The invention relates to apparatus for holding a roller of a surface cleaning assembly of the type used to remove contamination from a work piece. The apparatus comprises a hollow shaft (10) having an outer surface adapted to engage and rotate a roller. The hollow shaft (10) is mountable on an axle (14) (which is fixed axially) and axially moveable thereon. Formations (18, 20) are provided on the outer surface of the axle (14) and the inner core surface of the hollow shaft (10) respectively to define first and second volume variable chambers (A, B). The apparatus operates by alternately pressurising and depressurising the first chamber (A) with a fluid to cause the hollow shaft (10) to oscillate axially on the axle (14) as the pressure-volume ratios of the respective chambers (A, B) attempt to equalise.
Apparatus for Holding a Roller

The present invention relates to apparatus for holding a roller of a surface cleaning assembly and particularly, but not exclusively, to apparatus for holding an adhesive roller that oscillates axially with respect to a corresponding cleaning roller in order to prevent the circumferential accumulation of adhesive and particulate material at a position thereon corresponding to a lateral edge of the cleaning roller.

Surface cleaning apparatus employing cleaning and adhesive rollers is known. Such apparatus operates by providing a cleaning roller with a surface of relatively low tackiness that contacts an adhesive roller of relatively high tackiness, the respective rollers being arranged parallel to one another and contacting each other over at least part of their length. As a web or sheet material (hereinafter referred to as a work piece) is conveyed over the surface of the cleaning roller, particulate material is removed, in order that the cleaning roller remains effective over a period of time, the removed particulate material is transferred to, and retained by, the adhesive roller during rotation of the respective rollers. Commonly, the work piece to be cleaned is conveyed through the nip of at least two opposed cleaning rollers which simultaneously remove particulate material from its opposing surfaces.

An important factor in improving production line efficiency is the minimising of downtime. A feature of surface cleaning apparatus of the type described above is that periodic removal of the cleaning and adhesive rollers is necessary. For example, the adhesive rollers need to be removed in order to remove saturated exterior layers and expose underlying fresh areas of adhesive.
in order to facilitate quick and easy loading and removal of an adhesive roller, it is known to mount its hollow core on a rotatable shaft having selectively inflatable lugs. The lugs frictionally engage the inner surface of the core during operation of the surface cleaning apparatus and, when deflated, facilitate disengagement and removal of the roller from the rotatable shaft.

A particular problem with adhesive rollers is that adhesive and particulate material can accumulate in a linear fashion around its circumference thus necessitating its premature replacement. Such accumulation of adhesive and particulate material arises because the adhesive roller is longer than the cleaning roller and because each lateral edge of the cleaning roller repetitiously contacts the adhesive roller along the same circumferential line of contact. Accordingly, a portion of adhesive and the particulate material is progressively forced out laterally away from the nip of the respective rollers. The resulting gradual loss of adhesive from those lateral portions of the adhesive roller which contact the cleaning roller results in a reduction of its productive lifetime, and the build up of edge contamination may reduce the overall cleaning efficiency of the apparatus.

According to the present invention there is provided apparatus for holding a roller of a surface cleaning assembly comprising: an axle having an outer surface; and a hollow shaft having an inner core surface and an outer surface adapted to be engageable and rotatable with the core of a roller; the hollow shaft being mountable on said axle and axially moveable thereon; formations being provided on the outer surface of the axle and the inner core surface of the hollow shaft respectively, each adapted to sealingly engage the other of said surfaces; said formations and corresponding surfaces defining first and second volume-variable chambers; wherein the apparatus is adapted such that alternate fluid
pressurisation and depressurisation of the first chamber causes the hollow shaft to oscillate axially on the axle, thereby changing the volume ratios of the respective chambers.

Preferably, the axle and the hollow shaft are substantially cylindrical and the first and second chambers are substantially annular.

Preferably, the diameter of the axle is less than the diameter of the inner core of the hollow shaft.

Preferably, the formation provided on the outer surface of the axle is circumferential and extends radially towards the inner core surface of the hollow shaft.

Preferably, the formation provided on the inner core surface of the hollow shaft is circumferential and extends radially towards the outer surface of the axle.

Preferably, the first and second chambers are separated by the formation provided on the outer surface of the axle.

Preferably, the first and second chambers are connected by a first fluid communication passage.

Preferably, a non-return valve provided in the first fluid communication passage allows selective fluid flow from the first chamber into the second chamber.

Preferably, the first fluid communication passage is formed in the wall of the hollow shaft.
Preferably, a second fluid communication passage is formed in the axle and connects the first chamber to an external fluid supply.

Preferably, the outer surface of the hollow shaft is provided with one or more inflatable lugs adapted to selectively engage and disengage the core of a roller.

Preferably, the or each inflatable lug is inflatable by means of an external fluid supply.

Preferably, a third fluid communication passage is provided between the second chamber and the or each inflatable lug.

Preferably, a non-return valve is provided in the third fluid communication passage allowing fluid to selectively flow from the second chamber into the or each inflatable lug.

Preferably, the fluid is air.

Preferably, the rate of pressurisation and depressurisation of the first chamber is controllable to provide a desired rate of oscillation of the hollow shaft on the axle.

Preferably, the volume of the first chamber is less than that of the second chamber.

Preferably, a splined connection is provided between the axle and the hollow shaft.
Preferably, the axle and the hollow shaft rotate together about a common axis.

Preferably, the rotational and oscillating movement of the hollow shaft is adapted to occur simultaneously.

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

Fig. 1 is a cross-sectional side view of the apparatus showing the relative positions of the first and second shafts after pressurisation of the first chamber; and

Fig. 2 is a cross-sectional side view of the apparatus showing the relative positions of the first and second shafts after depressurisation of the first chamber.

As illustrated in Figs. 1 and 2, the surface cleaning apparatus of the present invention comprises a hollow shaft 10 provided with inflatable lugs 12 on its outer surface. When inflated, the lugs 12 engage the core of an adhesive roller such that the hollow shaft 10 and the adhesive roller rotate together. The lugs 12 may be inflated by an external fluid supply (not shown) which connects to an inflation valve 13 on the hollow shaft 10. The fluid may be any suitable gas, such as air, or any suitable liquid.

The hollow shaft 10 is mounted on an axle 14 by means of a splined connection 16. The splined connection 16 allows relative axial movement of the shaft 10 and axle 14 whilst preventing their relative rotation. The axle 14 is provided with an enlarged diameter portion 18 which sealingly engages the inner core surface of the hollow shaft 10 around its entire
inner circumference during the axial movement. Similarly, the hollow shaft 10 is provided with an annular flange 20 which extends inwardly from its inner core and sealingly engages the outer surface of the axle 14 around its entire outer circumference during the axial movement.

Taken together, the inner surface of the hollow shaft 10, the outer surface of the second shaft 14, the enlarged diameter portion 18 and the annular flange 20 define first and second volume variable chambers A, B. The initial volume of chamber A (as shown in Fig. 1) is approximately 50% of that of chamber B. The respective chambers A, B are annular in shape and connected by a first fluid communication passage 22 formed in the wall of the hollow shaft 10. The first fluid communication passage 22 has a non-return valve 24 (check valve) which permits fluid flow into the second chamber B. The chambers A, B are separated within the hollow shaft 10 by the enlarged diameter portion 18. The first chamber A is connected to an external fluid supply (not shown) by means of a second fluid communication passage 26.

A third fluid communication passage 28 is provided in the wall of the hollow shaft 10 between the second chamber B and the inflatable lugs 12 in order to provide a secondary or alternative means of inflating the lugs 12. The third fluid communication passage 28 has a non-return valve 30 (check valve) which permits the fluid into the inflatable lugs 12.

In use, the hollow shaft 10 is inserted into the core of an adhesive roller (not shown). For ease of insertion, the inner diameter of the adhesive roller is greater than the outer diameter of the hollow shaft 10. Before the surface cleaning apparatus can be operated, the lugs 12 are inflated with the fluid such that they increase the diameter of the hollow shaft 10 and
frictionally engage the core of the adhesive roller to allow the hollow shaft 10 and the adhesive roller to rotate together.

Inflation of the lugs 12 may be carried out manually by connecting an external fluid supply to the inflation valve 13. A secondary or alternative means of inflation is discussed further below. Removal of the adhesive roller is facilitated by deflation of the lugs 12 until they disengage from the inner surface of the core of the roller.

Once an adhesive roller is loaded onto the hollow shaft 10, pressurised fluid from the external source (not shown) is introduced into the first chamber A through the second fluid communication passage 26. When the apparatus is used for the first time the pressurised fluid passes through the first fluid communication passage 22 and the non-return valve 24 into the second chamber B which has approximately twice the initial volume of the first chamber A.

Subsequent pressurisation of the first chamber A causes the volume of the first chamber A to increase and the volume of the second chamber B to decrease as the pressure-volume ratios of the respective chambers A, B attempt to equalise in accordance with Boyle's Law. The increasing volume of the first chamber A causes the hollow shaft 10, and therefore the adhesive roller, to move axially to the left (as illustrated in Fig. 1) whilst both the hollow shaft 10 and the axle 14 simultaneously rotate about the longitudinal axis of the axle 14.

Once the movement of the hollow shaft 10 reaches the desired extent, the pressurised air is evacuated from the first chamber A by allowing it to equalise with atmospheric pressure. Loss of air from the second chamber B is prevented by means of the non-return valve 24 in the first fluid
communication passage 22. Accordingly, the volume of the second chamber B expands in accordance with Boyle's Law.

The increasing volume of the second chamber B causes the hollow shaft 10, and therefore the adhesive roller, to move axially to the right (as illustrated in Fig. 2) whilst both the hollow shaft 10 and the axle 14 simultaneously rotate about the longitudinal axis of the axle 14.

The pressurisation and depressurisation of the first chamber A completes one axial oscillation of the hollow shaft 10 and the cycle is repeated. In view of the fact that the non-return valve 24 prevents the loss of air from the second chamber B, subsequent pressurisation of the first chamber A will not open the non-return valve 24 unless any minor leakage has occurred within the second chamber B (discussed further below).

It will be appreciated that the simultaneous oscillation and rotation of an adhesive roller will prevent localised linear accumulation of adhesive and debris around its circumference. This is because the lateral edges of the cleaning roller do not continuously contact the adhesive roller along the same circumferential line of contact. Instead, the point of contact of the lateral edges of the cleaning roller on the adhesive roller is continually changing during oscillation of the adhesive roller. Advantageously, the effective lifetime of the adhesive roller is prolonged because the adhesive on the surface of the roller is spread over a larger area.

The rate of the axial oscillations may be controlled by controlling the timing, rate and extent of pressurising and depressurising the first chamber A. Indeed, the apparatus can be adapted such that the pressure-volume ratios of the respective chambers A, B do reach an equilibrium state whereby the hollow shaft 10 ceases to move in the axial
direction at the end of each axial movement to the left or right. Alternatively, the apparatus can be adapted such as to prevent any pausing of the axial movement between the axial movements to the left and right.

A further feature of the present invention allows the second chamber B to provide a secondary or alternative means of inflating the lugs 12. As discussed above, the lugs may be inflated by means of the inflation valve 13. For example, should there be any minor leakage of fluid from the lugs 12, the non-return valve 30 will open to allow fluid to flow through the third communication passage 28 and into the lugs 12 to compensate for any loss of pressure. Consequently, the resulting loss of pressure within the second chamber B will result in the non-return valve 24 opening to allow a replenishing flow of fluid from the first chamber A.

A further advantage of the present invention is that, if the apparatus is left idle for an extended period of time with the result that the fluid pressure in chamber B and/or in the lugs has been lost, the supply of fluid into chamber A will inflate chamber B and the lugs 12 automatically before oscillation commences.

Moreover, in the event that the lugs 12 suffer a serious fluid leak, the hollow shaft 10 would disengage from the core of the adhesive roller and the surface cleaning apparatus would cease to operate. Accordingly, if the leak is of a significant magnitude, the hollow shaft 10 will stop oscillating which will prevent the problem from escalating and warn the operator of a problem.

The invention therefore provides a mechanically simple solution to edge contamination at low cost.
Modifications and improvements may be made without departing from the scope of the present invention. For example, the invention may be adapted to oscillate the cleaning roller instead of, or in combination with, the adhesive roller.

Mechanical limit stops may be employed to limit the range of axial movement of the hollow shaft 10. Alternatively, programmable positional and/or pressure sensors may be employed to control the timing of the pressurising and depressurising of the first chamber A.
1. Apparatus for holding a roller of a surface cleaning assembly comprising:
   an axle having an outer surface; and
   a hollow shaft having an inner core surface and an outer surface adapted to be engageable and rotatable with the core of a roller;
   the hollow shaft being mountable on said axle and axially moveable thereon;
   formations being provided on the outer surface of the axle and the inner core surface of the hollow shaft respectively, each adapted to sealingly engage the other of said surfaces;
   said formations and corresponding surfaces defining first and second volume-variable chambers;
   wherein the apparatus is adapted such that alternate fluid pressurisation and depressurisation of the first chamber causes the hollow shaft to oscillate axially on the axle, thereby changing the volume ratios of the respective chambers.

2. Apparatus as claimed in claim 1, wherein the axle and the hollow shaft are substantially cylindrical and the first and second chambers are substantially annular.

3. Apparatus as claimed in claim 2, wherein the diameter of the axle is less than the diameter of the inner core of the hollow shaft.

4. Apparatus as claimed in any preceding claim, wherein the formation provided on the outer surface of the axle is circumferential and extends radially towards the inner core surface of the hollow shaft.
5. Apparatus as claimed in any preceding claim, wherein the formation provided on the inner core surface of the hollow shaft is circumferential and extends radially towards the outer surface of the axle.

6. Apparatus as claimed in claim 4, wherein the first and second chambers are separated by the formation provided on the outer surface of the axle.

7. Apparatus as claimed in any preceding claim, wherein the first and second chambers are connected by a first fluid communication passage.

8. Apparatus as claimed in claim 7, wherein a non-return valve provided in the first fluid communication passage allows selective fluid flow from the first chamber into the second chamber.

9. Apparatus as claimed in claim 7 or 8, wherein the first fluid communication passage is formed in the wall of the hollow shaft.

10. Apparatus as claimed in any of claims 7 to 9, wherein a second fluid communication passage is formed in the axle and connects the first chamber to an external fluid supply.

11. Apparatus as claimed in any preceding claim, wherein the outer surface of the hollow shaft is provided with one or more inflatable lugs adapted to selectively engage and disengage the core of a roller.

12. Apparatus as claimed in claim 11, wherein the or each inflatable lug is inflatable by means of an external fluid supply.
13. Apparatus as claimed in claim 11 or 12, when dependent on any of claims 7 to 10, wherein a third fluid communication passage is provided between the second chamber and the or each inflatable lug.

14. Apparatus as claimed in claim 13, wherein a non-return valve is provided in the third fluid communication passage allowing fluid to selectively flow from the second chamber into the or each inflatable lug.

15. Apparatus as claimed in any preceding claim, wherein the fluid is air.

16. Apparatus as claimed in any preceding claim, wherein the rate of pressurisation and depressurisation of the first chamber is controllable to provide a desired rate of oscillation of the hollow shaft on the axle.

17. Apparatus as claimed in any preceding claim, wherein the volume of the first chamber is less than that of the second chamber.

18. Apparatus as claimed in any preceding claim, wherein a splined connection is provided between the axle and the hollow shaft.

19. Apparatus as claimed in any preceding claim, wherein the axle and the hollow shaft rotate together about a common axis.

20. Apparatus as claimed in any preceding claim, wherein the rotational and oscillating movement of the hollow shaft is adapted to occur simultaneously.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. B08B7/00 F16C13/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

B08B B41F F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search: 29 September 2006

Date of mailing of the international search report: 09/10/2006

Name and mailing address of the ISA/Authorized officer:

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See patent family annex.

Form PCT/ISA/210 (second sheet) (April 2005)
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