

Aug. 2, 1966

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3,263,377

REINFORCED FLEXIBLE ABRASIVE WHEEL

Filed Dec. 13, 1963

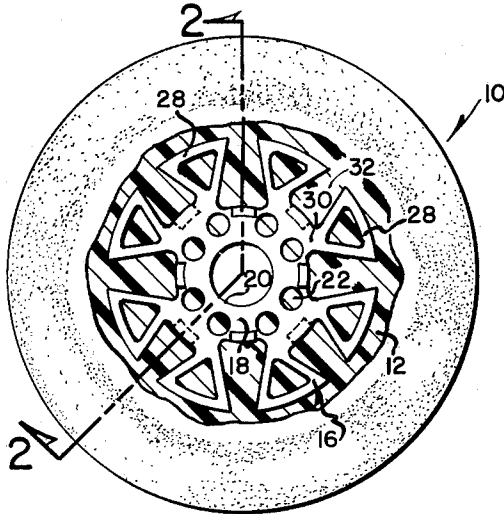


FIG. 1

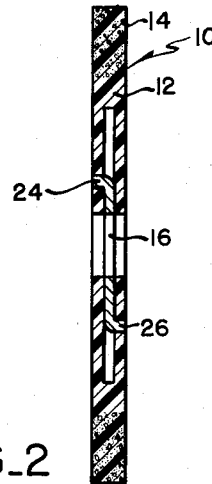


FIG. 2

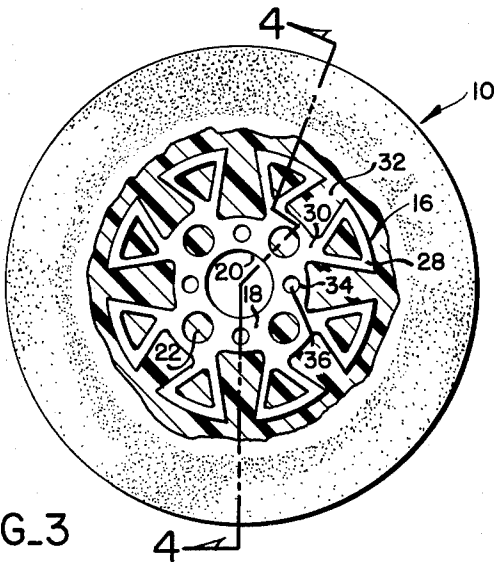


FIG. 3

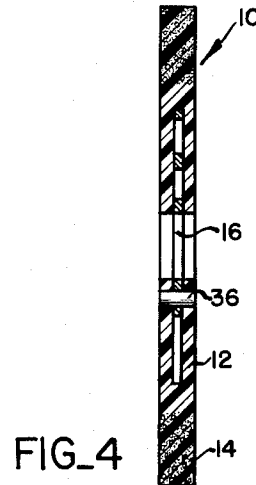


FIG. 4

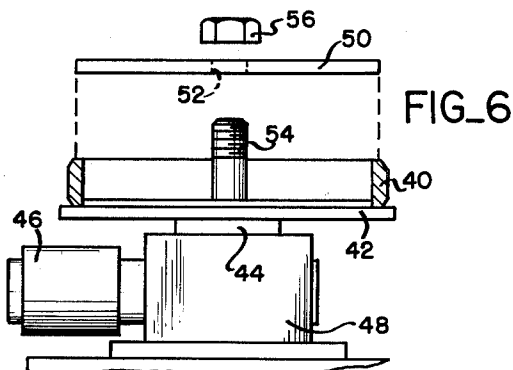


FIG. 6

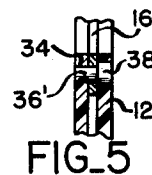


FIG. 5

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REINFORCED FLEXIBLE ABRASIVE WHEEL

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Filed Dec. 13, 1963, Ser. No. 330,347
13 Claims. (Cl. 51—394)

The present invention relates in general to abrasive wheels and more particularly, as indicated, to a reinforced flexible abrasive wheel. Such a flexible type abrasive wheel finds use, for example, in finishing and/or polishing workpieces, the flexibility thereof permitting the face of the wheel to follow closely the surface of the workpiece thereby to provide the desired polishing or finishing operation without substantial cutting of the workpiece, which distinguishes such flexible wheels from the relatively rigid grinding type wheels which are able to make relatively deep cuts in the workpiece.

In flexible abrasive wheels, there are certain desired characteristics which such wheels should possess to provide optimum results over extended periods of frequently high speed use. The wheel must of course be flexible, which places a decided limitation on the material forming the matrix or body of the abrasive wheel. Secondly, the wheel, while possessing the requisite flexibility, should during continued periods of use retain its concentricity with the arbor. In this regard, there is a strong tendency, especially during relatively high speed rotation, for the materials which form the wheel to expand or stretch radially outwardly, usually in a non-uniform manner, thereby to effect a non-smooth working surface, an obviously undesirable result. Such radial stretching also tends to increase the arbor hole size resulting in undesirable eccentric rotation.

A primary object of the present invention, then, is to provide a flexible abrasive wheel possessing the desired flexibility but which is resistant to radially outward expansion even during relatively high speed use so as to retain peripheral concentricity with the arbor.

A more specific object of the present invention is to provide an internally reinforced flexible abrasive wheel constructed to permit yielding where necessary and desired but wherein such reinforcing rigidifies the wheel for retaining its shape and concentricity even during high speed use and under relatively heavy loads. In other words, such reinforcing means permits substantial movement of the face of the wheel for following closely the surface of the workpiece but yet provides radial rigidity to the wheel for retaining the shape thereof.

A further object of the present invention is to provide such an internal reinforcing means for imparting to the wheel the noted resistance to radial expansion, but which itself is relatively lightweight and laterally flexible so as not to impair the lateral flexibility of the flexible wheel to any significant degree.

A still further object of the present invention is to provide a finishing and polishing wheel of foamed flexible plastic having granular abrasive concentrated only in a radially outer annular region thereof which, together with the comparatively lightweight internal reinforcing means, comprises a flexible abrasive wheel of substantially less weight than existing wheels of this general type.

A still further object of the present invention is to provide a novel method of making the flexible abrasive wheel with the reinforcing means incorporated therein.

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These and other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawings:

FIG. 1 is a side elevational view of the abrasive wheel of the present invention, incorporating one form of the flexible reinforcement, with the abrasive wheel being broken away in the central portion thereof to expose such reinforcing member;

FIG. 2 is a radial sectional view taken on lines 2—2 of FIG. 1, with certain material along the section line being omitted to expose the reinforcing member;

FIG. 3 is a side elevational view of an abrasive wheel incorporating a second form of reinforcing member and means for axially spacing the same within the mold, with the central portion of such wheel being broken away to expose such reinforcing member;

FIG. 4 is a radial sectional view taken on lines 4—4 of FIG. 3, with certain material along the section line being omitted to expose the reinforcing member;

FIG. 5 is a fragmentary view showing another means for spacing the reinforcing member of the FIGS. 3—4 form within the mold; and

FIG. 6 is a partially sectioned side view of the preferred mold apparatus for molding the reinforced flexible abrasive wheel of the present invention, with the mold parts being shown disassembled.

Referring now in more detail to the drawings, wherein like reference characters are used to designate like parts, and initially to FIGS. 1 and 2 thereof, the flexible abrasive wheel illustrated in completed form therein is generally indicated at 10 and comprises a body portion 12 of relatively low density foamed plastic having abrasive particles embedded therein in a radially outer annular belt or region relatively adjacent the periphery or working surface of the wheel. Although the particular composition of the foamed plastic body 12 forms no part of the present invention, with any suitable plastic mixture possessing the suitable foaming properties and being elastomeric upon setting being capable of use, highly satisfactory results have been obtained where the foamed plastic comprises polyurethane. Generally stated, such polyurethane foam comprises a gellable, foamable liquid resin and is combined with certain other ingredients such as, e.g., relatively inert or neutral filling material, catalysts, water, and of course the abrasive particles. The amount of the entire mixture is less than the mold cavity so as to allow for foaming and the incidental generation of gas bubbles during the molding process to be hereinafter specifically described. Substantially all of the abrasive particles or granules 14 during such molding process will move toward the radially outer regions of the wheel to form an outer annular abrasive region adjacent the periphery thereof. The particular plastic employed, the flexibility thereof, and the type of abrasive particles embedded therein will depend upon the particular use to which the wheel is put. It will be understood that the

elastomeric plastic foam employed should have the desired degree of softness, i.e., flexibility sufficient to do effectively the work intended.

Referring now in more detail to the means for reinforcing the wheel 10, a centrally disposed reinforcing member or skeleton 16 is embedded within the relatively non-abrasive region of the foam plastic body 12 during the molding of the wheel, the skeleton 16 being preferably constructed of a relatively lightweight laminated fibrous composition such as, e.g., cardboard. Such fibrous composition, and more particularly the configuration thereof, permits lateral deflection of the skeleton but resists radial expansion thereby to maintain the desired concentricity of the abrasive wheel. As can readily be seen in FIG. 2, the skeleton 16 is relatively thin in comparison with the total thickness of the abrasive wheel 10. Such thinness, in addition to providing the desired lateral flexibility, is desirable during the molding of the wheel 10, as will be hereinafter explained.

Referring to the specific configuration of the skeleton 16 in the FIGS. 1-2 form thereof, the skeleton 16 comprises a central body portion 18 formed with an opening 20 which defines the arbor opening for the finished wheel. A plurality of arcuately spaced openings 22 are formed in such central portion 18 of the skeleton for a reason hereinafter explained. Such central portion further includes a plurality of arcuately spaced tabs 24 and 26 upset from the central body portion and which extend normally thereto on both sides thereof. There are thus in the form shown four such tabs 24 which extend to one side of the skeleton and a second set of tabs 26 radially spaced outwardly from the tabs 24 and which extend in the opposite direction relative thereto. The oppositely directed tabs 24 and 26 serve to accurately axially set the skeleton 16 in the mold during the molding process thereby to ensure axial centering thereof in the completed wheel.

The skeleton 16 is further formed with a plurality of radial, finger-like extensions 28, each of which is generally triangular shaped with a relatively large opening therein and connected to the central body portion through neck portions 30. The width of the neck portions 30 should be relatively small, for example approximately twice the thickness of the skeleton, to permit the desired lateral movement or twisting of the skeleton in use of the wheel. The arcuate length along the outer periphery of each of the extensions 28 is likewise of importance in controlling the twisting action of the wheel since the foam plastic material rigidly chemically bonded thereto yields in tension as the wheel is laterally flexed, with the resistance afforded by the bonded interface varying with the length of the arcuate periphery of the extension.

In addition to controlling the lateral deflection of the skeleton 16, the arcuately spaced extensions 28, and more particularly the open areas 32 therebetween, serve effectively to key mechanically the foamed plastic to the skeleton 16. Thus, during the molding process, the foamed plastic enters such open areas 32 between the extensions 28, as well as the openings 22 in the central portion 18 of the skeleton, thereby mechanically keying the skeleton 16 to the plastic. As will be understood, in addition to such mechanical keying of the skeleton to the foam plastic, a rigid chemical bonding between the plastic and the surface of the skeleton will be effected. The open areas of the skeleton 16 in the form shown comprise approximately 50 percent of the total area of the skeleton.

Referring now to the abrasive wheel illustrated in FIGS. 3 and 4, with one exception the reinforcing skeleton illustrated therein is identical with that previously described above in reference to the FIGS. 1 and 2 embodiment, such similarity where present being indicated by the use of like reference characters. In FIGS. 3 and 4 form, however, the tabs 24 and 26 have been omitted and the skeleton 16 is completely flat. In order accurately to space the skeleton 16 within the mold during the molding process, a plurality of arcuately spaced openings 34

are formed in the central body portion 18 of the skeleton, and pins 36 are disposed therethrough, the opposed flat ends of such pins extending equal distances from each side of the skeleton so as accurately to space the skeleton within the mold. Although it will be apparent that the particular material employed for such pins is not critical, such material should be preferably capable of deformation rather than breakage in order to absorb forces acting thereon when the wheel is mounted for use, and in this regard polypropylene has been found to be an excellent material for this purpose. In addition to spacing the skeleton 16 within the mold, when the wheel 10 is mounted tightly within arbor assembly, the opposed ends of the pins 36 are generally contacted by the arbor mounting flanges to thus provide relatively rigid points of contact therebetween which tend greatly to decrease slippage of the wheel under the torque resulting from the pressure of the work.

There is illustrated in FIG. 5 yet another means for spacing the skeleton 16 within the mold during the molding process. In this form, a plurality of pins, one such pin being indicated at 36', are similarly used for such spacing. However, rather than being of the straight form shown in FIG. 4, the pins in the FIG. 5 form are provided with head portions 38, the depth of such head portions being predeterminedly calculated to ensure proper location of the skeleton within the mold. The opposite end of the pin 36' extends outwardly from the opposite face of the skeleton 16 an amount equal to the depth of the head 38 whereby the skeleton is accurately axially aligned in the mold when disposed therein.

There is diagrammatically shown in FIG. 6 suitable molding equipment for molding the wheel 10 in accordance with the present invention, and the method of centrifugal molding is preferably employed. The centrifugal molding process by itself forms no part of the present invention and will be described only in sufficient detail to enable one skilled in the art to fully understand the present invention and more particularly the preferred process by which the wheel 10 is formed. For a more complete discussion of the various methods of and apparatus for making articles by the centrifugal molding process, attention is hereby directed to my co-pending applications Serial No. 854,468, filed November 20, 1959, and Serial No. 15,135, filed March 15, 1960.

Referring now to FIG. 6, the mold comprises an annular ring 40 adapted to be centered and firmly secured to or clamped against a bottom plate 42 preferably detachably secured to a turntable support 44. The support 44 is rotatable about a vertical axis by any suitable drive means, for example a motor 46 and a worm gear assembly, the latter being enclosed in housing 48. As will be apparent, annular rings 40 having varying diameters may be employed to form various sized flexible abrasive wheels.

The mold further includes a removable cover plate 50 having a central opening 52 adapted to fit over an axially threaded stud 54 whereby such cover plate 50 may be firmly clamped against ring 40 upon tightening of a fastening nut 56. The foamable plastic ingredients and abrasive may be added simultaneously to the mold with the cover 50, of course, removed therefrom, in which event the cover 50 may be imperforate as shown. If, however, it is desired to add one or more of such ingredients after the plate 50 has been securely clamped in place and mold rotation initiated, the plate 50 may be additionally provided with an opening through which such ingredients can be added to the mold interior, with the opening preferably being closed during centrifuging. Sufficient clearance or other vent means is provided centrally of cover 50 to permit escape of excess gas generated during the foaming and centrifuging operations.

Regardless of the manner in which the ingredients which form the foamed plastic are added to the mold, the skeleton 16 is placed within the mold with the arbor

opening 20 fitting around the stud 54. The skeleton 16 is axially aligned within the mold by the various previously described spacing means, namely by tabs 24-26, pins 36, or pins 36'. Subsequent to the addition of the desired plastic ingredients, the mold is rapidly rotated, causing the abrasive particles 14 to collect, by centrifugal force, in an annular region in the outer portion of the mold cavity, as clearly illustrated in FIGS. 2 and 4. The foaming tendency is normally inhibited during centrifuging while the viscosity of the plastic increases, so that upon cessation of effective centrifuging the foaming takes place in the more viscous plastic to space the abrasive granules only slightly but uniformly apart and completely fill the mold cavity by radially inward expansion. Such foaming action is attended by an excess of gas, and such gas is allowed to escape from the mold interior by the aforesaid central venting means. The foamed plastic material thus completely fills the openings 32 between the extensions 28 of the skeleton, the openings within the extensions 28, and the openings 22 in the central portion 18 of the skeleton, the relative thinness of the skeleton 16 freely permitting flow of the plastic foam in the central region of the mold.

At the termination of the centrifuging operation, the plastic mixture is left in the mold for a period of time sufficient to cure the same, with or without the addition of heat. The skeleton 16 is thereby effectively mechanically keyed and firmly adhesively bonded to the foamed plastic. After such curing, the completed wheel 10 is removed from the mold.

It will thus be seen that the flexible abrasive wheel made in accordance with the present invention is unique and possesses distinct advantages over previously known flexible type abrasive wheels. The centrifuging operation employed permits the abrasive particles to be concentrated in a relatively narrow annular region band adjacent the periphery of the wheel. The wheel 10, although freely flexible in the outer regions thereof and laterally flexible throughout its entire radial dimension, is rigidly reinforced by the skeleton 16 which substantially entirely prevents radial expansion of the wheel even at relatively high speed uses thereof. In fact, the wheel 10 has been run at speeds in excess of 1750 r.p.m. under heavy loads, with no measurable loss of concentricity. The skeleton in addition serves to fix the arbor hole size and thus eliminates the problem of eccentric rotation or the necessity of having the foam plastic material itself rigid enough to hold such arbor size. In previous flexible abrasive wheels having no such reinforcement means, the making of the foamed plastic rigid enough to hold the arbor size was attended by a sacrifice of lateral flexibility thereby impairing polishing or finishing in use of the wheel. Through use of the skeleton reinforcement of the present invention, a flexible abrasive wheel can be designed having in mind the optimum characteristics for polishing or finishing without regard to previously required considerations such as, e.g., radial expansion and ability of the wheel to hold the arbor size.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

I therefore particularly point out and distinctly claim as my invention:

1. A finishing and polishing wheel comprising a body of foamed flexible plastic having granular abrasive concentrated in an outer annular region thereof, a flexible reinforcing skeleton embedded within the inner, relatively non-abrasive region of said plastic body, said skeleton being radially rigid thereby to prevent substantial radially outward expansion of said body when the wheel is rotated at high speed in use, but said skeleton being laterally flexible to permit an appreciable degree of lateral deformation of the working face of the tool in use.

2. A finishing and polishing wheel comprising a body

of foamed flexible plastic having granular abrasive concentrated in an outer annular region thereof, a flexible reinforcing skeleton incorporated within the inner, relatively non-abrasive region of said body, said skeleton being relatively rigid radially to prevent substantial radially outward expansion of said body when the wheel is rotated at high speed in use, but said skeleton being laterally flexible to permit an appreciable degree of lateral deformation of the working face of the wheel in use, said skeleton being relatively thin when compared to the thickness of said wheel and being provided with means for axially centering said skeleton in said wheel.

3. The combination of claim 2 wherein said centering means comprises a plurality of integral tab members up-set from a central body portion of said skeleton and directed to both sides thereof substantially normal thereto, the terminal portions of said tabs at both sides of said central body portion extending therefrom equidistantly.

4. The combination of claim 2 wherein said spacing means comprises a plurality of pins extending through openings in a central body portion thereof, the ends of each of said pins being equidistant from the sides of said central body portion.

5. The combination of claim 4 wherein at least certain of said pins are formed with head portions for achieving such equidistant spacing upon insertion of said pins in said openings.

6. In a method of molding an annular flexible body of foam plastic in a circular mold rotatable about a substantially vertical axis, the steps which comprise placing a radially rigid and laterally flexible reinforcing member within said mold in a manner to axially center the same within the mold, confining a plastic liquid body within said circular mold, rapidly rotating said mold, foaming such plastic body to cause the same to expand thereby filling the entire mold cavity and thus surrounding said reinforcing member, and setting such plastic thereby firmly to embed said reinforcing member within said plastic.

7. In a method of molding an annular flexible body of foamed plastic in a circular mold rotatable about a substantially vertical axis, the steps which comprise axially centering a radially rigid and laterally flexible reinforcing skeleton within said mold concentric with the vertical axis thereof, confining a plastic liquid body having abrasive particles associated therewith in said mold, rapidly rotating said mold about said vertical axis thereby to distribute said abrasive particles in a concentrated, radially outer annular region, foaming such plastic body to cause the same to expand thereby filling said mold cavity and surrounding said skeleton, and setting such plastic thereby to firmly embed said skeleton within said plastic.

8. A finishing and polishing wheel comprising a body of flexible resin, granular abrasive within said body, a flexible reinforcing skeleton of laminated fibrous composition embedded within said body, said skeleton being relatively rigid in a radial direction but laterally flexible thereby to prevent substantial radially outward expansion of said body but to permit an appreciable degree of lateral deformation of the working face of the wheel in use.

9. An abrasive wheel comprising a flexible body, granular abrasive within said body, a flexible reinforcing skeleton of laminated fibrous composition embedded within said body, the skeleton being relatively rigid in a radial direction but laterally flexible thereby to prevent substantial radially outward expansion of said body but to permit an appreciable degree of lateral deformation of the working face of the wheel in use.

10. A finishing and polishing wheel having a resin and abrasive body normally laterally flexible under lateral pressures encountered in use and radially distensible under centrifugal force at operating speeds encountered in use, a flexible reinforcing skeleton embedded within

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said body and concentric therewith, said skeleton extending radially outwardly from the central region thereof, with the radially outer periphery of said skeleton being spaced inwardly from the outer periphery of said wheel, said skeleton being readily laterally flexible so as not substantially to impair such normal lateral flexibility of said body in use but being substantially radially rigid effectively to resist the otherwise normal radial distension of said body due to centrifugal force developed during use thereof.

11. The combination of claim 10 wherein said reinforcing skeleton is of laminated fibrous material.

12. The combination of claim 10 wherein said body is of foamed resin and said reinforcing skeleton is of laminated fibrous material.

13. The combination of claim 10 wherein said abrasive is concentrated in an annular outer region of said resin

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body and said flexible reinforcing skeleton is embedded within the radially inner, nonabrasive region of said body.

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