Jan. 10, 1939. F. J. TONE 2,143,636

ABRASIVE WHEEL AND ITS MANUFACTURE

Filed Dec. 4, 1935 2 Sheets-Sheet 1

Fig. 1.

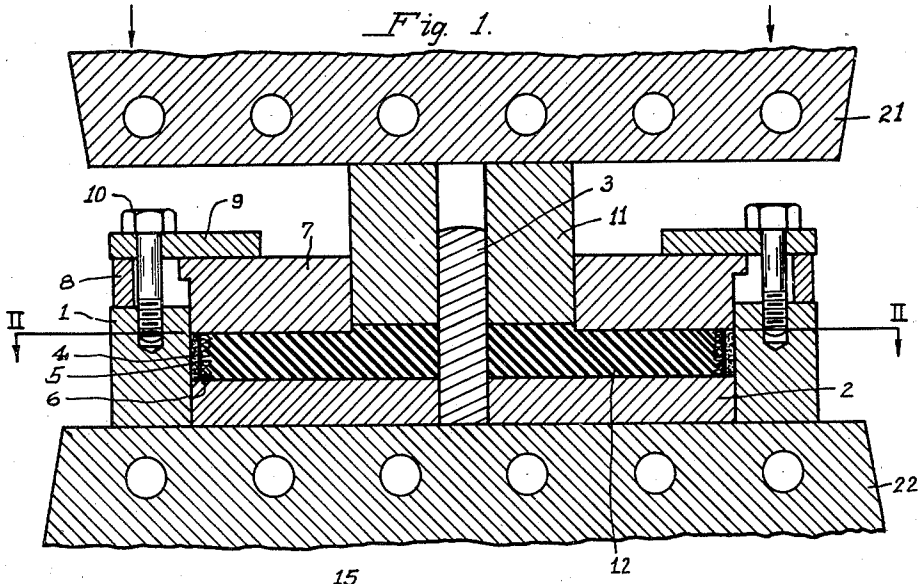
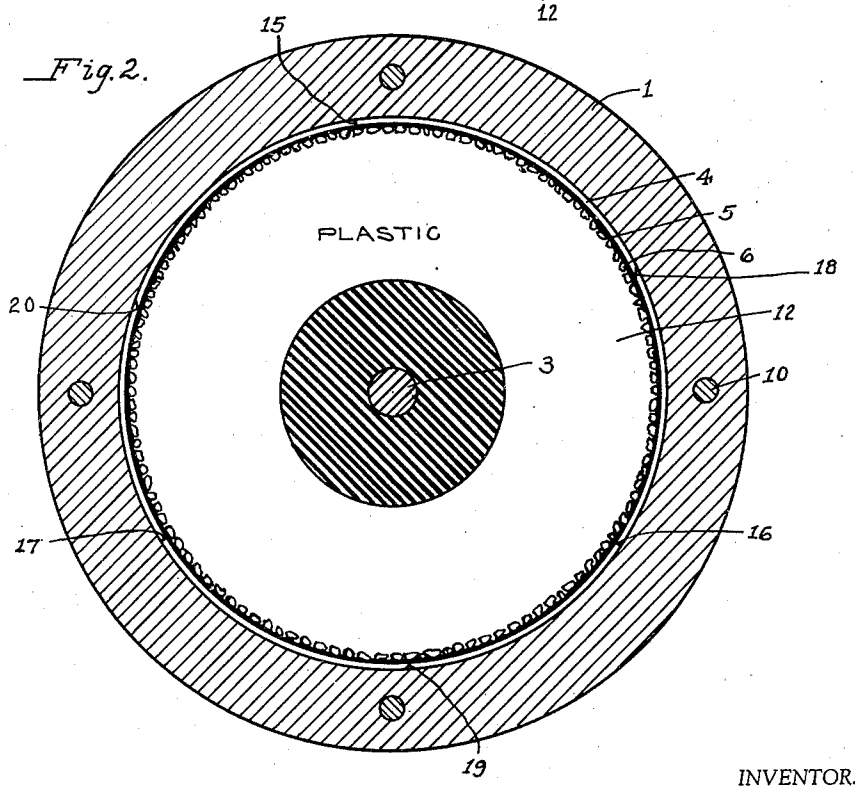


Fig. 2.



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Fig. 3.

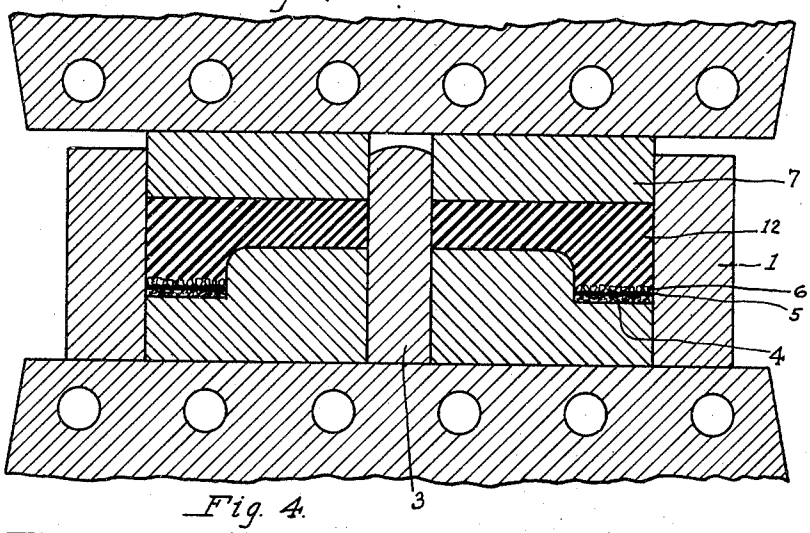


Fig. 4.

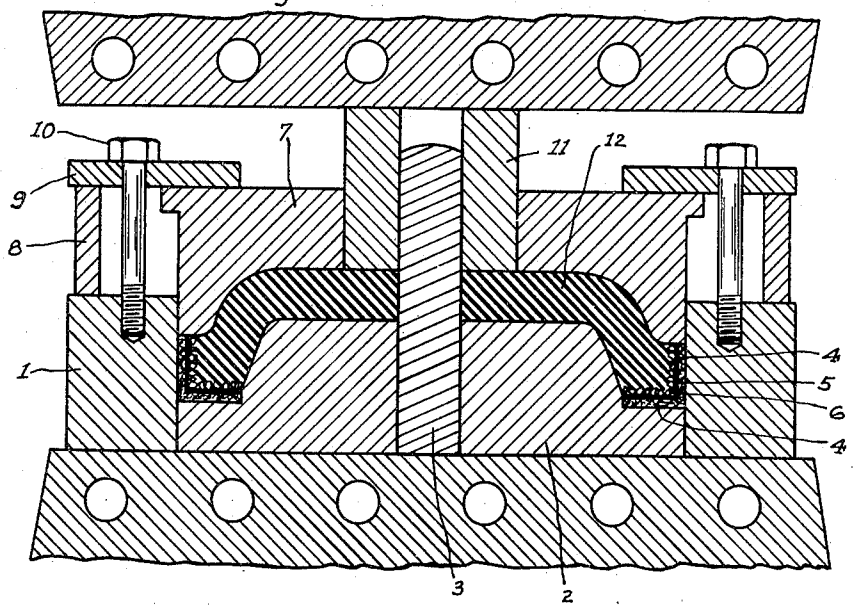


Fig. 5.

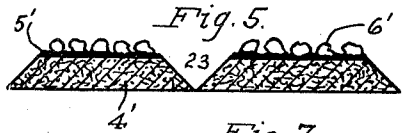


Fig. 6.

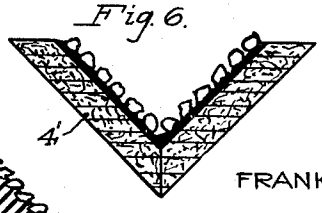
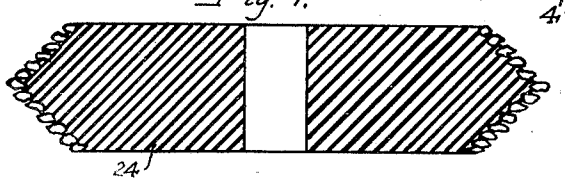


Fig. 7.



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ABRASIVE WHEEL AND ITS MANUFACTURE

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Application December 4, 1935, Serial No. 52,741

10 Claims. (Cl. 51—278)

This invention relates to abrasive articles and to methods of manufacturing the same, but relates more particularly to abrasive articles whose working surfaces are composed of thin layers containing particles of very hard and costly abrasive material. Examples of such abrasive material are diamonds, boron carbide, and other rare carbides which are very hard and which are difficult to manufacture in large quantities.

While many attempts have been made to make diamond wheels, for example, in such a manner as to utilize the diamond particles to the greatest possible extent, it is difficult to make thin layers of bonded diamond particles of the order of magnitude of 1/64 inch in thickness by the processes of the prior art. It is also difficult to make such thin layers of uniform thickness by the processes of the prior art. In making diamond tools, diamond particles have usually been embedded in a metallic matrix as in the case of steel cutting discs having diamond particles embedded therein. Diamond wheels have also been made in which the diamond particles are held in a non-metallic matrix such as a heat-hardened synthetic resin. Such resin-bonded diamond articles are difficult to make in a manner which economizes the costly diamond material to the desired extent in the operation of the article. It is also difficult to distribute the diamond particles in a uniform manner throughout a thin sheet of substantially uniform thickness, said sheet furnishing the working surface of the abrasive articles.

The general method of manufacture of abrasive articles in accordance with the present invention involves the formation of a sheet of bonded abrasive which is later attached temporarily or permanently to the face or to the periphery of a rotatable support. Some of the methods which may be followed in making a thin sheet of bonded abrasive in accordance with the present invention are illustrated by the accompanying drawings in which:

Fig. 1 shows a sectional elevation of apparatus for making an abrasive wheel having a thin layer of bonded abrasive on the periphery, the view indicating an intermediate position of a pressure member;

Fig. 2 shows a horizontal section of the apparatus referred to, the section being taken on the line II—II of Fig. 1;

Fig. 3 shows a sectional elevation of apparatus for making an abrasive wheel adapted for face grinding and having a thin layer of bonded abrasive on its working face;

Fig. 4 is a sectional elevation of apparatus used for making a cup-shaped wheel adapted for grinding on its side face and also on its periphery;

Fig. 5 is a sectional elevation of a backing strip or temporary support which is coated with a thin layer of bonded abrasive and which is notched so that it may be conveniently bent into a V shape;

Fig. 6 is a sectional elevation showing how the abrasive strip indicated in Fig. 5 may be folded for subsequent application to a rotatable mounting; and

Fig. 7 is an axial section of an abrasive wheel in which the strip shown in Fig. 6 is indicated in position on a rotatable mounting, the backing having been removed.

Referring to the drawings in more detail, the apparatus shown in Figs. 1 and 2 includes a wheel mold having a barrel 1, a base 2, and a core 3. The inner cylindrical surface of the mold barrel 1 is lined with a strip (or a plurality of strips of flexible abrasive) that has been cut from an abrasive sheet (such as a sheet of abrasive paper or abrasive cloth) or from a metal backing coated on one side with abrasive. Abrasive paper or abrasive cloth may be referred to generally as abrasive fabric or as an abrasive web. Other suitable backing material may be used for supporting the abrasive grain. The flexible abrasive sheets are prepared by methods similar to those commonly used in manufacturing abrasive paper or cloth. The backing to be coated is provided on one side with a layer of hardenable adhesive such as a synthetic resin in a fluid condition, or with glue, or with a reversible thermoplastic material. The diamond particles are distributed as uniformly as possible over the surface of the backing having the adhesive coating. Depending upon the intended use for the finished article, the abrasive granules may be coated upon the backing in a variety of ways to obtain a coating that is dense, open, oriented, etc. Abrasive grains may be electrostatically or otherwise manipulated in the coating process so the longer axis of each grain is substantially perpendicular to the plane of the backing. Such articles thus prepared are when used in carrying out this invention particularly advantageous because the grains are securely bonded with the long axis normal to the cutting plane in the finished article. After the adhesive has hardened, strips of the desired width are cut from the finished abrasive sheet or sheets. It is not essential that the adhesive for holding the grains upon the backing be the same as the bond used in making the final article.

The abrasive strips are indicated in Figs. 1 and 2 as placed close to the inner cylindrical surface of the mold barrel, the strip or strips comprising a backing 4, a layer of bonding material 5, and abrasive particles 6, which particles are distributed with substantial uniformity over the inner surface of the backing and which project from the backing toward the interior of the mold.

The cap 7 of the mold is supported on the backing 4 of the flexible lining (4, 5, 6) or (if

the flexible strip is not sufficiently strong) on a thin metal ring interposed between the backing 4 and the mold barrel 1, the ring being of substantially the same height as the abrasive strip (4, 5, 6). The object of a stiff backing on or adjacent the flexible abrasive strip is to prevent movement of the cap 7 after it has been positioned to rest upon the edge of said flexible strip (4, 5, 6). In Figs. 1 and 4 of the drawings the clamping member 9 reinforces the cap 7 against upward pressure exerted from the interior of the mold when plastic material 12 therein is subjected to high pressures. The clamping member 9 is disposed between the ring 8 and the bolt head 10, the bolt being screwed into the mold barrel 1. Other support for the cap 7 (such as screw bolts extending laterally from the mold barrel 1 into said cap) can be provided if required.

The abrasive lining (4, 5, 6) referred to above may consist of a single long strip whose ends are brought together in a square joint or may consist of a plurality of strips whose ends are brought together in square joints as indicated at 15, 16 and 17 in Fig. 2. As a modification of this form of jointure, the ends of some of the strips may be joined obliquely as indicated at 18, 19 and 20.

After the abrasive strips have been placed in position against or adjacent the inner surface of the mold barrel, the body of the mold is filled with a plastic material 12 mentioned briefly above, which material can be hardened by heat, such, for example, as a phenolic condensation product resin in the A-stage or in the B-stage. Unvulcanized rubber mixed with vulcanizing materials and suitable fillers can also be used as the plastic material. Reversible thermoplastic materials may also be used (instead of the plastic materials just mentioned) to fill the main portion of the interior of the mold. Such thermoplastic materials may be resins which have a high softening point and great mechanical strength at room temperature. For purposes of illustration, the following formulae of suitable plastic molding support mixes are given:

A. For a heat hardenable mixture—

	Parts by weight
Powdered B-stage phenol formaldehyde resin	75
80. grit fused alumina abrasive	25

These ingredients are well blended and made ready for use by any of the conventional trade practices for such operations. Wide variations in the materials used may be made and still produce plastic moldable mixes which will answer the purposes of this invention.

B. For a thermoreversible mixture—

	Parts by weight
A polymerized product of vinyl acetate, the physical and chemical states of which may be defined by saying that the polymerization has been continued until a molar solution of the resin in benzol has a viscosity of 15 centipoises, and that 70% of the replaceable acetate groups have been replaced by acetaldehyde	35
200 and finer mesh flint	65

Pressure is applied to the plastic material 12 by moving the plunger 11 toward the base 2, the mold being positioned between two steam-heated platens 21 and 22. The application of pressure by the platens through the members 2 and 11 forces plastic material 12 against the abrasive layer 6. This plastic material may be any of the types just described above and is of such a character that it adheres to the abrasive layer 6 and is hardened by heat transmitted from the platens or by congelation in the subsequent cooling process. After the molded article that comprises the abrasive web (4, 5, 6) and the rotatable support (formed by pressure and heat treatment of 12) has cooled, it is removed from the mold. The cooling may be performed while the mold is in the press after the heating medium has been shut off from the press. After the article is available in cooled condition, the backing 4 and part of the adhered layer 5 are removed by dressing, such as a gentle lapping action with loose fine grit applied to the surface while the article is rotated slowly. If a water softenable adhesive such as glue has been used to hold the abrasive on the temporary support, the molded and cooled article may be soaked in water until the glue is soft, then the support 4 may be stripped off and the residue of 5 easily brushed away.

It is sometimes desirable to modify the structure of the backing 4, if it is of a porous nature, by impregnating it with resin or glue or other filler; the adhesive layer itself may contain a filler to stiffen it and reduce its flow characteristics. The purpose of this procedure is to prevent penetration of the backing by the plastic material 12 being forced against it and into its pores during the pressure steps of the process.

In the case of the modified apparatus shown in Figs. 3 and 4, the same general methods are employed as in the case of the apparatus shown in Figs. 1 and 2.

In making the abrasive article shown in Fig. 7, a strip of backing 4' is notched as indicated at 23 in Fig. 5. This can be done, for example, by means of a grinding wheel having a V-shaped periphery. The backing is then provided with a layer of hardenable adhesive 5' and with a layer of abrasive particles 6'. After the adhesive has hardened, the abrasive-coated strip is folded into a V shape, as illustrated in Fig. 6.

It is also feasible to make strips of the character illustrated in Fig. 5 by coating a plane sheet of backing material with a layer of adhesive and abrasive grain, allowing the adhesive to harden, and finally notching and cutting the abrasive-coated sheet to obtain a strip having a transverse section as illustrated in Fig. 5. The V-shaped abrasive strip may be provided with a rotatable mounting in a manner similar to that described in connection with Figs. 1 to 4 inclusive. The V-shaped strip is notched transversely in such a manner that it can be bent to form a double frustoconical surface similar to that shown in Fig. 7.

The thickness of the layers of abrasive on the finished article obtained by the method above described is less than the thickness of the original sheet of abrasive fabric since the backing is removed by dressing as a step in the process of manufacture. It is possible therefore to obtain abrasive layers whose thickness is less than a thirtieth of an inch.

Another method of making a sheet of abrasive material for use in accordance with the present invention is to make a mixture of diamond particles along with a heat hardenable binder and a filler, including enough plasticizing material in the binder or filler to enable the operator to press or roll the abrasive mix into thin somewhat flexible sheets. The pressing of the mix out into a thin sheet may be performed between the

platens of a hydraulic press. The mix may also be fed between revolving rolls to obtain sheets of the desired thickness. One example of a mix which may be cold pressed or cold rolled into thin flexible sheets would be:

	Percent
Granular abrasive	89
Powdered B-stage phenol-formaldehyde resin	8
Liquid or A-stage phenol-formaldehyde resin	3

If desired, a portion of the granular abrasive content may be substituted by fine grit flint, magnesia or other filler. The sheets are subsequently cut into strips which are used to line the interior surfaces of the mold barrels shown in Figs. 1 to 4 inclusive. An alternate method of forming thin, flat, flexible strips would be to mold the abrasive mixture directly to the desired dimensions in a mold designed to produce plane strips which may subsequently be bent to conform to the curvature of the interior of the mold barrel. Great accuracy of strip thickness is obtainable by this method when stops are used to limit the distance to which the press platens may approach each other. The mounting is formed inside the peripheral lining in a manner similar to that described above in connection with the use of the molding apparatus shown in Figs. 1 and 2 of the drawings.

The method of forming the thin sheets (containing diamond particles or other abrasive particles of great hardness) that has just been described has the advantage that it is not necessary to dress the periphery of the finished article to remove the fabric backing, the function of a temporary support being performed by the material which is used to bond the abrasive grit.

Another method of making a sheet containing abrasive material is to incorporate abrasive particles in a metal which has been melted or softened by the application of heat, the mass of metal and abrasive being subsequently rolled or pressed out into a thin sheet containing abrasive particles distributed throughout. The sheet is then cut into strips which may be trimmed to fit as a lining on the inner surface of a mold barrel, the ends of the strip being fastened together by brazing or welding, and the rotatable support formed within the metal strip according to the methods given in this disclosure.

A variation of the foregoing method of manufacture consists in coating a thin sheet of metal on one side with a layer of hardenable adhesive and distributing abrasive particles with substantial uniformity over the adhesive coating. After the adhesive has hardened sufficiently, the coated sheet is cut into strips and attached to the surface of a rotatable support which may have been preformed prior to contact with the strips, or which may be molded in contact with the metal strips in the manner described in connection with the description of the apparatus shown in Fig. 1 of the drawings. In this case, the abrasive particles are turned outwardly. Materials which adhere well both to metal and to certain abrasive materials are to be found among the synthetic resins, for example, vinyl acetate resins which have been polymerized to give them the necessary hardness. The metal strip can be provided with depending metal lugs which extend into the interior of the rotary support and are bonded thereto when the plastic material forming the rotatable support is hardened.

The abrasive strips indicated by the reference numbers 4, 5 and 6 in the drawings may be given an additional coating of hardenable adhesive and of abrasive before the body of the mold is filled with the plastic material 12. In this way, an abrasive wheel can be made in which the rotatable mounting carries on its periphery an inner abrasive layer containing particles of silicon carbide (or of fused alumina or of cemented carbides) with an outer layer containing particles of diamond. The inner layer may be called a reinforcing abrasive layer and continues the work of abrasion at parts of the working surface where the diamond particles have been largely worn away. The hardness of the abrasive material in the inner or reinforcing layer is about 9, or a little harder, on the Mohs scale.

The methods of manufacture of abrasive wheels which have been described above make it possible to obtain thin peripheral layers containing very hard and costly abrasive distributed with substantial uniformity throughout the layer. It would be difficult or impracticable to obtain thin layers of abrasive distributed with substantial uniformity on the working surface of an abrasive wheel by using the customary methods of the prior art. Many variations may be made in the character of the abrasive or of the binder or of the backing without departing from the invention which is defined within the compass of the following claims.

I claim:

1. The method of making an abrasive wheel which comprises lining the interior surface of a mold barrel with a thin strip of abrasive sheet material disposed with the non-abrasive backing adjacent the interior surface of the mold barrel and with the abrasive particles projecting into the interior of the mold, filling the interior of the mold with a hardenable plastic material, pressing the plastic material against the abrasive strip with hot platens, hardening the plastic material, and removing the non-abrasive layer from the outer surface of the abrasive coating.

2. The method of making an abrasive wheel which comprises lining the interior surface of a mold barrel with a thin strip of abrasive fabric that has the non-abrasive backing in contact with the interior surface of the mold barrel so that the abrasive particles project into the interior of the mold, the abrasive consisting of diamond particles that are distributed with substantial uniformity over the area of the strip, filling the interior of the mold with a plastic material composed mainly of a heat hardenable synthetic resin, pressing the plastic material against the abrasive strip with hot platens, hardening the synthetic resin, and removing the non-abrasive material from the outer surface of the abrasive coating.

3. The method of making an abrasive wheel which comprises bonding diamond particles in contact with a flexible backing, attaching a layer of abrasive particles having a hardness of approximately 9 on the Mohs scale to the diamond layer by means of an adhesive coating, placing a strip of the backing and its double abrasive coating in a mold with the non-abrasive side of the strip in contact with the inner surface of a mold barrel, filling the interior of the mold with a plastic heat hardenable material, pressing the contents of the mold, hardening the plastic material in intimate contact with the abrasive coating, and removing the backing from the outside of the abrasive strip.

4. The method of making an abrasive wheel having a thin surface layer of abrasive particles,

which method comprises lining the inner surface of a mold barrel with a strip of abrasive-coated web having the uncoated side of the web next to the mold barrel, filling the interior of the mold with a plastic mass of hardenable material, subjecting the plastic material to pressure in a radially outward direction against the abrasive lining, hardening the plastic material to form a rotatable support for the abrasive lining, and removing the web from the abrasive wheel.

5. The method of making an abrasive wheel having a thin surface layer of abrasive particles, which method comprises lining the inner surface of a mold barrel with a strip of an abrasive web in which abrasive particles are held on one side of the web by means of a thermoplastic resin, the uncoated side of the web being placed next to the mold barrel, filling the interior of the mold with a plastic mass of hardenable material under pressure with hot platens, hardening the plastic mass to form a rotatable support for the abrasive lining, and removing the web from the abrasive wheel.

6. An abrasive wheel having a thin superficial layer of abrasive particles, said wheel comprising a hub molded in intimate contact with and bonded to one or more strips of sheet metal, and a layer of hard abrasive distributed with substantial uniformity over the outer surface of the metal and bonded thereto.

7. The method of making an abrasive wheel having a thin surface layer of abrasive particles, which method comprises forming a flexible sheet containing a mixture of abrasive particles and hardenable bond, cutting said flexible sheets into strips and lining the interior of a mold barrel with one or more of such strips, filling the interior of the mold with a hardenable plastic mixture under pressure, and hardening the bond and plastic material by means of heat and pressure.

8. An abrasive wheel having a thin superficial layer of abrasive particles, said wheel comprising a resinoid support formed of heat hardened thermal condensation product resin which was molded in intimate contact with and bonded to a thin metal layer on the exterior surface of the support, and particles of hard abrasive distributed with substantial uniformity over and in the metal layer and bonded thereto by the cooling of the metal from a thermoplastic state.

9. The method of making an abrasive wheel which comprises lining the interior surface of a mold barrel with a thin strip of abrasive sheet material disposed with the non-abrasive backing adjacent the interior surface of the mold barrel and with the abrasive particles projecting into the interior of the mold, filling the interior of the mold with a heat hardenable granular material, pressing the granular material against the abrasive strip with hot platens to harden and condense said granular material, and removing the non-abrasive backing from the outer surface of the abrasive coating.

10. The method of making an abrasive wheel having a thin surface layer of abrasive particles, which method comprises lining the inner surface of a mold barrel with a strip of abrasive-coated web having the uncoated side of the web next to the mold barrel, filling the interior of the mold with a granular mass of hardenable material, subjecting the granular material to pressure in a radially outward direction against the abrasive lining, hardening the granular material to form a rotatable support for the abrasive lining, and removing the web from the abrasive wheel.

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