May 15, 1956 J. R. ERICKSON 2,745,224

REINFORCED ABRASIVE WHEEL AND METHOD OF MAKING SAME

Filed May 12, 1955 2 Sheets-Sheet 1

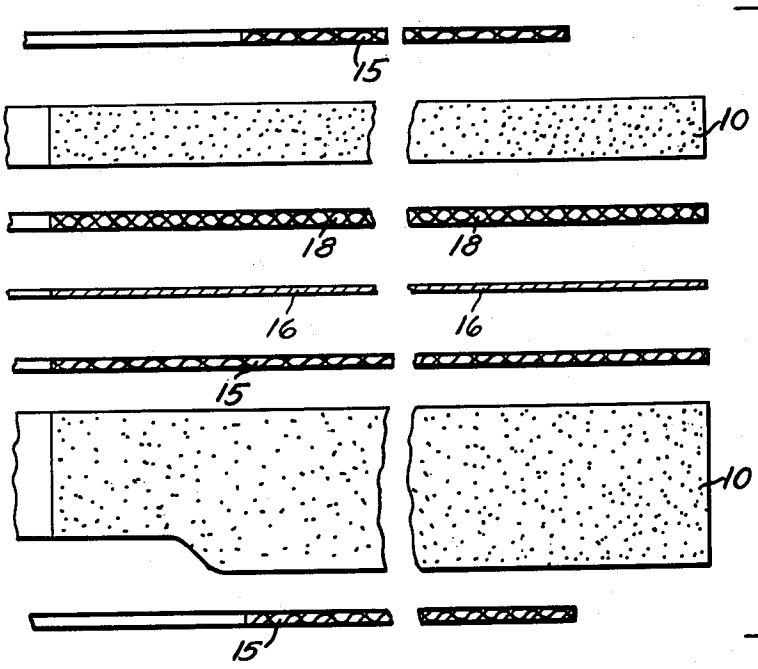


Fig. 1

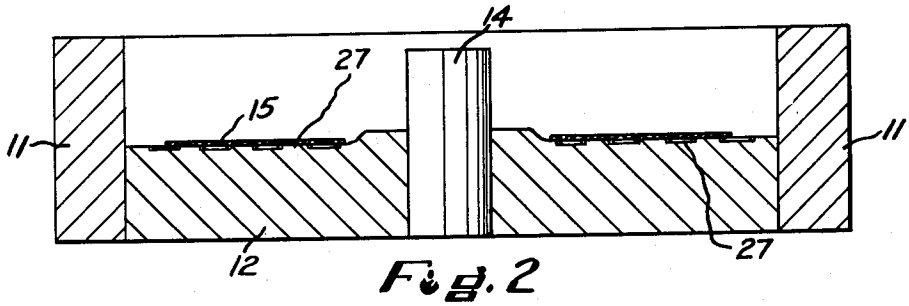


Fig. 2

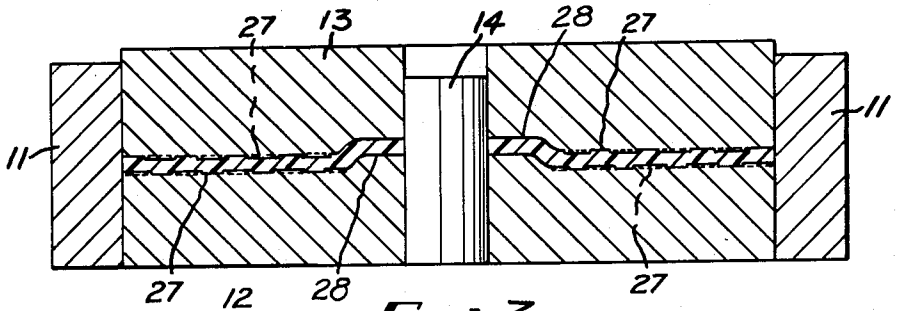


Fig. 3

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REINFORCED ABRASIVE WHEEL AND METHOD OF MAKING SAME

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FIG. 4

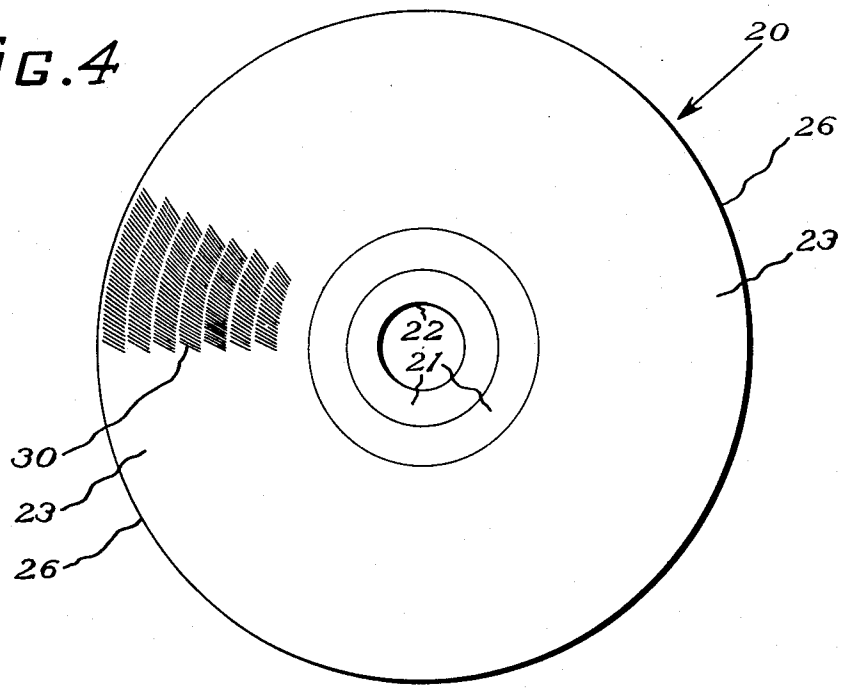


FIG. 5

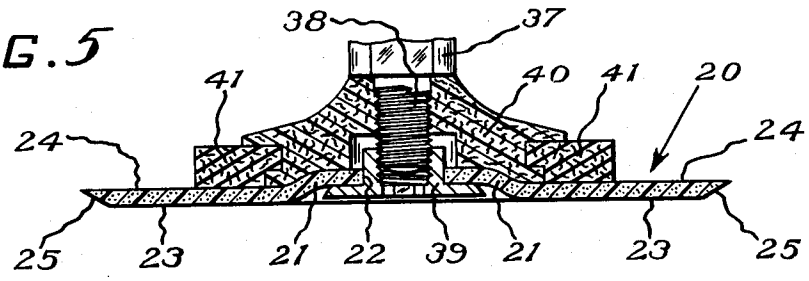
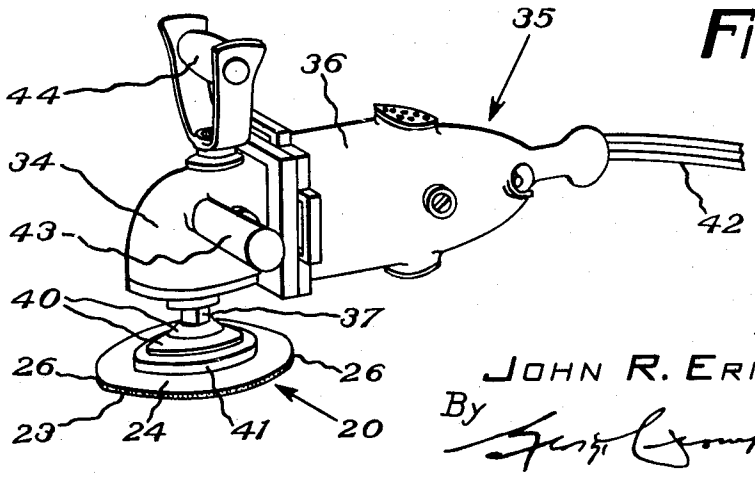


FIG. 6



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2,745,224

REINFORCED ABRASIVE WHEEL AND METHOD OF MAKING SAME

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Application May 12, 1955, Serial No. 507,895

2 Claims. (Cl. 51—195)

The invention relates to reinforced abrasive wheels particularly adapted for grinding by the use of a portable hand tool on which the abrasive wheel is mounted for rotation thereby, such a wheel usually having a depressed center so that the nut holding it to the spindle of the tool will not project beyond the face of the wheel. An example of this type of wheel is shown and described in my U. S. Letters Patent No. 2,656,654 of October 27, 1953. This application is a continuation-in-part of my copending application Serial No. 459,771 filed October 1, 1954, now abandoned.

One object of the invention is to provide an abrasive wheel of this type having all of the following characteristics and features:

1. High overall strength.
2. Long wheel life (low rate of wheel wear).
3. High rate of cut (high rate of material removed).
4. Abrasive on the rear as well as on the front side.
5. Having a strong safety web which will hold a broken segment from flying off.
6. Having a rough molded front side.

Another object of the invention is to provide an abrasive wheel having all of the above six characteristics and features with the safety web of feature No. 5 capable of holding a segment at a speed of 50% above the maximum operating speed set by the manufacturer when such segment is deliberately broken back to an angle of 90° to the rear face of the wheel.

Another object of the invention is to provide abrasive wheels of the nature indicated particularly suitable for use in smoothening the welds in automobile bodies or on other fabricated metal and in smoothening protuberances, irregularities or rough spots on any kind of metal. Another object of the invention is to provide an abrasive wheel to take the place of coated abrasive discs which have only a single layer of abrasive, thus eliminating frequent replacement of the abrasive element. Another object of the invention is to provide an abrasive wheel of the above type which will quickly take on a bevel or mitre on the periphery since grinding with a portable hand tool of the type herein illustrated is often done with the wheel held at an acute angle to the face of the work. Another object of the invention is to provide a wheel capable of grinding as in the preceding object and also capable of use as a cutting-off wheel. Another object of the invention is to provide a wheel with one or more of the characteristics indicated which has a good abrasive action on the rear side since frequently, for one reason or another, the workmen wish to use the rear or back side of the wheel after it has been beveled through use because thereby they can grind hollow spots, grooves or notches as the wheel is held with the front side at an obtuse angle to the workpiece. Another object is to provide a wheel suitable for removing rust and scale from steel plate. Another object is to provide a general all purpose grinding wheel especially

adapted for use on a portable hand tool of the kind herein illustrated and described.

Other objects will be in part obvious or in part pointed out hereinafter.

In the accompanying drawings illustrating a preferred procedure for manufacturing a wheel according to the invention and the wheel so produced together with a representation of the power tool upon which it may be used.

Figure 1 is an exploded view illustrating in section the several components of the wheel in the raw state,

Figure 2 is a cross sectional view of a mold partly filled, that is containing one of the components of Figure 1,

Figure 3 is a cross sectional view of the mold of Figure 2 completely filled and closed, that is the components having been pressed to unite to form the wheel,

Figure 4 is a plan view of the completed wheel,

Figure 5 is a cross sectional view of the wheel after it has acquired a bevel or mitre together with the mounting disc therefor,

Figure 6 is a perspective view of a power hand tool such as used for smoothening welds, etc., having the wheel of the invention secured thereon.

Referring first to Figure 1, I provide a quantity of dry granular mix **10** having organic bond. This comprises abrasive grains each granule of which is coated with the organic bond. As a practical matter the abrasive grains will usually be either aluminum oxide grains or silicon carbide grains. However other abrasives such as garnet or even diamonds can be used. Aluminum oxide abrasive is available in several different grades including the so-called regular grade which is a brown abrasive about 95% Al_2O_3, the white porous variety which is about 98% pure or better and contains a small percentage of soda, and recently developed aluminum oxide abrasive produced in discrete crystals and being usually better than 99% Al_2O_3. Silicon carbide abrasive is also available in several different grades such as the black grades and the green, the latter being the purest grade. All this is known to the art and any variety of these or other abrasives can be used.

While so far as the broad aspects of the invention are concerned many different organic bonds might be used I prefer to use available commercial grades of phenol formaldehyde resin otherwise known as resinoid. Unconverted phenol formaldehyde resin is available to the manufacturer in two forms, the solid phase material and the liquid phase material. For the production of a dry granular mix in which each abrasive granule is coated with an organic bond, the abrasive is placed in a mixing pan and then wet with a liquid and then, while continuing the mixing, bond in powdered form is added and eventually the abrasive coated with liquid picks up the powdered bond until each granule has an envelope of bond and the entire mix appears to be fairly dry even though it does contain liquid phase material. Thus the abrasive grains can be wet with liquid phenol formaldehyde resin and then solid phase powdered phenol formaldehyde resin can be added to complete the formation of the dry granular mix. On the other hand the abrasive grains can be wet with furfural and then powdered resin added. The powdered phenol formaldehyde resin available and which is hereinafter identified contains a minor percentage of cresol formaldehyde.

In describing an illustrative embodiment of the manufacture of a wheel according to the invention, I shall describe the manufacture of a wheel nine inches in diameter, one-quarter inch thick and with a seven-eighths inch hole, the wheel having an off-set hub.

For the manufacture of this wheel a dry granular mix can be made from the following ingredients:

EXAMPLE I

Dry granular mix ingredients

	Pounds
No. 24 grit size aluminum oxide abrasive, regular grade	5.90
Powdered reactive phenol formaldehyde resin brand BR2417	1.70
Natural cryolite powder	1.37
Lime, CaO	.12
Carbon black	.04
	Cubic centimeters
Furfural	25
Anthracene oil fractions from coal tar, Carbosota brand	25

In making the mix the abrasive is placed in a mixing pan and mixing is started whereupon the furfural is added. When all of the abrasive is wet a mixture of the cryolite, lime, carbon black and the powdered phenol formaldehyde is slowly added and mixing is continued until the powder is well distributed. Then the anthracene oil is added. This has the function of laying the dust. The cryolite improves the grinding action of the wheel, makes it stronger and also improves the consistency of the mix. With this small amount of furfural in the mix about 80% of the bond is loose in the mix. The carbon black gives a uniform color, to wit, black. The lime absorbs any water which may be liberated.

Referring now to Figures 2 and 3, I provide a steel mold consisting of a cylindrical mold band **11**, a bottom plate **12**, a top plate **13**, and an arbor **14**. For the manufacture of a wheel with an offset center, the bottom plate **12** and the top plate **13** can be shaped as shown. Both of these plates have knurled surfaces in the form of concentric ratchet teeth from the periphery to one and a half inches from the center. For the manufacture of a 9 inch diameter wheel the mold band **11** has an inside diameter of 9⅜ inches since the cured wheel is trued to size. Further description of the mold would seem to be superfluous since the drawings are clear and molds of this general character are well known to everybody concerned with the manufacture of grinding wheels.

Figure 2 shows the mold with the mold band **11**, the bottom plate **12** and the arbor **14**, the top plate **13** being absent. The mold in this condition is filled with the various ingredients to be pressed as follows:

I first place in the mold on top of the bottom plate **12** a piece of woven glass cloth **15** six inches in diameter with a 2½ inch central hole. This glass cloth is a very open plain weave material. It has a thread count of 10 picks to the inch and 10 sley (warp ends to the inch) and a breaking strength in both directions that is along the filling and along the warp of approximately 400 pounds per inch of width. In order to avoid fraying of the glass yarn (threads) at the edges of the glass cloth discs it is coated with starch. This glass cloth, besides the coating of starch, has a superimposed coating of the same BR2417 brand of powdered reactive phenol formaldehyde resin as is mentioned above. The resin is simply brushed onto the glass cloth while the latter is at room temperature. Each nine inch disc with the seven-eighth inch central hole (hereinafter mentioned) will pick up two grams of this resin. Due to the fact that the filling and the warp of the cloth have appreciable diameter the openings therein are about one-sixteenth of an inch square. Thus even though the glass cloth is on both sides of the wheel the molding operation forces the abrasive grain, being of No. 24 grit size, right through the openings to the sides of the wheel. Figure 2 shows the open mold without the top plate **13** having been charged only with the disc of glass cloth.

Next I add 580 grams of the mix of Example I and

follow this with a nine inch in diameter, seven-eighths inch central hole layer of the same glass cloth **15** also coated with starch and BR2417 resin to the same amount per square inch. I then add an annular sheet **16** nine inches in diameter with a seven-eighths inch hole of porous technical paper No. 69 of the Industrial Paper Company. This paper is made of regenerated cellulose and wood pulp with the fibres in random orientation. Its porosity cannot be measured on a densimeter test as defined by the Technical Association of the Pulp and Paper Industry, as no readings were obtained even with the lightest (5 ounce) cylinder used. This paper is approximately .003 inch thick. It weighs about .75 ounce per square yard.

On top of the sheet of paper just described I place an annular sheet **18** of nylon woven cloth. This is nine inches in diameter with a seven-eighths inch central hole. This nylon cloth has a plain weave with a sley of 35 and with 34 picks to the inch. The ravelled tensile strength of the warp is 460 pounds, of the filling 430 pounds. The tongue tear test of the warp is 39.2 pounds and of the filling 36 pounds. The percentage elongation of the warp is 35.3% and of the filling 33.5%. The cloth as a whole has a thickness of about .018" and the weight is 8.5 ounces per square yard.

The annular sheet or disc of nylon woven cloth is then followed by 185 more grams of the mix **10** of Example I. This of course is spread level as was the 580 grams below it and then another annular piece of the same glass cloth **15** six inches in diameter with a two and a half inch diameter central hole is added. The top plate is now inserted on top of the material above mentioned and the assembly is taken to a hot press. The mold and contents are then pressed for about 15 minutes at a temperature of 160° C. at a pressure of from 500 to 1,000 pounds per square inch. After this the mold is cooled in the press and then removed from the press whereupon it is stripped from the cured wheel. The pressure is not exactly critical although a fairly substantial pressure should be used, for example 500 pounds or more. If the mix is very flowable, a low degree of pressure should be used, otherwise resin will ooze out between the top plate and the mold band. In general I have found that the pressure should be not higher than 1500 pounds per square inch and not less than 300 pounds per square inch. In practice the movement of the top mold plate **13** is measured and when an average figure for the best wheels is found mold stops are set to close the mold to the stops regardless of slight variations in pressure involved in so doing. Molding to stops is now per se well known in the art.

The completed wheel **20** is shown in Figures 4, 5 and 6. It is a disc with an offset hub **21** and a central hole **22**, a front face **23** and a rear face **24**. After grinding the welds on automobile bodies, its periphery usually acquires a taper **25** but prior to grinding it has a square edge periphery **26**. The faces **23** and **24** are desirably knurled and this may be achieved as follows: the mold plates **12** and **13**, being made of a soft steel such as cold rolled steel, are mounted in a lathe and then a knurling tool is fed against the face of the plate to make a ring of knurling and then the knurling tool is moved inwardly or outwardly and the operation is repeated until the flat portion **27** outward of the offset forming portion **28** has been knurled all over its surface. Figure 4 shows the knurling **30** thus illustrating the pattern on the plates. I prefer ratchet teeth knurling. This knurling of the faces gives the wheel a better appearance but additionally it improves its action when used as a cut-off wheel.

The glass cloth discs **15** gives strength to the wheel so that it is found it does not break until a speed of 30,000 surface feet per minute is reached. It is well known that grinding wheels of a given composition break at a given speed measured in surface feet per minute regardless of varying diameter provided the central hole is proportionately the same size in the different wheels, so therefore a breaking speed of so many surface feet per minute has

a real meaning even though the diameter is not specified and the variation due to different ratios of the diameter of the central hole is usually a small variation.

Referring now to Figure 6, a typical power driven hand tool **35** for using the wheel **20** is shown. There are many varieties of hand tools that can use the wheel of this invention, but to give a typical example of the use of the wheel I have provided a perspective view of a particular hand tool **35** which comprises a metal casing **36** containing a motor having a shaft which drives bevelled gearing in a casing **34** attached to the casing **36** and the bevelled gearing drives a spindle **37** which has a threaded end **38** receiving a nut **39** which holds the wheel **20** against a hub **40** integrally connected to a back plate **41**. Power is supplied to the tool **35** by electric cables **42** and the operator holds the hand tool **35** by means of handles **43** and **44**. By means of this or any other kind of hand tool the wheel **20** can be used for any of the purposes hereinbefore given.

The thickness of the abrasive section **10** on the grinding side of the wheel, that is to say the abrasive mixture which was first put into the mold and is the lower one in Figure 1, will vary depending upon the thickness of the wheel. In the case of a one-quarter inch thick wheel the thickness of the abrasive section on the grinding side is three times that of the abrasive section on the back side which is in the upper position in Figure 1. In the case of a one-eighth inch thick wheel the thickness of the abrasive sections on the two sides are equal. In other words, the nylon sheet **18** is in the same position relative to the back of the wheel in the several varieties.

Nylon is the condensation product of hexamethylenediamine and adipic acid. It is a polyamide. It can be called polyhexamethylenediadipimide. It will be noted that both components of nylon contain six carbon atoms. The chains link together and as nylon filament is made it is drawn to stretch the material several times its original length which lines up the chains to give the filament great strength. It not only has great tensile stength, of the order of a hundred thousand pounds to the square inch, but it also has high elongation up to 40% or more. However, other yarn can be substituted for nylon such as Dacron and Orlon provided it has tensile strength of at least fifty thousand pounds per square inch and an elongation of at least 15%. So-called regular nylon is listed in the tables as having a tensile strength in pounds per square inch of 68 to 85 thousand, Orlon from 62 to 71 thousand and regular Dacron from 81 to 88 thousand. The corresponding elongations as given in the tables are respectively 26%–32% for regular nylon, 15%–17% for Orlon and 19%–23% for regular Dacron. However, the nylon that I have had has an elongation of 33%.

It has been found that no matter how strong these grinding wheels are made they can become cracked. Wheels made according to the present invention can be placed between two bricks and then stood upon by a 200 pound man without breaking. They can be dropped from a considerable height onto a concrete pavement without breaking. Nevertheless other types of wheels have become cracked at times. This should be a rare occurrence with the present wheels since the three layers of glass cloth greatly strengthen the wheels. The tensile strength of glass is around 210,000 pounds to the square inch. I have found that the discs of this open weave glass cloth **15** do not detrimentally affect the cutting performance of the wheel. This is because of their location in the wheel and also because glass is itself an abrasive. It is readily disintegrated by the grinding action. Also it will be noted that the top sheet or disc of glass cloth is not reached until the wheel has been worn down practically to discard size where the wheel is being used at an angle of 30 degrees to the work. Discard size for a nine inch diameter wheel which has been described is about four inches in diameter.

A critical feature of this wheel is in the bonding of the abrasive phenolic resin mixture to the nylon cloth **18**. If the paper **16** were omitted a cracked segment of wheel could hardly be bent back at all before the nylon cloth would break clean. This is because the resin bonds very well to nylon. If this bond were spoiled completely, for example by using a sheet of cellophane in place of the paper, the wheel would give short life due to the lack of adhesion and spalling away of the abrasive mix at the cellophane edge. With the use of the paper herein described, I obtain just the right strength of bond between the nylon cloth **18** and the lower or abrasive side mix **10**.

Wheels made according to the invention have been deliberately broken and the broken segments bent back to 90 degrees from the bodies of the wheels. Such wheels were then speed tested to breakage with the following results:

Table I

Wheel Size	S. F. P. M. M. O. S.	S. F. P. M. Breaking Speed
9 x 1/8 x 7/8	14,000	21,600
9 x 3/16 x 7/8	12,500	19,200
9 x 1/4 x 7/8	11,000	16,650

In the above table the wheel size is given in inches, first for the diameter, then for the thickness and then for the central hole. S. F. P. M. M. O. S. means surface feet per minute maximum operating speed as set by the manufacturer. The manufacturer has every inducement to set the maximum operating speed as high as possible consistent with safety to show the merits of his wheel. The figures given are rather high operating speeds. Calculation will show that the broken wheel segment which was bent back 90 degrees did not tear loose from the wheel until the wheel speed was better than 50% greater than the maximum operating speed set by the manufacturer.

These wheels made in accordance with the present invention have grinding characteristics superior to wheels made in accordance with my prior Patent No. 2,656,654. Wheels made according to that patent were certainly good wheels; hundreds of thousands of them have now been sold. They gave extreme satisfaction and were superior to all other wheels on the market in my belief. Nevertheless this invention represents a further improvement. Standard wheels according to Patent No. 2,656,654 were tested against a standard wheel according to the present invention. The wheel of the present invention, as made according to the foregoing description, is harder acting than the standard wheel according to the foregoing patent. Experience indicated that the customers would like a little harder wheel which would not remove material quite so fast but would last a good deal longer. The material removal is of course a function of the pressure used and the operators appeared to want a harder acting wheel which would nevertheless remove the welds quickly enough for their purposes. A wheel that cuts too quickly can cut right into the metal of the automobile body thus causing a great deal of expense to the automobile manufacturer. The grinding data of Tables II and III are taken right out of my copending application referred to but the tests were made on an outer portion of the invention wheel which in structure was identical with the invention wheel of the invention hereof. Therefore, the same figures are used.

Table II

	WW on Dia. in Inches	MR in Gms.	Efficiency, MR/WW	Quality Number
Standard Wheel Patent 2,656,654	1.187	570	480	273,715
Wheel of Present Invention	.375	430	1,140	493,066

WW means wheel wear and MR means material removed. Dia. means diameter and gms. means grams. The quality number is simply the square of the material removed divided by the wheel wear as will be found by calculation from the other figures given. This particular quality number has no relationship to the quality numbers in other units which will be found in the literature. It is not arbitrary, however, because by squaring the material removed an allowance is made which has been found to be valid for the operator's pay and the manufacturer's overhead. The superiority of the wheel of the present invention is shown both by the efficiency and by the quality number and is also shown by the smaller wheel wear. Both wheels were 7 x ¼ x ⅞ wheels.

Another test was made comparing the hard wheel of the present invention made as above described against a standard cotton carded web filled abrasive wheel which is in regular production and is preferred by many customers for various purposes. This standard cotton carded web abrasive filled wheel has been on the market for a number of years and many thousands thereof have been sold. These wheels are also 7 x ¼ x ⅞ and a comparison in the same units is shown in the following table:

Table III

	WW on Dia. in Inches	MR in Gms.	Efficiency, MR/WW	Quality Number
Standard Cotton Carded Web Filled Wheel	.375	290	775	224,266
Wheel of Present Invention	.250	460	1,840	846,400

It will be seen that the wheel of this invention is superior to the standard carded web wheel in all points. Nevertheless the cotton carded web filled wheel has been extensively used in grinding welds on automobile bodies which makes it a good object of comparison to show the superiority of the present wheel.

I have made these wheels in three sizes, seven inches, eight inches and nine inches in diameter. The diameters of the various components of these wheels were as shown in the following table:

Table IV

[Diameters of components of wheels in inches.]

Wheel, Overall	7	8	9
Central Hole	⅞	⅞	⅞
Outside Glass Cloth, Overall	6	6	6
Outside Glass Cloth, Hole	2.5	2.5	2.5
Inside Glass Cloth, Overall	7	8	9
Inside Glass Cloth, Hole	⅞	⅞	⅞
Porous Paper, Overall	7	8	9
Porous Paper, Hole	⅞	⅞	⅞
Woven Nylon Cloth, Overall	7	8	9
Woven Nylon Cloth, Hole	⅞	⅞	⅞

It will be seen from the drawings, Figure 1, from the description hereinbefore given and especially from Table IV that the porous paper and the glass cloth are interposed between the nylon cloth and the resinoid bonded abrasive. This gave me a chance to make tests of the adhesion between the nylon cloth and the resinoid bonded abrasive mix by cutting discs out of a wheel made in accordance with this invention. These discs were actually one inch in diameter and they were fastened to parallel metal plates and then the tensile strength was tested on an Olsen testing machine. Araldite cement was used as the bonding material for joining the discs to the metal plates. A special wheel was made just for the purpose of testing in which there was only the glass cloth between the nylon cloth and the resinoid bonded abrasive. One inch diameter discs were cut from this wheel and cemented to parallel metal plates and then tested on the Olsen testing machine. All results were translated to pounds per square inch and are given in the following table, many tests having been made. The wheels are

identified as wheels **1** and **2** of which wheel **1** was a wheel according to the invention, and wheel **2** was the special wheel with only the glass cloth between the nylon cloth and the resinoid bonded abrasive. Four discs were cut from each wheel and all of the discs were cut from near the periphery but the results should be in the same range if they were cut elsewhere outside of the hub. At the end of the table the figures are totaled for convenience and under that the average strength is given. Below that will be found the ranges of strength.

Table V

[Tensile strength of adhesion of nylon cloth to resinoid bonded abrasive in pounds per square inch.]

Wheel	With Porous Paper and Glass Cloth between Nylon Cloth and Resinoid Bonded Abrasive	Wheel	With only the Glass Cloth between Nylon Cloth and Resinoid Bonded Abrasive
1	744	2	958
1	829	2	882
1	757	2	1,005
1	956	2	1,140
Total	3,286	Total	3,985
Average	821.5	Average	996.25

In an earlier test reported in my above identified copending application the figures for the strength of a zone with porous paper and glass cloth between nylon cloth and resinoid bonded abrasive for two different wheels were as given below and this test was exactly parallel to the test on the left hand side of table V.

Table VI

Wheel	Tensile Strength in Pounds per Square Inch of Zone Corresponding to Inner Zone Hereof
Old 2	982
Old 2	690
Old 2	682
Old 2	686
Old 3	1,000
Old 3	792
Old 3	1,010
Old 3	1,090
Total	6,932
Average	866

In certain of the tests reported in the copending application the tensile strength of the inner zones of some wheels thereof was found to average 499 pounds per square inch and I am content with a low limit of my inner zone of 500 pounds per square inch as some wheels made according to my invention of my aforesaid copending application delaminated in use and I believe that was because their inner zones had a tensile strength below 500 pounds per square inch.

The broken segments reported in Table I were broken across the outer part of the inner zone about half way from the periphery to the central hole on nine inch diameter wheels. It will be seen from Table V that wheel **2** was bonded with a strength which in some places was less than the strength of bonding of wheel **1** in some places. Consequently it follows that useful wheels can be made with the porous paper terminating inside of the full diameter of the wheel, for example at six inches in Table IV. While these wheels will not be quite so resistant to flying apart if broken by a blow, they will be superior to prior wheels and might be used. Satisfactory wheels according to the invention can be made if in an inner zone defined as three inches less in diameter than the

diameter of the wheel the woven cloth disc is bonded to the abrasive grains bonded with phenol formaldehyde through the glass cloth disc with a tensile strength of from 500 to 1090 pounds per square inch and in an outer zone defined as the outer half inch of the wheel in the radius the aforesaid are bonded with a tensile strength of from 500 to 1140 pounds per square inch. Good wheels having tensile strength in the inner zones at the lower limit (500) and at the upper limit (1090) and having tensile strength in the outer zones at the lower limit (500) and at the upper limit (1140) have been made as in part pointed out in my copending application referred to. The paper or some substitute, either in two sheets or one, need not extend right to the central hole although I prefer it that way, but it will suffice if there is paper between the glass cloth and the woven cloth in at least 90% of the area of the inner zone. There could be a disc of paper in the inner zone and none in the outer zone, or one in each but of different characteristics, but the preferable arrangement is as shown and described.

In the illustrative embodiment the woven cloth disc is approximately .060 inch from the back side of the wheel. It can be defined as nearer to one side than to the other.

It will thus be seen that there has been provided by this invention a reinforced abrasive wheel and method of making same in accordance with which the various objects hereinabove set forth together with many thorougly practical advantages are successfully achieved. As many possible embodiments can be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and limited only by the scope of the claims.

I claim:

1. An abrasive wheel comprising a disc with a hole centrally located therein, said disc being made of abrasive grains bonded with a matured phenol formaldehyde resin, and said disc containing three discs of woven glass cloth, one on each side and one intermediate, and a disc of woven cloth between the intermediate glass cloth and one of the glass cloth discs on the side of the wheel, said woven cloth being made of yarn having a tensile strength of at least 50,000 pounds per square inch and an elongation of at least 15%, and paper between the intermediate glass cloth disc and the woven cloth disc, the latter being bonded to the abrasive grains bonded with phenol formaldehyde through the glass cloth disc at an inner zone defined as three inches less in diameter than the diameter of the wheel with a tensile strength of from 500 to 1090 pounds per square inch and bonded at an outer zone defined as the outer half inch of the wheel on the radius with a tensile strength of from 500 to 1140 pounds per square inch, there being paper between the intermediate glass cloth and the woven cloth in at least 90% of the area of the inner zone, the woven cloth being nearer to one side of the wheel than to the other.

2. An abrasive wheel according to claim 1 in which the inner zone and the outer zone are bonded together with the same tensile strength.

No references cited.