April 7, 1936. D. E. WEBSTER 2,036,903

CUTTING-OFF ABRASIVE WHEEL

Filed March 5, 1934

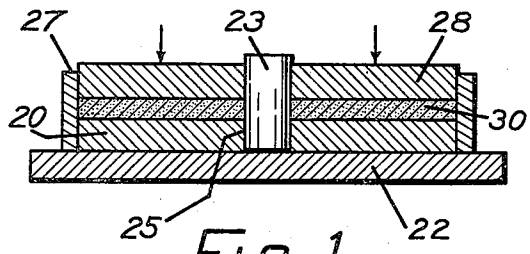


FIG. 1

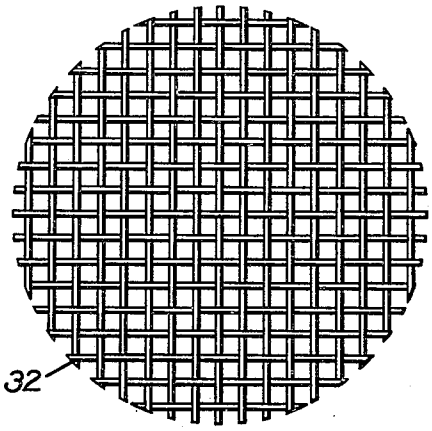


FIG. 2

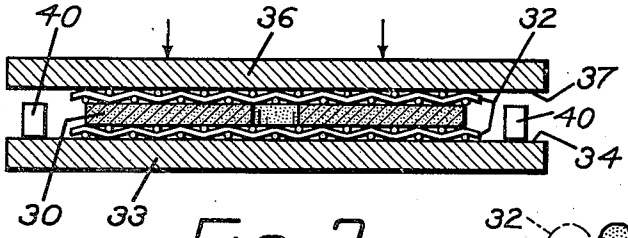


FIG. 3

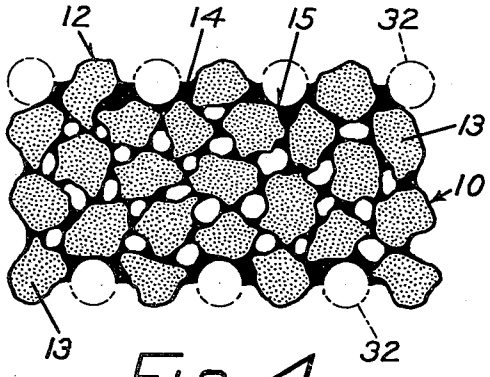


FIG. 4

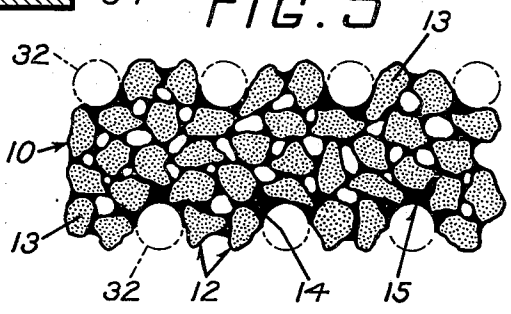


FIG. 5

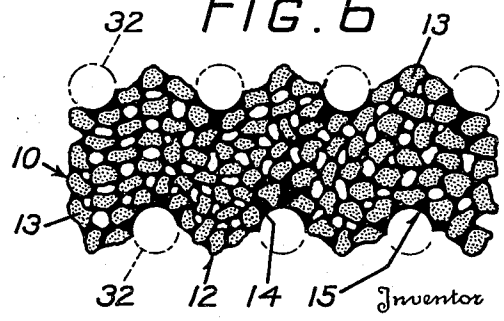


FIG. 6

WITNESSES

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CUTTING-OFF ABRASIVE WHEEL

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7 Claims. (Cl. 51—206)

This invention relates to a cutting-off abrasive wheel and more particularly to a disk shaped wheel whose diameter is very great as compared to its thickness and which is relatively thin and fragile and of such a size that it may be employed in the nature of a rotary saw for rapidly cutting deep, narrow grooves or cutting off lengths of materials.

Due to the efficiency of present day high speed grinding operations, with constantly increasing demands of industry for higher rates of production, abrasive cutting-off wheels are replacing circular steel saws in many cutting operations. These cutting-off wheels are relatively thin as compared with their diameters. For example, such a wheel may be 20 inches or less in diameter and ⅛ of an inch or less in thickness. These wheels have substantially parallel flat opposed side faces and they depend entirely upon the sharp projecting abrasive grains which protrude from the narrow wheel periphery to accomplish the entire cutting operation. Due to the narrow width of these wheels, they are very fragile and cannot be subjected to much transverse pressure.

It has been found that a high speed cutting-off grinding wheel is capable of an extremely fast cutting operation as compared with that of the common types of circular steel saws heretofore employed, and the rapidity of such a grinding operation is so great that there is insufficient opportunity for dissipation of the heat of grinding. This excessive heat of grinding tends to cause a softening of the wheel bond, resulting in uneven stresses within the grinding wheel and changes of its abrading characteristics, thereby causing warpage and often breakage of the wheel and injury to the work as well as endangering the machine operator. It has been found that the common type of flat sided cutting-off wheel as heretofore employed, tends to wear away rapidly at its edges and such a wheel gradually becomes narrower in thickness at its periphery than at its central portion. When a wheel which has become worn in this manner, is fed into the work for a cutting-off operation, it does not cut sufficient clearance for itself as it enters the work and it tends to bind in the cut and to break therein, as well as to produce an unsatisfactory cut which is not perpendicular to the axis of wheel rotation. In view of the fact that cutting-off wheels of this type are often rotated at such excessive speeds as 16,000 surface feet per minute, it will be appreciated that breakage of such a wheel might easily cause considerable damage and endanger the machine operator.

Many of these thin cutting-off grinding wheels become warped during the process of manufacture owing to the fact that gases present within the wheel structure are not evenly released during the maturing of the bond. In view of the fact that cutting-off wheels are so extremely thin and fragile, it is essential that they must not be subjected to transverse pressures. Even a slight wheel warpage would cause transverse wheel pressures and result in wheel chatter and breakage. As a consequence, all of the warped wheels must be discarded during manufacture as unfit for use.

In order to provide cooler cutting wheels, various expedients have been contemplated, such as cutting spaced grooves and indentations in the opposed flat parallel side faces of a cutting-off wheel, but these indentations have only served to weaken the wheels and have not provided sufficient surface cooling to permit a high speed cutting-off wheel to operate at maximum efficiency within its greatest cutting capacity.

It is, therefore, the principal object of this invention to provide a cutting-off wheel which is capable of a cool, rapid abrading operation and which is adapted to grind deep narrow grooves at its maximum cutting capacity without heating sufficiently at the point of grinding contact to soften the wheel bond or to affect the cutting capacity of the wheel.

It is a further object of this invention to provide a cutting-off wheel structure which will serve to maintain parallel faces in the cut and so prevent the wheel from binding therein.

It is a still further object of this invention to provide a method of producing a cutting-off wheel wherein the gases within the raw wheel may be evenly liberated during the maturing of the wheel bond to prevent wheel warpage during manufacture.

As a result of extensive experimentation I have found that high speed cutting-off grinding wheels of greater efficiency than those heretofore manufactured, may be easily, cheaply and accurately produced by providing the opposed side wheel faces with a large number of sharp abrasive cutting teeth which extend for a predetermined distance out beyond the main body portion of the wheel. Each of these projecting teeth is preferably composed of one or a plurality of protruding abrasive grains bonded together and cemented to the body portion of the wheels in various cluster-like formations which extend out from the opposed side faces of the wheels in spaced relation to each other; and they are preferably arranged to form a substantially uniform pat-

tern. It is also preferable that a relatively large portion of each outside abrasive grain project from the side wheel face and that these individual grains thus form a large number of minute sharp abrasive cutting edges or teeth which constitute the major portion of each side wheel face. In other words, the opposed side faces of the cutting-off wheel as disclosed in this invention are comparable with an abrasive paper or cloth wherein a large number of abrasive grains each project upwardly from a supporting body which contains a cementing matrix, and thereby provide a multiplicity of extremely sharp individual cutting edges.

During the grinding operation, these abrasive teeth abrade the side faces of the work cut in order to relieve the grinding wheel from binding within the work and to compensate for any slight out of true condition of wheel alignment. They also provide ample opportunity for clearance of ground particles and chips of the work from the cut as well as to aid in circulating air or other suitable fluid between the wheel and work in order to keep the face of the wheel cool and prevent wheel warpage. Since there is no tendency for the chips to remain within the cut, they do not tend to rub into the side faces of the wheels and glaze the wheel as is often the case with a smooth sided cutting-off wheel.

These abrasive teeth are relatively small in size, as compared with the thickness of the cutting-off wheel, and they are so positioned and shaped that the relatively small amount of bond which secures the grain clusters together onto the main body portion of the wheel will not appreciably affect their cutting action or interfere with their abrading engagement with the work. These teeth are preferably formed by extruding the abrasive grains and bond in the surface of a cutting-off wheel up through a wire screen of fine mesh during the process of shaping the raw material and before the maturing of the bond. It will be appreciated, however, that a suitable mixture of abrasive grains and bond may be coated on a separately manufactured grinding wheel and thereafter be extruded up through a wire screen to form the desired rough wheel face. Such a wire screen may be suitably supported and pressed against the opposed side faces of a grinding wheel in such a manner as to force one or more abrasive grains into the spaces between the wires of the mesh. The screen serves to displace the surface abrasive grains on the side faces of the wheel causing many of them to be oriented and projected up through the meshes of the screen. During the process of impressing the wire screening against the opposed faces of the raw wheel, a small amount of bond will also be forced up between the wires. However, such bond as is extruded with the abrasive grains through the mesh of the screen, is of a relatively fragile nature, and during the operation of grinding it will rapidly wear or break away so that sharp protruding edges of the abrasive grains are left fully exposed for a cutting operation. The mesh of the wire screen is preferably comparatively fine so that only one or a very small number of abrasive grains may be extruded into each of the spaces between the meshes of the wires and thus form a large number of sharp substantially uniformly distributed abrasive teeth projecting from the main body portion of the wheel. The impression on the wheel face of the mesh of the impressed screen may or may not be apparent to the eye, depending upon the size of the abrasive grains employed and the amount of bond present. For example, if a single abrasive grain and a very small amount of bond flows up into each mesh of the screen, the pattern will not show, but the wheel face will appear rough like a very coarse abrasive paper or cloth. If the grains are small as compared with the apertures of the wire mesh and there is a relatively large amount of bond present, the impressions of the wire screen in the side wheel faces may appear as a definite reticulated repetitive arrangement with the clusters of abrasive grains in a substantially tessellated pattern. It should be understood that the size and shape of the wire mesh screen is not important except it must be so chosen as to permit a relatively small number of abrasive grains to be extruded through each screen aperture so that many sharp abrasive teeth will project laterally from the side wheel faces in spaced relation and serve to abrade the sides of a work-cut and relieve the wheel during the grinding operation. Impressing of suitable wire screens into the opposed side wheel faces also serves to evenly release the gases within the cutting off wheel during the maturing of the bond and thereby prevent any tendency towards wheel warpage.

My invention will be more fully understood by reference to the accompanying drawing in which like numerals indicate like parts and wherein:

Fig. 1 shows one method of shaping a suitable mixture of abrasive grains and bond into a cutting off disk,

Fig. 2 shows a screen employed in forming the rough wheel sides,

Fig. 3 shows one method of producing cutting teeth which project from the wheel sides and

Figs. 4, 5 and 6 diagrammatically illustrate the various types of cutting off wheels produced by my method, which have one or a plurality of grains in each of the cutting teeth.

As illustrated in the accompanying drawing, the preferred type of my invention comprises a cutting-off grinding wheel 10 which is very thin as compared with its diameter. The wheel may be composed of abrasive grains, such as crystalline alumina or silicon carbide, of suitable size and secured into an integral grinding wheel structure by any suitable matured bond, and particularly an organic bond, such as rubber, shellac or other natural resins, or the synthetic resinoids including the well-known phenolic condensation products, as are commonly employed in this art.

The finished grinding wheel is provided with two opposed side faces which are of a predetermined roughness and have a large number of small spaced tooth-like portions 12 composed of abrasive grains 13 which project singly (Fig. 4) or in clusters (Figs. 5 and 6) above the main body portion of the wheel and are secured by a small amount of suitable bond 14 to the main body portion of the wheel as an integral part thereof. These tooth-like portions are substantially uniformly distributed over each of the opposed wheel faces similar to the granular abrasive material in sand paper, so that the projecting sharp cutting edges of each protruding abrasive grain may serve as a sharp cutting tooth which will abrade the side faces of a cut as the wheel enters the work. In order to provide a substantially even tooth size and uniform spacing thereof, a plurality of evenly spaced intersecting grooves 15 which may form a reticulate or other suitable pattern are impressed into the opposed side faces of the wheel. Although the width of

these grooves may not be important in some types of wheels, they are preferably narrow as compared with the size of the sharp projecting abrasive teeth, so that the teeth cover the major portions of the opposed wheel faces, thereby providing a large number of sharp cutting edges projecting from each wheel face and extending above the general level of the wheel body. The number and size of the teeth determine the extent of roughness of the opposed wheel faces. In the preferred form of my invention these abrasive teeth project singly or in clusters in spaced formation from the main body portion of the grinding wheel in a substantially tessellated or other suitable uniform pattern as desired. It is to be understood, however, that these surface projecting portions of abrasive teeth need not necessarily be arranged in any definite pattern on the wheel side; but they should be of such a size and so spaced with relation to each other as to provide the wheel sides of a high degree of roughness so that the side wheel faces are capable of rapidly cutting themselves free of the work and thereby preventing any tendency of the grinding wheel to bind within the work.

Various methods may be employed to produce this rough sided cutting-off grinding wheel, but in accordance with my preferred method of manufacture, I propose to impress a fine mesh screen into each of the opposed side faces of the raw wheel mixture prior to the maturing of the bond, so that one or more abrasive grains in the surface of the raw wheel mixture will be extruded out between each of the apertures in the screen and thereby provide a large number of spaced cutting teeth projecting from the side wheel faces.

In the manufacture of this rough sided cutting-off wheel, I may employ any suitable raw, unmatured bond to unite the granular abrasive material, such as sodium silicate, with or without various fillers, or an organic bond, including the resinoids, rubber, etc. The abrasive grains and bond are intimately mixed in any desired proportions in suitable mixing machinery, as is well known to the art. If desired, various temporary binders or fillers may be employed in the mixture of raw bond and abrasive. It is essential, however, that the raw wheel mixture must be of such a consistency that it may be temporarily pre-shaped by any suitable cold or hot moulding operation and thereafter by proper application of heat, the raw bond may be matured in position to bind the abrasive grains together and form an integral grinding wheel structure.

Figs. 1 and 3 illustrate one convenient method of quickly and easily producing my invention as applied to a wheel having a resinoid bond. As shown in Fig. 1, the raw wheel mixture is first placed in a suitable type of pressed wheel mould wherein a cylindrical press plate 20 of required diameter and thickness is rigidly supported upon a press bed 22. A cylindrical post or hub 23 having a diameter corresponding to that of the finished wheel hole is slidably and coaxially fitted within a central hole 25 in plate 20 and supported by bed 22. An annular member 27 of required size slidably fits against the periphery of press plate 20 and is supported by bed 22. A desired amount of raw mixture of abrasive and bond is poured or otherwise placed and evenly distributed over press plate 20 between the annular member 27 and post 23, and a top pressure plate 28 is placed upon the wheel mixture and arranged to slidably engage annular member 27 and post 23. The top pressure plate 28 is forced towards plate 20 by any suitable mechanism thereby causing the raw wheel mixture to be compressed and temporarily formed into a smooth disk shaped raw abrading member 30 having substantially parallel flat side faces.

The disk shaped grinding member 30 is next removed from the mould preparatory to having the rough, sharp abrasive cutting teeth provided on its opposed smooth side faces. To accomplish this, a wire mesh screen is impressed into the opposed side wheel faces for a predetermined distance, causing the abrasive grains in the surfaces of the side faces to become oriented and extruded up through the apertures in the mesh of the screen, thereby providing a large number of surface abrasive grains having sharp cutting edges projecting from the main body portion of the side wheel faces. It will, of course, be appreciated that some of the raw wheel bond 14 will also be extruded up through the screen, but this will not interfere with the sharp cutting edges of the protruding abrasive teeth, since the engagement of the wheel and work in a grinding operation will cause the extruded bond to rapidly wear away and leave the edges of the teeth free for a cutting operation.

As illustrated in Fig. 3, I employ a supporting plate 33 having a plane supporting face 34 of greater area than the side face of the grinding member 30. A flat sheet of wire screening 32 of suitably sized wire and mesh is next placed upon the surface 34 and the grinding member 30 is laid thereon so that its entire lower side face is engaged and supported by the screen 32. A similar wire screen 32 is next placed upon the upper flat face of the abrading member 30 and a top metal plate 36 is placed upon said screen so that its lower plane face 37 will tend to evenly impress the upper screen 32 into the grinding member. The top pressure plate 36 is of sufficient weight and size to cause each of the wire screens 32 to impress a definite pattern into the opposed side faces of the grinding member 30. If desired, pressure may also be applied to cause the top plate to move toward the supporting plate 33 and thereby impress the patterns of the wire screens into the opposed side wheel faces.

In order to prevent the screens 32 from being too deeply impressed into the opposed wheel sides and to prevent too great a pressure from being applied on the opposite sides of the raw unmatured grinding member 30 and thereby forming smooth faces of bond and grain pressed against the plates 33 and 36, a series of spacing blocks 40 are placed on the top face 32 of the supporting plate 33 and between plates 33 and 36. These blocks are of the same height so that they will limit the extent of downward movement of plate 36 towards plate 33 and the extent to which screens 32 are impressed into the opposed side wheel faces. In my preferred type of rough wheel side, I impress the wires of screens 32 for approximately one-half of their diameters into the side faces of the opposed flat sides of the grinding member 30, thereby causing a large number of the surface abrasive grains to be engaged by the wires and oriented so that one or more grains is upended and extruded between the mesh apertures as shown in Figs. 4, 5 and 6. It has been found that in this way the extruded abrasive grains will tend to form irregular projections separated by a large number of intersecting depressions in the opposed side wheel faces.

For example, successful rough sided cutting-off

grinding wheels have been produced in accordance with my invention by employing wire screens composed of interwoven wires 0.018" in diameter forming a mesh of 20 apertures to the linear inch, and simultaneously impressing said screens into the opposed flat faces of a raw unmatured grinding member having a phenolic resinoid bond and abrasive grains of alumina or silicon carbide of such size that a single abrasive grain or a number of grains may be simultaneously extruded up through a single screen aperture, dependent upon the purposes to which the cutting-off wheel is to be employed. It will be appreciated that due to the irregular shape and the many projecting edges of the grains, a wheel having coarse grains will not show the screen pattern as clearly as will one having the small grains. If coarse grains are used, the wheel faces will appear very much like a coarse abrasive paper or cloth wherein a large number of abrasive grains are secured by a suitable cement to a flexible backing material. It is immaterial whether or not a visible pattern is impressed into the opposed side wheel faces, since the purpose of the screen is simply to orient the surface abrasive grains and to extrude them from the main body portion of the wheel, thereby forming a large number of sharp abrasive cutting projections. It will also be appreciated that various sizes of screens and shapes of mesh may be employed to produce my type of cutting-off wheel and it is not desired to limit my invention to any particular size or type of screen. It will also be appreciated that the teeth may be provided by other suitable types of apparatus, since they may be formed by means of pressure plates, rollers, etc., which have been shaped to the required pattern having projections adapted to produce the grooves 15 and grooves into which the abrasive grains may be extruded. Hence, such other forms of apparatus are to be considered as full equivalents of the screens above described. In the use of such rollers or pressure plates, the grains and bond are not to be extruded into contact with the bottoms of the grooves on the plate or roller, unless the pattern is such as to give a simulation of the sandpaper-like appearance of the cutting-off wheel above described. In the latter case, the pressure plate or roller might be shaped as the intaglio of the sandpaper pattern or in other desired arrangement which produces the spaced cutting teeth of the present invention.

After the screens have been impressed into the opposed side wheel faces to form sharp projecting cutting teeth thereon, sufficient heat is applied to set the bond and secure the abrasive grains together into an integral wheel structure, whereupon the finished cutting-off grinding wheel may be removed from between the pressure plate and screens and other cutting-off wheels made with the same apparatus and by the same method. The resinoid bond is preferably matured while the screens are in place.

It will be appreciated in accordance with the above disclosure that my invention involves two important aspects: first, a large number of sharp abrasive cutting teeth projecting in spaced relationship from the opposed side faces of a thin disk shaped cutting-off wheel which serve to abrade the sides of a work cut and provide sufficient clearance between the wheel and work so that the wheel will not bind within the work during a cutting operation; and second, a reticulated or other suitable pattern impressed by a wire screen or other suitable devices into the opposed side wheel faces whereby the wheel is provided with a series of interconnecting depressed portions which aid in clearing chips from the work cut and in providing clearance spaces between the wheel and work into which suitable coolants may be entered to prevent the wheel and work from overheating and glazing during the cutting operation.

If a wire screen is employed to impress a desired pattern and form the projecting abrasive cutting teeth in the opposed wheel sides, the shapes, sizes and general contours of the cutting teeth may be controlled by the size of wire and mesh of the screen as well as by the depth to which the screen is impressed into the wheel and the size of abrasive grains and amount and type of wheel bond present. Hence, it will be apparent that the present invention relates to a rough sided cutting-off wheel manufactured by my method and having side faces of any desired degree of roughness. For example, my invention provides for a cutting-off wheel having very rough side faces which are comparable in appearance to an abrasive paper, wherein the wire screen or other pattern making device serves to locate single large abrasive grains which are mixed with a small amount of bond, or the pattern making device may serve to locate small abrasive grains present in a relatively large amount of bond into definite cluster formations which may appear in tessellated formation separated by a reticulate or other suitable pattern impressed into the side wheel faces. In either of the above cases, the individual abrasive cutting teeth will project to substantially the same extent from the body portion of the wheel and these teeth will be separated by a suitable series of interconnecting depressions in the side wheel faces.

It will therefore be recognized that this invention contemplates many types of grinding wheels as well as the methods of their manufacture and is not limited to the types of bond and abrasive employed. Various modifications in structure and in the method of manufacture will be apparent to one skilled in the art and the claims are to be interpreted broadly within the scope of this disclosure.

Having thus described the invention, what is claimed as new and desired to obtain by Letters Patent is:

1. A cutting off grinding wheel adapted for producing deep narrow cuts comprising a thin disk shaped body of abrasive grains and an organic bond united in a compressed heat set condition as an integral body having a peripheral cutting face and two opposed side faces, each of the latter carrying a pattern impressed thereon which provides a multiplicity of exposed, laterally projecting, small abrasive teeth separated by clearance spaces which present sharp edges substantially free from the bond that are free cutting and capable of abrading the sides of the cut and preventing the wheel from binding therein.

2. A cutting-off grinding wheel adapted for producing deep, narrow cuts comprising abrasive grains and an organic bond united in a compressed dense heat set condition as an integral disk shaped central body portion having a thickness which is very small in comparison with its diameter and providing a peripheral grinding face, and side face portions of a predetermined roughness and cutting ability carrying patterns impressed thereon which provide a multiplicity of spaced abrasive teeth, each of which contains one or a relatively small number of exposed abrasive

grains projecting from the opposed wheel sides, said teeth being separated from each other by clearance spaces no smaller in size than that of an abrasive grain within the wheel which are substantially free from bond so that the teeth present sharp edges which abrade the sides of the work cut and prevent the wheel from binding therein.

3. A cutting-off grinding wheel adapted for producing deep, narrow cuts comprising a thin disk shaped body of bonded abrasive grains having a peripheral cutting face and two opposed side faces, each of which has a surface of predetermined roughness carrying the reticulated pattern of a wire screen impressed thereon and providing a multiplicity of abrasive grains having exposed cutting edges free of bond and laterally protruding in spaced clusters from the wheel sides, which is fast and free cutting and will not bind within the work during a cutting operation.

4. The method of producing a cutting-off grinding wheel adapted for making deep, narrow cuts, comprising the steps of pressing a mixture of raw organic bond and abrasive grains into the shape of a thin body having two opposed substantially flat faces, impressing a pattern into the opposed faces to make them of a desired roughness and provide a multiplicity of sharp abrasive cutting teeth projecting therefrom in spaced relation, and treating the body in the shape of a disk to mature the wheel bond and form an integral grinding wheel structure having rough side faces which are composed largely of sharp abrasive cutting teeth projecting therefrom and adapted to abrade the sides of the work cut during the cutting operation.

5. The method of producing a cutting-off grinding wheel adapted for making, deep, narrow cuts, comprising the steps of preforming a mixture of abrasive grains and raw organic bond into the shape of a thin disk having two flat opposed side faces, pressing a screen of such mesh into the side wheel faces so that only a small number of abrasive grains will be extruded through the screen apertures, thus providing a multiplicity of raised, sharp abrasive cutting teeth separated by depressed wheel portions and protruding laterally from each of the side wheel faces, and thereafter maturing the wheel bond to form an integral abrasive cutting-off wheel structure having side faces of predetermined roughness.

6. The method of producing a cutting-off grinding wheel adapted for making deep, narrow cuts comprising the steps of pressing a mixture of abrasive grains and raw organic bond into the shape of a thin disc having two substantially parallel opposed flat side faces, pressing a wire screen of such mesh into each of the side wheel faces and for such a distance that a relatively small number of surface abrasive grains will be extruded up through each screen aperture in the form of a sharp tooth-like projection having a mound-like formation and providing a multiplicity of spaced teeth which cover the major portion of each side wheel face in a predetermined pattern formation, and thereafter maturing the organic bond to provide an integral wheel structure having side faces of a predetermined roughness.

7. The method of producing a cutting-off wheel adapted for making deep, narrow cuts, comprising the steps of preforming a mixture of abrasive grains and raw organic bond into the shape of a thin disc having two substantially parallel opposed flat side faces, pressing a wire screen of such small mesh size and for such a distance into each of the opposed side wheel faces that a small number of surface abrasive grains will be extruded through each screen aperture and project from the wheel sides in a sharp tooth-like mound-shaped formation, thus providing a large number of spaced abrasive cutting teeth which cover the major portion of the side wheel faces in a predetermined pattern formation, and thereafter maturing the organic bond before the wire screens are removed from wheel engagement in order to provide a wheel structure having side faces of a desired roughness.

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