(12) UK Patent Application (19) GB (11) 2 106 020 A

(21) Application No **8226261**
(22) Date of filing **15 Sep 1982**
(30) Priority data
(31) **305716**
(32) **25 Sep 1981**
(33) **United States of America (US)**
(43) Application published **7 Apr 1983**
(51) **INT CL**[3] **B24D 13/02** **A46D 1/00**
(52) Domestic classification **B3D** 1C **A4K** FA **U1S** 1660 A4K B3D
(56) Documents cited **GB 1480673** **GB 1456693** **GB 1274508** **GB 1063911**
(58) Field of search **B3D**
(71) Applicants **Avco Corporation, (USA-Delaware), 1275 King Street, Greenwich, Connecticut 06830, United States of America.**
(72) Inventors **Anthony V. Forte, Kenneth E. Walker.**
(74) Agents **Stanley Popplewell Poole, 57 Lincoln's Inn Fields, London, WC2A 3LS.**

(54) Deburring method and apparatus

(57) A deburring method and apparatus is presented wherein a cylindrical brush 10 rotationally contacts a workpiece. The brush 10 includes a mandrel 12 having a central axle to provide support during use. To the mandrel 12 is attached a multiplicity of long bristles 14. Each bristle 14 is flexible and has impregnated therein a plurality of abrasive particles 94,96. The population density of the bristles 14 on the brush 10 is such that the outwardly-extending ends can readily flex both in the plane of rotation and sidewise along the lengthwise dimension of the brush 10. Setting the brush 10 so that the bristle ends overlap the surface of the workpiece being deburred, each bristle makes a slapping contact therewith. This results in 2.5 to 5 cm (1 to 2 inches) of each bristle 14 being dragged endwise across the surface of the workpiece. The endwise movement of each bristle 14 causes the abrasive particles imbedded therein to abrade the sharp edges of the workpiece. An automatic conveyor may be used to feed workpiece stock past the rotating brush at a predetermined rate.

FIG. 1

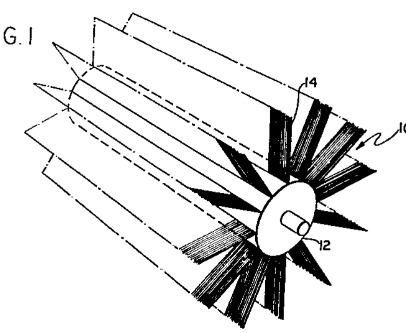
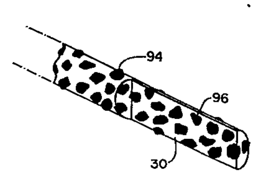


FIG. 7



The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

GB 2 106 020 A

2106020

1/3

FIG. 1

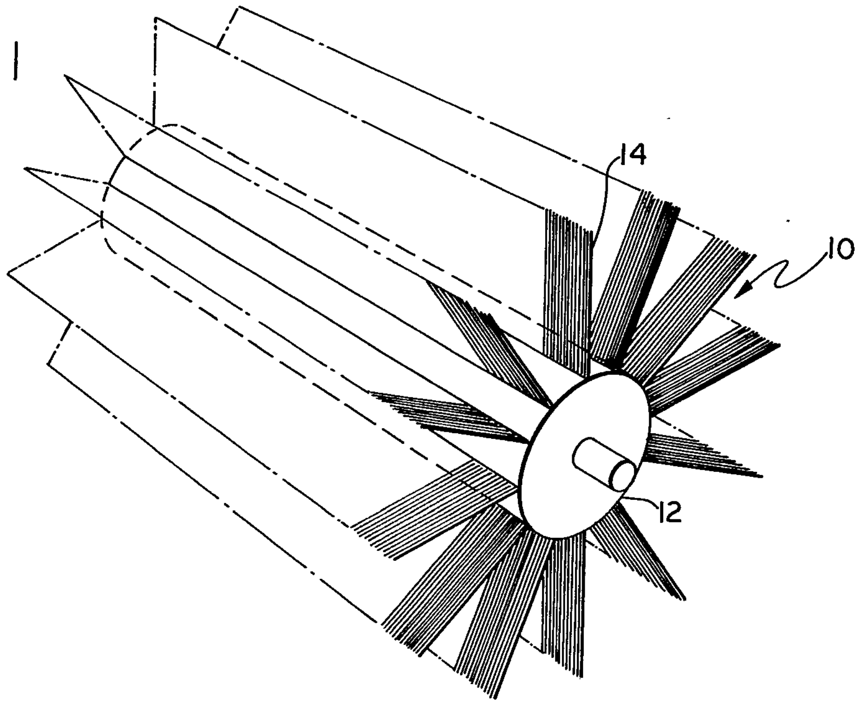


FIG. 2

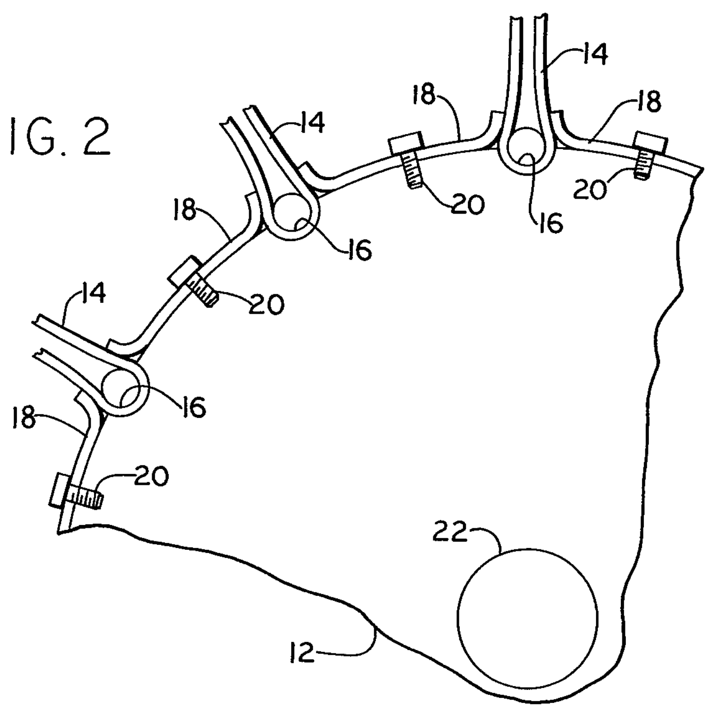


FIG. 3

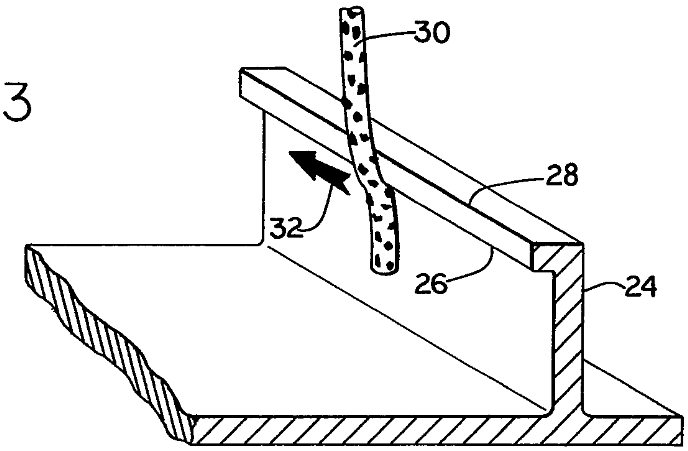


FIG. 4

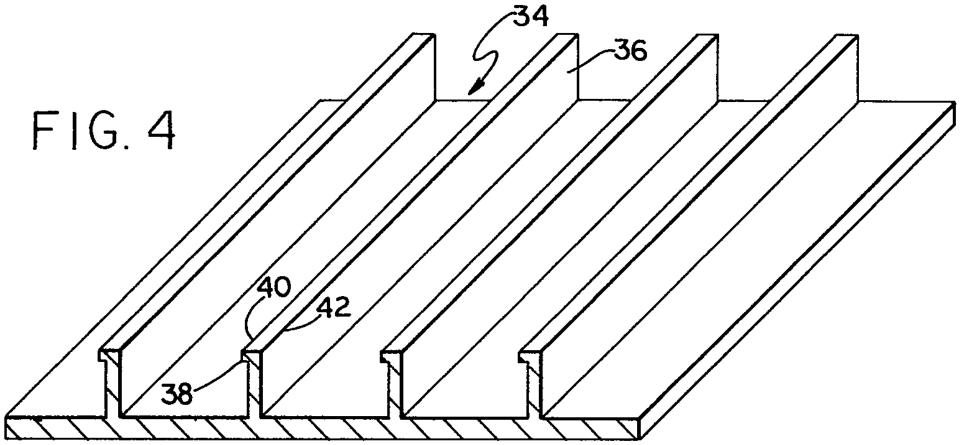


FIG. 5

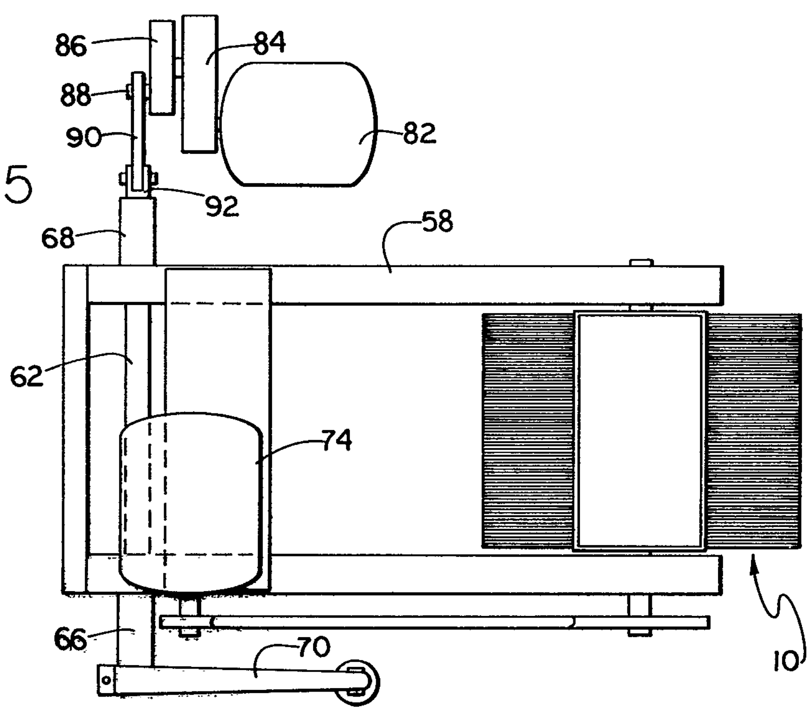


FIG. 6

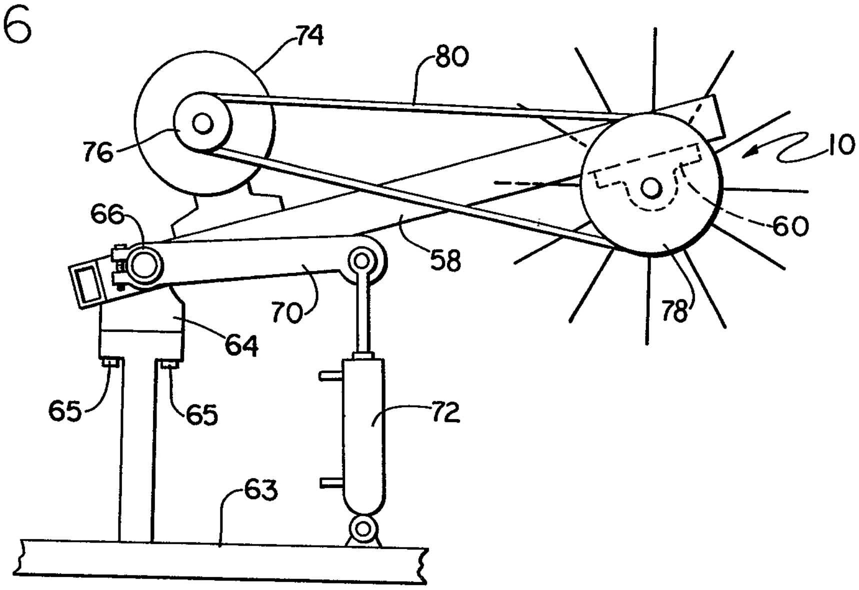


FIG. 7

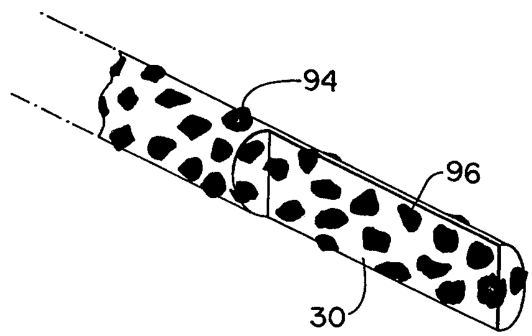
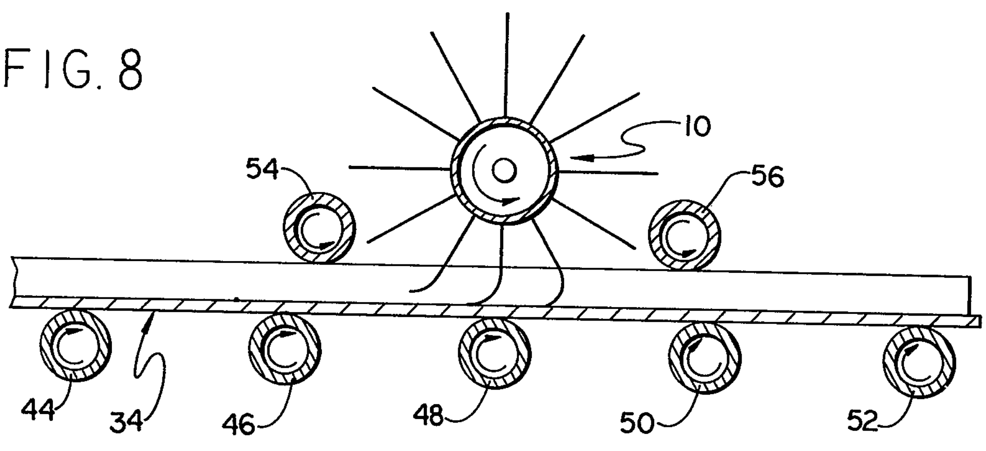


FIG. 8



SPECIFICATION

Deburring method and apparatus

The present invention relates to a method of deburring and apparatus therefor.

A deburring method and apparatus is disclosed which is particularly suited for use with large extrusions which have been shaped to size by multiple spindle milling machines.

Several automated deburring systems exist in the prior art. U.S. Patent No. 4,280,304 discloses a method for deburring workpieces by the combined operations of finishing by rotary tools and gyro-finishing. U.S. Patent No. 4,275,529 discloses a rotative abrasive flap wheel which has been used as a deburring tool in some of the prior art systems.

The general status of the art is presented in the book, *Deburring Technology for Improved Manufacturing* authored by LaRoux K. Gillespie and published by the Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, Michigan 48128, copyright 1981. This text discloses deburring methods used either separately or in combination including: viration with abrasive media, composite wheels driven by electric or air motors, flap wheels of the type disclosed in U.S. Patent No. 4,275,529, buffing with Scotch-Brite pads and use of hand-held routers and similar cutters.

Many of the methods described in the text were tried. None seemed adaptable to automation in a system capable of handling the various part shapes and sizes present in an aerospace manufacturing facility. It was then discovered that there was an extruded fiber available which consisted of a nylon resin impregnated with abrasive granules. We then determined that this abrasive fiber could be made into a large diameter brush which, when rotated at proper speeds in contact with the workpiece, did a satisfactory job of deburring.

One aspect of the present invention provides apparatus for deburring a workpiece, comprising: a generally cylindrically-shaped mandrel adapted to be mounted for rotation; a multiplicity of flexible fibres, each of said fibres being attached to said mandrel, the attachment means forming the fibres into bristles which extend generally radially outward from said mandrel to form thereby a generally cylindrical-shaped brush, each of said flexible fibres being impregnated with abrasive particles; said bristles being attached to said mandrel at preset intervals, said mandrel having spaces wherein it is free of said bristles; means for rotating said cylindrical-shaped brush; and means for positioning said cylindrical-shaped brush in contact with a said workpiece to thereby accomplish deburring.

The invention further provides an apparatus for deburring a workpiece, comprising: a generally cylindrically-shaped brush mounted for rotation on its axis, said brush comprising a multiplicity of elongate, radially-extending flexible fibres, each of said flexible fibres being impregnated throughout with abrasive particles, the population density of said bristles being low, whereby the outer ends of said bristles are free to flex both axially and in the plane of rotation; and means for rotating said cylindrically-shaped brush, said brush being positioned so that a said workpiece is contacted by said bristles at a location inward from said outer ends, and whereby the bristles lap the surface of the workpiece, each bristle making an initial slapping contact with said workpiece.

The deburring means of this invention preferably utilizes a cylindrically-shaped rotating brush having long bristles. The bristles consist of flexible fibres which have impregnated therein abrasive particles. Both aluminum oxide and silicon carbide impregnated bristle fibres can be used to carry out the principles of the invention. Use of a conveyance device is found to enhance the deburring of machined parts as they pass beneath the rotating brush.

On aim is to have a brush with long flexible fibres. The population density of fibres on the brush should be such that the outwardly extending ends can readily flex both axially and in the plane of rotation. The goal is to have each brush fibre slap against the sharp edge of the workpiece. Due to brush rotation, the fibres, after making a slapping contact with the workpiece, are dragged endwise across the surface. With abrasive particles embedded in each fibre, the endwise movement of the fibres creates a rasp-like action which abrades the sharp edges of the workpiece. By using a large diameter brush having long flexible fibres extending therefrom, changes in workpiece contour can be accommodated.

It has been found advantageous to rotate the brush at a relatively slow speed so that the abrasive impregnated fibres are dragged over the surfaces to be deburred at rates of about 900 to 1200 metres (3000 to 4000 feet) per minute (for example 600 rpm times π D where D equals a 51 cm (20-inch) diameter brush). Secondly, it was found beneficial to cyclically move the brush back and forth endwise over a span of several inches. This assures that the bristle fibres of the rotating brush always have some motion which is operating crosswise to the edges present on the face of the workpiece. Typical endwise oscillatory motion of the brush is 30 to 50 cycles per minute. For a 56 cm (22-inch) diameter brush rotating at 600 to 700 rpm and oscillating back and forth endwise some 3 inches, it has been found that large aluminum extrusions can be deburred when passed under the abrasive fibres at a feed rate of 3 feet per minute. Aluminum oxide abrasive particles embedded in 40 mil diameter fibres were used in the above implementation.

An automatic conveyor unit may be used which includes switches for starting and sequencing events. To use the system, an operator feeds a piece of machined stock into the input end of the deburring equipment. The automatic conveyor then takes over with switches turning on means for positively transporting the stock to be deburred under the rotating brush. The conveyor advances the stock at a constant rate under the rotating brush while at the same time supporting it in a steady fashion.

The invention will be further described by way of example with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a cylindrical-shaped brush configured according to one aspect of the invention;

Figure 2 is an enlarged partial end view of the mandrel of the brush of Figure 1 showing one method of attaching abrasive fibres;

Figure 3 depicts an abrasive fibre in contact with a sharp edge of a workpiece;

Figure 4 is a perspective view of a typical aerospace extrusion which has been milled ready for deburring;

Figure 5 is a top view of a unit assembly for driving brush of Figure 1;

Figure 6 is an end view of the assembly of Figure 5;

Figure 7 is a cutaway view of an abrasive fibre for use in the brush of Figure 1;

Figure 8 is a side view of the conveyor showing in simplified form how a workpiece can be transported beneath a revolving brush of Figure 1;

Figure 1 shows a brush 10 forming an embodiment of one aspect of the invention. Brush 10 consists of a mandrel 12 which carries a multiplicity of rows of abrasive impregnated fibres 14. In the example shown, the diameter of mandrel 12 is approximately 5.25 cm (6 inches), and the fibres 14 extend outward about 20.3 cm (8 inches) from the mandrel, thereby producing a cylindrical brush that has an overall diameter of 55.8 cm (22 inches). The length of mandrel 12 is 45.7 cm (18 inches). The fibres making up each row of bristles consists of 45 mil diameter DuPont Tynex A nylon impregnated with aluminum oxide according to Product Code 9336-0406. There are 780 bristles used per 45.7 cm (18-inch) row, and the brush contains 12 rows of bristles. Other brushes might be assembled using different diameter fibres. For example, DuPont Tynex A is available in either aluminum oxide or silicon carbide abrasive particle impregnation with several choices of fibre diameters ranging from 20 to more than 100 mils. The composition of the material to be deburred will regulate the choice of fibre diameter and abrasive selected. For example, aluminum extrusions can be deburred with aluminum oxide abrasive whereas it may be preferable to deburr steel millings with silicon carbide impregnated fibres.

Figure 2 shows on method of attaching the abrasive fibres to mandrel 12. 40.6 cm (16 inch) lengths of DuPont Tynex A are bent in the middle so as to encircle dowel rods 16 which extend the length of mandrel 12. A multiplicity of clamping plates 18 secured to mandrel 12 by screws 20 hold the fibre/dowel combination in place while maintaining the brush bristles in a generally erect condition. This mounting arrangement is intended as being only exemplary, and bristles secured to the mandrel by other means would function equally well. In making test brushes, some were made by potting the bristles in grooves cut in the mandrel.

The finished brush 10 is configured to be rotatably mounted on mandrel axle shaft 22. The brush 10 can then be rotatably driven so that the bristles overlap the sharp edges of the workpiece.

Figure 3 shows a fragmentary view of a milled extrusion 24 having sharp edges 26 and 28 which are to be deburred. One bristle 30 from the Figure 1 brush 10 is shown in contact with milled edges 26 and 28. It is assumed that the mandrel to which bristle 30 is attached turns so as to move the bristle in the direction shown generally by arrow 32. Thus due to rotation of the brush mandrel, bristle 30 extending therefrom is dragged sidewise along edges 26 and 28 removing materials from the workpiece with a sort of rasping action due to the abrasive particles impregnated into the flexible bristle fibre.

Figure 4 shows a cross-sectional perspective view of a typical extrusion 34 which has been successfully deburred by an implementation of the invention. Each strut 36 has three sharp edges 38, 40 and 42 which must be deburred as it is delivered from the cutting mill. A conveyance arrangement is incorporated to move the Figure 4 extrusions under the rotating brush. A cross-sectional side view of a suitable conveyor is shown in Figure 8. Extrusion 34 is shown supported on a plurality of parallel rollers 44, 46, 48, 50 and 52. Rollers 46 and 50 are driven, and rollers 44, 48, and 52 are undriven, but free to turn on their respective axes. Topside rollers 54 and 56 are each pivotally mounted for rotation on arms which allowed rollers 54 and 56 to make contact with the uppermost side of extrusion 34. Air pistons (not shown) are used to actuate arms which bring rollers 54 and 56 into contact with the uppermost side of extrusion 34. Rotating brush 10 carries out the deburring of the extrusion by being able to span the entire width of the milled section at one time. Arrows show the direction of rotation of both the rollers and the brush. A series of even-sequencing switches controls all steps in the operation. The surfaces of rollers 44, 46, 48, 50, 52, 54 and 56 are covered with neoprene or equivalent to ensure that the workpiece being deburred is not scratched or scuffed. Rollers 46 and 50 are driven so as to provide a feed rate through the system of approximately 3 feet per minute.

Figures 5 and 6 show top and side views of an assembly to actuate brush 10. There is a generally U-shaped subframe 58 to which brush 10 is rotatably attached by means of bearing mounts 60. The base end of the subframe is supported by stub shaft 62. Stub shaft 62 is secured to the main frame 63 of the machine by bolts 65 which are attached to mounting support 64. The U-shaped subframe 58 is attached to stub shaft 62 by means of sleeve bearings 66 and 68. Crankarm 70 is clamped to the exterior surface of sleeve bearing 66. The second end of crankarm 70 is attached to the piston rod of air cylinder 72 whose base is rotatably attached to main frame 63. As may be seen in Figure 6, operation of air cylinder 72 serves to raise and lower brush 10. In the Figure 8 system, the air cylinder 72 shown in Figure 6 is programmed to lower brush 10 into a position where it contacts the workpiece with an overlap of at least an inch by the bristle ends.

Figures 5 and 6 also depict a brush drive by first motor 74 which is secured to subframe 58 by appropriate bolts. Pulley 76 on the shaft of first motor 74 and pulley 78 on the shaft of brush 10 are properly sized so that drive belt 80 rotates brush 10 at the desired speed. Brush 10 is preferably driven at a speed of between 600 and 700 rpm. For a 55.8 cm (22-inch) diameter brush whose bristles overlap the workpiece by at least 2.5 cm (1-inch), this means the surface speed of the bristles on the workpiece is 1000 to 1175 metres (3300 to 3850 feet) per minute.

In addition to rotation of brush 10, it has been found advantageous to simultaneously move brush 10 endwise in an oscillatory manner. Oscillatory endwise motion is accomplished by use of second motor 82 (See Figure 5) which is secured to frame 63 (not shown). A down-geared transmissiion 84 attached to the output shaft of second motor 82 provides an output to flywheel 86 having an eccentric drive 88 for oscillatory movement of pitman arm 90 whose first end is attached thereto. The second end of pitman arm 90 is rotatably secured by bolt means to a pair of brackets 92 secured to and extending outwardly from sleeve bearing 68.

Rotation of motor 82 thus causes subframe 58 to move back and forth by an amount equal to twice the offset of eccentric drive 88. Oscillatory motion of subframe 58 moves brush 10 endwise back and forth causing each brush bristle 30 to have a bidirectional component of motion. Rotational rate of motor 82 and the step-down ratio of transmission 84 are preferably combined to provide an endwise oscillatory motion of brush 10 equalling 30 cycles per minute.

Figure 7 is an enlarged view of one of the brush bristles 30 showing a cutaway of the interior. On the left abrasive particles 94 extend through the surface of the nylon resin. In the cutaway portion on the right, abrasive particles 96 are shown to be impregnated throughout the interior of the bristle fibre. This means that as the resinous material wears away during the deburring action, abrasive material will continue to make contact with the workpiece.

While the invention has been disclosed using a brush having long bristles composed of nylon fibres impregnated with abrasive particles, the use of nylon fibres is intended only as being exemplary. Use of other materials can be considered as within the scope of the invention. The prime criteria is to use a somewhat flexible material which is both wear-resistant and capable of having impregnated therein abrasive particles of a size and hardness factor which will cause deburring of the specified workpiece.

While only a single embodiment of the invention has been presented, various modifications will be apparent to those skilled in the art. For example, both the brush length and the length of the bristles thereon may be changed to fit operating conditions.

CLAIMS

1. Apparatus for deburring a workpiece comprising:

a generally cylindrically-shaped mandrel adapted to be mounted for rotation;

a multiplicity of flexible fibres, each of said fibres being attached to said mandrel, the attachment means forming the fibres into bristles which extend generally radially outward from said mandrel to form thereby a generally cylindrical-shaped brush, each of said flexible fibres being impregnated with abrasive particles; said bristles being attached to said mandrel at preset intervals, said mandrel having spaces wherein it is free of said bristles;

means for rotating said cylindrical-shaped brush; and

means for positioning said cylindrical-shaped brush in contact with a said workpiece to thereby accomplish deburring.

2. Apparatus as claimed in claim 1 further comprising means for oscillatory endwise movement of said cylindrical-shaped brush while it is in contact with a said workpiece.

3. Apparatus as claimed in claim 2 wherein the oscillatory movement is at a rate between 30 and 60 times per minute.

4. Apparatus as claimed in claim 1, 2 or 3 wherein the cylindrical-shaped brush has a diameter in excess of 50 cm (20-inches).

5. Apparatus as claimed in claim 4 wherein the means for rotating said brush includes provision rotating said brush at between 600 and 700 rpm.

6. Apparatus as claimed in any one of claims 1 to 5, wherein the fibres from which said bristles are formed are 40 mil or greater diameter nylon impregnated with aluminum oxide abrasive particles.

7. Apparatus as claimed in any one of claims 1 to 5, wherein said bristles are impregnated throughout with silicon carbide abrasive particles.

8. Apparatus as claimed in any one of claims 1 to 7, wherein the means for attaching said bristles to said mandrel comprises dowel rods secured to said mandrel by clamping plates which extend the length of the brush.

9. Apparatus as claimed in any one of claims 1 to 8, wherein the brush comprises a 15 cm (6-inch) diameter mandrel having secured thereto 12 rows of bristles, the density of bristles in each row being such as to provide 780 bristles per row for a 46 cm (18-inch) long brush.

10. Apparatus as claimed in any one of claims 1 to 9, wherein the flexible fibres are of substantially equal length.

11. Apparatus as claimed in any one of claims 1 to 10, wherein said fibres are impregnated throughout with abrasive particles.

12. An apparatus for deburring a workpiece, comprising:

a generally cylindrically-shaped brush mounted for rotation on its axis, said brush comprising a multiplicity of elongate, radially-extending flexible fibres, each of said flexible fibres being impregnated throughout with abrasive particles, the population density of said bristles being low, whereby the outer ends of said bristles are free to flex both axially and in the plane of rotation; and

means for rotating said cylindrically-shaped brush, said brush being positioned so that a said workpiece is contacted by said bristles at a location inward from said outer ends, and whereby the bristles lap the surface of the workpiece, each bristle making an initial slapping contact with said woripiece.

13. Apparatus as claimed in claim 12, further comprising means for imparting a first and second component of motion between said bristles and said workpiece.

14. Apparatus as claimed in claim 13 or 14, wherein the linear velocity of the bristle ends is in the range of from 900 to 1200 metres (3000 to 4000 feet) per minute.

15. Apparatus as claimed in claim 12, 13 or 14, wherein said bristles are formed of nylon fibres impregnated with aluminum oxide abrasive particles.

16. Apparatus as claimed in claim 12, 13 or 14, wherein said bristles are nylon fibres impregnated with silicon carbide abrasive particles.

17. A generally cylindrically-shaped brush adapted for rotation on its axis, said brush comprising a multiplicity of elongate, radially-extending flexible fibres, each of said flexible fibres being impregnated throughout with abrasive particles, the population density of said bristles being low, whereby the outer ends of said bristles are free to flex both axially and in the plane of rotation when said brush is rotated on said axis in contact with a workpiece and when said bristles make contact at a location inward from said outer ends.

18. Apparatus for deburring a workpiece, substantially as hereinbefore described with reference to the accompanying drawings.

19. A brush for use in deburring a workpiece, substantially as hereinbefore described with reference to the accompanying drawings.

20. A method of deburring a workpiece, comprising positioning the workpiece relative to a rotating brush which has flexible fibres mounted thereon, the fibres being impregnated with abrasive particles, to cause the fibres to lap the workpiece.

21. A method of deburring a workpiece, substantially as hereinbefore described with reference to the accompanying drawings.

22. The features hereinbefore disclosed, or their equivalents, in any novel combination.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1983.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.