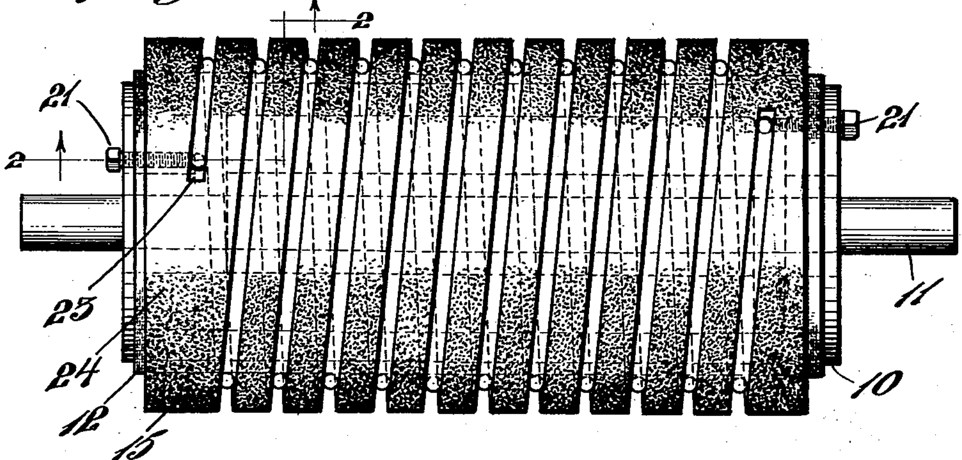
April 26, 1938. D. E. MULHOLLAND ET AL 2,115,209

ABRASIVE WHEEL AND METHOD OF USING SAME

Filed July 11, 1934

Fig. 1.



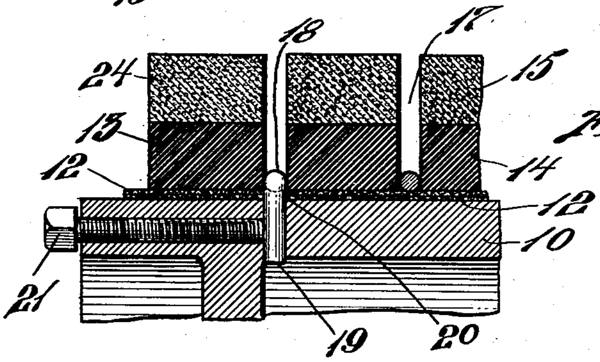


Fig. 2.

Fig. 3.

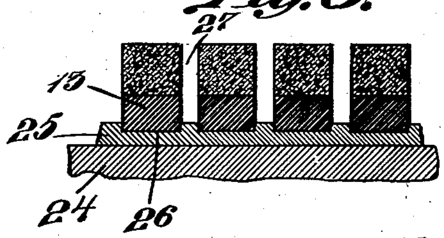
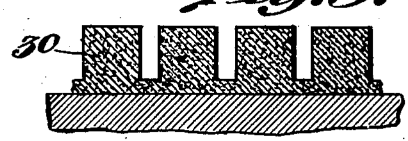


Fig. 4.

Fig. 5.



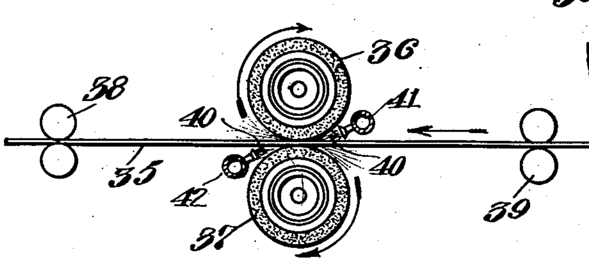


Fig. 6.

INVENTOR.
David E. Mulholland
Walter S. Mulholland
BY
Barlow & Barlow
ATTORNEYS.

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ABRASIVE WHEEL AND METHOD OF USING SAME

David E. Mulholland, Niagara Falls, N. Y., and Walter S. Mulholland, Upper Montclair, N. J., assignors to General Abrasive Company, Inc., a corporation of New York

Application July 11, 1934, Serial No. 734,588

13 Claims. (Cl. 51—190)

This invention relates to an abrasive article, more particularly to one for use in what is called flexible polishing, and has for one of its objects the provision of an article in unit form, which may be used as a flexible polishing unit or wheel, and which may be formed in standardized grades and sizes both for the cases in which the work is presented by hand, and particularly for incorporation as an element in equipment where the work is presented to the abrasive member mechanically.

Another object of the invention is to provide an abrasive article for flexible polishing of such a nature that it is not injured by a liquid coolant, thus the generated heat can be controlled and the rate at which work can be done increased.

Another object of the invention is to provide an abrasive article with which a liquid coolant may be so used to control the heat that both sides of a sheet of material may be operated upon at the same time to not only increase the amount of work done, but to also better control the work operated upon.

Another object of the invention is to provide an abrasive article of such a nature and in such form that when included as an element in an automatic or semi-automatic machine, the required work to be done in each operation can be accomplished by one pass under the wheel, eliminating necessity for the present reciprocating movements of the material under the polishing wheel.

Another object of the invention is to provide an abrasive article for flexible polishing of relatively long life in terms of work produced, thus reducing the number of wheels necessary to carry on continuous production of polished material and avoiding the necessity of frequent replacement of the polishing element and consequent interruption of the work.

Another object of the invention is to provide an abrasive article that will not load with accumulations of abraded material which is a common fault of present set-up wheels.

Another object of the invention is to provide an abrasive article for flexible polishing whose surface can be dressed and especially when it becomes worn on less than its full face restoring an abrasive surface to the entire face comparable to shape provided before being worn.

A further object of the invention is to provide an abrasive article that will not create the optical effect or pattern on the work commonly referred to as chattermarks.

A still further object of the invention is the provision of a wheel which may be so secured in place that it will not be expanded to a detrimental amount by centrifugal force acting on it at practical polishing speeds.

With these and other objects in view, the invention consists of certain novel features of construction, as will be more fully described, and particularly pointed out in the appended claims.

In the accompanying drawing:

Fig. 1 is an elevation of an abrasive wheel formed in accordance with our invention;

Fig. 2 is a fragmental portion thereof in section;

Fig. 3 is a fragmental sectional view of a modification;

Fig. 4 is a fragmental sectional view of a different modification;

Fig. 5 is a fragmental sectional view of a still different modification;

Fig. 6 is a diagrammatic view illustrating two wheels as operating upon a sheet of work.

As opposed to grinding which is done with rigidly bonded wheels, flexible polishing to produce good work requires an abrading medium having varying degrees of flexibility and resiliency depending upon the characteristics of the material to be treated. Since the inception of the art it has been the practice to apply thin coats of abrasive to the periphery of wheels whose bodies have these varying degrees of flexibility and resiliency. Animal glue is the adhesive generally employed and it both bonds the abrasive grains and attaches them to the wheels. The grades of glue best adapted to this purpose are somewhat flexible but this degree of flexibility is not of the order required for flexible polishing but is merely a property of toughness which avoids the crumbly structure resulting from the use of the more brittle grades. Before being placed in use, this glue bonded abrasive coating is generally cracked into a number of small sections which enables the resilient and flexible properties of the body of the wheel to have effect.

The useful life of this coating is very short, and hence as a matter of practical necessity is applied in the plants where used. Some mechanical devices have been developed to aid in this coating process, but it is for the most part a manual operation and great dexterity is required to produce good results. Because of this short life of the coating and the fact that forty eight hours are required for the glue to attain its maximum strength a large number of wheels are required to carry on continuous work.

The necessity for polishing the surface of stainless steel sheets in order to fully develop their corrosion resisting properties has made new and severe demands on the art. Wheels up to eighteen inches in diameter and seventy two inches face are in use. Also in these wide faced wheels which are generally of laminated construction, being made of discs of cloth stitched and pressed together on a shaft, it is extremely difficult to attain a uniform degree of resiliency across the face of the wheel body and to put and maintain the wheel in dynamic balance. These faults together with the fact that since the abrasive coating when in use is cracked and breaks into many different sized sections of varying weights, under centrifugal force in combination with other factors, result in a chattermark on the polished sheet whose frequency depends on the rate of travel of the sheet as it passes under the abrasive agent.

Flexible polishing ordinarily consists of three or more operations; roughing, one or more intermediates and finishing. As known, the coating of a set-up wheel or even a belt is broken or breaks into a number of small sections. The abrasive grains in these sections being bonded with glue are held rigidly with respect to each other, and as a result, their abrasive action is harsh, and while this harsh surface is often used untreated in the roughing operation, its action must be tempered by the application of various waxes or greases to serve in connection with some intermediate and the finishing operations. This treating of a wheel or belt (and it applies to factory coated abrasive paper or cloth as well) enables it to finish a surface, but its maintenance in proper condition is dependent upon the skill of the operator. The use of grease for this purpose, moreover, increases the difficulty of re-coating the wheels and belts. It works down through the cracks and penetrates the fibres of the wheel or belt body and seriously interferes with the adhesion of subsequent coatings.

Surface abrasion develops heat. In the case of grinding wheels, varying amounts are generated, depending upon the bond and structure. With these, it is possible to use a liquid coolant. In flexible polishing, this method of controlling heat has not been possible because of the glue bond, and the heat developed has often limited the rate at which work can be done. In the case of manual work, it is usually necessary for the workman to wear gloves to protect his hands from the heat. Gloves are easily caught on wheels and other revolving parts and are a great source of danger.

In polishing metal sheets, the widths vary and it is not always possible to arrange the production schedules so that the narrower widths follow the wider ones. When work is done on narrow sheets first the surface of the abrasive member becomes worn, and it is not practical to dress this surface so that work may be done on wider sheets even though the coating is not worn out because the coating is in small sections and the character of their adhesion to the wheel body is such that these sections are torn loose rather than dressed down when a tool is applied for this purpose.

Rubber was one of the earliest materials used to bond abrasives. Rubber bonded wheels, when compared to vitrified grinding wheels, may have a measure of resiliency and flexibility and have greater strength which are properties that make them well adapted to certain grinding operations, but these properties of resiliency and flexibility do not exist to the degree that makes the product applicable, to the present day so-called flexible polishing, in spite of the fact that some of these products are referred to as polishing or finishing wheels. One of the objects in compounding the rubber used, is to produce a material that when combined with abrasive grains and cured, will form an aggregate having the greatest possible tensile strength. This material is in the class known as hard rubber or ebonite, and at the upper end of this class having maximum tensile strength. The compounds in the lower end of this phase of rubber while also having the property of crumbling or disintegrating to a dust with abrasion, lack the tensile strength of the compounds in the upper end and they have found little use in industry aside from valve parts.

In our studies, we have found that in attempts to bond abrasives with soft rubber which has the degree of flexibility and resiliency needed, the grain is released at a rate beyond the ability of the bond to break down and the article thus fails to continuously present an efficient abrasive surface and is therefore impractical. In changing the compounding so that adequate holding power of the grain is obtained, the necessary resiliency is lost. Attempts to get around this impasse by utilizing an aggregate having efficient abrasive effect but not either the required resiliency or flexibility, but supplying these characteristics in another and supporting body either as spaced teeth extending to the surface, or as irregular shapes interspersed throughout the resilient body, fail to remain continuously abrasive in their action because the resilient body in order to adequately support the abrading members extends to the outer surface of the wheel where abrasion is to take place, and this resilient body not having the necessary characteristic of breaking down as the abrasive teeth wear, defeats the purpose of the wheel. There have been no fundamental improvements in a flexible polishing or grinding tool since abrasive grain was first glued to the periphery of a set-up wheel.

In order to overcome the difficulties and undesirable effects which occur in the prior art, we have constructed a wheel which is shown in the accompanying drawing and consists of a metallic cylinder or drum designated 10 which may be of such a character that it may be mounted upon a shaft 11 for rotation thereof at the desired number of revolutions to secure the desired surface speed. Removably mounted upon this metal drum or cylinder 10, there is a sleeve designated 12 which we choose to form of fabric, although other substances may be used, if desired. Attached to this fabric and extending in a helical manner, there are relatively narrow strips designated generally 13 which extend helically across the face of the wheel throughout its length. These strips 13 are composed of two different strata of material, one a relatively soft, resilient rubber 14 adjacent the sleeve, and the other a harder rubber material 15 at the outer surface comprising bonded abrasive grain, the bond being of sufficiently hard rubber of a friable composition, although somewhat flexible, so that the surface will break down as used and continue to expose fresh grain to the work.

The thickness and width of the strip of this abrasive containing material 15 is such that it will flex to some extent and transmit some of the pressure to the softer backing rubber 14 which will absorb it. It is found this thickness may be made at least one-half an inch, although we do not limit ourselves to this dimension. This softer rubber 14 is disposed to provide a cushion or flexible backing and support for the abrasive grain containing material 15. The helical strips 13 are separated by a helical groove 17 to permit of expansion of the soft rubber in a direction longitudinally or axially of the wheel when the same is compressed from the surface toward the axis of the drum.

In the formation of this wheel, the fabric is impregnated with rubber and helically wound on the drum, the soft rubber applied either as a sheet or a helical strip, and then the abrasive grain bonded material applied either as a sheet or as a helical strip and the whole vulcanized together. When wound as a helix in the vulcanization, the edges of the helical wound abrasive grain material are fused together, and when a sheet is spirally wound the surfaces which contact are fused together, and after vulcanizing, slots 17 between the helical strip 15 are cut and may extend to the fabric sleeve 12, thus providing a helical slot between the strips 13 and a recess into which a wire 18 may be positioned along the length of the drum for binding the sleeve to the drum at closely related points so that this sleeve cannot expand to an uncontrollable extent by centrifugal force developed at practical polishing speeds, and thus remains firmly secured to the drum at all times.

In order that there may be no undue expansion of the sleeve at the ends thereof, we terminate the helical slot 17 at a point inward from the end as at 23, leaving a solid portion or ring 24 at each end. This maintains a more even slight expansion than were there a free thin end due to a taper of the material which would otherwise occur at its end formed by the helical groove.

The ends 19 of the wire or binding element are secured by each end extending into a hole or recess 20 in the metal drum and there held by a set screw 21 threaded into the drum to extend across the recess 20.

In the modification shown in Figure 3, we have shown the metal drum 24 with a sleeve 25 grooved as at 26 and the composite strip 13 as set and cemented therein definitely spacing the strip 13 and leaving a groove 27 between the helical wound strip for lateral expansion to occur upon compression and allowing the proper amount of flexibility.

In the modification shown in Figure 4, the helical groove 28 does not extend through the softer rubber 29, thus leaving a continuous inner surface forming a sleeve for removably positioning of the whole as a unit on the drum.

In the modifications shown in Figures 2, 3 and 4, the outer bonded abrasive portion and the inner cushioning backing portion comprise annular-shaped members which are arranged concentrically one inside of the other.

In Figure 5 we show a sleeve 30 the material of which is the same throughout, and a material of a lower phase of the hard rubbers as a bond for the abrasive grains, whereby it is sufficiently resilient so as to be satisfactory for some limited work. The bond is such that it has the property of breaking down into powder or dust on abrasion exposing new grain, before the grain becomes dulled. There are sufficient of the grains present in the bond so that the proportion of grain and bond presents in cross section a honeycomb matrix, that is, a cross section of the bond alone will be as a honeycomb.

The bond of all the grains above described is such that the grains are individually resiliently suspended while doing their work, and so tend to make more uniform depth scratches in the work than where a glue bond is used which glue bond cracks into small sections or segments, and some grains project further than others, and thus receive more pressure and make deeper scratches than where a flexible bond is used such as is used by us, and this quality of binding the grain is such as to cause even scratches and yet has the property of crumbling away or breaking down in use, the combination of which is new in a flexible polishing wheel of this character.

We have further found that by using this lower phase of hard rubber, that the grains are so bonded that they are not held rigidly with respect to each other, and therefore do not offer the resistance that allows abraded material to become packed between groups of grains. This condition is known as loading and is common in the use of set-up wheels.

The material for bonding grains, although it is sufficiently hard to break down as the wheel is used affords the flexibility required by reason of the soft rubber backing beneath the layer of bonded grain; and by this layer being of sufficient dimension so that it is resilient to transmit some of its pressure, the needed property of resiliency is transmitted to this flexible abrasive facing which has not heretofore been attained in a wheel in which the bond would satisfactorily break down as the wheel was used. The helical form in which the outer layers are formed also assists in the resiliency required as it permits movement of the helical strip or layer without undue restriction of the flexible bond and the soft rubber backing; this displacement largely occurring under compression in the soft rubber backing in a direction parallel with the axis of the wheel and into the space of the grooves 17, as illustrated in the drawing.

This helix or helical form of the abrasive facing is held in place, as above described, and the helical groove between the helical strips of facing material performs several functions in connection with the use of this wheel; it permits of the expansion of the material in a direction parallel to the axis when under compression and permits of the securing of the sleeve and abrasive face in position on the drum, both of which have heretofore been mentioned; and in addition, serves as a coolant and lubricant distributing medium, which by reason of the use of a bond of rubber is permitted, whereby a faster cut may be obtained.

In grinding with a rigid wheel, there is practically line contact of the wheel with the work and a coolant as here shown can carry away the heat generated. In flexible polishing the wheel has a broader contact with the work due to the compression of the wheel. The surface speed of the wheel is so much greater than the speed of the work past the wheel that either a damaging amount of heat develops, or the rate at which the work can be done is limited. We have discovered that the actual heat generated by the wheel in one revolution is not damaging, and that if this can be effectively carried away, it will prevent progressive accumulation of heat to the point where it becomes damaging to the work or wheel, resulting in either warping or so-called burning. We have found that a helical groove or grooves in the flexible surface member or in it and the resilient backing member as well will permit a large and sufficient volume of a coolant to sweep across the actual contact area at least once each revolution of the wheel to prevent both this building up and progressive accumulation of heat that would otherwise occur, although it will be apparent that the helical groove may be varied for the desired cooling. In the mechanical polishing of metal sheets in some instances, the sheets rest on a bed and are passed under the abrasive member in a flat condition. In others the sheet is passed over rollers whose height is above the general level of the sheet narrowing the area of contact. In others the sheet is so supported as it passes under the abrasive element that the sheet tends to bend around the wheel and thus increase the area of contact. In all three cases, the helical groove specified increases the rate at which abrasion can take place by making possible complete contact of the area being worked with a large volume of fluid coolant at least once in each revolution of the wheel.

In the flexible polishing of sheets and some other items as heretofore practiced, it is necessary to pass the work back and forth under the polishing wheel a large number of times during each operation. The factors responsible for this are the rate of abrasion and lack of adequate control of the heat generated. To accomplish line production where tonnage is handled, would require a large number of heads and such further excessive investment in equipment to operate them that costs would be raised unduly. We have found that the combination of elements here set forth in connection with the coolant so raise the efficiency with which work can be done, that each operation can be accomplished in one pass under the wheel or drum and line production which is so much desired is possible without prohibitive investment.

Further, as the coolant may reduce the temperature to the desired degree opposite surfaces of a sheet may be polished at the same time, as shown diagrammatically in Figure 6. This has not only the advantage of speeding up production, but also enables the wheels on the opposite sides of the sheet to be run in opposite directions to balance the pull on the work and prevent thin work from buckling. In Figure 6 the work is shown at **35**, between an abrasive wheel **36** on one side and **37** on the other side operating in opposite directions. The feed rolls **38** on one side and **39** on the other governing the advance of the work through the apparatus. Coolant and lubricant **40** will be used in conjunction with both wheels by discharging it from nozzles **41** and **42** to control the heat developed which may be nicely accomplished by being carried across the face of each wheel by the helical groove in the surface thereof enabling this operation of operating on both surfaces to be performed.

A set-up wheel should have a curing period of forty eight hours, and as the effective life is short in service, a large number of heads are required to maintain production. We have found that the use of the elements specified in connection with the coolant avoids the necessity for this large number of heads materially reducing the investment.

We have found that the use of the elements specified permits an abrasive coating of at least one-half an inch in thickness, and acting more efficiently with the coolant which protects the wheel as well as the work has far greater life in terms of the quantity of work done per wheel obviating the necessity for frequent wheel changes which interfere with production.

We have found that by the use of the combination of elements referred to, the face of the abrasive member can be repeatedly dressed restoring a level surface when portions become worn through use on sheets that are narrower than the wheel permitting subsequent use of the full face.

We have found that the combinations of the elements specified with particular reference to the property of flexibility of the abrasive member avoids the optical pattern or chattermark made by an abrasive surface that must be broken or breaks into various sized segments to give effect to the resilient body of the wheel.

The foregoing description is directed solely towards the construction illustrated, but we desire it to be understood that we reserve the privilege of resorting to all the mechanical changes to which the device is susceptible, the invention being defined and limited only by the terms of the appended claims.

We claim:

1. An abrasive wheel comprising a central body adapted to be mounted on a shaft, a sleeve removably mounted on said body comprising a face of abrasive and bond therefor, and a layer of material more resilient than said abrasive bond positioned inwardly from the bonded abrasive portion, the surface of said wheel being grooved to provide relatively short work contacting portions along the engaging surface, said groove extending sufficiently deep to permit lateral displacement of the resilient backing, and means located in said groove for securing said sleeve to said central body.

2. An abrasive wheel comprising a central body adapted to be mounted on a shaft, a sleeve removably mounted on said body comprising a face of abrasive and bond therefor, and a layer of material more resilient than said abrasive bond positioned inwardly from the bonded abrasive portion, said wheel being provided with a helical groove in its face and extending into said backing material, and means located in said helical groove for securing said sleeve to said central body.

3. A flexible polishing tool having an abrasive and organic bond therefor the surface of said tool being grooved at an angle to the direction of movement of the surface to provide coolant channels for carrying liquid coolant along the entire width of the engaging surface, said groove terminating short of the opposite edges of the tool.

4. A flexible polishing tool having an abrasive and organic bond therefor the surface of said tool being provided with a helical groove to provide coolant channels for carrying liquid coolant along the entire width of the engaging surface, said groove terminating short of the opposite edges of the tool.

5. An abrasive tool comprising a central body of a width greater than its diameter adapted to be mounted on a shaft, a sleeve also of a width greater than its diameter and removably mounted on said body comprising flexibly bonded abrasive face, the surface of said wheel being grooved to provide coolant circulating channels along the engaging surface, and means in said channels for removably mounting said sleeve on said body.

6. An abrasive tool comprising a central body adapted to be mounted on a shaft, a sleeve removably mounted on said body comprising flexibly bonded abrasive face, the surface of said wheel being helically grooved to provide coolant circulating channels along the engaging surface, and means in said helical groove for removably mounting said sleeve on said body.

7. An abrasive wheel comprising an outer face portion of abrasive grains integrally united together by a hard friable organic bond, and an inner layer of a relatively soft resilient organic material back of said bonded abrasive portion and integrally united thereto, the exterior surface of said wheel periphery being grooved therealong to provide a plurality of short work contacting portions and liquid coolant circulating means between them spaced axially along the work-engaging surface thereof, said groove extending inwardly from the wheel surface into the soft backing layer to a sufficient depth to permit lateral displacement of the resilient backing material.

8. An abrasive wheel comprising an outer face portion of granular abrasive material integrally united together by a non-water soluble bond, and an inner backing layer integrally united therewith of a material more resilient than the bond of said abrasive face portion, the exterior polishing portion of said wheel being provided with a helical groove in its peripheral face and extending into said backing material forming a liquid coolant circulating channel therein.

9. An abrasive wheel comprising a central support, a body thereon having a peripheral abrading face portion of abrasive grains integrally united together by a bond, and a backing portion containing a material more resilient than the bond employed in the abrasive portion and positioned inwardly from said bonded abrasive portion, the exterior surface of said wheel being grooved to provide relatively short work contacting portions along the engaging surface, said groove extending sufficiently deep to permit a lateral displacement of the resilient backing, and means located in said groove and of a character which serves to strengthen the wheel and render it more resistant to rupture by the action of centrifugal force arising during rotation and normal use of the wheel.

10. An abrasive wheel comprising a central support, a body thereon having a peripheral abrading face portion of abrasive grains integrally united together by a bond, and a backing portion containing a material more resilient than the bond employed in the abrasive portion and positioned inwardly from said bonded abrasive portion, said wheel being provided with a helical groove in its face and extending into said backing material, and means located in said helical groove and of a character which serves to strengthen the wheel and render it more resistant to rupture by the action of centrifugal force arising during rotation and normal use of the wheel.

11. An abrasive wheel comprising a central support of a width greater than its diameter and adapted to be mounted on a shaft, a body also of a width greater than its diameter and mounted on said support and having an abrading face portion of bonded abrasive grains, the exterior surface of said wheel being grooved to provide coolant circulating channels along the engaging surface, and means located in said channels and of a character which serves to strengthen the wheel and render it more resistant to rupture by the action of centrifugal force arising during rotation and normal use of the wheel.

12. An abrasive wheel comprising a central support of a width greater than its diameter and adapted to be mounted on a shaft, a body also of a width greater than its diameter and mounted on said support and having an abrading face portion of bonded abrasive grains, the exterior surface of said wheel being helically grooved to provide coolant circulating channels along the engaging surface, and means located in said helical groove and of a character which serves to strengthen the wheel and render it more resistant to rupture by the action of centrifugal force arising during rotation and normal use of the wheel.

13. An abrasive wheel comprising an outer face portion of abrasive grains integrally united together by a hard friable organic bond, and an inner layer of a relatively soft resilient organic material back of said bonded abrasive portion and integrally united thereto, the exterior surface of said wheel periphery being grooved therealong to provide a plurality of short work contacting portions and liquid coolant circulating channels spaced axially along the work engaging surface thereof, said groove extending inwardly from the wheel surface and through the soft backing layer to permit lateral displacement of the resilient backing material.

DAVID E. MULHOLLAND.
WALTER S. MULHOLLAND.