United States Patent

Giardini et al.

[15] **3,699,728**

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[54] **METHOD AND APPARATUS FOR INTERNAL PLUNGE GRINDING**

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[73] Assignee: **The Bendix Corporation**

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[52] **U.S. Cl.** **51/356,** 51/267

[51] **Int. Cl.** **B24b 55/02**

[58] **Field of Search**.....51/50, 266, 267, 356, 281, 51/290, 322, 325, 206 R

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[57] **ABSTRACT**

An internally lubricated grinding wheel arrangement for plunge or form grinding in which the voids of a porous grinding wheel are occluded by lubricant applied internally while in the grinding zone to prevent wheel loading. The wheel is cooled by directing a coolant supply externally of the wheel.

5 Claims, 7 Drawing Figures

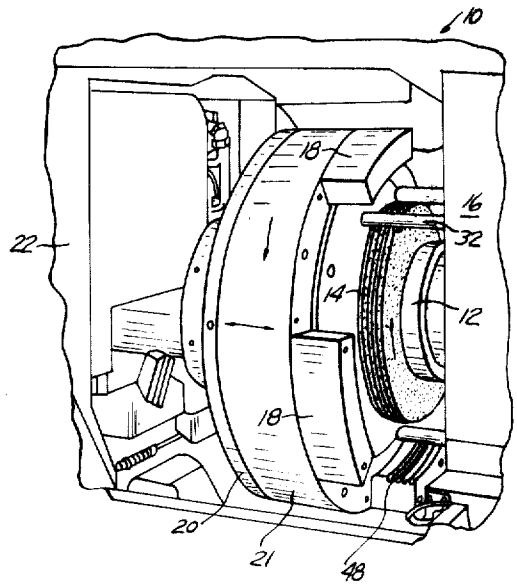

FIG. 1

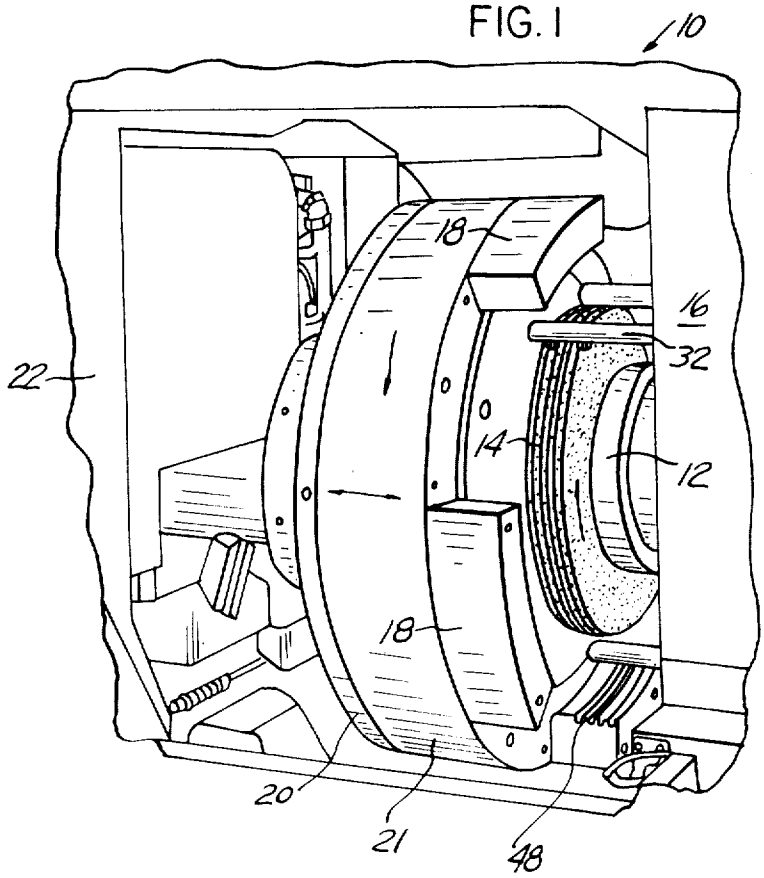

FIG. 2

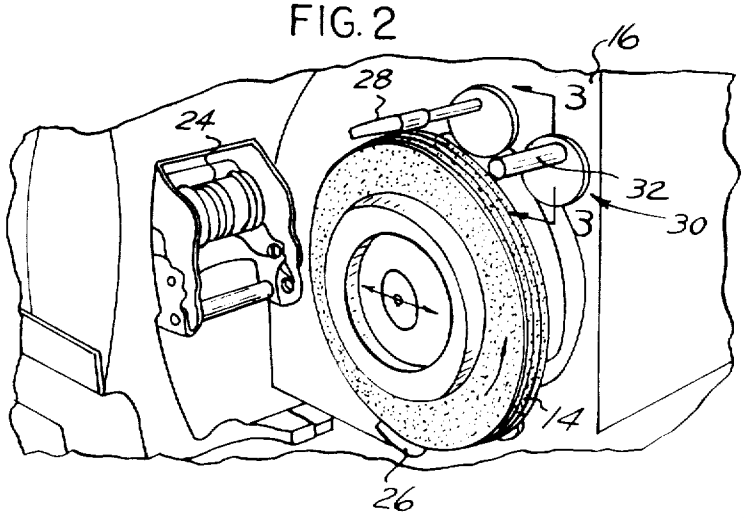

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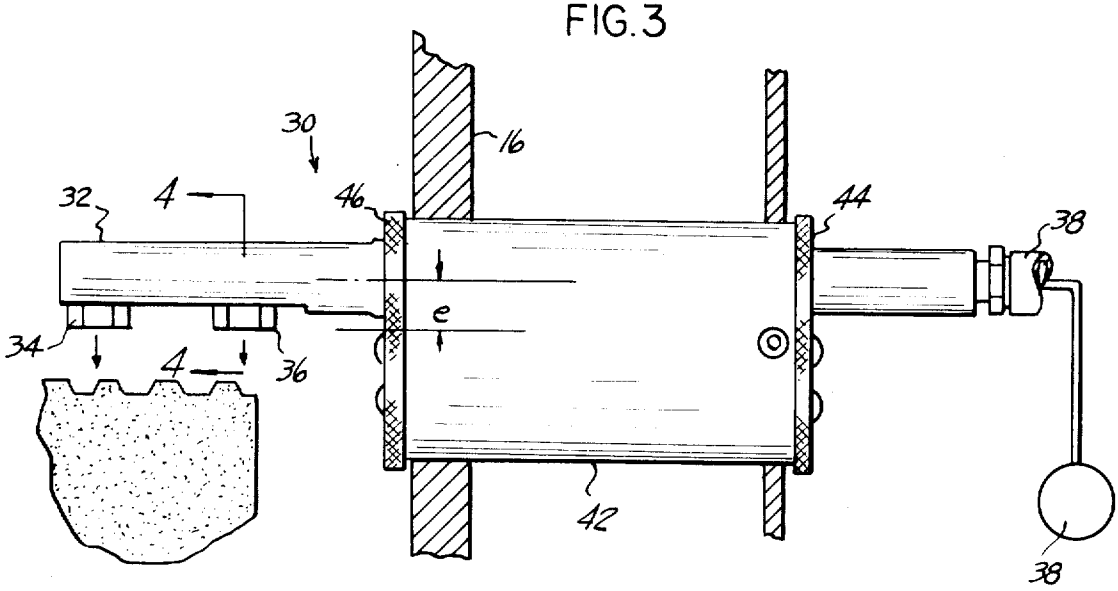
FIG. 3



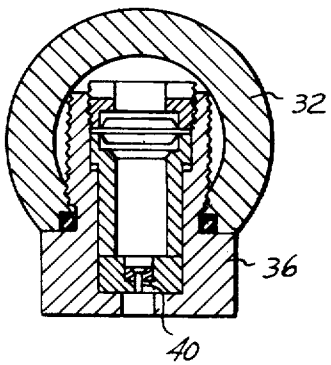


FIG. 4

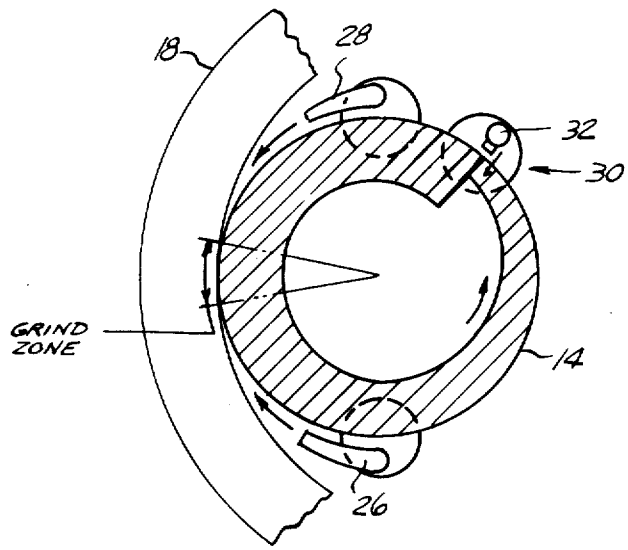


FIG. 5

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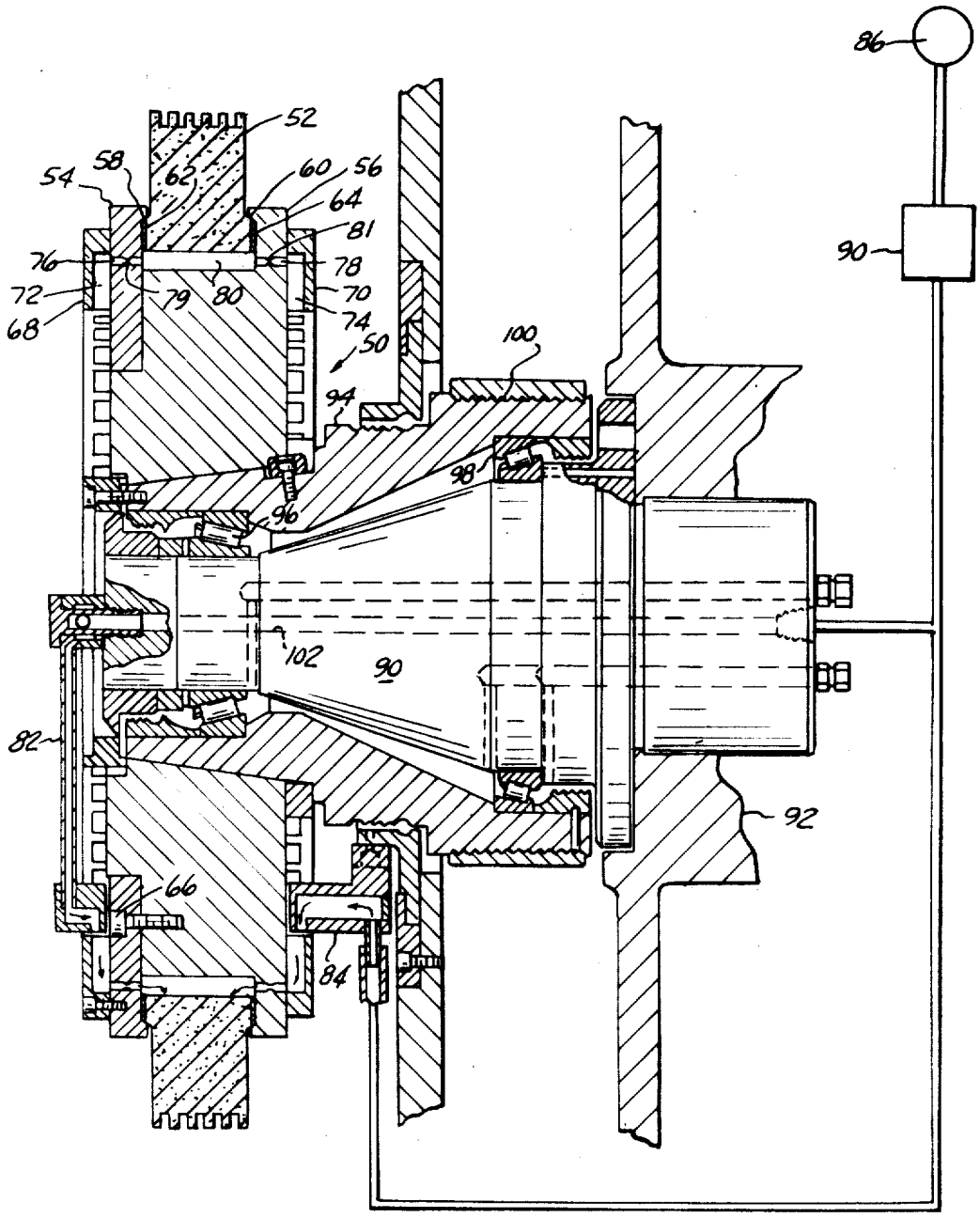

FIG. 6

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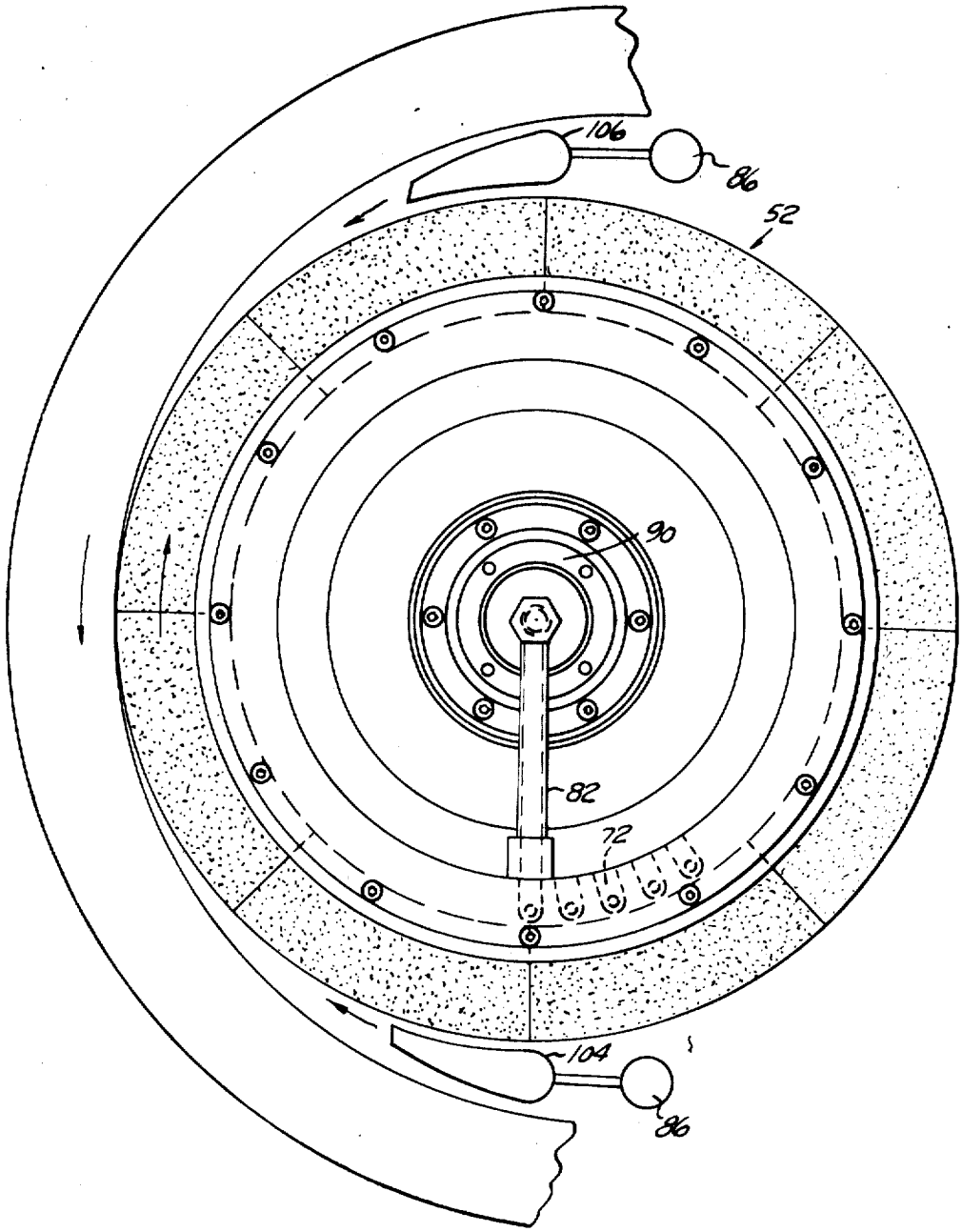

FIG. 7

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METHOD AND APPARATUS FOR INTERNAL PLUNGE GRINDING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention concerns apparatus for plunge or form grinding in which a grinding wheel is advanced into the ground part during the grinding action.

2. Description of the Prior Art

Prior art attempts at internal plunge or form grinding have been unsuccessful due primarily to excessive grind wheel loading with the base material of the workpiece. This has resulted since the extent of the grind zone is considerably greater in internal grinding than for external grinding due to the relative geometry of the grinding wheel and the workpiece, and coolant and lubricant starvation tends to occur. Thus, forms on internally curving surfaces have by necessity been machined by individual cutting tool operations which require a great deal of set-up and machining time for complex shapes and also yields inferior results as to surface finishes and tolerance levels in comparison to those produced by grinding methods.

SUMMARY OF THE INVENTION

It has been determined that the excessive grinding wheel loading is attributable to chemical reactions and resulting bonding between the grinding wheel and the workpiece material which will occur if the presence of atmospheric oxygen is allowed in the grind zone. The lubricant starvation problem thus created excessive grind wheel loading since the atmospheric oxygen could then occupy the surface voids of the relatively porous grinding wheel and be available for chemical reactions in the grid zone.

This result is avoided by the present invention by substantially occluding with a liquid coolant or lubricant the grinding wheel surfaces voids throughout the grind zone.

The apparatus for accomplishing this includes a jet wheel lubricator that saturates the porous grinding wheel with a liquid to a sufficient depth that centrifugal migration back to the surface of the grinding wheel insures substantially complete void occlusion at the surface of the grinding wheel throughout the grind zone.

Alternatively, a novel arrangement for internally lubricating a grinding wheel while supplying coolant externally is used to produce the same result.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an internal form grinding arrangement according to the present invention.

FIG. 2 is a perspective view of the apparatus shown in FIG. 1 from another direction with the workpiece withdrawn.

FIG. 3 is a partial view of a section taken along the line 3—3 in FIG. 2 showing the jet wheel cleaner in detail.

FIG. 4 is a view of the section taken along the line 4—4 in FIG. 3.

FIG. 5 is a diagrammatic view of the coolant and lubricant distribution occurring during the grinding operation.

FIG. 6 is a sectional view of an internally lubricated wheel according to the present invention together with a schematic representation of the lubricant supply circuit.

FIG. 7 is a diagrammatic representation of the coolant and lubricant distribution during an internal grinding operation utilizing the internally lubricated grinding wheel of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following detailed description, certain specific terminology will be used for the sake of clarity and specific embodiments described in order to provide a full and complete understanding of the invention, but it is to be understood that the invention is not so limited and may be practiced in a variety of forms and embodiments.

Referring then to the drawings, and particularly FIGS. 1–5, an internal plunge grinding apparatus **10** is shown. This includes a wheel head **12**, to which a conventional porous aluminum oxide form grinding wheel **14** is secured and is rotated by a motor (not shown) in the conventional manner. The wheelhead **12** is mounted on a carriage **16** which in turn is mounted and controllably driven to move into the workpiece **18** laterally as indicated in FIG. **2** in order to create the plunging feed characteristic of this type of grinding operation.

The workpiece **18** is secured to the wheelhead **20** with two spacers **21** utilized to provide axial clearance for the wheel head **12**, which is also rotated in the conventional manner, and supported on a carriage **22** so as to be retracted and extended into the proper position with respect to the form grinding wheel **14**.

The form grinding wheel **14** is dressed by means of a crush roller **24** (FIG. **2**) into which it is advanced by the carriage **16** feed mechanism with the workpiece retracted, and then slowly rotated to true the form profile after a number of grinding cycles, in the manner known to those skilled in the art.

The arrangement for cooling includes a pair of nozzles **26** and **28** arranged to direct coolant towards the grind zone, with a pump (not shown) supplying filtered coolant, which for a typical application would be at the rate of 10–15 gpm at 30 psi to each nozzle. This arrangement serves primarily to carry off the heat generated by the grinding process, and hence prevent the heat build-up in the workpiece from reaching harmful levels. In connection with this function refrigerating equipment may be utilized to cool the circulated coolant.

The jet wheel lubricator assembly **30** is provided in this embodiment in order to accomplish the occlusion of the grinding wheel surface voids as described above.

This device has been used as a grinding wheel cleaner in conventional grinding arrangements, and is the subject of U.S. Pat. No. 3,167,893 of which the present inventor is a coinventor, and which is assigned to the same assignee as the present application.

The assembly **30** includes a nozzle member **32** positioned circumferentially spaced above the grind zone (FIG. **5**), and has a pair of orifice assemblies **34**, **36** (FIG. **3**) directed toward the surface of the grinding wheel **14**.

The nozzle member **32** is supplied with high pressure cooling or lubricating fluid such as oil or water with a

rust inhibitor, or other similar liquid from a source **38**, via supply hose, **39**, and directs it through orifices **40** in each orifice assembly **34**, **36** normally towards the surface of the grinding wheel **14**.

The nozzle member **32** is carried by a cylinder body **42** and slidable therein so that a power cylinder (not shown) acting on the high pressure supply hose **39** can cyclically move the nozzle member **32** to and fro across the surface of the wheel. The frequency should be selected so that the pores or voids at each point are resaturated before centrifugal force causes complete elimination of the lubricant therefrom.

The cylinder body **42** is rotatably carried in the carriage frame **16**, and due to the eccentric location of the nozzle member **32** therein, the knurled end plates **44**, **46** fixed to the cylinder body **42** may be manipulated to relocate the orifice opening **40** spacing from the surface of the grinding wheel **14** as its diameter is reduced. The hose **39** is clamped against rotation so that the orifice assemblies **34**, **36** will always be directed toward the grinding wheel throughout the range of adjustment.

The proper supply pressure will vary from 4,000 to 10,000 psi depending on the orifice sizes, wheel speed, nozzle frequency, and other factors, but the flow volume and pressure must be sufficient to saturate the wheel voids to a sufficient depth so that as each wheel surface portion passes into the grind zone, centrifugal force will not have been able to cause all of the lubricant to pass out of the wheel, and all of the wheel voids at the surface will remain "wet" or occluded with lubricant throughout. This is represented in the exaggerated shaded area of FIG. **5**.

In actual designs, 0.008 inch diameter orifices were successfully used with 10,000 psi supply pressure and a flow of 0.2 gal. per minute at wheel speeds on the order of 5,000–7,000 SFM, while a 0.012 inch diameter orifice at 5,000 psi at 0.2 gpm was also used successfully in this same application.

Hence, in use, intricate forms such as that depicted at **48** in FIG. **1**, may be plunge ground, and materials such as titanium and stainless steel have been internally form ground, successfully replacing machining procedures taking many times the length of time required for this process while improving surface finishes and tolerance levels.

In the above-described embodiment the occlusion was obtained by forcing lubricant into the wheel via a jet stream, with the centrifugal action then causing a steady flow back to the surface.

In the embodiment shown in FIGS. **6** and **7**, the lubricant is supplied internally and allowed to migrate outwardly to produce the same effect of void occlusion at the grinding wheel surface.

The internally lubricated grinding wheel assembly **50** includes an annular grinding wheel **52** which is retained between a pair of hub members **53**, **56** cooperating with tapered shoulders **58**, **60** on the grinding wheel and clamped between a pair of paper washers **62**, **64**. The hub members **54**, **56** are secured together with a plurality of machine screws **66**.

Secured to hub member **54** is an oil ring **68** and to hub member **56** an oil ring **70**. Each of the oil rings **68** and **70** is provided with a series of evenly spaced oil pockets **72**, **74**, each aligned with respective passages **76**, **78** in each hub member.

The passages **76** and **78** communicate with an annular chamber **80** formed by the radial clearance between the grinding wheel **52** and the hub member **56**. Each of the passages **76** and **78** has a respective metering orifice **79** and **81** to control the amount of liquid flow therethrough for a given pressure differential.

In order to provide a lubricant supply, a pair of distributor tubes **82** and **84** are disposed so as to direct fluid from source **86** into the oil pockets **72** and **74**. The lubricant should be circulated through filter **88** before being directed therefrom to avoid clogging of the grinding wheel voids.

The lubricant then enters the passages **76** and **78**, being acted upon by the centrifugal force created by rotation of the assembly **50**, moving into the chamber **80**. From thence, it migrates outwardly by the action of centrifugal force through the interstices of the annular grinding wheel **52**, ultimately emerging at the surface.

In order to provide for directing of the liquid at both sides of the grinding wheel assembly **52**, while allowing for the internal plunge grinding application described, the grinding wheel assembly **52** is dead shaft mounted. That is, the supporting stub shaft **90** is fixed to the wheelhead **92**, while the hub member **56** is secured to a hollow drum member **94**, which is in turn rotatably mounted on the stub shaft **90** via bearings **96**, **98**, and may be belt driven at the surface **100**. This construction allows the distributor tube **82** to be supplied via central passage **102** bored in the stub shaft **90** from the same side of the grinding wheel assembly **52** as distributor tube **84**. Hence, "blind" mounting arrangements for internal surfaces may be successfully carried out.

In operation, the internally lubricated grinding wheel assembly **50** is used in conjunction with coolant supply devices **104** and **106** (FIG. **7**) directing relatively large volumes of coolant towards the grind zone to perform the cooling function, while the flow internally is adjusted by proper selection of orifice sizes **82** and **84** to just wet the surface of the grinding wheel **52** under the operating conditions.

Thus, the occlusion of the surface voids by the lubricant will allow successful internal form grinding in a similar manner to that of the embodiment shown in FIGS. **1-5**.

While the internally lubricated grinding wheel of FIGS. **6-7** is particularly suitable for carrying out void occlusion according to the present invention, it also exhibits a substantial advantage for general grinding use:

Since only a small portion of the coolant/lubricant is circulated internally, and the bulk is circulated externally, filtering requirements are drastically reduced, while retaining the advantages of the internally lubricated grinding wheel. Prior art attempts at this device have always involved circulating the entire coolant/lubricant supply internally, since clogging of the wheel voids would soon occur unless a very efficient filtering system was used, and this requirement rendered the approach unfeasible despite substantial performance advantages. In addition, prior art attempts usually involved passing the liquid through a relatively thick section of grinding wheel aggravating these problems, whereas in this design, a relatively thin section tends to further alleviate these problems.

While particular embodiments have been described, many modifications and substitutions are of course possible within the scope of the appended claims.

What is claimed is:

1. An internally lubricated grinding wheel arrangement for a grinding machine comprising:

a relatively porous grinding wheel member;

means mounting said grinding wheel member for rotation and advancement into a workpiece;

lubricating means for supplying a liquid internally to said grinding wheel member to produce outward migration of said liquid through said grinding wheel member voids and including a circumferentially extending internal chamber in said grinding wheel member and means for directing said liquid into said chamber; and

cooling means for directing a coolant supply externally of said grinding wheel member to the grinding zone, whereby said grinding wheel is lubricated by internal liquid flow, while being cooled by external liquid flow.

2. An internally lubricated grinding wheel arrangement for a grinding machine comprising:

a relatively porous grinding wheel member;

means mounting said grinding wheel member for rotation and advancement into a workpiece;

lubricating means for supplying a liquid internally to said grinding wheel member to produce outward migration of said liquid through said grinding wheel member voids including metering means having a plurality of pockets arranged circumferentially about said grinding wheel member and further including an internal circumferential passage having a radially outer surface defined at least in part by a portion of said grinding wheel member, and also including passage means providing a fluid connection between each of said pockets and said chamber; and

cooling means for directing a coolant supply externally of said grinding wheel member to the grinding zone, whereby said grinding wheel is lubricated by internal liquid flow, while being cooled by external liquid flow.

3. The arrangement of claim 2 further including means for directing said liquid into said pockets.

4. The arrangement of claim 2 further including metering orifices in said passage means.

5. The arrangement of claim 4 wherein said metering orifices control the liquid flow so that the surface of the grinding wheel member is just wetted by the outward migration at the rate of rotation of said grinding wheel member.

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