United States Patent

[11] 3,596,406

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Continuation-in-part of application Ser. No. 710,993, Mar. 6, 1968.

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[54] **SONIC POLISHING APPARATUS**
6 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **51/7,** 51/163, 51/313
[51] **Int. Cl.** **B24b 19/00,** B24b 31/00, B24b 1/00
[50] **Field of Search** ..... 51/7, 163, 313—317

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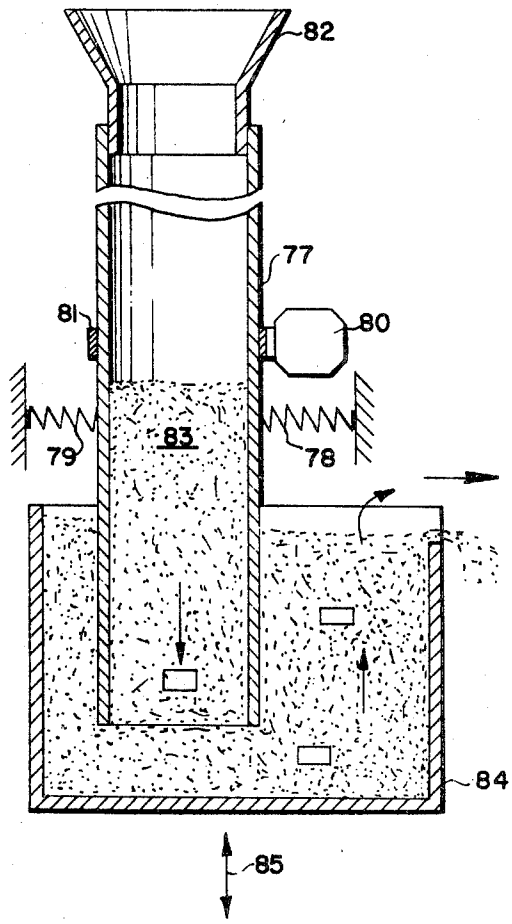
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ABSTRACT: Method and apparatus for improving the rate of surface treatment of industrial parts being treated in a continuous flow sonic finishing apparatus by adjusting the pressure exerted by the treating medium on articles being treated as they pass through the treating chamber.



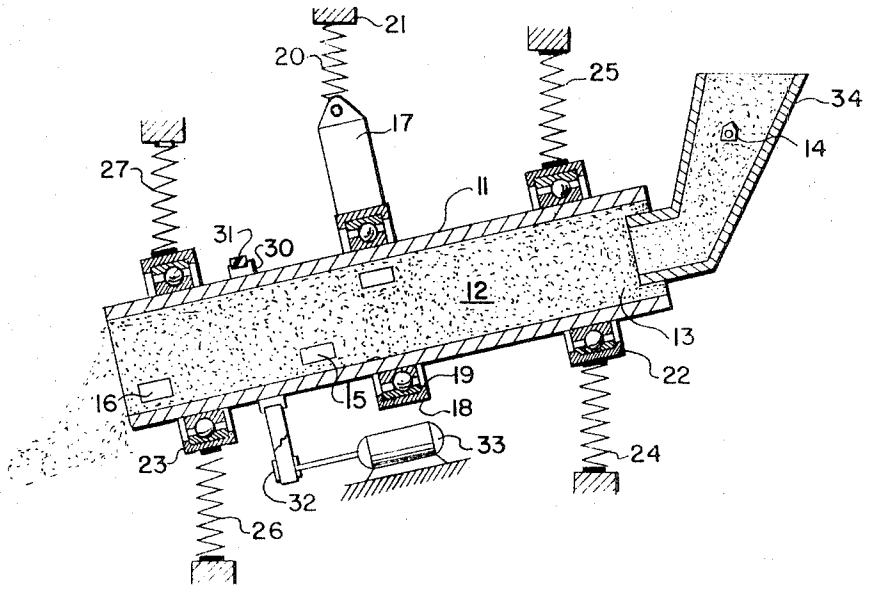


FIG. 1

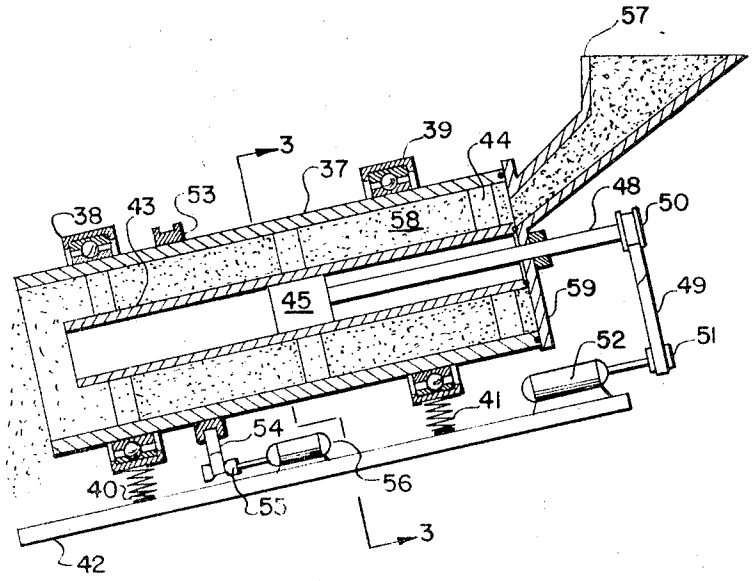


FIG. 2

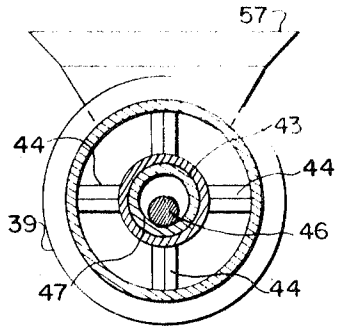


FIG. 3

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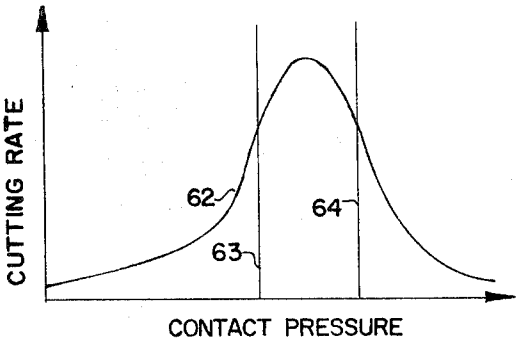


FIG. 4

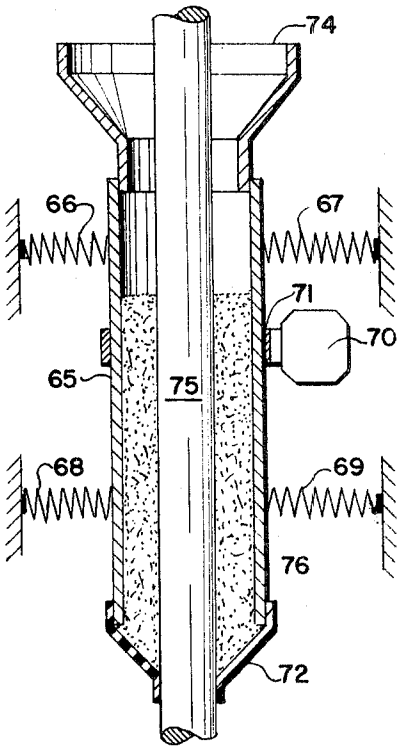


FIG. 5

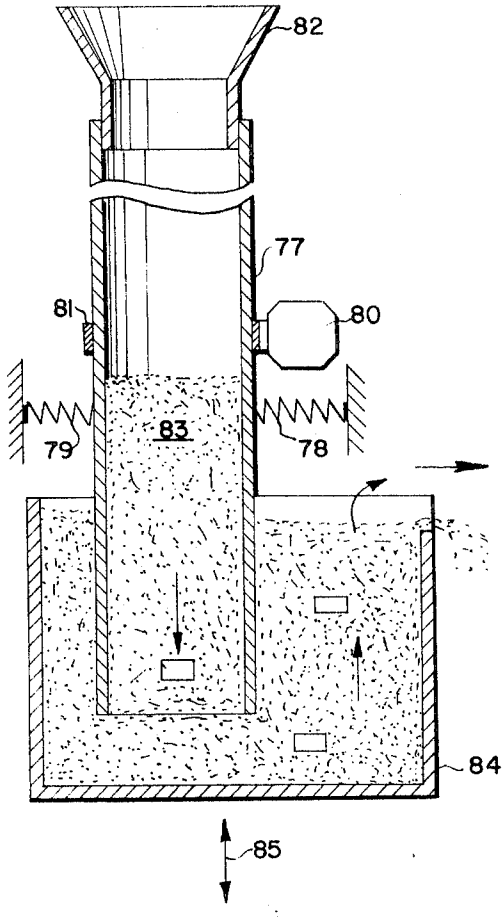


FIG. 6

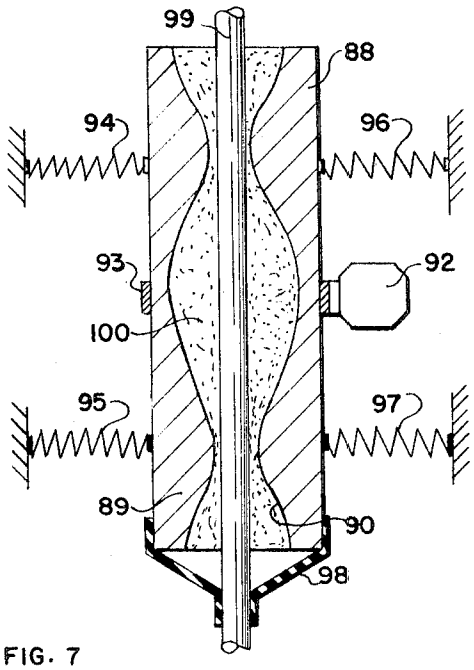


FIG. 7

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SONIC POLISHING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of my copending application Ser. No. 710,993, filed Mar. 6, 1968.

BACKGROUND OF THE INVENTION

The present invention relates to the art of sonic finishing of industrial parts and pertains more particularly to improved methods and apparatus for improving the rate of finishing of industrial parts in a continuous flow process.

One of the problems associated with production of industrial parts and articles is the surface treatment of these parts either as a final finish or in preparation for further finishings. Such treatments include cleaning, deburring, polishing, pitting, etc. It has been disclosed in the inventor's copending application Ser. No. 710,993, filed Mar. 6, 1968, an apparatus for the sonic treatment of such articles and parts in a continuous flow process. The above-identified application discloses a sonic finishing apparatus having a sonic finishing chamber in the form of a conduit through which a flow of parts and finishing medium flow in intimate contact as sonic energy is applied thereto.

It has now been discovered that in the above and other types of finishing processes in which a finishing medium is forced to move against or across the surfaces of the article or part to be finished, the contact pressure of the finishing medium against the surfaces of the article is critical to the rate of finishing obtained. I have found that within this critical range the rate of surface treatment increases at a dramatically rapid rate to many times the normal rate and then it falls off very rapidly as soon as this range is passed. Prior art treating or finishing devices do not recognize this critical range of pressure and therefore do not provide for the adjustment of this pressure to within the critical or optimum range.

It is therefore a primary object of the present invention to provide improved methods and apparatus for the sonic treating and finishing of industrial parts and articles.

It is a further object of the present invention to provide improved methods and apparatus to increase the rate of sonic finishing of articles of manufacture.

It is still another object of the present invention to provide apparatus for improving the rate of sonic surface treatment of industrial parts by adjusting the surface contact pressure between the treating medium and the part being treated.

SUMMARY OF THE INVENTION

In my invention I preferably employ an elastic resonant transmission system for transmitting sonic energy or vibrations from a sonic oscillator into a finishing medium. Such a system typically employs an elastic member coupling the sonic oscillator to the finishing chamber. In my system I preferably employ an elastic-walled finishing chamber to which is directly coupled the sonic oscillator. Such a resonant vibratory system is closely analogous to a resonant AC circuit such that when tuned to its resonance frequency, energy is most efficiently delivered to the load in which the resonant system is coupled. A suitable discussion of this analogy may be found in chapter 2 of *Sonics*, by Hunter and Bolt, published in 1955 by John Wiley and Sons.

In accordance with one aspect of my invention I utilize centrifugal force to increase the pressure applied by the finishing medium against the surface of articles or members or articles to be finished.

In accordance with another aspect with my invention I utilize flow restriction means downstream from the finishing chamber to aid in the establishment or adjustments of pressure head formed such as by means of a column of combined finishing medium and articles upstream from the finishing chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and additional objects and advantages of the present invention will be evident to those skilled in the art from the following detailed description when read in conjunction with the accompanying drawings in which:

FIG. 1 is a side elevational view, partially in section, of a first embodiment of the present invention;

FIG. 2 is a side elevational view, partially in section, of a second embodiment of the present invention;

FIG. 3 is a view in section taken along line 3–3 of FIG. 2;

FIG. 4 is graphical illustration of the effect of medium pressure on finishing rates;

FIG. 5 is an elevational view, partially in section, of a third embodiment of the present invention;

FIG. 6 is a side elevational view, partially in section, of a third embodiment of the present invention;

FIG. 7 is an elevational view, partially in section, of a further embodiment of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings and in particular to FIG. 1 there is illustrated an elongated elastic conduit member **11** forming a finishing chamber **12** through which a flow of finishing medium **13** and industrial articles or parts **15** and **16** flow in intimate contact. Elastic conduit **11** may be constructed of any suitable elastic material such as steel, fiberglass, or suitable plastic having the required strength and elasticity. A suitable sonic oscillator **17** is operably coupled such as by suitable clamp **18** and bearing means **19** through substantially the center of the elastic conduit member **11**. This bearing means permits rotation of the elastic conduit member **11** with respect to sonic oscillator **17**. Suitable elastic or resilient isolation means **20** anchors the sonic oscillator **17** to a suitable portion of the housing or frame member **21** while permitting compliance therebetween. Elastic member **11** is rotatably journaled in suitable bearing means **22** and **23** which in turn are resiliently supported by suitable resilient means **24**, **25**, **26** and **27** and suitable housing or support member not shown. Suitable drive means for rotating the conduit member **11** comprises a pulley **30** operably coupled to member **11** and suitable coupled by means of a belt **31** and pulley **32** to a suitable variable-speed motor **33**. A suitable hopper or chute **34** provides means for feeding a suitable polishing medium and articles or parts into the system.

Referring now to FIG. 2 there is shown an elongated elastic conduit member **30** designated by the numeral **37** which is suitably rotatably supported in bearing means **38** and **39** which are in turn supported by suitable isolation means such as elastomeric mounts **40** and **41** on base or frame member **42**. A second somewhat smaller elongated elastic member **43** is concentrically mounted, such as by means of radially directed spokelike members **44**, concentrically within the elongated elastic member **37**. A suitable sonic oscillator **45** is mounted within the elongated conduit member **43**. The sonic oscillator **45** may be of any suitable type capable of generating the desired forces within a desired frequency range. One suitable such type oscillator is shown, for example, in U.S. Pat. No. 2,960,314, issued on Nov. 15, 1960 to A. G. Bodine, Jr. Such oscillators generally comprise an eccentric rotor **46** orbitally driven about an internal raceway **47**. In FIG. 2 the sonic oscillator is illustrated as being driven such as by a suitable torque shaft **48** coupled by suitable transmission means, such as belt **49** and pulley **50** and **51**, to a suitable variable speed motor **52**. A suitable transmission system such as a pulley **53** coupled to conduit **37**, belt **54** and pulley **55** operatively coupled to a suitable variable speed motor **56** for rotatably driving the conduit member **37**. Suitable means such as a hopper **57** provides means for feeding articles and finishing medium into the chamber **58** formed between the elongated members **43** and **37**. A suitable end plate **59** closes off the upper end of conduit member **37**.

Illustrated in FIG. 4 is a curve showing cutting rates plotted as against contact pressure for a typical sonic finishing system. The curve 62 undergoes a very dramatic rise within a very narrow contact pressure range to many times the cutting rate at contact pressures above and below this particular range. The optimum cutting or finishing range, as indicated by this curve, would be within an area bounded by line 63, curve 62 and line 64. The lines 62 and 63 represent the narrow optimum contact pressure range for a given system. This pressure range, of course, varies with various systems depending upon the accelerating forces imposed on the medium to move it across and against the face or surface of the parts or articles to be finished.

In FIG. 5 is illustrated a further embodiment of my invention in which a suitable elastic conduit member 65 is suitably supported such as by suitable resilient means 66, 67, 68 and 69 to a suitable frame or housing means not shown. A suitable sonic oscillator 70 is operatively coupled, such as by means of a clamp member 71, to the elastic member 65. Flow-restricting means 72, which may be of any suitable form such as, for example, a rubber or neoprene gate, is attached to the lowermost end of the conduit member 65 to restrict the flow of finishing medium and parts to such a degree that a sufficient head may be built up by the column of medium in the finishing chamber 73 to obtain the optimum contact pressure between the medium and parts or member to be cleaned. This modification is particularly adaptable to the cleaning of elongated articles or members such as rods, pipes, aircraft spars etc. as well as for cleaning small parts. As illustrated, an elongated member 75 is fed through the bore of conduit 65 while a suitable level of finishing medium 76 is maintained. A suitable hopper such as 74 provides suitable means for introducing medium and parts into the chamber 73. The flow-restricting means 72 may preferably be adjustable to provide a suitable steady flow of medium and parts to flow through the chamber 73 to achieve the desired finishing within the minimum amount of time. In addition the flow-restricting means 72 may also be constructed to be controllable to completely cut off the lower end of the member 65 to retain the articles and finishing medium within the chamber 73 for suitable length of time to obtain the suitable finishing and then opened to discharge this combined flow of medium and articles intermittently.

Illustrated in FIG. 6 is a further embodiment of my invention in which a suitable elastic conduit member 77 is suitably supported by resilient means 77 and 78 to frame a base member not shown. A suitable sonic oscillator 80 is coupled by means of a suitable clamp means 81 through the elastic means 77. A suitable hopper or chute 82 provides means for introducing medium and parts or articles into the chamber 83. Suitable flow restricting means in this case in the form of a bin 84 catches the discharged medium and particles from chamber 83 and restricts the flow therefrom to permit sufficient head buildup above the chamber 83 to achieve the desired contact pressure to obtain the optimum finishing rate. The bin 84 is preferably adjustable as indicated by arrow 85 to adjust the flow restriction and thus adjust the head provided by the column of medium and particles in chamber 83 to thereby obtain the optimum contact pressure to achieve the proper finishing rate.

In FIG. 7 is illustrated another embodiment of my invention in which an elastic conduit 88 is formed so as to have flow-restricting passageway 89 below chamber 90 and may also have flow-restricting passageway 91 above chamber 90. This construction with thickened walls in the nodal area serve also to strengthen the walls in areas of high stress. A suitable oscillator 92 is coupled, such as by means of a clamp 93, to conduit 84. Suitable resilient support means 94, 95, 96 and 97 support elastic member 88 and suitable base or frame member not shown. Elastic conduit member 88 is preferably mounted on adjustable means to adjust the angle of tilt which, in combination with the feeding rate adjustment, may be utilized to adjust the head or pressure established by the finishing medium to thereby adjust the contact pressure between the finishing medium and the parts to be finished in chamber 90. Further flow-restricting means in the form of a rubber or neoprene gate 98 may be provided to more closely control the flow of finishing medium therethrough. This modification is also particularly adaptable for the cleaning of elongated articles or members such as aircraft spars, etc. In the illustrated embodiment, as elongated element or member 99 passes through the chamber 90 in intimate contact with a suitable level of finishing medium 100.

Operation

In the operation of the present invention, a charge of finishing medium such as a granular material together with a number of parts to be finished is fed into the finishing chamber with the contact pressure between the finishing medium and the parts adjusted to within the optimum range as sonic energy is applied thereto to activate the finishing material causing the finishing medium to obtain the proper degree of finishing. The above process may be a batch type process. Preferably I have described herein a continuous flow process. The sonic energy is transmitted into the finishing chamber from the sonic oscillator by an elastic transmission system which as indicated herein may be the elastic conduit members serving to form the finishing chamber. Referring more particularly to FIGS. 1 and 2, the sonic oscillator 17 or 45 is operated at a frequency to set up in the elastic conduit member 11 or 37 elastic standing wave vibrations within the resonant frequency range of the system. These elastic standing wave vibrations may be lateral standing wave type or gyratory type. While the elastic standing waves are being generated in the conduit member, the conduit member is being rotated about its axis by the drive system 30–33 in FIG. 1, thus, generating centrifugal forces which increase the pressure of the finishing medium in contact with the parts 15, 16 being finished within the chamber. The centrifugal forces generated are a function of the r.p.m. or angular velocity of the member 11 since the contact pressure in the chamber may be adjusted by regulating the angular velocity of the chamber by means such as a variable-speed motor 33. As pointed out above, the optimum contact pressure for the maximum cutting rate or finishing rate occurs within a very narrow contact pressure range. Thus, if can be readily seen that the above system shown in FIGS. 1 through 3 provides effective means for dynamically adjusting the pressure of the finishing medium or the parts within the finishing chamber.

Referring now to FIGS. 5 through 7, there are shown systems for adjusting the static pressure of the finishing medium on the parts within the finishing chamber. In operation of these systems, an elastic standing wave vibration is set up in the elastic transmission means between the sonic oscillator and the finishing chamber. A batch of parts and finishing medium fed into the sonic finishing chamber remains therein for sufficient residence time as the contact pressure of the medium on the parts is adjusted to within the optimum range to obtain the desired rate and degree of finishing. The adjustment of the contact pressure in these systems is obtained by adjusting a column of the finishing medium above the finishing chamber and thus forming a static head thereabove to obtain the desired or optimum contact pressure to obtain a desired rate and degree of finishing. These systems likewise may be operated as batch type systems, that is, with a batch or charge of finishing medium and parts fed into the chamber treated and then discharged in an interrupted-type process or may be operated as a continuous flow-type process with adjustment of the residence time to obtain the optimum degree of finishing. The flow rates and/or establishment of the head buildup may be regulated by regulating a flow-restriction means as well as regulating the degree of tilt of the elastic tubular member.

Thus, it can be readily seen that I have disclosed an improved method and apparatus for the sonic finishing of industrial parts and articles wherein a combined flow of finishing medium and parts are fed into a sonic finishing chamber with

means provided to adjust the pressure of the finishing medium in the finishing chamber to obtain the optimum rate of finishing of the parts. While I have described my invention with respect to specific embodiments it will be apparent to those skilled in the art that many modifications and changes may be made in the apparatus and its arrangements without departing from the scope of the present invention as defined by the appended claims.

I claim as my invention:

1. A sonic finishing apparatus, said apparatus comprising:
an elastic vessel forming a finishing chamber for containing a combined continuous flow comprising an article to be finished in intimate contact with a finishing medium;
an oscillator operatively coupled to said chamber to transmit vibrations thereto to elastically vibrate said chamber, and;
means to adjust the pressure of said polishing medium on said article to be finished as said article and medium moves through said chamber in a continuous flow.

2. The apparatus of claim 1 comprising mounting means rotatably mounting said finishing chamber; and
said pressure-adjusting means comprises driving means operatively connected to said chamber for rotating said chamber to apply centrifugal force to said polishing medium to thereby adjust the pressure of said medium on said article.

3. The apparatus of claim 1 wherein:
said pressure-adjusting means comprises flow-restricting means to restrict the flow of said article and medium through said chamber to thereby create a column of said medium establishing a head of pressure in said chamber.

4. A method of finishing industrial parts or articles, said method comprising the steps of:
continuously moving a combined flow comprising at least an article along a path in intimate contact with finishing medium;
applying to said combined flow of finishing medium and parts sonic energy in at least a portion of said path;
adjusting the contact pressure of said finishing medium on the surface of said article to a value to yield the optimum finishing rate of said article by said medium as said articles and medium flow therethrough.

5. The method of claim 4 wherein the step of adjusting said contact pressure comprises the step of:
subjecting at least a portion of said combined flow to centrifugal force to thereby increase the contact pressure between said finishing medium and said article.

6. The method of claim 4 wherein the step of adjusting said contact pressure comprises the step of adjusting the height of said flow of medium and article to an optimum height above the region of application of sonic energy thereto.