July 12, 1949. H. W. WAGNER ET AL 2,475,811

PLURAL FLUID APPARATUS FOR GRINDING MACHINES

Filed Jan. 15, 1948 4 Sheets-Sheet 1

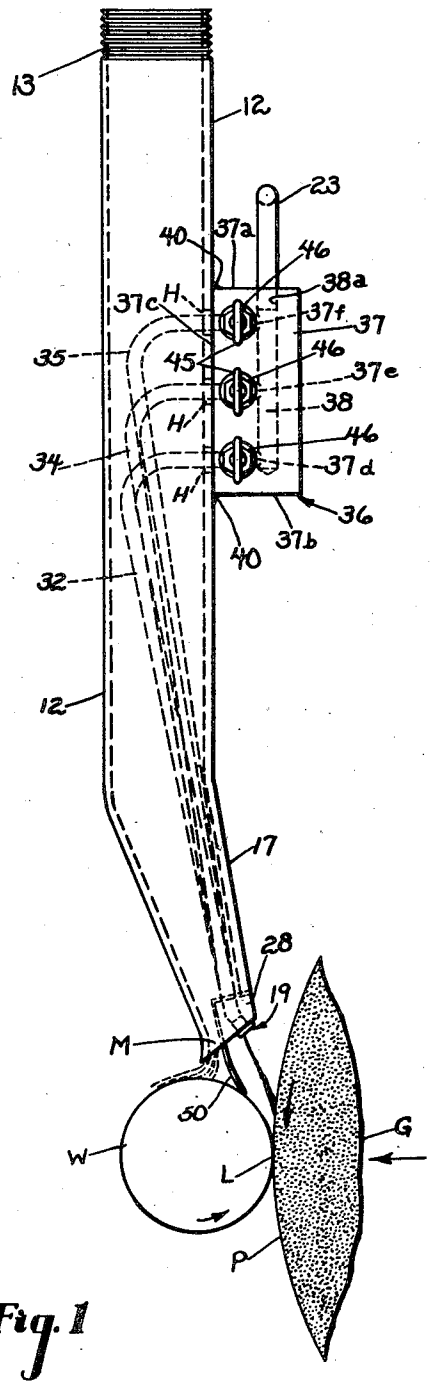


Fig. 1

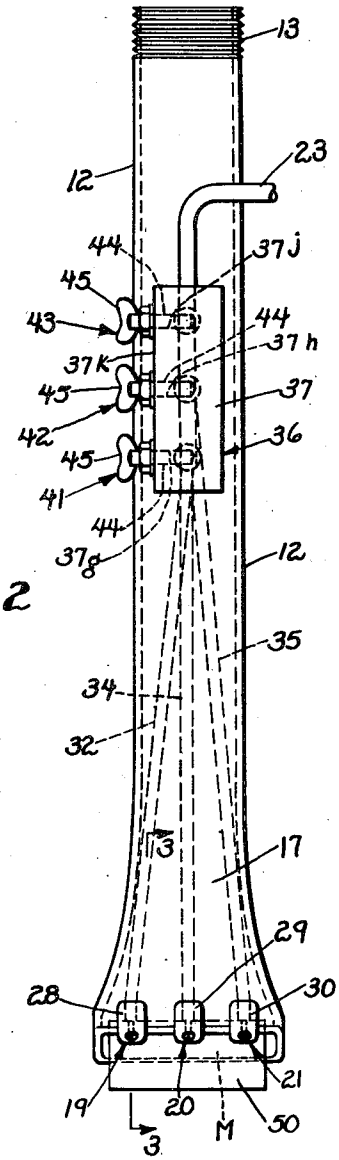


Fig. 2

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PLURAL FLUID APPARATUS FOR GRINDING MACHINES

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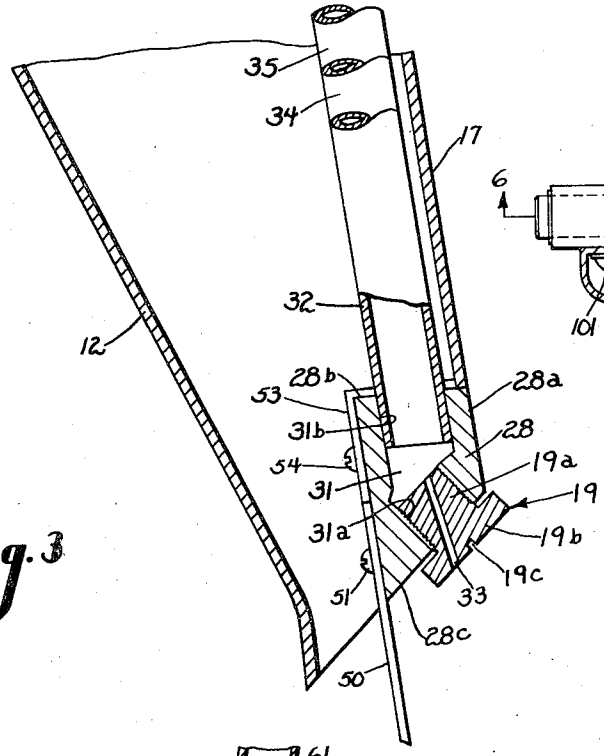


Fig. 3

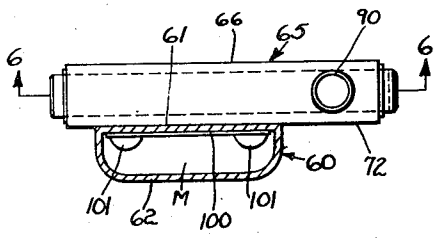


Fig. 5

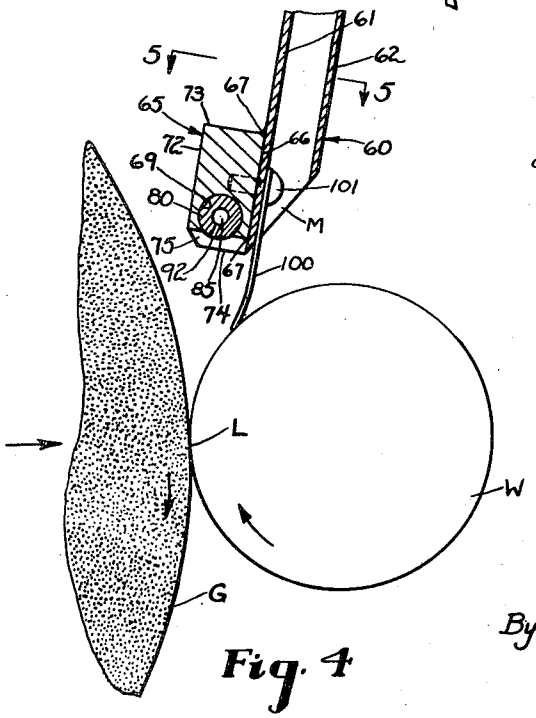


Fig. 4

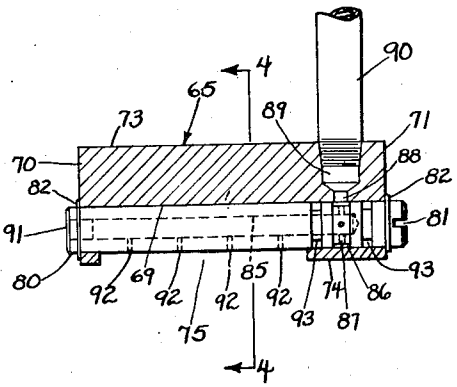


Fig. 6

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PLURAL FLUID APPARATUS FOR GRINDING MACHINES

Filed Jan. 15, 1948 4 Sheets-Sheet 3

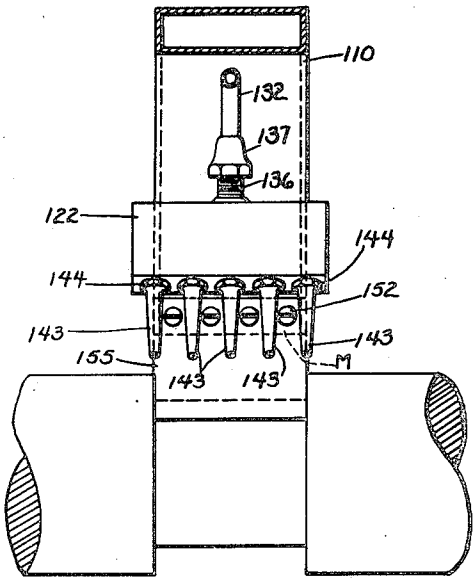


Fig. 8

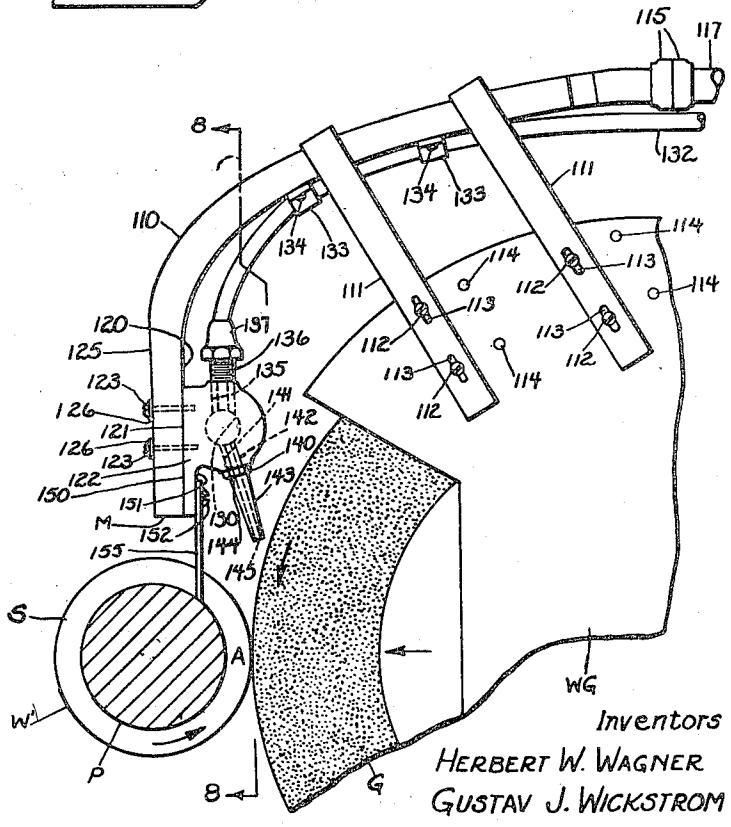


Fig. 7

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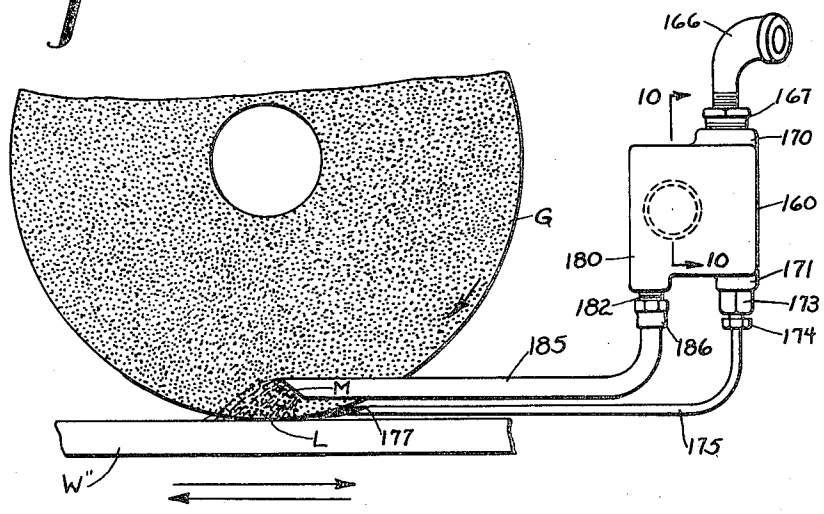
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PLURAL FLUID APPARATUS FOR GRINDING MACHINES

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Fig. 9



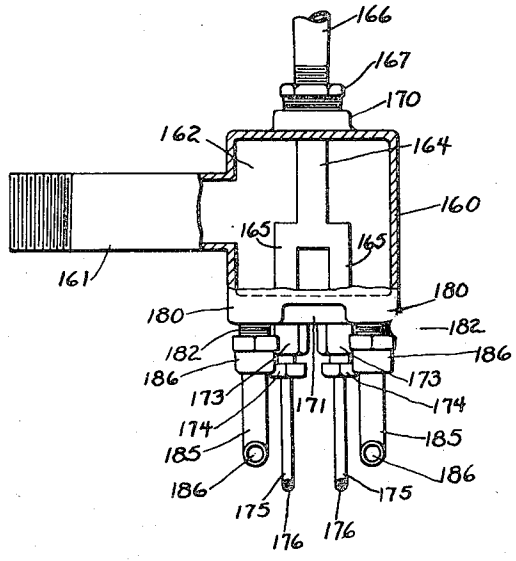


Fig. 10

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UNITED STATES PATENT OFFICE

2,475,811

PLURAL FLUID APPARATUS FOR GRINDING MACHINES

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Application January 15, 1948, Serial No. 2,505

6 Claims. (Cl. 51—267)

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The invention relates to apparatus for applying cooling and cutting fluids to grinding wheels and to the work piece being ground thereby. This application is a continuation in part of our copending application Serial No. 593,814, filed May 15, 1945, to be issued as U. S. Patent No. 2,434,679, dated January 20, 1948.

As conducive to a clearer understanding of certain objects and features of this invention, it might at this point be noted that the rate, cost and efficiency of grinding of work pieces, such as parts made of steel, alloys, and various other metals, both hard and soft, are limited in heretofore known methods and apparatus, by a number of factors, such as depth of cut which the grinding wheel can take, rate of relative feed or traverse between the work and the grinding wheel, wheel wear, character of finish produced, frequency of wheel truing (which also greatly affects the life of the wheel), temperatures produced at the grinding line and also in the work, and the like; this is true even if the best heretofore known coolants or cutting fluids are employed according to the best heretofore known standards. If, for example, the attempt is made to increase production as by taking heavier cuts or increasing rate of feed beyond the optimum, loading and breakdown of the wheel face and shortened life thereof and increased power consumption together with poor finish of the work and need of more grinding passes and other detriments result, and hence it has been heretofore impossible to increase grinding production or efficiency and to lower cost of grinding beyond the limitations inherent in the optimum conditions for the different types or kinds of work pieces to be operated upon. This is true for various types of grinding, such as surface grinding, internal and external grinding of round or cylindrical surfaces, etc. etc., and these limitations become still more restrictive where the grinding wheel is called upon to function by way of both surfaces of its corner or corners, as, for example, when the wheel, as in crankshaft grinding, has to function by way of its outer cylindrical surface and its two side faces as well; in such cases, the burden at the corner or corners of the wheel is multiplied, the corner or corners break down or wear too rapidly if the grinding burden is too heavy, and the shortening of wheel life by too frequent trueing of the cylindrical face to restore the corners becomes prohibitive. We have discovered a method and apparatus, applicable to such types of grinding operations and to the corresponding grinding machines as above mentioned, whereby such limitations as those above mentioned are substantially lifted and whereby such grinding machines may be operated and their grinding operations performed at a rate and with efficiency of grinding heretofore unachieved and heretofore impossible of achievement by known grinding methods or apparatus.

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Other objects of this invention are to provide a grinding apparatus of the just-mentioned nature that is efficient and economical and that will be readily and inexpensively adaptable to known types of grinding machines and applicable to grinding machines in general, as well to those types where relative traverse movement between the work and grinding wheel takes place, as to those types where grinding is performed by direct infeed. Another object is to provide an apparatus for increasing the capacity of a given grinding wheel. Another object is to provide an apparatus for increasing the life of a grinding wheel. Another object is to provide an apparatus for grinding in which the grinding wheel may be made to perform at greater than heretofore-considered normal capacity, at better wheel life, and at the same or materially lessened power input. Another object is to provide an apparatus for protecting the grinding wheel and the workpiece, under conditions of increased duty of the grinding wheel, against loading of the wheel and detrimental breakdown of the wheel and against temperature conditions in both the wheel and the work that are detrimental to either or both.

Another object is to provide a practical and efficient apparatus for controlling the application to the grinding wheel and workpiece of a plurality of coolant and grinding liquids in a manner to effect increased grinding performance and efficiency while achieving the desired standard of finish on the workpiece and maintaining economical wheel life. Another object is to provide an apparatus for carrying out the last-mentioned object in a manner to permit a wide range of control or action to meet widely varying practical requirements for different kinds or types of grinding operations. Another object is to provide an easily-controlled flexibility or variability of action and application of a plurality of liquid coolants and grinding liquids to the grinding wheel and workpiece to meet different conditions met with in the grinding of certain kinds or shapes of workpieces and also to meet varying conditions imposed by different kinds or shapes of workpieces or different grinding operations. Another object is in general to achieve

superior grinding and longer wheel life than has heretofore been possible.

Another object of the invention is to provide a practical and efficient apparatus for the application of two or more fluids to the grinding action. Another object is to provide apparatus to direct coolant fluid mainly upon the workpiece and cutting fluid mainly upon the grinding wheel. Another object is to keep the workpiece cool (relatively) with coolant fluid (usually chiefly water) and the grinding action efficient by applying cutting fluid (for example oil) to the grinding line. Another object is to keep the two fluids separate so far as possible on the combination of workpiece and grinding wheel. Another object is to cause the cutting fluid to impinge with high velocity and the coolant fluid to impinge in large volume.

Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements and arrangement of parts, all as will be illustratively described herein and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings in which are shown several illustrative embodiments of the mechanical features of cur invention,

Figure 1 is a side elevation of the apparatus together with an end view of a workpiece and a fragmentary side elevation of a grinding wheel,

Figure 2 is a rear elevation of the apparatus of Figure 1,

Figure 3 is an enlarged vertical sectional view of the apparatus of Figures 1 and 2,

Figure 4 is a vertical sectional view, taken along the line 4—4 of Figure 6 illustrating a modification of the invention,

Figure 5 is a cross-sectional view taken on the line 5—5 of Figure 4,

Figure 6 is a cross-sectional view taken on the line 6—6 of Figure 5,

Figure 7 is a side elevation of a further modification especially for the grinding of crankpins.

Figure 8 is a view taken along the line 8—8 of Figure 7,

Figure 9 is an elevation illustrating an embodiment of the invention for surface grinding,

Figure 10 is a view partly in elevation and partly in section along the line 10—10 of Figure 9.

Our invention is probably best illustrated with respect to grinding machines in which a grinding wheel performs a grinding operation upon a round or cylindrical surface of a metal workpiece which is supported and rotated during the grinding operation, suitable means being provided for effecting relative movement between the workpiece and the grinding wheel for various purposes, such as for example, for axially progressing the workpiece relative to the grinding wheel or vice versa, for effecting "feed," thus to determine the depth of cut of the grinding wheel, for effecting relative movement between the workpiece and the grinding wheel in a direction transverse to the axis of the rotating workpiece as when one or both of the side faces of the grinding wheel are to grind portions of the workpiece, with or without having the peripheral face of the wheel performing a grinding operation, and the like, and to achieve greater simplicity of description and to avoid limitation by implication, any such apparatus, chosen for illustration of the applicability of our invention, is indicated in the drawings by a simple representation of a

grinding wheel G and a workpiece W which may be supported and rotated by any suitable means not shown and traverse feed and other movements, relative or otherwise, are simply indicated by appropriate arrows. Any well known form of grinding machine may be employed and for greater facility of description it may be assumed, but not by way of limitation, that the workpiece is mounted on centers and driven at suitable speed and in suitable direction.

Referring to Figures 1, 2 and 3 supported in any suitable way, from any suitable part of the apparatus—conveniently from the heavy guard that covers over or encloses most of the grinding wheel G—is a device constructed and adapted to supply a plurality of liquids for coaction with the grinding wheel G and the workpiece W.

The device comprises a nozzle 12 or other suitable device for discharging and generally directing a liquid preferably in large volume and preferably at low pressure; it is to handle a liquid, the principal or primary characteristic of which is that it have good capacity for abstracting heat and, hence, we refer to it as a coolant liquid. The nozzle 12 we may term a coolant liquid nozzle or a low-pressure nozzle. It is conveniently made of steel piping of suitable diameter and length, being provided at its upper end with suitable means for connecting it into a liquid circulating or liquid pumping system, and conveniently the upper end may be threaded, as at 13, to receive a pipe coupling by which it may be connected to other conduits or pipes.

Its lower end curves inwardly from the vertical axis of the part 12 and, hence, toward the grinding wheel G, as viewed in Figure 1 and, where made up of round tubing, its lower end preferably also is shaped—as by flaring it out laterally to both sides of its vertical axis, as viewed in Figure 2, and by progressively narrowing it in internal and external dimensions, as viewed in Figure 1—to provide a discharge mouth M that is of a length commensurate with the width of the peripheral face P of the grinding wheel G and, hence, is of a length commensurate with the length of the grinding line L along which the work is contacted by the wheel face P. The mouth M may thus be of generally rectangular area or shape or slightly flared as shown, and may have uniform transverse dimension or width, and thus it is capable of discharging coolant liquid in large volume, preferably in the manner hereinafter described, at not only a uniform rate per unit area of the mouth M, but also at substantially uniform volume per unit length of the mouth M.

In so shaping the mouth end of the tube 12, we are enabled also to provide, upon that wall of the mouth nearest the grinding wheel G, a flat or plane portion 17 along or by which is suitably aligned or related to the mouth M of the nozzle 12, suitable discharge means for a liquid, the principal or primary characteristic of which is to promote the action of cutting or grinding at the grinding line and throughout the relatively small area or region where such action takes place; this liquid we sometimes term herein the active liquid or the grinding liquid, and, since, in a preferred embodiment of the invention, we apply it at relatively high pressure and in low volume, the discharge means for it—which, illustratively, comprises one or more nozzles—we sometimes term herein a high-pressure nozzle or nozzles. If more than one nozzle is employed, they may be aligned along the flat

portion 17 of nozzle device 12, and an illustrative number for an illustrative width of grinding wheel face is three—best indicated in Figure 2 by the reference characters 19, 20, and 21. For example, where the mouth M of the coolant liquid nozzle has a length on the order of three inches for a width of grinding wheel face P of about three inches, the high-pressure or active liquid nozzles 19, 20, and 21 have discharge orifices which are preferably and most conveniently circular in shape and of a diameter on the order of one-sixteenth of an inch, and their distribution along the length of the mouth M is preferably substantially uniform and an illustrative distribution may be like that indicated in Figure 2.

The nozzles 19, 20, and 21 are arranged to be connected to a supply system, preferably a pressure circulating or pumping system described in the above mentioned patent and preferably the supply of liquid and the action of each nozzle are controllable and regulatable.

A convenient, illustrative arrangement for coupling the individual nozzles to the conduit 23 may be like that shown in Figures 1, 2 and 3. Thus, the flat wall 17 (Figure 1) of the low-pressure nozzle 12 may be slotted, as by milling, at its lower end so as to receive therein blocks 28, 29 and 30, respectively, preferably shaped, constructed and mounted in the manner illustrated in enlarged scale in Figure 3 with respect to the block member 28. Thus its front face 28*a* is preferably aligned with the front face of the flat wall 17 as it is fitted into its slot, and it is preferably welded or brazed or otherwise secured in position to the wall portion 17. It has an upper face 28*b* which extends substantially at right angles to the front face 28*a* and hence to the plane of the flat front wall 17 and contains an angular channel 31 formed as by drilling from the top face 28*b* and also by drilling from the inclined bottom face 28*c*. The outwardly exposed end of channel 31 is preferably constructed to detachably and adjustably mount therein the high pressure nozzle 19 and preferably the latter is constructed to have a threaded shank 19*a* receivable into the downwardly and outwardly exposed end of the channel 31 which is threaded as indicated at 31*a*; through the nozzle element 19 is a passage 33 conveniently formed as by drilling and serving also as an orifice. Preferably, orifice channel 33 extends at an angle to the axis of the threaded shank 19*a*, illustratively an angle on the order of 25°, so that, by changing the rotary position of the nozzle element 19 about the just-mentioned axis, the point at which the emerging stream of liquid impinges upon the face P of the grinding wheel may be shifted both horizontally and vertically, that is, to the right or left as viewed in Figure 2 and up or down as viewed in Figure 1.

Referring now to Figure 3 to simplify the control of the setting of the orifice element 19, the fit of the threaded shank 19*a* in the threaded channel part 31*a* is preferably made relatively tight and hence self-locking or self-holding against unintentional rotary movement and the shank 19*a* is provided with an external larger-diametered portion 19*b* which may be given an external hexagonal or other suitable shape to permit application thereto of a wrench or may be slotted as at 19*c* to permit engagement of a tool like a screw driver. Thus ease of rotary adjustment and dependable maintenance of the desired setting are achieved.

The other end of channel 31 which, in the illustrated preferred structure is exposed internally of the tube 12, is constructed to have a relatively small tube or pipe 32 connected to it, conveniently as by providing that end of the channel 31 with a socket 31*b* and to receive the tube 32, a sealed connection being effected as by soldering or sweating the two parts together.

Where more than one high pressure nozzle element is employed, and as will now be clear, they are similarly constructed and mounted as just described with respect to the orifice-nozzle element 19, and it will be seen that the supporting block, such as the block member 28, and the nozzle element carried by it, such as member 19 of Figure 3, may be constructed in quantity as units and may be assembled to low pressure nozzle members like the element 12 in any desired spacings and in any desired number. In Figures 1, 2 and 3, the connecting tubular conduits of the additional nozzle units 20—29 and 21—30 are indicated at 34 and 35, respectively, the three relatively small tubes extending upwardly within the tube element 12 to a control distributor, Figures 1 and 2, generally indicated by the reference character 36. The tubes 32, 34 and 35 are relatively small, and are preferably made of a metal like copper or bronze; the tubes are also mechanically encased and housed by the relatively large heavy and strong tube member 12 and thus protected against mechanical injury, distortion or the like. Since the tubes 32, 34 and 35 are relatively small in cross section as compared to the cross-sectional interior of the low pressure nozzle member 12, the capacity of the latter is not detrimentally affected by their presence.

The control distributor 36, referring now to Figures 1 and 2, comprises a block 37 of suitable metal provided with a main distributing channel 38 formed as by drilling a hole of substantial diameter from one end face 37*a* toward the opposite end face 37*b*, but falling short of the latter, the open end of the channel 38 being threaded as at 38*a* to provide for the threaded connection thereto of the high pressure conduit 23 above mentioned. This control distributor 36 may be secured to the outer face of the nozzle 12 in any suitable manner as by welding, indicated at 40.

We then arrange for the connection to the distributing channel 38 of as many pipes or tubes as there are high pressure nozzles, illustratively the three tubes 32, 34 and 35, but preferably in a manner to provide for the individual control of the volume and pressure of flow of liquid to each high pressure nozzle. Thus we may provide, as by drilling from the side face 37*c*, three channels 37*d*, 37*e* and 37*f* which intersect the distributing channel 38 at their inner ends and in their outer ends receive and have sweated or soldered thereto the tubes 32, 34 and 35 which pass through suitably large holes H provided in the adjacent wall of the nozzle tube 12.

Suitable controllable valve means are provided, preferably one for each high pressure nozzle circuit and such control means we preferably assemble to or build into the above-described block 37, conveniently relating each to one of the channels 37*d*, 37*e* and 37*f*. Such means may comprise valve structures generally indicated by the reference characters 41, 42 and 43 and preferably of identical construction. Thus, each may comprise a needle valve stem 44, preferably threaded and conveniently of the same diameter throughout its length that preferably slightly larger in diameter than the diame-

ter of the drilled channels 37*d*, 37*e* and 37*f*. The stems 44 are threaded into holes 37*g*, 37*h* and 37*j* which respectively intersect the channels 37*d*, 37*e* and 37*f*, being formed as by drilling from the face 37*k* of the block 37 toward the opposite face to a depth sufficient to intersect the tube-connecting channels. Each valve member 44 may be provided with a handle or thumb grip 45 to facilitate setting by hand if desired; the threaded fit of the valve members 44 into the just-mentioned threaded holes is preferably relatively tight so as to be leakproof and self-locking, but lock nuts 46 may be provided for them and, if desired, a gasket of suitable material that is compressible and radially expandable under the compression of the lock nut may be employed to insure against leakage, particularly where the pressures dealt with are very high, or any other suitable form of stuffing box or packing gland may be employed.

Accordingly, the amount of liquid flowing to each high pressure nozzle and hence also the pressure effective upon the orifice channel of each nozzle may be set by adjustably positioning the valve structures 41, 42 and 43 to any such respective positions as may be desired between complete cut-off of the channels 37*d*, 37*e* and 37*f*, as when the valve stems 44 are threaded inwardly to completely obstruct these channels, to maximum flow as when the valve stems are threaded outwardly to positions in which they do not materially obstruct the flow in the channels or materially reduce the cross-section thereof at the valving point therein.

We provide a suitable circulating system for supplying grinding liquid under high pressure to the pipe 23. In the aforementioned patent there is described a circulating system for the active liquid which promotes grinding. This liquid to promote grinding, termed the active liquid, may be an oil, such as a mineral, animal or vegetable oil, preferably treated to embody one or more ingredients, such as sulphur or chlorine compounds, to improve the action at the grinding line, that is to say to promote cutting of the work piece W by the abrasive grains of the grinding wheel G. Oils of this nature may be loaded, in known manner, with suitable sulphur compounds or chlorine compounds or both, for example sulphur chloride. The oil which is preferably used with the apparatus of this invention is a grinding oil of the insoluble type meaning that it is not soluble in water.

The liquid supplied to the nozzle 12 is a coolant to keep the work piece W relatively cool; this is preferably water. In the aforementioned patent there is described a circulation system for circulating water. Furthermore the patent describes a separation system to separate the oil and water, the two liquids being collected together after they have run off the work piece W and the grinding wheel G respectively. This separation can be accomplished as pointed out in the patent because the oil is not soluble in the water and because the oil has a different specific gravity from the water.

It is desirable that the two fluids shall not mix at the grinding line L or otherwise on the work piece W any more than is inevitable. This is for the reason that the active liquid or oil, if present on the work piece W in a surface layer has a tendency to limit the withdrawal of heat from the work piece and the coolant liquid or water has a tendency to weaken the action of the active liquid in promoting grinding efficiency. At the grinding line L there should be so far as possible only oil which has been pre-applied to the grinding wheel G. The work piece W, on the other hand, is efficiently cooled if the water is applied to its surface at any part of the surface which has been ground, but mechanical considerations and requirements direct that this part should be somewhere near the top of the work piece and not so far toward the front of the machine as to spray the operator with water. Since the work piece W is revolving counterclockwise in Figure 1, the rotation has a certain tendency to sweep the water to the left. However gravity and the force of the jet have a tendency to sweep the water down into the grinding line L. We have found that an effective way of keeping the major part of the coolant or water away from the grinding line L is to provide a doctor 50 which may be a blade of suitable material such as fiber suitably secured to the blocks 28, 29 and 30 as by means of screws 51. In order to prevent the water from passing between the blocks 28, 29 and 30 we further provide a sheet metal cover 53 of L-shape which may be secured to the blocks 28, 29 and 30 by means of screws 54. Thus the coolant flows mainly to the left of the doctor 50, Figures 1 and 3, and only a minor proportion thereof will reach the grinding line L. If the mouth M looks narrow in Figures 1 and 3, it must be remembered that it is very wide as seen in Figure 2 and consequently can discharge a large volume of water.

Referring now to Figures 4, 5 and 6 we illustrate another embodiment of our plural fluid apparatus for the grinding of cylindrical workpieces. A nozzle 60 has a flat side 61 and a rounded side 62 and can be supported overhead in any convenient manner; preferably it is attached to the grinding wheel guard heretofore known as a water guard, not shown. It has as will readily be apparent from Figure 5 a wide mouth M and is positioned and adapted to deliver a large volume of coolant, preferably water, to the work piece W at low pressure. Attached to the flat side 61 of the nozzle 60 is a block 65 which may be made of copper or brass. The block 65 has a flat side 66 which can be strongly secured to the flat side 61 of the nozzle 60 by brazing or the like as shown at 67, 67 in Figure 4. Near the bottom thereof the block 65 is drilled to form a cylindrical bore 69 extending from end face 70 to end face 71 of the block 65. The block 65 may have the shape of a rectangular parallelopiped, as shown, and besides the flat side 66 it has a parallel front side 72 and in addition to the end faces 70 and 71 it has a top face 73 and a bottom face 74. The latter, however, is cut away to form a wide opening 75 merging with cylindrical bore 69.

In the bore 69 is a cylindrical distributor nozzle member 80 which fits in the bore 69 with a tight fit—not so tight but what it can be turned as by a screw driver engaging a slot 81 at one end of the member 80, but tight enough to prevent accidental turning and to eliminate or reduce leakage of the active liquid, such as oil, which the distributor nozzle member 80 directs onto the peripheral face of the grinding wheel G. Secured to the distributor nozzle member 80 near the ends thereof and in contact with the end faces 70 and 71 of the block 65 are washers 82 to prevent axial movement of the member 80; these washers may be secured in place by brazing, one before and one after assembly.

The member 80 has a bore 85 lengthwise there-

of extending from the end adjacent the face 70 of the block 65 just short of the opposite end near which is an annular groove 86 in the cylindrical surface of the member 80 communicating with the bore 85 by means of radial holes 87. In line with the groove 86 is a small hole 88 in the block 65 extending between the bore 69 and a tapered threaded bore 89 drilled from the face 73 of the block 65. Screwed into the threaded bore 89 is a tube or pipe 90 to convey the active liquid, for example oil, as in the case of the three tubes 32, 34 and 35, only in the embodiment of Figures 4, 5 and 6 a single tube or pipe 90 serves for delivery of all of the active liquid to promote the grinding action. This liquid under pressure is thus, regardless of the angular position of the distributor nozzle member 80, conveyed to the bore 85 in the member 80. The left hand end of the bore 85 is plugged with a plug 91.

The bore 85 thus contains liquid such as oil under high pressure. A number of orifices 92 are provided in the distributor nozzle member 80, preferably upon the same element of the cylindrical surface of the member 80, and extending from such surface to the bore 85. These orifices 92 can be located in the wide opening 75 to spray oil or other active liquid upon the grinding wheel G right across the grinding surface of the latter, or the orifices can be located in the bore 69 to shut off the flow of liquid—the foregoing may be done simply by turning the member 80 with the aid of a screw driver and in the same way the streams of oil may be raised or lowered to hit the grinding wheel near or far from the grinding line L as is found most advantageous in particular cases. Further to reduce or eliminate leakage of oil or other active fluid we may provide annular grooves 93 in the cylindrical surface of the distributor nozzle member 80, one on either side of the fluid entrance groove 86, such grooves 93 being filled with suitable gland or packing material, which is not shown in order that the drawing shall be clear.

In this embodiment of the invention, as in the case of the embodiment of Figures 1, 2 and 3, the coolant liquid in great volume (water) is delivered to the surface of the work piece W while the active liquid (oil) is delivered at high pressure and therefore high velocity to the surface of the grinding wheel G at points from just above the grinding line L to points more remote but still not far from the grinding line L. The streams of oil, upon impact with the grinding wheel, spread over its active surface to cover all of it—that is the member 80 can be adjusted so as to achieve this desired condition.

As in the case of the other embodiment, it is desired in this embodiment of Figures 4, 5 and 6 to eliminate or minimize the flow of the coolant liquid (e. g. water) into the grinding line L. Accordingly again we provide a doctor 100, like the doctor 50, which may take the form of a sheet or blade of fiber secured as by screws 101 to the inside of the flat side 61 of the nozzle 60, the screws 101 extending into the block 65 which further serves to secure the block 65 to the nozzle 60. This doctor 100 contacts the work piece W between the wide stream of coolant liquid and the grinding line L and thus deflects most of such liquid from the grinding line and keeps it from mixing with the active liquid during the grinding action. This doctor 100 may readily be replaced whenever it becomes worn or in case, for the grinding of a different size of work piece, a longer or a shorter one is needed. It will be noticed that in Figure 4 we show the doctor 100 as slightly curved or bent. It should be made of material which is stiff but still flexible in order that it may contact the work piece W with a slight pressure. Furthermore with the doctor located on the work piece as shown in Figure 4 and with the plural fluid apparatus mounted for movement with the cross slide so that its relation to the grinding wheel G will be unchanging, the reduction in diameter of the work piece W is at a greater rate than the advance of the doctor in the direction of the center of the work piece and therefore a slight flexing of the doctor 100 is desirable so that it will maintain contact with the work piece W. The same situation exists in the case of the embodiment of Figures 1 and 2 where the doctor 50 is also shown as slightly flexed.

Referring now to Figures 7 and 8, we illustrate the invention applied to crankpin grinding. The work piece W' has a reduced diameter portion P which constitutes the crankpin leaving shoulders S. In the grinding operation the grinding wheel G grinds the plane annular surfaces of the shoulders S and finally grinds the cylindrical surface of the pin P. The plural fluid apparatus in this embodiment comprises a nozzle 110 secured by metal straps 111 to the wheel guard WG of the grinding machine which encloses the grinding wheel G. The metal straps 111 may be secured to the nozzle 110 by welding, brazing, or the like and these straps 111 are secured to the wheel guard WG by means of screws 112 screwed into tapped holes in the wheel guard WG. The screws 112 pass through long slots 113 in the straps 111, which are parallel to each other, whereby the position of the nozzle 110 relative to the work piece W' may be readily varied in order to adjust the nozzle 110 for different sizes of work pieces. To the same end we may provide extra tapped holes 114 in the wheel guard WG for relocating the apparatus for different sizes of work pieces or grinding wheels and furthermore it is a simple matter to drill and tap still additional holes 114 in the wheel guard WG.

The nozzle 110 is connected by couplings 115 to a flexible hole 117 which is connected to a low pressure supply of coolant fluid, for example as disclosed in our aforesaid patent. The nozzle 110 is wide as shown by the cross section thereof in Figure 8 and ends in a wide mouth M positioned to discharge the coolant fluid, such as water upon the crankpin P and the shoulders S.

The nozzle 110 has a flat rear face 120 against which is the flat face 121 of a distributor 122. The distributor 122 may be attached to the nozzle 110 by means of screws 123 extending right through the nozzle 120 from the front face 125 thereof and being provided with fiber washers 126 to prevent leakage. The screws 123 may be made of brass to avoid rusting.

The distributor 122 has a central horizontal bore 130 which is plugged at the ends thus to form a distributing chamber in the distributor 122. A flexible metal pipe 132, such as a copper pipe, is secured by means of brackets 133 and screws 134 to the slightly curved underside 135 of the nozzle 110. This pipe 132 is connected to the high pressure source of active fluid, for example oil, as disclosed in our aforesaid patent or in any other suitable manner.

The distributor 122 is drilled and tapped at a point somewhere near the middle of the top thereof to form a threaded bore 135 extending into the bore 130. A short threaded pipe 136 is screwed into the threaded bore 135. The pipe

132 is connected to the short pipe 136 by means of a leakproof coupling 137. Thus active fluid under high pressure is admitted to the bore 130.

On the underside of the distributor 122 is a plane face 140 pitched on a slight inclination to the horizontal as shown. A series of threaded bores 141 are drilled and tapped from the plane face 140 into the bore 130. In each of these threaded bores 141 is the threaded end 142 of a nozzle 143 having a hex portion 144 for engagement by a wrench whereby the nozzle may be screwed into its threaded bore 141. Each nozzle 143 has a fine bore 145 and through these fine bores 145 streams of active liquid emerge at high velocity and impinge upon the grinding wheel G. There are enough nozzles 143 and they are so spaced that the fluid covers the width of the peripheral face of the grinding wheel G; the end nozzles 143 are located so that the streams therefrom impinge upon the corners of the grinding wheel G overflowing to a slight extent upon the plane sides thereof a short distance from the corners. Thus the grinding wheel G is lubricated, that is supplied with active cutting fluid, for grinding the shoulders S and also is lubricated eventually for grinding the pin P. The nozzles 143 are preferably made of some bendable non-ferrous metal, such as copper so that they can readily be bent thus to adjust the streams of fluid.

Extending downwardly from the distributor 122 is a portion 150 having a plane face 151 to which is attached by means of screws 152 a doctor 155 which extends between the shoulders S and contacts the pin P at the start of the grinding operation as shown in Figure 7. In this case as the grinding wheel G and therefore the doctor 155 move toward the center of the work piece W', the doctor 155 is flexed by the infeed, but being made of fiber or other flexible material it can readily withstand such flexure. Thus in this embodiment also coolant fluid is directed to the work piece W' and active fluid is directed to the grinding wheel G and they are prevented from mixing to any large extent at the grinding area A, for in crankpin grinding the cutting action takes place over a significant area.

Referring now to Figures 9 and 10, we have illustrated our plural fluid grinding apparatus applied to surface grinding. In surface grinding, the work piece W'' usually reciprocates in a horizontal plane under the grinding wheel G which is usually adjustable in a vertical direction and also movable in the direction of its axis, but generally is held in a fixed position during any given stroke of the work piece W''. As described in the aforesaid patent or otherwise, we provide a source of coolant under low pressure but with large volume of flow and a source of active fluid under high pressure but small volume of flow. Referring now to Figure 10, we provide a distributor casing 160 having an integral pipe connection 161 for connection to the low pressure coolant. The casing 160 has a large chamber 162 in communication with the interior of the pipe connection 161. Extending across chamber 162 from top to bottom is a conduit 164 having branches 165, 165 leading to the bottom of the chamber 162. A pipe 166 leading to the source of active fluid under high pressure is connected by a connection 167 with the conduit 164, the connection 167 being threaded and screwed into the threaded bore, not shown, of a boss 170 on top of the casing 160. There is an elongated boss 171 on the bottom of the casing 160 through which are threaded bores, not shown, connecting with the branches 165. Connections 173 and nuts 174 connect bent nozzles 175 to the bores in the boss 171 and thus to the conduits 165. These nozzles 175 have relatively small passages 176 therein ending in small orifices 177 for discharging active fluid under high pressure to impinge upon the peripheral face of the grinding wheel G thus to lubricate the grinding line L.

A pair of bosses 180 have tapped holes, not shown, extending into the chamber 162. Short pipes 182 which are externally threaded are screwed into the threaded bores in the bosses 180 and bent nozzles 185 are connected by couplings 186 to the pipes 182. In the above manner coolant liquid under low pressure is supplied to the nozzles 185 while active liquid under high pressure is supplied to the nozzles 175. These nozzles 185 have relatively large passages 186 therein ending in large mouths M for discharging coolant fluid under low pressure onto the work piece W'' thus to cool it.

The casing 160 is attached to any suitable part of the machine so as to be in a fixed position relative to the grinding wheel G; this may be done by securing and supporting the pipe connection 161 or the pipe to which it is connected or otherwise. As it will be seen from Figures 9 and 10, the nozzles 185 are located outside the nozzles 175 and the former extend to either side of the grinding wheel G and a coolant liquid is discharged at either side of the grinding line L but spreads over the work piece to keep it cool. The ends of the nozzles 175 are located to deliver active fluid directly upon the surface of the grinding wheel G thus to keep that surface lubricated. Because of the relative positions of the nozzles 175 and 185 due to their location on the casing 160, the two fluids do not mix to a great extent at the grinding line L. Accordingly, one fluid efficiently lubricates the cutting action and the other fluid acts as an efficient coolant to keep the work piece W'' cool.

It will be noted that in this, as well as in other embodiments of the invention, the active fluid is kept cool by the coolant fluid. Thus in the distributor casing 160 the conduit 164 and the branches 165 which convey the active fluid are surrounded by a coolant fluid in the chamber 162. Therefore the active fluid, such as oil, is kept at low temperature or is reduced to a low temperature just before it impinges upon the grinding wheel G. We have found that this is highly advantageous and promotes grinding efficiency.

It will thus be seen that there has been provided by this invention an apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiments above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. Plural fluid apparatus for grinding machines comprising a low pressure nozzle having a large mouth, a high pressure nozzle having a small orifice, and a separator blade located between the low pressure nozzle and the high pressure nozzle and extending from one edge of the former in the direction of a workpiece to keep the fluids apart thereon.

2. Plural fluid apparatus for grinding machines comprising a low pressure nozzle having a large mouth, a high pressure nozzle having a small orifice, and means for keeping the fluids apart at the grinding line or area, said means constituting a flexible separator blade in the nature of a doctor extending from that side of the low pressure nozzle which is adjacent to the high pressure nozzle and being between the streams of fluids issuing from the nozzles.

3. Plural fluid apparatus for grinding machines comprising a low pressure nozzle having a large mouth to direct coolant under low pressure to a work piece, nozzle means having a plurality of small orifices to direct active liquid to a grinding wheel, distributor means to distribute the active liquid among said plurality of small orifices, and means for keeping the coolant and the active liquid apart during grinding by diverting the coolant away from the grinding line or area while directing the active liquid against the grinding wheel, said means constituting a flexible separator blade in the nature of a doctor extending from that side of the low pressure nozzle with the large mouth adjacent to the nozzle means with the small orifices and being between the stream of coolant issuing from the low pressure nozzle and the streams of active liquid issuing from the small orifices.

4. Plural fluid apparatus for grinding machines comprising a low pressure nozzle having a large mouth to direct coolant under low pressure to a work piece, nozzle means having a plurality of small orifices to direct active liquid to a grinding wheel, means mounting said nozzle means adjustably to vary the axes of said orifices thereby to adjust the streams of active liquid, and means for keeping the coolant and the active liquid apart during grinding by diverting the coolant away from the grinding line or area while directing the active liquid against the grinding wheel, said means constituting a flexible separator blade in the nature of a doctor extending from that side of the low pressure nozzle with the large mouth adjacent to the nozzle means with the small orifices and being between the stream of coolant issuing from the low pressure nozzle and the streams of active liquid issuing from the small orifices.

5. In apparatus as claimed in claim 4, the combination with the parts and features therein specified, of distributor means to distribute the active liquid among said plurality of small orifices.

6. Plural fluid apparatus for grinding machines comprising a large nozzle having a large bore and a large mouth for delivering water under low pressure but in large volume to a workpiece being ground by a grinding wheel, a plurality of small nozzles having small bores and small orifices for delivering oil under high pressure but in small volume to said grinding wheel, a distributor connected to all of the small nozzles to distribute the oil among them, connecting means mechanically connecting the small nozzles to each other with their axes in a plane and mechanically connecting the small nozzles and the distributor to the large nozzle whereby is a unit to be mounted on a grinding machine and when so mounted adjacent and above the grinding wheel will direct oil to the grinding wheel and water to the workpiece, and a wide separator blade in the nature of a doctor fixed to the large nozzle on the side near the small nozzles and extending away from the large nozzle and being spaced from the plane of the axes of the small nozzles to keep the bulk of the water away from the grinding line and away from the grinding wheel.

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