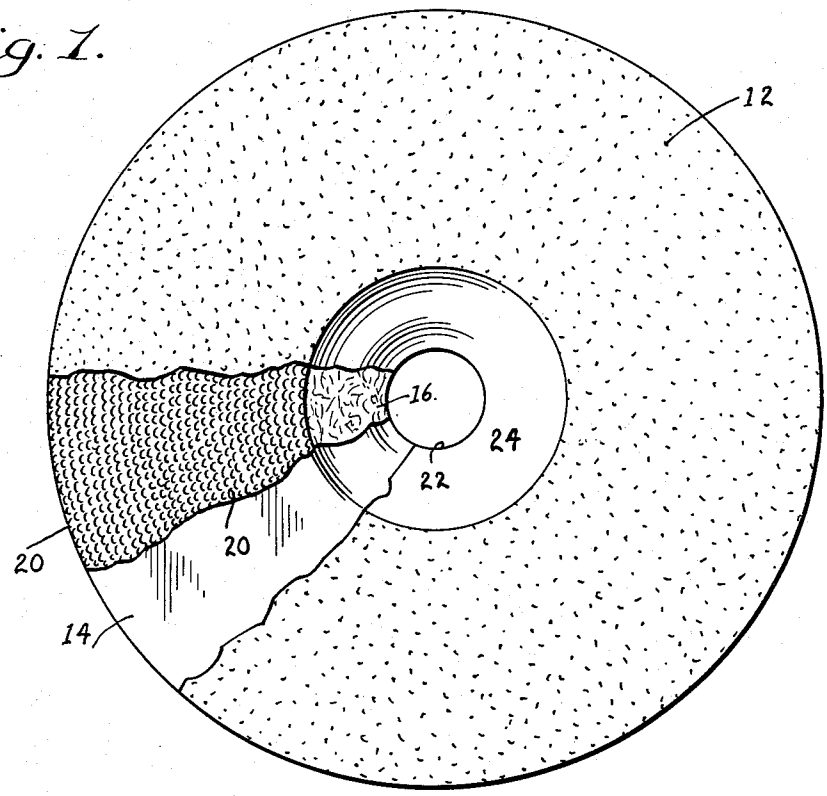
July 6, 1954 O. S. BUCKNER 2,682,735

HEAVY-DUTY ABRASIVE ARTICLE

Filed June 29, 1950 2 Sheets-Sheet 1

Fig. 1.



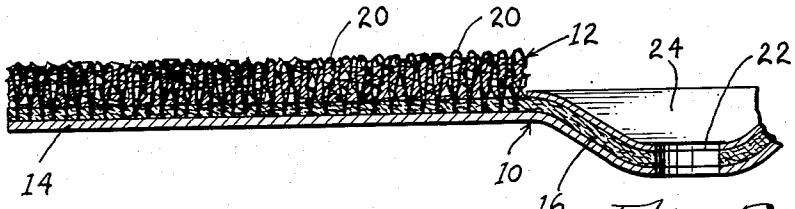


Fig. 2.

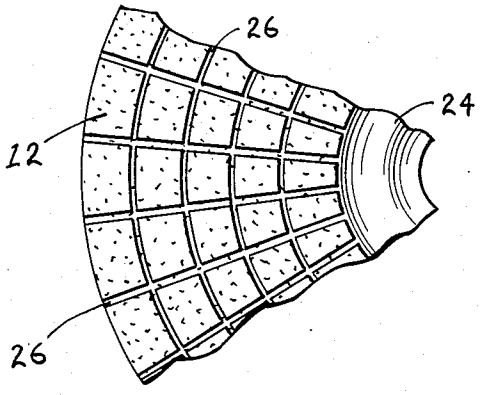


Fig. 3.

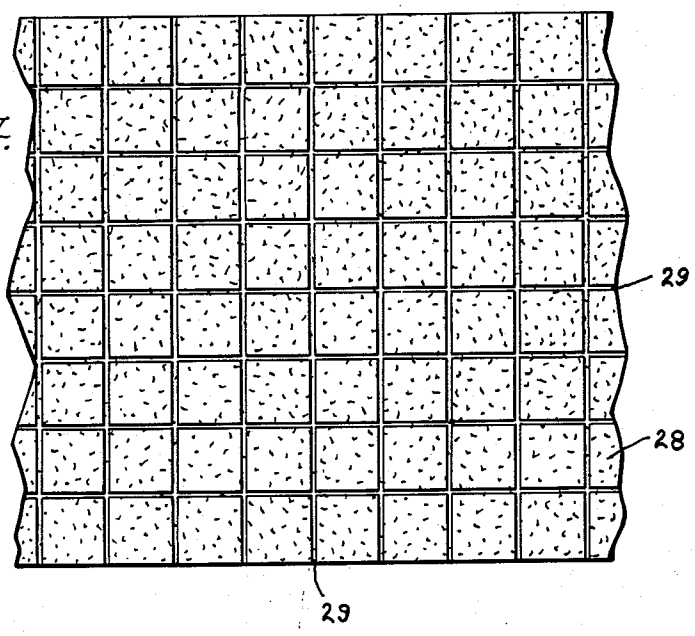
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HEAVY-DUTY ABRASIVE ARTICLE

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Fig. 4.



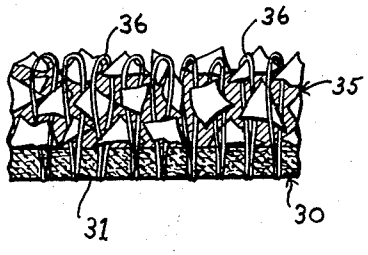


Fig. 5.

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UNITED STATES PATENT OFFICE

2,682,735

HEAVY-DUTY ABRASIVE ARTICLE

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Application June 29, 1950, Serial No. 171,165

9 Claims. (Cl. 51—195)

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This application relates to heavy duty flexible abrasive articles and a process for manufacturing such articles and is particularly concerned with improved flexible abrasive articles such as abrasive discs.

It is an object of the present invention to provide an abrasive article such as a disc with a thick, dense, bonded mass of abrasive granules in which means are incorporated for anchoring the bonded abrasive mass to a backing.

Another object of the invention is to provide flexible abrasive articles such as discs, pads and the like which are resistant to damage by heat and will withstand prolonged use at elevated grinding temperatures without damage.

A further object of the invention is to provide an inexpensive and simple process for the manufacture of a flexible abrasive article such as a disc which has on one face thereof a thick, dense, bonded mass of abrasive granules and which cuts rapidly, is highly efficient, and has a long life even under hard usage.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a top plan view of an abrasive disc constructed in accordance with the present invention with portions of the disc broken away to show the sub-surface construction thereof;

Figure 2 is an enlarged, fragmentary, sectional view through the abrasive disc shown in Figure 1;

Figure 3 is an enlarged, fragmentary view of the work surface of an abrasive disc such as is shown in Figure 1 illustrating one of the various patterns or combinations of grooves which may be provided in the face of the bonded abrasive mass;

Figure 4 is a fragmentary view of the work surface of an abrasive belt constructed in accordance with the teachings of the present invention illustrating one of the various patterns or combinations of grooves with which the face of the bonded abrasive mass thereon may be provided; and

Figure 5 is an enlarged, fragmentary, sectional view through a modified form of abrasive disc.

Hitherto, flexible abrasive articles such as abrasive discs and belts have usually comprised a more or less flexible backing to which there has been attached by an adhesive binder a substantially single layer of abrasive granules. Such articles may give very efficient abrasive action, but only for a brief period since the single layer of abrasive granules has a short life. As a result, they are expensive to use. Although attempts have been made to provide flexible abrasive articles with thick abrasive coatings, the resultant products have been unsatisfactory either because of their cost or because in use the thick abrasive layer rapidly disintegrated and became detached.

By the process of the present invention, it becomes possible to produce an abrasive article such as a disc or the like which has a considerable degree of flexibility and at the same time is provided with a thick, dense layer or bonded abrasive granules, the abrasive layer being securely held in place so that the article has a long useful life.

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An embodiment of the invention as applied to an abrasive disc is illustrated in Figures 1 and 2 of the drawings in which the numeral 10 indicates generally the support for the improved disc and the numeral 12 indicates the abrasive facing thereon. The support 10 ordinarily will comprise two layers. The outer layer or base 14 is a circle preferably cut from a sheet of a dense, strong, tough material such as vulcanized fiber that has a comparatively small difference in strength in different directions.

The other layer 16 of the support 10 is formed of sheeted material which may be composed of felted fibers or plastic materials such as natural, synthetic, or silicone rubber, neoprene or polymerized vinyl compounds. If a felted fibrous sheet is used, the fibers may be of natural materials such as cellulose or of synthetic organic materials or they may be of inorganic materials such as glass, asbestos, mineral wool and the like. A suitable adhesive such as a heat-hardenable phenolic resin cement is employed for attaching the sheeted backing layer 16 to one face of the base 14. In general a felted sheet of glass fibers is preferred for the backing 16 because of the uniform structure of such sheets and their high strength. Moreover the glass fibers, unlike cellulosic fibers and fibers of many other organic materials, do not absorb appreciable amounts of moisture from the atmosphere or suffer material loss of strength when wet.

As shown in Figure 1, the backing layer 16 is an annulus cut from a felted fibrous glass sheet, the diameter of the annulus being the same as that of the base 14 and its width being determined by the width desired for the abrasive layer.

The annulus 16 is provided with a large number of strands or filaments of thread or similar material projecting outwardly from the exposed face thereof. Although filaments having a free end may be employed in some cases, it is preferred to have the filaments formed as loops 20. Thread of common types such as cotton, linen, silk, nylon and the like, as well as other thread-like materials, such, for example, as monofilaments of nylon, may be used for the strands. Nylon is preferred because of its high strength.

The loops 20 may be provided on the surface of the felted backing 16 in any suitable way. It has been found that a very convenient way of forming the loops is with a sewing machine which may be adjusted to provide stitch loops of the required height and spaced as wanted. When thus provided, a plurality of loops is, of

course, formed in a single, continuous filament or thread attached to the backing. The loops preferably are unmatted and are of such length as to extend outwardly from the surface of the felted sheet about ¼ inch, but this distance may be varied in accordance with the thickness of the abrasive layer which is desired. It is also preferred to closely space the loops **20**, a spacing between adjacent loops of ⅛ inch to $\frac{3}{16}$ inch having been found satisfactory.

Stiffening the loops **20** and the felted fibrous backing **16** prior to their use in forming an abrasive article has been found desirable. This may be done conveniently by applying a light coating of a solution, in a suitable solvent, of a stiffening material such, for example, as latex, polyvinyl alcohol, and the like to both sides of the felted, stitched sheet. Very excellent results have been obtained by spraying the sheet with a thin solution of latex. The impregnating coating on the backing **16** and the loops **20** minimizes any tendency of the sheet to absorb bond from the abrasive layer and the stiffened loops are more easily pushed into the abrasive-bond mix during assembly of the abrasive disc as hereinafter described.

The abrasive layer **12** forms an abrasive annulus on the surface of the sheet **16** surrounding and embedding the loops **20**. It is preferred to have the abrasive layer of such thickness as to be at least substantially level with the tops of the loops **20**. The layer should not, however, be much thicker if full advantage is to be obtained from the anchoring effect of the loops. At the center of the disc, around the arbor hole **22** in the base **14** and inside the abrasive annulus, a small stiffening disc **24**, preferably of vulcanized fiber, is adhesively mounted on the felted sheet backing **16**. The center portion of the abrasive disc is, as shown in the drawing, depressed in accordance with common practice. However, it may be made with a flat bottom face if desired.

Preferably the assembly of a heavy duty flexible abrasive disc such as is described above is carried out in the following manner. A mass of a loose abrasive, bond mix is placed in an annular cavity in the bottom of a cylindrical metal mold and is levelled off. The small stiffening disc **24** of vulcanized fiber is placed in the center of the mold with its periphery adjacent the cavity and its upper face is coated with a suitable adhesive such as a liquid phenolic resin. A backing **16** of felted fibers is then placed in the mold over the abrasive and the small disc **24**, the felted backing having previously been provided with loops **20** in an annular band and stiffened as described above. The felted sheet backing **16** is positioned with the loops **20** extending downwardly into the abrasive-bond mix. Suitable adhesive such as a liquid phenolic resin is then applied to the upper surface of the felted fibrous backing **16** and the circular reinforcing base **14** of vulcanized fiber is placed in position on top of the backing. The mold is thereupon closed by placing the upper plate in position and the disc is ready for pressing and curing.

The abrasive-bond mix preferably employed in the manufacture of abrasive articles according to the present invention is formed of abrasive granules, which may be of any desired type and grit size, pre-coated with a liquid phenolic resin and subsequently coated with a dry powdered, reactive phenolic resin. Such coated grain gives a very convenient, distributable mix which easily penetrates the loop apertures while cold, and, during the hot pressing step, consolidates into a dense mass, the bond flowing around and having good adhesion to the strands of thread or loops embedded therein and some of the abrasive granules being forced by the pressure into the loop filaments themselves. It will be understood that, if desired, mixtures of a heat-setting resinoid powder and abrasive granules may be used instead of the resinoid coated abrasive granules, but such mixtures have been found less convenient than the latter and more likely to result in lack of uniformity in the product. Cold molding resinoid-abrasive mixtures are also usable but are considered less satisfactory.

It is preferred to subject the disc to a forming pressure prior to curing. For this, the mold is placed in a press of suitable type and subjected to a pressure of approximately 600 p. s. i. Following such cold pressing, the disc is hot pressed at a temperature of 320 degrees F. under lower pressure for 30 minutes to set the resin bond. The disc, upon removal from the mold and cooling, is ready for use.

As described thus far, abrasive articles produced in accordance with the present invention have a smooth abrasive face. It is frequently desired, however, to provide a face having grooves or similar identations therein to permit the removal of detritus formed during grinding and thereby prevent loading or filling of the abrasive surface. Accordingly, as shown in Figure 3, abrasive discs manufactured according to the present invention may be formed with a pattern of grooves **26** in the exposed abrasive surface thereof. Such grooves in any pattern desired may be easily provided by using a mold plate which has a suitable configuration of ribs in the face thereof.

The use of a support formed of a base of vulcanized fiber and a felted fibrous sheet backing instead of a woven cloth sheet reduces the directional effect which frequently causes curling of abrasive discs. Abrasive discs manufactured in accordance with the present invention do not curl and hence exert a constant and uniform abrasive action during rotation.

Tests of abrasive discs constructed in accordance with the present invention in comparison with commercial abrasive discs of the conventional coated single-grit thickness type show unexpectedly superior results and many advantages over the latter. In such tests it was found that not only did the discs embodying the invention of the instant application, with abrasive layers several times greater in thickness than the average diameter of the individual abrasive granules therein, cut metal at a substantially uniform rate for several hours instead of the minutes which constitute the life of a conventional disc, but the metal cutting rate was two and one-half times greater than that of the conventional discs.

Moreover, the present invention makes possible the selection and use of correct grade hardness abrasive structures for various types of metal because the ratio of bond to abrasive to pores can be selected and controlled whereas these factors scarcely exist in the single layer type of article. Furthermore, in production work much time is saved with a consequent gain in efficiency since the frequent changing required when using ordinary discs is avoided.

Although the present invention has been described above as applied to an abrasive disc, it will be evident that the invention is also applicable to the production of other abrasive ar-

ticles, such as belts, pads, and sleeves, and the like, which have a thick layer of abrasive. The procedure involved in the manufacture of such articles is substantially the same as that hereinabove described, the belts and sleeves, for example, being formed as strips and then having their ends joined by any of the methods well known in the art for making joints for abrasive belts. A portion of such a belt is shown in Figure 4, the abrasive surface **28** thereof being provided with grooves **29** similar to the grooves **26** in Figure 3. It will be understood that where more convenient or suitable, as for example in the case of long belts, the base or reinforcing layer of the support for such flexible abrasive articles may be formed of other materials such as woven textiles.

According to a further modification of the invention herein described, it is possible to produce flexible abrasive articles which are extremely resistant to elevated temperatures and are therefore of great value for abrasive applications in which large quantities of heat are generated or in which the work piece is hot.

In such modification as exemplified, for example, in an abrasive disc, the backing **30** (see Figure 5) comprises an impregnated sheet **31** of inorganic fibrous material. Among the inorganic fibrous materials which are suitable are asbestos, glass fibers, and the mineral wools produced from molten slag or rock by air or steam blasting. The inorganic fibers may be either felted into sheets or they may be formed into yarn or cords which are then woven into a fabric sheet.

Either before or after cutting a circular piece of the desired size from the inorganic fibrous sheet, the fibrous portion of the backing is impregnated with a heat-resistant plastic material. Although certain types of phenolic resins are to some extent heat-resistant, it is preferred to employ in the backing an impregnating material such as that known as "silicone rubber" which is even more resistant to heat and is also flexible.

Silicone rubber is a soft, resilient, pliable material formed from polysiloxane by a process involving polymerization and cross-linking. It is very resistant to heat, being unaffected by continuous exposure to temperatures as high as 350° F. and by temperatures as high as 520° F. for short periods of time. Silicone rubber is also possessed of great chemical stability, which prevents deterioration in storage or by oxidation, and is not affected by water or atmospheric moisture. When glass cloth is impregnated or coated with silicone rubber, the resultant product after curing is quite strong, a specimen 0.02 in. in thickness having a tensile strength of 30,000–50,000 p. s. i. and a tear resistance of 350–400 lbs./in. More detailed information regarding the manufacture, properties and uses of silicone rubber may be found in the U. S. Patent to J. F. Hyde, No. 2,371,-050, March 6, 1945, and in Silastic—The Heat Stable Silicone Rubber, P. C. Servais, Rubber Age, vol. 58, No. 5, pp. 579–584, February 1946, and Polysiloxone Elastomers, C. M. Doede et al., Ind. & Eng. Chem., vol. 39, No. 11, pp. 1372–1375, November 1947.

As in the case of the backing **16** of felted fibers described above, the silicone rubber impregnated sheet backing **30** is provided with means for anchoring an abrasive layer **35** on one face thereof. Such means preferably comprises a plurality of loops **36** of fine wire of suitable metal, such as steel, bronze, Monel or the like, which project outwardly from one face of the sheet. Since the preferred size and spacing of the wire loops **36** are determined by the same factors as are the thread loops **20** described above, the size and spacing are substantially the same. While they may be formed in any desired manner, the formation of the loops **36** by a sewing machine in the above described manner is considered to be most convenient.

The silicone rubber-inorganic fiber backing **30** may then be covered in the same manner as the backing **16** with a layer of a mixture of abrasive and a heat-setting resinoid bond which is pressed and cured in accordance with the practice set forth above. It is important to note that no deterioration of the backing **30** results from the elevated temperatures used in curing the resinoid bond.

Most heat-setting resins as used in the abrasive industry have a tendency to deform or flow under stress at temperatures above about 300° F. As a consequence, in grinding or abrading operations where a large amount of heat is generated, the surface of an abrasive article utilizing a bond of such resins is likely to glaze or smear. For use at high temperatures a silicone resin is therefore preferred as an abrasive bond. These resins are polymerized silico-organic materials having large molecules and are so much more resistant to thermoplastic flow or deformation that they may safely be used at temperatures above 500° F.

The heat-resistant qualities of a flexible abrasive disc or other abrasive article manufactured in accordance with this modification permit the efficient use of such articles under conditions which cannot otherwise be endured. Thus, for example, an abrasive disc having a silicone rubber-glass fabric backing, wire loops and a silicone resin abrasive bond may be employed in grinding flash from aluminum and magnesium die castings while they are still hot or may be used in continuous dry-grinding operations without damage and while maintaining its efficiency. The efficiency of such abrasive articles may be somewhat increased where they are used at high temperatures for prolonged periods, by incorporating in the abrasive coatings and in the silicone rubber of the backings heat-conducting filling materials such as metal powders and the like to aid in the transfer of heat away from the abrasive surfaces.

Although the production of extremely heat resistant flexible abrasive articles has been described above with respect to abrasive discs only, it will be understood that heat resistant abrasive belts, sleeves, pads and other articles embodying the same principles of construction may be produced by suitable changes in procedure as set out earlier in the present application.

As will be evident from the foregoing description, in each of the embodiments of the invention the abrasive-bond layer is substantially uniform in thickness and of a thickness several times greater than the average diameter of the individual abrasive granules. The abrasive layer is, in each case, firmly anchored to a flexible backing by closely spaced loops of thread, wire, or the like, which are embedded therein. Thus, even when the abrasive layer is cracked by flexing or otherwise, each of the small blocks or chunks of bonded abrasive granules is firmly held to the backing and consequently the relatively even abrasive surface is preserved. The firm anchoring of the abrasive layer and the use of a thick, substantially uniform layer of abrasive which is permitted by the construction of the invention results in flexible abrasive articles con-

structed in accordance with the invention being characterized by an extremely long useful life. In addition, the heat resistance of flexible abrasive articles constructed in accordance with the present invention, and particularly the modification thereof described above, permits their use in such manner as to give very high cutting rates and enlarges their usefulness.

It is to be understood that the embodiments of the present invention hereinabove described may be considerably modified and varied without departing from the spirit of the invention. Thus, for example, the backing **16** may, if desired, be impregnated with a suitable heat-resistant material in the same manner as the backing **30**; and the structure shown in Figure 5 may, if desired, be provided with a base similar to the base **14** of Figures 1 to 3. As mentioned above, the abrasive granules used may be of any desired type and grit size so that the best abrading results may be obtained. The foregoing mention of possible variations is not, however, to be considered as limiting the invention beyond the scope of the appended claims.

The invention claimed is:

1. A flexible abrasive article comprising a flexible fibrous glass backing, a plurality of flexible wire loops projecting from one face of said backing, and a layer of bonded abrasive granules on said backing surrounding and embedding said loops, said abrasive layer being dense and compact and having a thickness several times greater than the average diameter of the individual abrasive granules therein.

2. A flexible abrasive article comprising a flexible fibrous glass backing, a plurality of flexible wire loops projecting from one face of said backing, and a layer of bonded abrasive granules on said backing surrounding and embedding said loops, said abrasive layer being dense and compact and having a thickness several times greater than the average diameter of the individual abrasive granular therein, and said backing being impregnated with a flexible heat-resistant material.

3. A flexible abrasive article comprising a flexible fibrous glass backing, a plurality of flexible wire loops projecting from one face of said backing, and an abrasive layer on said backing surrounding and embedding said loops, said abrasive layer comprising abrasive granules and a heat-resistant bond therefor, and said backing being impregnated with a flexible heat-resistant material.

4. A flexible abrasive article comprising a flexible felted fibrous glass backing, a plurality of flexible wire loops projecting from one face of said backing, and an abrasive layer on said backing surrounding and embedding said loops, said abrasive layer comprising abrasive granules and a heat-resistant bond therefor, and said backing being impregnated with silicone rubber.

5. A flexible abrasive article comprising a flexible, fibrous sheet backing, a plurality of flexible, unmatted, stitch loops projecting from one face of said backing, said loops being closely and substantially regularly spaced on said backing, and a dense but porous, smooth, compact layer of bonded abrasive granules molded from a granular mix encasing said loops, said abrasive layer being attached to said backing and having a thickness several times greater than the average diameter of the individual abrasive granules therein and an outer face which is substantially free from deep random depressions.

6. A flexible abrasive article comprising a flexible, felted, fibrous sheet backing, a plurality of flexible stitch loops attached to said backing and projecting from one face thereof, said loops being stiffened by impregnation and substantially unmatted and being closely and substantially regularly spaced on said backing, and a dense but porous, smooth, compact layer of bonded abrasive granules molded from a granular mix encasing said loops, said abrasive layer being attached to said backing and having a thickness several times greater than the average diameter of the individual abrasive granules therein and an outer face which is substantially free from deep random depressions.

7. A flexible abrasive article comprising a flexible, felted, fibrous sheet backing, unmatted flexible stitch loops attached to said backing and projecting from one face thereof, said loops being closely and substantially regularly spaced on said backing, a plurality of said loops being formed in a single, continuous length of filament and a dense but porous, smooth, compact layer of bonded abrasive granules molded from a granular mix encasing said loops, said abrasive layer being attached to said backing and having a thickness several times greater than the average diameter of the individual abrasive granules therein and an outer face which is substantially free from deep random depressions.

8. A heavy-duty abrasive article comprising a flexible, felted, fibrous backing, said backing being circular and having a central arbor hole, a reinforcing layer on one face of said backing, a plurality of flexible, unmatted stitch loops projecting from an annular area on the other face of said backing and a dense but porous, smooth, compact layer of bonded abrasive granules molded from a granular mix encasing said loops, said abrasive layer being attached to said backing and having a thickness several times greater than the average diameter of the individual abrasive granules therein and an outer face which is substantially free from deep random depressions.

9. The process of producing a heavy-duty, flexible abrasive article which comprises the steps of providing a flexible, fibrous sheet backing having a plurality of flexible stitch loops formed from a single, continuous length of filament attached thereto and projecting from one face thereof; covering said backing and loops with a substantially dry mixture of abrasive granules and heat settable bond; pressing said mixture against said backing to provide thereon a dense but porous, compact abrasive layer, the outer surface of which is substantially free from deep random depressions, encasing said loops; and heating said bond to cure it.

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