7), a fan (5) for conveying a stream of dry heated air heated by the heater (7) through drum (1), and a cyclone separator (11) for removing fluff from the stream of drying air leaving the drum (1);

characterized in that the fan (5) is upstream of the drum (1) and **in that** the dryer further comprises a second fan (15) downstream of the drum (1) and upstream of the cyclone separator (11) to increase the velocity of the drying air entering the cyclone separator (11).

2. A tumble dryer as claimed in Claim 1, in which the cyclone separator (11) has a removable portion (14) accessible from the front of the dryer to permit disposal of fluff.

3. A tumble dryer as claimed in Claim 1, in which the cyclone separator (11) comprises:

a cylindrical outer housing (30);
an inner tube (32) coaxially located within the outer housing (30) and extending part way into one end of the outer tube (32) to define an annular space (34) there between at that one end of the cyclone separator (11), the inner tube (32) also defining an outlet duct (31) from the separator (11);
an inlet port (36) in the outer tube (32) opening into the annular space (34) between the inner tube (32) and outer housing (30); and
an end cap assembly (14) closing off the opposite end of the outer tube (30) and cyclone separator (11).

4. A tumble dryer as claimed in Claim 3 in which the end cap (14) comprises a cylindrical portion (44) which fits within the outer housing (30) of the cyclone separator (11) and within which fluff is in use collected.

5. A tumble dryer as claimed in claim 3 or 4 in which the end cap (14) is removable and comprises a removable portion of the cyclone separator (11) accessible from the front of the dryer to permit disposal of fluff.

6. A tumble dryer as claimed in Claim 2 or Claim 5, in which the removable portion (14) is at least partially transparent so that fluff build-up is visible from outside the tumble dryer.

7. A tumble dryer as claimed in Claim 2 or 5 or 6, in which the removable portion (14) has projecting surfaces (17,18) to prevent the collected fluff from revolving with the cyclone air.

8. A tumble dryer as claimed in Claim 7 in which the projecting surfaces comprise radially projecting ribs (17) or vanes (18).

9. A tumble dryer as claimed in claim 2 or any one of Claims 5 to 8, in which the removable portion (14) is laterally spaced from the opening (36) of a duct (12) through which drying air leaving the drum (1) is directed.

10. A tumble dryer as claimed any preceding claim, in which the cyclone separator (11) is arranged to receive drying air tangentially.

11. A tumble dryer as claimed in any preceding claim, in which a barrier (20) is provided to shield the second fan (15) from the flow of air (A) from the drum (1), and in that the second fan (15) draws in and directs a further separate flow of air (E) which is directed to entrain and combine with the air (A) leaving the drum (1) to thereby increase the velocity of air (A) leaving the drum (1) as it enters the cyclone separator (11) as a combined air stream (B+E).

12. A tumble dryer as claimed in any preceding claim in which an outer periphery of the inner tube (32) includes a projecting spiral vane (19) which spirals around the circumference of and long at least part of the length of the inner tube (32).

13. A tumble dryer comprising a rotating drum (1) into which a load is placed, a heater (7), a fan (5) for conveying a stream of dry heated air though drum (1), and a cyclone separator (11) for removing fluff from the stream of drying air leaving the drum (1); the cyclone separator (11) comprising a cylindrical outer housing (30), an inner tube (32) coaxially located within the outer housing (30) and extending part way into one end of the outer housing (30) to define an annular space (34) there between at that one end of the cyclone separator (11), and an inlet port (36) in the outer housing (30) opening into the annular space (34) between the inner tube (32) and outer housing (30);

characterized in that an outer periphery of the inner tube (32) includes a projecting spiral vane (19) which spirals around the circumference of and along at least part of the length of the inner tube

(32).

14. A tumble dryer comprising a rotating drum (1) into which a load is placed, a heater (7), a fan (5) for conveying a stream of dry heated air heated by the heater though drum (1), and a cyclone separator (11) for removing fluff from the stream of drying air leaving the drum (1); the cyclone separator (11) comprising a cylindrical outer housing (30), an inner tube (32) coaxially located within the outer housing (30) and extending part way into one end of the outer housing (30) to define an annular space (34) there between at that one end of the cyclone separator (11), and an inlet port (36) in the outer housing (30) opening into the annular space (34) between the inner tube (32) and outer housing (32);

characterized in that within the outer housing (30) there are inwardly projecting surfaces (17,18) to prevent the collected fluff from revolving with the cyclone air.

15. A tumble dryer as claimed in claim 14 further comprising a removable end cap assembly (14) removably fitted to the outer housing (30) and closing off an end of the outer housing (30), and within which the inwardly projecting surfaces (17,18) comprise internal ribs (17) or vanes (18) of the end cap assembly (14).

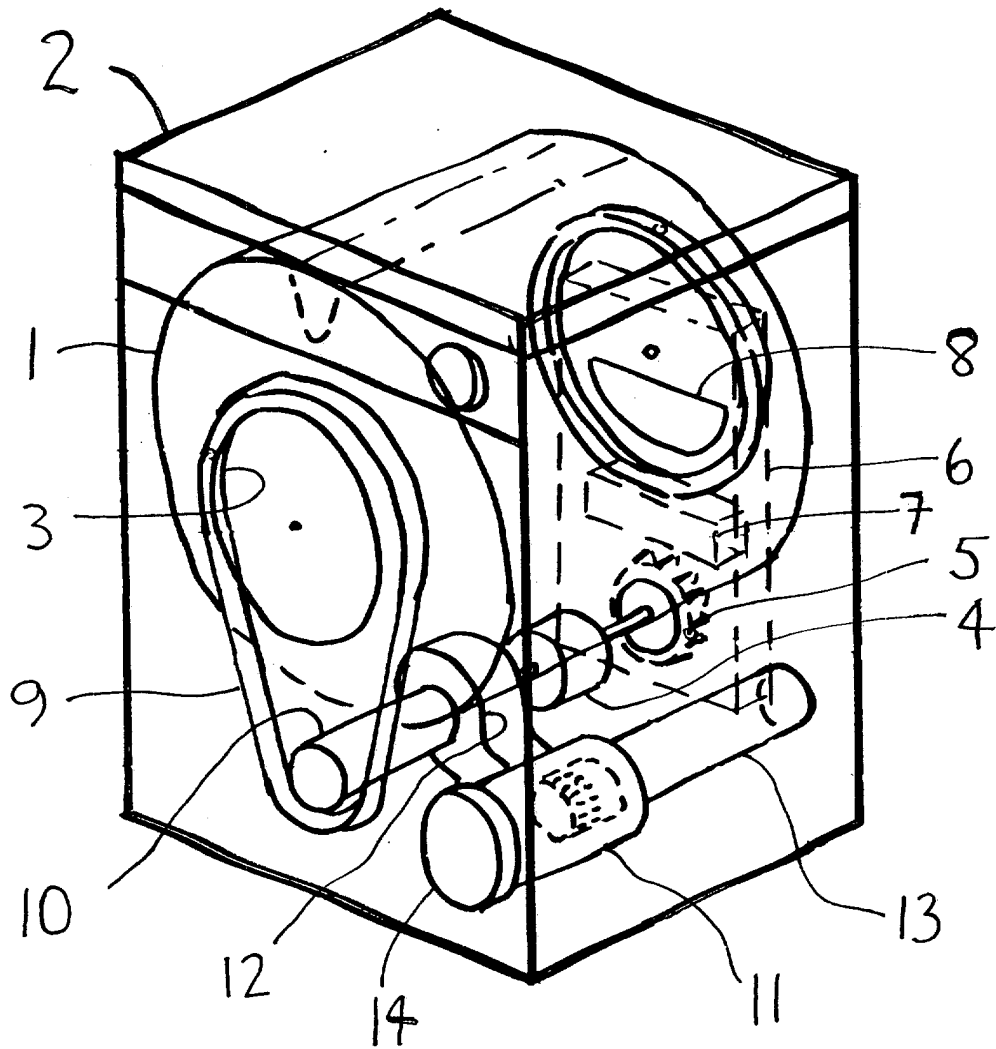


FIG 1

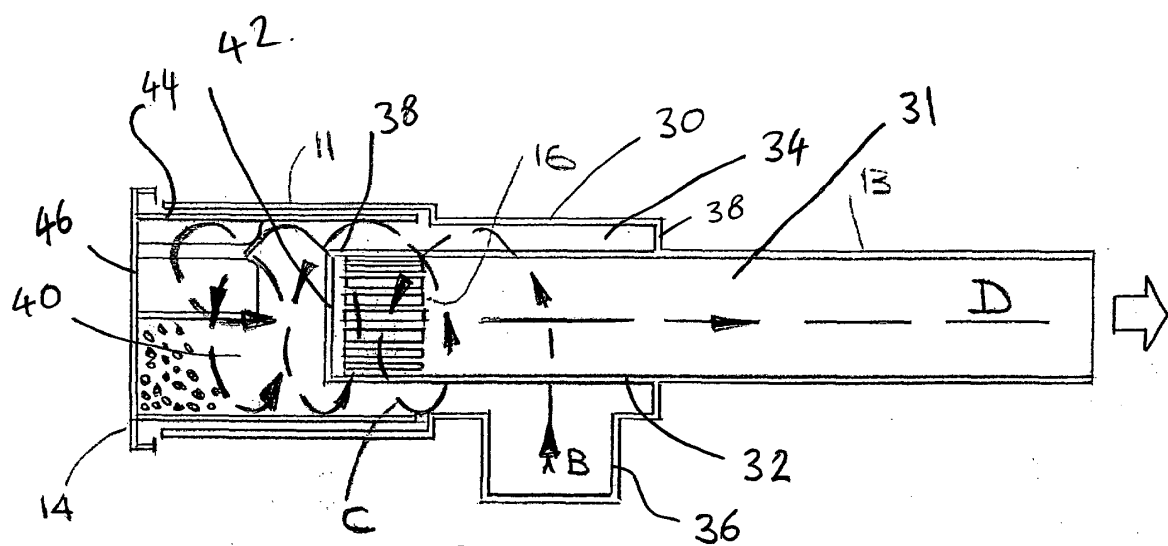


FIG 3

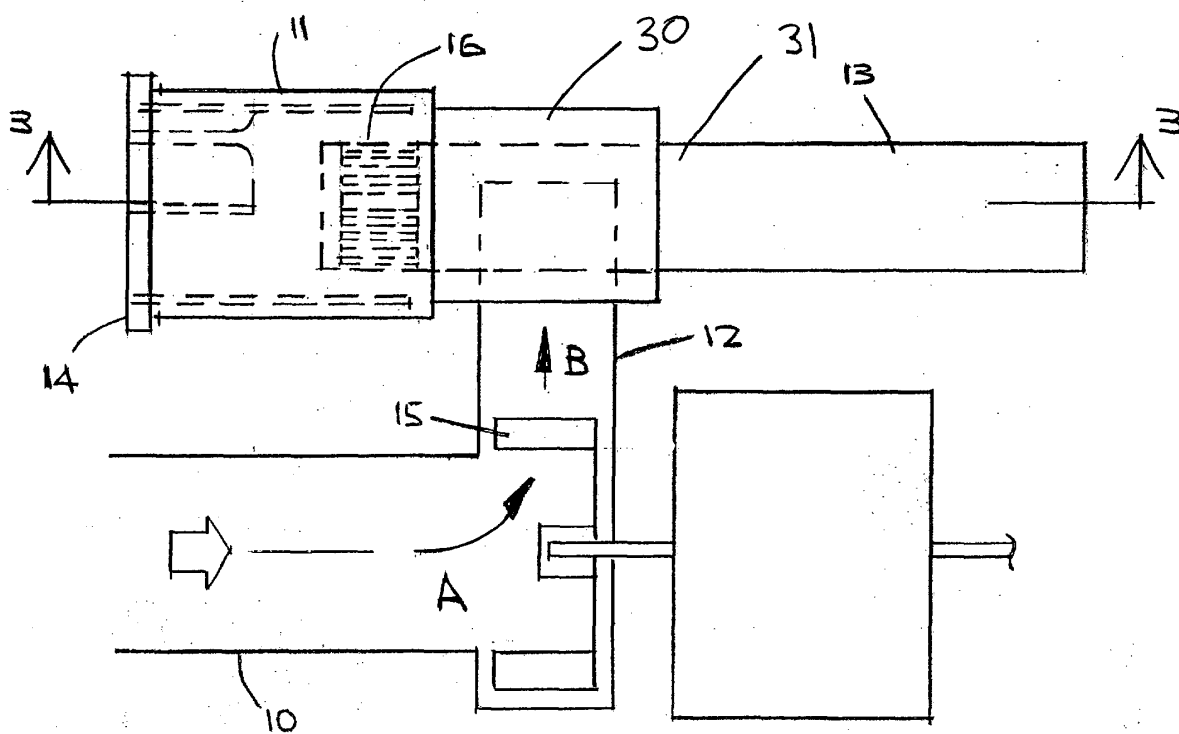


FIG 2

