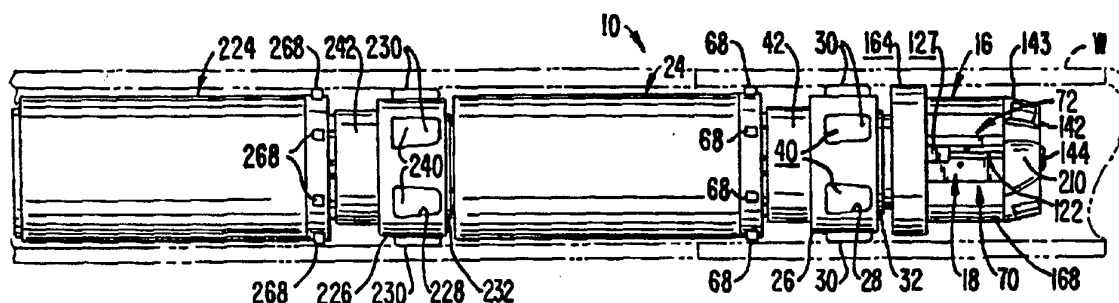




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(54) Title: DUAL ROLLER BURNISHING SYSTEM



(57) Abstract

A tool for boring, skiving, and roller burnishing the interior of a cylindrical workpiece utilizes a dual roller burnishing system incorporated into the tool. The tool includes a drive tube assembly (24-224) which attaches to a drive member for rotating the tool. A boring assembly (142) at the forward end of the tool includes cutting blades (204) oriented to bore the cylinder to a first diameter. A skiving assembly (16) is located rearward of the boring assembly and includes retractable knives (18) for skiving the cylinder to a second diameter greater than the first. A first burnishing roller set (22-30) is provided rearward of the skiving assembly and a second burnishing roller set (222-230) is located rearward of the first roller set, to finish burnishing the cylinder.

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DUAL ROLLER BURNISHING SYSTEM

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FIELD OF THE INVENTION

The present invention provides a tool for boring, skewing and roller burnishing of the interior of a cylindrical workpiece and in particular provides a dual roller burnishing system for such a tool.

10

BACKGROUND OF THE INVENTION

The present invention provides an improved tool and is related to tools described in U.S. Patents 4,574,442; 4,509,885; 4,367,576; and 4,425,693 to Lawrence C. Dickinson and assigned to the assignee of this invention. These patents are incorporated by reference herein for all purposes.

15

The above noted U.S. Patent 4,574,442 contains a description of the prior art relating to rotary skiving and roller burnishing tools. The patent discloses a tool which allows boring, skiving and roller burnishing in a single pass.

20

Specifically, U.S. Patent 4,574,442 provides a single tool which includes means for boring, skiving, and burnishing a cylindrical hole in a single pass. The tool is mounted on one end of a drive shaft and is used for finishing the internal surface of a cylindrical hole by passing the tool through the hole in a forward direction.

25

The means for boring comprises a plurality of cutting teeth fixedly mounted in a cutter head secured to the forward end of the boring, skiving, and burnishing tool of the present invention. The forward end of the tool is the end which first enters the hole being finished. The cutting teeth are mounted to bore out the existing hole to a fixed diameter which is approximately equal to the minimum diameter which can be cut by the skiving blades. Thus, the boring means accomplishes the major portion of the material removal, while the skiving means removes an incremental portion to provide the precise diameter desired.

30

35

The single roller burnishing means burnishes the interior of, typically a cylinder, by engaging said interior surface with a plurality of frustoconical rollers encompassed by a roller cage having a plurality of apertures for receiving
5 said individual rollers. The frustoconical roller race is arranged so that its radius increases in the forward direction, that is the direction in which the tool is moved to polish the interior surface.

The skiving means includes a retractable knife
10 having a knife blade radially movable with respect to the axis of the tool and a push dart which is operatively coupled to the blade so that axial motion of the push dart causes that blade to move radially between an extended and a retracted position.

A common means is provided for actuating both the retractable knife and the roller burnishing means. He means includes a pair of concentric cylinders, one of which is coupled to the push dart and the other of which is coupled to the rollers. The cylinders are reciprocatably mounted within
15 the tool and actuated by a preselected fluid pressure which acts on both pistons simultaneously. In this way, the skiving blade can be extended and the burnishing rollers urged against the interior of the work piece while the tool is in use by applying fluid pressure on the pistons, and both the blade and
20 the rollers can be retracted by bleeding the fluid pressure to allow the tool to be removed from the work piece without scratching or scoring the now polished surface.

SUMMARY OF THE INVENTION

30 The present invention provides an improved tool for boring, skiving and roller burnishing of a cylindrical workpiece and in particular provides a dual roller burnishing system for a tool such as described in U.S. Patent 4,574,442.

In a broad aspect the present invention provides a
35 boring, skiving and roller burnishing tool for mounting on a rotatable drive member to bore, skive and burnish the interior of a cylinder or other workpiece. The tool includes an elongate drive tube assembly having means for attachment to

the drive member. A means is provided for boring the cylinder attached to the drive tube at the forward end thereof. The means for boring includes a plurality of cutting blades oriented to remove material from the cylinder to a preselected diameter as the tool is rotated. A means for skiving the cylinder is attached to the drive tube rearward of the boring means and includes at least one retractable knife capable of removing material from the cylinder at a diameter greater than the preselected diameter as the tool is rotated. A first roller means for burnishing the cylinder is attached to the drive tube rearward of the skiving means and a second roller means for burnishing the cylinder is attached to the drive tube rearward of the first roller means for burnishing the cylinder.

In a more specific aspect, a boring, skiving and roller burnishing tool is adapted for mounting on a rotatable drive member to bore, skive and burnish the interior of a cylinder or other workpiece. The tool includes an elongate drive tube assembly having means for attachment to the drive member. A means for boring the cylinder is attached to the drive tube at the forward end thereof. The means for boring includes a plurality of cutting blades oriented to remove material from the cylinder to a preselected diameter as the tool is rotated. A means for skiving the cylinder is attached to the drive tube rearward of the boring means and includes at least one retractable knife capable of removing material from the cylinder at a diameter greater than the preselected diameter as the tool is rotated. A first means is provided for burnishing the cylinder and is attached to the drive tube rearward of the skiving means. The first roller burnishing means includes a roller race having a central axis coincident with that of the drive tube assembly and a frustoconical outer surface tapering radially outward in the axially forward direction.

A plurality of frustoconically tapered rollers each having a large end and a small end and being arranged about the outer surface with the small ends of the rollers facing forward so that the surface portion of each roller

furthest from the central axis of the roller race is generally parallel to the central axis.

5 A roller cage having a plurality of slots is provided, said roller cage circumscribing and being spaced apart from the roller race so that the slots and the roller race together define a plurality of cavities for receiving individual rollers.

10 A roller pusher having (1) a forward extension which directly engages the rear surfaces of individual rollers when the pusher is moved forwardly relative to the roller race to push the rollers forward and cause the rollers to translate radially outward along the tapered surface of the roller cage, and (2) a lip for directly engaging the roller cage when the pusher is moved rearwardly relative to the roller race to draw
15 the rollers rearward and allow the rollers to translate radially inward.

20 A means are provided for biasing the roller pusher in the forward direction with a preselected force so that the force exerted upon said internal surface of said hole remains constant over a range of sizes of said hole and for retracting the roller pusher when the axial force is reduced to draw the roller cage rearwardly so that the rollers move radially inward and the tool can be withdrawn from the workpiece.

25 A second means for burnishing the cylinder is attached to the drive tube rearward of the first means for burnishing the cylinder. The second burnishing means includes a roller race having a central axis coincident with that of the drive tube assembly and a frustoconical outer surface tapering radially outward in the axially forward direction and
30 a plurality of frustoconically tapered rollers each having a large end and a small end and being arranged about the outer surface with the small ends of the rollers facing forward to that the surface portion of each roller furthest from the central axis of the roller race is generally parallel to said
35 central axis.

A roller cage is also included and has a plurality of slots, said roller cage circumscribing and being spaced apart from the roller race so that the slots and the roller

race together define a plurality of cavities for receiving individual rollers.

A roller pusher having a forward extension for directly engaging the rear surfaces of individual rollers when the pusher is moved forwardly relative to the roller race pushes the rollers forward and causes the rollers to translate radially outward along the tapered surface of the roller cage. A lip directly engages the roller cage when the pusher is moved rearwardly relative to the roller race to draw the rollers rearward and allow the rollers to translate radially inward.

Means are provided for biasing the roller pusher in the forward direction with a preselected force so that the force exerted upon said internal surface of the cylinder remains constant over a range of sizes of the cylinder.

Means are included for retracting the roller pusher when the axial force is reduced to draw the roller cage rearwardly so that the rollers move radially inward and the tool can be withdrawn from the workpiece.

OBJECTS OF THE INVENTION

A particular object of the present invention is to provide a tool for boring, skewing and roller burnishing the interior of a workpiece wherein dual roller burnishing means are used to provide better accuracy and better stability of the tool. Further objects and advantages of the present invention will become apparent from the following detailed description read in view of the accompanying drawings which are made a part of this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional elevation view of the preferred embodiment of the boring, skiving, and roller burnishing tool of the present invention.

FIG. 2 is a side view of the tool of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment 10 of the boring, skiving and roller burnishing tool of the present invention is illustrated generally by way of reference to FIGS. 1 and 2.

5 The tool 10 includes boring means, skiving means and dual roller burnishing means, as will be discussed in detail below, and is mounted to the forward end 11, (i.e., to the right in FIG. 1) of a drive member 12 which drives the tool through the interior of a cylinder or other workpiece W. Most often, the
10 tool 10 of the present invention is used to finish the interior surfaces of a large hydraulic or pneumatic cylinder.

The boring means includes a cutter head 142 mounted on the forwardmost end of the tool 10. The cutter head 142 is a solid disc which is chamfered about the periphery of the
15 forward surface to define chamfer 202. A plurality of cutting blades 204 are mounted on the chamfer, with the cutting edges 206 of the blades oriented in a converging manner. The cutting edges 206 are thus able to accommodate unfinished bore holes having a minimum diameter equal to d in FIG. 1 and a
20 maximum diameter equal to D in FIG. 1. Regardless of the initial diameter, the boring operation will provide a rough bore hole having a diameter equal to D . The cutter head 142 also includes coolant flow and chip extraction grooves 208 formed in the chamfer 202 adjacent each cutting blade 204.

25 The coolant flow and chip extraction grooves 208 direct the material removed by the cutting blades 204 forward of the tool 10 to avoid interference in the skiving and burnishings operation while allowing cooling/lubricating fluid to reach the cutting blades 208. Similar coolant flow and chip
30 extraction grooves 210 are provided in the chamfer 202 immediately forward of each retractable knife 18 in the skiving means (as discussed hereinafter). The extraction grooves 210 direct the material removed by the skiving operation forward of the tool 10 and provide the necessary
35 coolant/lubricant flow to the knives 18.

The skiving means includes a knife support 16 located immediately behind the cutter head 142. The outer peripheral surface 16B of knife support 16 between rear

surface 16A and cutter head 142 is stepped down from surface 16A and a transverse slot 19 is provided in knife support 16 having axial dimensions generally equal to the stepped portion 16B of the knife support. A retractable knife 18 includes first and second knife blade holders 70, 72 extendible radially outwardly in opposite directions within slot 19. Knife holders 70, 72 have centered depressions 146, 147 respectively, and a spring plug 144 threadable engaged in end cap 142 maintains the holders in a centered or near centered position.

The radial movement of knife blade holders 70, 72 is controlled by a push dart 82 riding within a slot 74 in knife blade holder 70 which engages a guide dart 92 fixed to holder 72. A spring 84 biases push dart 82 rearwardly to maintain the knife blade holders in their normally retracted configuration. The push dart 82 actuates the knife blade holders and moves them radially outwardly; the details of the knife holder mechanism will be illustrated in more detail hereinafter.

Knife blade holder 72 has a knife blade and a support having a knife blade supporting surface 127 at its outer extremity. A corresponding knife blade and support are provided at the radial extremity of knife holder 70. When the knife blade holders are actuated and moved radially outwardly, the cutting knife blades and supports extend radially beyond the outer surface 16A of knife support 16 to cut the interior of a workpiece W. When retracted, the knife blades and blade supporting surfaces are radially within peripheral surface 16A and will not contact the interior of workpiece W.

In accordance with the invention a first roller means for burnishing the cylinder is attached to the drive tube rearward of the skiving means. A second roller means for burnishing the cylinder is attached to the drive tube rearward of the first roller means. Means are provided for extending the first roller means and the second roller means against the inside of the cylinder for burnishing the cylinder. Means are also provided for retracting the first roller means and the second roller means so that the first roller means and the

second roller means can move radially inwardly and the tool can be withdrawn from the cylinder.

5 The use of dual roller means for burnishing the cylinder improves accuracy and provides better stability of the tool. Two sets of roller burnishing means provide better support and results in less roller pressure. Horsepower requirements are therefore reduced and the work can be done at reduced cost.

10 In more detail, the dual roller burnishing means involves the first roller burnishing means includes a roller drive 22 which is attached at its forward end to the knife support 16 and at its rear end to a drive tube 24 attachable to the forward end of the second roller burnishing means. A roller cage 26 circumscribes roller drive 22 aft of holder 16. 15 Roller cage 26 has a plurality of apertures 28 (see FIG. 2) accommodating a corresponding plurality of rollers 30. The apertures 28 in cage 26 restrict the movement of rollers 30 while allowing the rollers to rotate and translate to a limited degree in a radial direction.

20 A roller race 32 circumscribes drive 22 beneath roller cage 26. Race 32 has a key 34 engaging a corresponding slot 36 in drive 22 so that the roller race is nonrotatable relative to the drive shaft.

25 Roller race 32 has an inclined outer surface 38 which is frustoconical in section. Surface 38 tapers outwardly in a forward direction. Rollers 30 are also frustoconical in section and have sufficient taper so that the rollers, bearing on surface 38 of race 32, are aligned so that their outer surfaces 40 are parallel to the common central 30 axis 39 of roller drive 22 and drive member 12.

A roller pusher 42 circumscribes drive shaft 22, and also has a key 44 engaging a corresponding slot 46 in drive shaft 22 so that the roller pusher is nonrotatable relative to the drive shaft. Roller pusher 42 has a forward extension 48 35 which bears against the rear surfaces of rollers 30 so that the roller pusher can apply a forward force directly to the rollers. In addition, the forward extension 48 of roller pusher 42 has a lip 49 engaging a corresponding lip 50 on

roller cage 26 so that aft movement of the roller pusher will draw the roller cage rearwardly.

A hydraulic (or pneumatic) piston 52 is located in the interior of drive tube 24. A corresponding plug 54 is also located in drive tube 24 to define a cavity 56 between the plug and piston 52. A bore 58 in plug 54 communicates with a hydraulic or pneumatic fitting 60 which couples to a source of hydraulic or pneumatic fluid (not shown) within the drive member 12.

A plurality of dowel pins 62 emanate from the forward surface 63 of piston 52. Dowel pins 62 threadably engage the roller pusher 42, and a dowel retainer 64 secures the ends of dowel pins 62 near piston 52. A coil spring 66 biases dowel retainer 64 rearwardly so that dowel pins 62 are maintained in contact with the forward surface of piston 52.

Actuation of piston 52 by supplying a fluid through fitting 60 applies a forward force to dowel pin 62 which is transmitted through roller pusher 42 to rollers 30. This force moves rollers 30 up the inclined surface 38 of roller race 32 until the applied force is balanced by the force of the rollers against the interior of the workpiece.

It is readily apparent that rollers 30 will adapt themselves to the actual diameter of the interior of the cylinder, and will apply an equal force throughout a range of diameters depending upon the force applied to piston 52. Moreover, if the interior of the cylinder is undersized, the rollers will merely move a lesser distance up inclined surface 38, and there will be no tendency for the tool to jam in the workpiece. In addition, the fact that dowel pins 62 are not rigidly connected to piston 52 assures that an equal force is applied to all rollers 30, and the system is self-stabilizing and does not require an independent stabilizing mechanism such as nylon pads which contact the inside of the hole which the roller burnishing is taking place.

Piston 52 includes a central bore 55 which serves as a cylinder 55 for an elongate actuator piston 53. The forward end of actuator piston 53 passes through the interior of a bore 130 in roller drive 22. The actuator piston has a raised

shoulder 134 with washer 128 abutting thereagainst to be biased rearwardly by a spring 136 until actuator piston 53 contacts plug 54. A groove 31 is provided in the end of piston 53 abutting plug 54 to allow fluid to pass from bore 58 into cavity 56. When pressurized fluid is supplied through bore 58 to cavity 56, not only does piston 52 move forwardly, but also, when pressure is sufficient, piston 53 moves forwardly as well. The leading end 13 of the actuator piston forces push dart 82 forwardly to actuate the knife blade holders. The forward travel of actuator piston 53 is limited by the abutment of washer 128 against shoulder 35. This insures that piston 53 does not become jammed against knife 18 which would prevent the desirable self-centering action of the knife in slot 19.

A plurality of guide pads 68, which may be nylon, can be provided about the outer circumference of tool 10. Pads 68 have a lesser diameter than knife blades 120, 122 and rollers 30 when the knife blades and rollers are actuated so that the pads do not contact the interior of the cylinder while cutting and roller burnishing are taking place. However, when tool 10 is retracted, pistons 52 and 53 are deactuated and springs 66 and 136 bias them to their closed positions to retract the knife blades and the rollers. In this configuration, pads 68 have a greater diameter than the knife blades and the rollers and the tool will slide smoothly out of the interior of the cylinder on the pads and will not score the surface.

The second roller burnishing means is attached to the drive tube rearward of the first roller burnishing means. The second roller burnishing means includes a roller drive 222 which is attached at its forward end to the knife support 216 and at its rear end to a drive tube 224 attachable to the forward end of the second roller burnishing means. A roller cage 226 circumscribes roller drive 222 aft of holder 216. Roller cage 226 has a plurality of apertures 228 (see FIG. 2) accommodating a corresponding plurality of rollers 230. The apertures 228 in cage 226 restrict the movement of rollers 230

while allowing the rollers to rotate and translate to a limited degree in a radial direction.

5 A roller race 232 circumscribes drive 222 beneath roller cage 226. Race 232 has a key 234 engaging a corresponding slot 236 in drive 222 so that the roller race is nonrotatable relative to the drive shaft.

10 Roller race 232 has an inclined outer surface 238 which is frustoconical in section. Surface 238 tapers outwardly in a forward direction. Rollers 230 are also frustoconical in section and have sufficient taper so that the rollers, bearing on surface 238 of race 232, are aligned so that their outer surfaces 240 are parallel to the common central axis 39 of roller drive 222 and drive member 12.

15 A roller pusher 42 circumscribes drive shaft 222, and also has a key 244 engaging a corresponding slot 246 in drive shaft 222 so that the roller pusher is nonrotatable relative to the drive shaft. Roller pusher 242 has a forward extension 48 which bears against the rear surfaces of rollers 230 so that the roller pusher can apply a forward force directly to the rollers. In addition, the forward extension 20 248 of roller pusher 242 has a lip 249 engaging a corresponding lip 250 on roller cage 226 so that aft movement of the roller pusher will draw the roller cage rearwardly.

25 A hydraulic (or pneumatic) piston 252 is located in the interior of drive tube 224. A corresponding plug 254 is also located in drive tube 224 to define a cavity 256 between the plug and piston 252. A bore 258 in plug 254 communicates with a hydraulic or pneumatic fitting 60 which couples to a source of hydraulic or pneumatic fluid (not shown) within the drive member 12.

30 A plurality of dowel pins 262 emanate from the forward surface 263 of piston 252. Dowel pins 262 threadably engage the roller pusher 242, and a dowel retainer 264 secures the ends of dowel pins 262 near piston 252. A coil spring 266 biases dowel retainer 264 rearwardly so that dowel pins 262 are maintained in contact with the forward surface of piston 252.

Actuation of piston 252 by supplying a fluid through fitting 60 applies a forward force to dowel pin 262 which is transmitted through roller pusher 242 to rollers 230. This force moves rollers 230 up the inclined surface 238 of roller race 32 until the applied force is balanced by the force of the rollers against the interior of the workpiece.

It is readily apparent that rollers 230 will adapt themselves to the actual diameter of the interior of the cylinder, and will apply an equal force throughout a range of diameters depending upon the force applied to piston 252. Moreover, if the interior of the cylinder is undersized, the rollers will merely move a lesser distance up inclined surface 238, and there will be no tendency for the tool to jam in the workpiece. In addition, the fact that dowel pins 262 are not rigidly connected to piston 252 assures that an equal force is applied to all rollers 230, and the system is self-stabilizing and does not require an independent stabilizing mechanism such as nylon pads which contact the inside of the hole which the roller burnishing is taking place.

Piston 252 includes a central bore 255 which serves as a cylinder 255 for an elongate actuator piston 253. The forward end of actuator piston 253 passes through the interior of a bore 230 in roller drive 222. The actuator piston has a raised shoulder 234 with washer 228 abutting thereagainst to be biased rearwardly by a spring 236 until actuator piston 253 contacts plug 254. A groove 31 is provided in the end of piston 253 abutting plug 254 to allow fluid to pass from bore 258 into cavity 256. When pressurized fluid is supplied through bore 258 to cavity 256, not only does piston 252 move forwardly, but also, when pressure is sufficient, piston 253 moves forwardly as well. The leading end 13 of the actuator piston forces push dart 282 forwardly to actuate the knife blade holders. The forward travel of actuator piston 253 is limited by the abutment of washer 228 against shoulder 235. This insures that piston 253 does not become jammed against knife 18 which would prevent the desirable self-centering action of the knife in slot 19.

A plurality of guide pads 268, which may be nylon, can be provided about the outer circumference of tool 10. Pads 268 have a lesser diameter than the knife blades 220, 222 and rollers 230 when the knife blades and rollers are actuated so that the pads do not contact the interior of the cylinder while cutting and roller burnishing are taking place. However, when tool 10 is retracted, pistons 252 and 253 are deactuated and springs 266 and 236 bias them to their closed positions to retract the knife blades and the rollers. In this configuration, pads 268 have a greater diameter than the knife blades and the rollers and the tool will slide smoothly out of the interior of the cylinder on the pads and will not score the surface.

The tool 10 of the present invention is useful for boring, skiving and burnishing a rough cut cylindrical hole in a wide variety of workpieces. For example, the tool 10 will find use in finishing the interior walls of the cylinders of internal combustion engines, hydraulic cylinders, pneumatic cylinders, and other round passages formed in machinable metals where the surface smoothness and finish must be maintained within very close tolerances. Each tool 10 will be constructed to correspond to a particular nominal diameter for the finished cylinder or bore. The nominal diameter refers to the finished size of the bore. The tool 10 may be used on bores with varying initial diameters since the boring means of tool 10 can increase the diameter to that necessary for the skiving means and the burnishing means. Such ability to machine rough cut bores without first boring out the hole to a suitable initial diameter is unique to the present invention.

In operation, the tool 10 is mounted on the drive member 12 having a suitable hydraulic connector for attaching to fitting 60. Rotation of the is commenced and the tool is fed into the bore of workpiece W, typically using a feed tube (not illustrated) to prealign the tool 10. As the tool 10 enters the bore and workpiece W, the cutting teeth 204 of the boring means are able to enlarge the hole in the workpiece to a diameter slightly below the desired diameter, typically from about 0.1 to 0.001 inches below the desired diameter. As the

tool 10 is fed through the workpiece, a cooling and lubricating fluid is introduced into the area where the cutting is taking place. Such fluid is circulated by the coolant flow and chip extraction grooves 208 and 210.

5 The skiving and burnishing means are operated as follows. The tool 10 is actuated by supplying hydraulic or pneumatic fluid under pressure through fitting 60 to chamber 56. While the tool is still in the draw tube the pressure is reduced so the inside of the draw tube does not become
10 overworked. The first roller burnishing means is activated as the hydraulic fluid moves piston 52 forwardly, against spring 66, forcing roller pusher 42 against rollers 30 to move them up frustoconical ramp 38. In addition, the hydraulic or pneumatic fluid in chamber 56 forces piston 53 forwardly
15 against spring 136 so that end 138 of piston 53 moves push dart 82 forwardly. Push dart 82 interacts with guide dart 92 to extend knife blade holder 70, 72 to their fully extended position, and continues to move forwardly to lock the knife blade holders in their extended position. The second roller
20 burnishing means is thereafter extended in a similar manner by action of the hydraulic fluid.

 In the extended configuration of knife blade holders, knife blades and their corresponding supports project outwardly beyond the periphery of the knife blade holder and
25 are in position to provide the appropriate cutting action. As tool 10 is advanced through the interior of a workpiece W, it both cuts and roller burnishes the workpiece, and at the finish of its traverse, the dual rollers and knife blades are both retracted and the tool withdrawn from the workpiece on
30 the pads.

 While a preferred embodiment of the present invention has been illustrated in detail, it is apparent that modifications and adaptations of that embodiment will occur to those skilled in the art. However, it is to be expressly
35 understood that such modifications and adaptations are within the spirit and scope of the present invention, as set forth in the following claims.

WHAT IS CLAIMED IS:

1. A boring, skiving and roller burnishing tool for mounting on a rotatable drive member to bore, skive and burnish the interior of a cylinder or other workpiece, said tool comprising:

an elongate drive tube assembly having means for attachment to the drive member;

a means for boring the cylinder attached to the drive tube at the forward end thereof, said means for boring including a plurality of cutting blades oriented to remove material from the cylinder to a preselected diameter as the tool is rotated;

a means for skiving the cylinder attached to the drive tube rearward of the boring means and including at least one retractable knife capable of removing material from the cylinder at a diameter greater than the preselected diameter as the tool is rotated; and

a first roller means for burnishing the cylinder attached to the drive tube rearward of the skiving means, a second roller means for burnishing the cylinder attached to the drive tube rearward of the first roller means, means for extending said first roller means and said second roller means against the inside of said cylinder for burnishing said cylinder and means for retracting said first roller means and said second roller means so that said first roller means and said second roller means move radially inwardly and the tool can be withdrawn from the cylinder:

2. A boring, skiving, and roller burnishing tool as in claim 1, wherein the means for attachment to the drive member is located at the forward end of the drive tube assembly.

3. A boring, skiving, and roller burnishing tool as in claim 1, wherein the means for attachment to the drive member is located at the rearward end of the drive tube assembly.

4. A boring, skiving and roller burnishing tool for mounting on a rotatable drive member to bore, skive and burnish the interior of a cylinder or other workpiece, said tool comprising:

5 an elongate drive tube assembly having means for attachment to the drive member;

10 a means for boring the cylinder attached to the drive tube at the forward end thereof, said means for boring including a plurality of cutting blades oriented to remove material from the cylinder to a preselected diameter as the tool is rotated;

15 a means for skiving the cylinder attached to the drive tube rearward of the boring means and including at least one retractable knife capable of removing material from the cylinder at a diameter greater than the preselected diameter as the tool is rotated; and

a first means for burnishing the cylinder attached to the drive tube rearward of the skiving means, said burnishing means comprising:

20 a roller race having a central axis coincident with that of the drive tube assembly and a frustoconical outer surface tapering radially outward in the axially forward direction;

25 a plurality of frustoconically tapered rollers each having a large end and a small end and being arranged about said outer surface with the small ends of said rollers facing forward so that the surface portion of each roller furthest from the central axis of the roller race is generally parallel to said central axis;

30 a roller cage having a plurality of slots, said roller cage circumscribing and being spaced apart from the roller race so that said slots and said roller race together define a plurality of cavities for receiving individual rollers;

35 a roller pusher having (1) a forward extension for directly engaging the rear surfaces of individual rollers when the pusher is moved forwardly relative to the roller race to push the rollers forward and cause the rollers to translate

radially outward along the tapered surface of the roller cage, and (2) a lip for directly engaging the roller cage when the pusher is moved rearwardly relative to the roller race to draw the rollers rearward and allow the rollers to translate

5 radially inward;

means for biasing said roller pusher in said forward direction with a preselected force so that the force exerted upon said internal surface of said hole remains constant over a range of sizes of said hole; and

10 means for retracting the roller pusher when the axial force is reduced to draw the roller cage rearwardly so that the rollers move radially inward and the tool can be withdrawn from the workpiece; and

a second means for burnishing the cylinder attached to the drive tube rearward of the first means for burnishing the cylinder, said second burnishing means comprising:

15 a roller race having a central axis coincident with that of the drive tube assembly and a frustoconical outer surface tapering radially outward in the axially forward direction;

20 a plurality of frustoconically tapered rollers each having a large end and a small end and being arranged about said outer surface with the small ends of said rollers facing forward so that the surface portion of each roller furthest from the central axis of the roller race is generally parallel to said central axis;

25 a roller cage having a plurality of slots, said roller cage circumscribing and being spaced apart from the roller race so that said slots and said roller race together define a plurality of cavities for receiving individual rollers;

30 a roller pusher having (1) a forward extension for directly engaging the rear surfaces of individual rollers when the pusher is moved forwardly relative to the roller race to push the rollers forward and cause the rollers to translate radially outward along the tapered surface of the roller cage, and (2) a lip for directly engaging the roller cage when the pusher is moved rearwardly relative to the roller race to draw

the rollers rearward and allow the rollers to translate radially inward;

means for biasing said roller pusher in said forward direction with a preselected force so that the force exerted upon said internal surface of said hole remains constant over a range of sizes of said hole; and

means for retracting the roller pusher when the axial force is reduced to draw the roller cage rearwardly so that the rollers move radially inward and the tool can be withdrawn from the workpiece; and

5. A boring, skiving, and roller burnishing tool as in claim 4, wherein the means for attachment to the drive member is located at the forward end of the drive tube assembly.

6. A boring, skiving, and roller burnishing tool as in claim 4, wherein the means for attachment to the drive member is located at the rearward end of the drive tube assembly.

7. A boring, skiving and roller burnishing tool as in claim 4, wherein the biasing means comprises hydraulic cylinders operatively coupled to the roller pushers.

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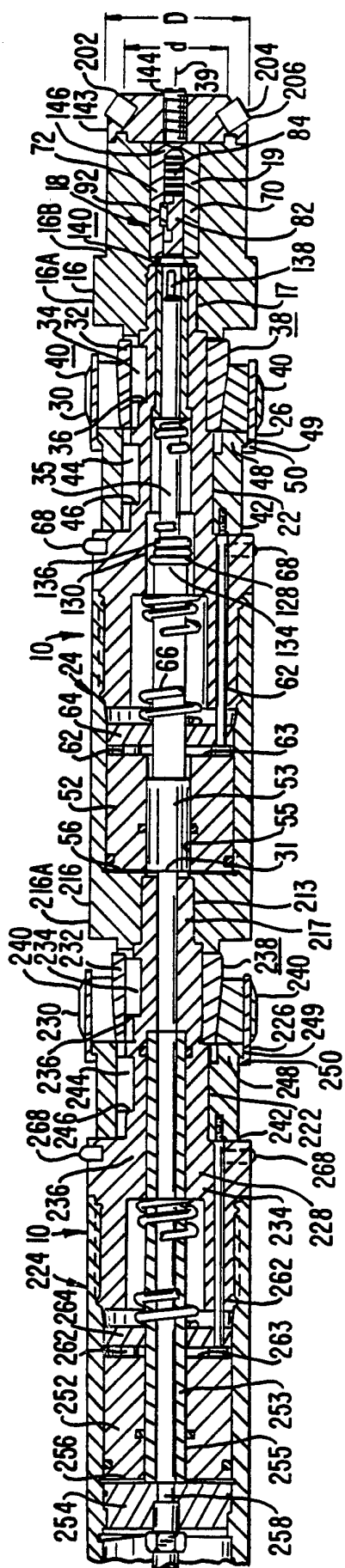


FIG. 1.

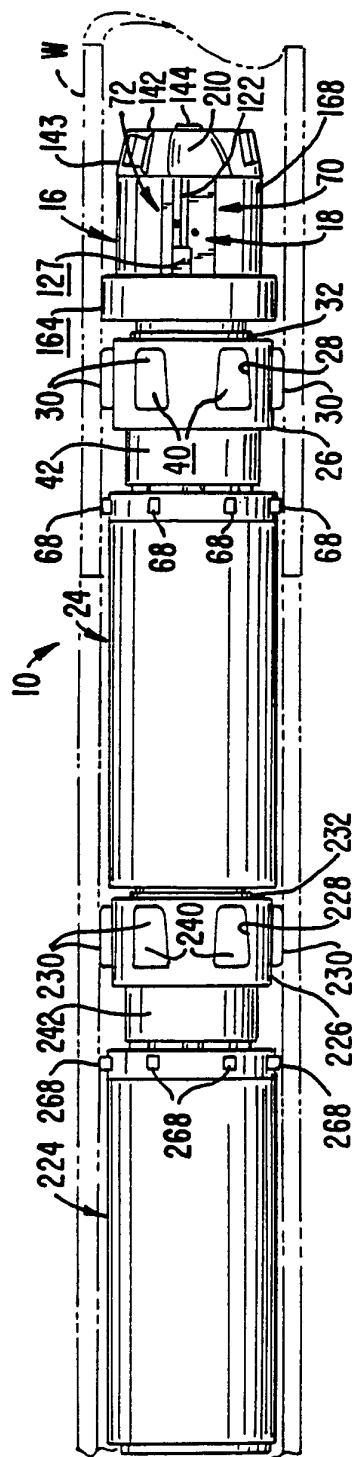


FIG. 2.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/08673

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :B24B 39/02; B23B 41/02
US CL : 29/90.01; 407/1; 408/147

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)

U.S. : 29/90.01; 407/1; 408/147

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 practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A 4,527,929 (DICKINSON) 09 JULY 1985 see entire document	1-7
Y	US, A 4,574,442 (DICKINSON) 11 MARCH 1986 see entire document	1-7



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be part of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"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

01 SEPTEMBER 1994

Date of mailing of the international search report

21 SEP 1994

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