Oct. 22, 1968 K. J. RYKKEN 3,406,488

ABRASIVE FLAP WHEEL

Filed Sept. 23, 1965

FIG. 1

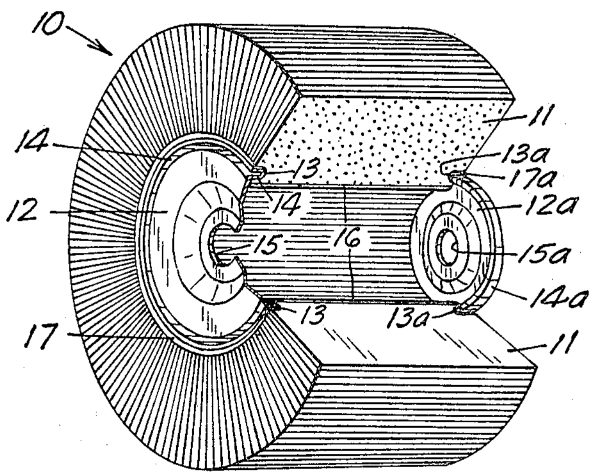
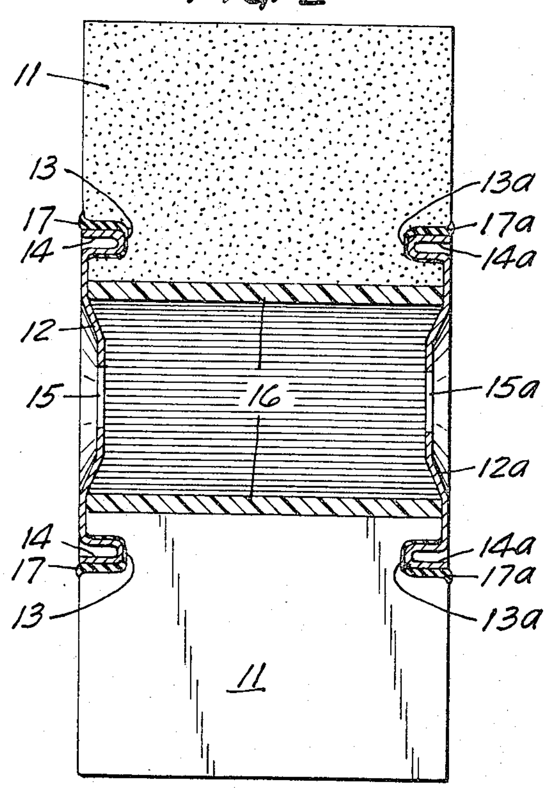


FIG. 2



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ABRASIVE FLAP WHEEL

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ABSTRACT OF THE DISCLOSURE

The useful life of coated abrasive flap wheels is improved by the presence of elastomeric material at and between the flaps where they are gripped by the radially outer portion of the mounting side flanges. The elastomeric material should be located radially outward of any other flap-contacting means which unifies the radially inner ends of the flaps.

This invention relates to an improved coated abrasive flap wheel structure.

Coated abrasive "flap wheels," which comprise an annulus of juxtaposed radially extending coated abrasive sections, have been known for at least seventy-five years. The scores of patents which have been issued on variations of this general configuration bear mute testimony to industry's interest in such products. For approximately the last decade the coated abrasive flap wheel having the greatest commercial significance has been of the type disclosed and claimed in Miller et al. U.S. Patent No. 2,842,902. In this type of wheel, densely packed flaps are rigidified and firmly adhesively bonded together over an inner end area to form a rigidly reinforced inner rim, enabling the wheel to be rotated at high speeds and subjected to high presures, e.g., in automatic equipment, while achieving a higher rate of cut than was previously possible. Convenient ways of making such wheels are described in the aforesaid Miller et al. patent and in Meyer et al. U.S. Patent No. 2,991,165.

Since the advent of the Miller et al. product, industry has subjected flap wheels to progressively more severe pressures and demanding abrading operations. Under such conditions, otherwise satisfactory wheels may fail prematurely by flap loss, i.e., individual flaps or blocks of flaps tearing near their radially inner ends and flying out of the wheel before their ability to abrade has been completely utilized. In heavy duty polishing operations, repeated flexing of the flaps generates high internal temperatures, especially in wheels 4 to 8 inches wide, sometimes distorting the core and permitting the entire wheel to fly apart. Flap loss can be reduced by following the teachings of Lang U.S. Patent No. 3,102,010, in which at least the non-abrasive surfaces of the flaps are provided with a thin flexible highly adherent polymerized binder film or coating characterized by its tenacious slip-resistant surface. This treatment may reduce the rate of cut, however, and generally does not significantly prevent heat buildup.

The present invention provides a novel flap wheel in which flap loss is essentially eliminated while the rate of cut is maintained at the same high level as in conventional wheels. Deleterious heat buildup is prevented, even in wide wheels, and the market for flap wheels is thus greatly enlarged, especially for automated grinding and polishing operations. Wheels made in accordance with the invention run smoothly, i.e., with minimum vibration, thereby greatly improving the finish imparted to workpieces.

The invention is conveniently incorporated in an abrasive flap wheel of the type in which the radially inner

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ends of annularly disposed coated abrasive flaps are firmly bonded together with a hard, tough, resinous material. Laterally opposed grooves concentric with the axis of the wheel are provided slightly radially outward from the location of the resinous material, an annularly flanged side plate being seated in each such groove. In accordance with the invention, such a wheel is modified by providing, at or beyond the radially outer locus where each side plate would otherwise contact the annulus, a resilient elastomeric material which insulates each flap both from the side plate and from its neighboring flaps. The elastomer may conveniently be applied by pouring it into the grooves in liquid form, and permitting it to solidify. An extremely small amount of elastomer is required; in fact, a 6-inch diameter 1-inch wide Grade 60 flap wheel, normally failing by flap loss, eccentric wear, and internal heating in less than 20 minutes of particularly severe operation, may require less than ½ gram of elastomer per circumferential inch of groove to totally prevent flap loss, eccentric wear, and damaging heat buildup, while still maintaining the wheel's normal rate of cut.

Although effective elastomers fall within chemically dissimilar polymeric families, they are found to possess common physical characteristics. For example, an effective elastomer is highly resilient, so that it returns to its original form promptly when subjected to cyclic compression and/or elongation. The tensile strengths of useful elastomers have varied nearly a hundred fold, indicating that this characteristic is not especially critical. Hardness may also vary considerably, e.g., as high as Shore A 90, but preferably lies within the range of 20 to 50. Speaking in general terms, the softer the elastomer, the lower the tensile strength and ultimate elongation required. Because flap wheels may be used over an extended period of time while exposed to high working temperatures, and because they may be stored in hot warehouses prior to use, it is generally desirable for the elastomer to retain the aforementioned physical characteristics after being subjected to elevated temperatures, e.g., 150° F. for 24 hours or more.

For further understanding of this invention, reference is made to the attached drawing in which like numbers identify like parts in the several views and in which:

FIGURE 1 is a view in perspective of a coated abrasive flap wheel assembly made in accordance with the present invention with certain parts shown broken away in the interest of clarity, and

FIGURE 2 is a diametric cross-sectional view of the flap wheel assembly shown in FIGURE 1.

In the drawings, flap wheel assembly **10** is made up of an annulus of coated abrasive flaps **11** and side plates **12** and **12***a*. Each coated abrasive flap has a notch on each side, the notches aligning to form grooves **13** and **13***a* on the lateral edges of the wheel into which grooves annular flange **14** or **14***a* on side plates **12** and **12***a* snugly fit. Side plates **12** and **12***a* are respectively provided with center holes **15** and **15***a* for mounting on a drive shaft. The annulus of flaps is bound together at its radially innermost portion by a relatively hard tough resinous material **16**. In the area immediately at and radially outwardly adjacent to grooves **13** and **13***a* is positioned elastomeric material **17** and **17***a*, penetrating between flaps **11** and forming therewith a continuous ring which lies radially outward from the circumference of side plates **12** and **12***a*.

In order to facilitate understanding of the invention and to suggest the variety of elastomeric materials which may be successfully employed, the following illustrative but non-limiting examples are provided.

EXAMPLE 1

A flap wheel having a width of 8", an outer diameter of 16", and an inner diameter of 5" was formed from 725 notched flaps of coated abrasive sheet material having a treated drills cloth backing, phenolic make and sandsize adhesive, and Grade 120 aluminum oxide mineral. Approximately one inch of the radially inner end of the flap annulus was bonded together with an amine-hardened bisphenol "A"—epichlorohydrin epoxy resin. One each side of the annulus, located 1 5/16 inch from the inner periphery, was a groove approximately 9/32" wide and 1 3/32" deep. The wheel was placed on one side and the upper groove then filled approximately half full of a room temperature-vulcanizing fluid silicone resin, commercially available from the General Electric Company under the trade designation "Clear Seal," approximately 22 grams being used. A stamped sheet metal side plate having an annular flange complementary to the dimensions of the groove was then seated, the force of inserting the flange in the groove displacing part of the silicone resin into the flap area immediately surrounding the groove, some resin additionally spreading over the lateral edges of the flaps in the area immediately adjacent the mouth of the groove. The wheel was then inverted and the process repeated on the opposite side. After 24 hours at room temperature the silicone resin had cured to a rubbery consistency: ("Clear Seal" silicone resin is an acetylated vinyl silane which, when exposed to the water normally spent in the atmosphere, splits out acetic acid, the resin polymerizing into a rubbery solid).

Flap wheels of the size and type just described are commonly employed in continuously cleaning strip steel. A wheel made in accordance with this example was driven at 1725 r.p.m., successfully cleaning strip steel for over three weeks, during which time approximately 80,000 lineal feet of steel strip had been processed. In contrast, a wheel identical to that of this example except for omission of the silicone, frequently runs less than one day, i.e., cleans less than 5,000 feet of steel strip, before failure results from heat buildup, distortion of the core, and total disintegration of the wheel; almost never do such wheels clean more than 30–40,000 lineal feet of steel before totally disintegrating.

To compare a variety of elastomeric materials, a series of 1" wide x 6" O.D. and 1 3/4" I.D. flap wheels were formed from Grade 60 aluminum oxide coated abrasive sheet material having a treated drills cloth backing and phenolic resin make and sandsize adhesives. Each such wheel contained 175 die cut flaps having a width of 1" and a length of 2 1/8", a 3/16" wide x 1/4" deep notch being located 3/8" from the radially inner end of each flap. The flaps were assembled in annular form according to the method taught in Meyer et al. U.S. Patent 2,991,165, the radially inner ends being coated with an amine-catalyzed epoxy resin. A stamped sheet metal side plate having an annular flange conforming to the dimensions of the groove defined by the aligned flap notches, was forced against each lateral surface of the annulus to hold it in circular configuration until the epoxy resin had cured. The wheels of the succeeding examples herein were modified by removing the side plates after the epoxy resin had cured, filling each groove with approximately 5 grams of a fluent elastomer, replacing the side plate, thereby forcing the elastomer material into the area immediately adjacent the flaps, and solidifying the liquid elastomer. Each such wheel was evaluated in a simulated heavy duty grinding operation in which it was rotated at 5500 r.p.m. while being urged against the flap surface of an oscillating mild steel workpiece. Performance was evaluated in terms of (1) ability to run smoothly (2) total amount of steel cut obtained before wheel failure, and (3) time required to run the wheel to its end point. Failure was considered to occur if there was excessive flap loss or if an unbalanced condition developed. The test was halted after 25 minutes if no such failure had occurred.

TABLE I

Example	Elastomer				Duration of test, minutes	Total grams steel cut	Wear ratio, grams steel cut per 1/32 in. flap wear	No. of flaps lost
	Type	Shore A hardness	Tensile strength, p.s.i.	Elongation at break, percent				
Control	None				20	138		23
2	Room temperature vulcanizing silicone ("Clear-Seal").	20–25	210	620	25	187	7.8	0
2a	Same as 2, but heated 16 hours at 250° F		390	550	25	190	11.0	0
3	100 parts polyurethane (in 20% solution of prepolymer [1]) and 14 parts 4,4',4"-triphenylmethane-triisocyanate) (also in 20% solution).	20–30	3,700	580	25	198	9.9	0
3a	Same as 3, but heated 24 hours at 250° F		1,000	180	25	185		0
4	2 parts NCO-terminated reaction product of polyol and diisocyanate ("Flexane 30", sold by Devcon Corp.), 3 parts polypropylene glycol.	30	65	130	25	162	6.5	0
4a	Same as 4, but heated 24 hours at 150° F				25	149	9.2	0
5	1 part NCO-terminated reaction product of polyol and diisocyanate ("Flexane 60", sold by Devcon Corp.), 2 parts polyol.	60	260	150	25	160	10.0	0
5a	Same as 5, but heated 24 hours at 150° F				25	164	9.1	0
6	3 parts NCO-terminated reaction product of polyol and diisocyanate ("Flexane 85", sold by Devcon Corp.), 2 parts polypropylene glycol.	85	800	280	25	145	11.1	0
6a	Same at 6, but heated 24 hours at 150° F				25	161	8.0	0
7	Blend of polychloroprene and magnesia:oil-soluble phenolic resin reaction product, as described in U.S. Patent 2,918,442.[2]	65	450	850	25	215	5.2	0
7a	Same as 7, but heated 24 hours at 150° F	80	1,150	500	25	153	12.8	0
7b	Same as 7, but heated 24 hours at 250° F		Too brittle to measure; elastomer black and charred.		[3] 25	140	5.3	0
8	Polyurethane foam formed from 70 parts polypropylene glycol (M.W. approx. 2,000—"Niax Diol PPG2025," sold by Union Carbide) 2.5 parts triol (reaction product of glycerine and polypropylene oxide, M.W., approx. 3,000, OH No. 56," LG56", sold by Union Carbide) 40 parts toluene 2,4-diisocyanate, 3 parts H_2O.				25	190	6.8	0

[1] 1–2% nitrogen, 0.17% OH, acid number 0; made by reacting toluene diisocyanate with an excess of polyesters comprising polyethylene adipate; available commercially from Mobay Chemical Company under the trade designation "Multranil 176".

[2] Available commercially as "Super Weatherstrip Adhesive," from Minnesota Mining and Manufacturing Company.

[3] Chattered at 24 minutes.

TABLE II

Example	Elastomer				Duration of test, minutes	Total grams steel cut	Wear ratio, grams steel cut per 1/32 in. flap wear	No. of flaps lost
	Type and size	Shore A hardness	Tensile strength, p.s.i.	Elongation at break, percent				
Control					20	138		23
9	Neoprene rubber, 3/16" diameter circular cross section, C-reinforced	80-90	>1,400	>200	25	[1] 181	5.3	0
10	Silicone rubber, 1/8" diameter circular cross section, PbO-reinforced	70			25	192	5.6	0
11	"Clear Seal" silicone elastomer, 1/8" x 3/16" cross-section	20-25	214	617	25	192	12.0	0

[1] All wheels smooth running except No. 9, which developed minor chatter.

TABLE III

Example	Elastomer, type	Duration of test, minutes	Total grams steel cut	Wear ratio, grams steel cut per 1/32 in. flap wear	No. of flaps lost	Remarks
12	"Clear Seal" silicone	28	180	7.2	0	
13	Room temperature vulcanizing silicone ("RTV732," sold by Dow Corning).	25	166	8.7	0	
14	2-part castor oil-containing polyurethane	25	182	8.9	0	Elastomer cracked but continued to form ring with flaps.
15	PbO-cured polysulfide; Shore A hardness, 40-50, tensile 250 p.s.i., E_b= 300%.	25	151	9.2	0	Do.

Experiments were run in which a room temperature vulcanizing silicone elastomer was applied to 1" to 6" flap wheels of the type used as the control in Table I, the only variable being the amount of elastomer. It was found that when 3.7 grams of silicone was employed, the wheel ran for 25 minutes and cut approximately 170 grams of steel with a wear ratio in excess of 9. Lesser amounts appeared inadequate to prevent failure by flap loss, and greater amounts did not appear to further improve the performance. The amount of elastomeric material to be applied is dependent to some degree, however, on such factors as the grade of abrasive mineral used, wheel size, dimensions of the annular groove, and the viscosity of the elastomer as applied. Generally speaking, coarse grits and small diameters require somewhat more elastomeric material per circumferential inch of groove than do fine grits and/or larger diameters, but it has been found desirable to fill the groove at least abut half full, regardless of its cross-sectional dimensions. It also appears that the superior performance imparted by the elastomeric material is related to its volume; thus, less weight of an elastomer is required if it is foamed.

The elastomer may also be preformed as a band or strip and inserted in the grooves of an abrasive flap wheel. In each of the following tabulated examples, a 1" x 6" wheel, like the control in Table I, was modified by inserting a preformed ring of elastomer in each annular lateral groove prior to seating the flanged side plates. The force of axial compression applied when the wheel was mounted forced the rings of elastomer snugly against and between the flaps in the area at and immediately adjacent to the grooves. Test procedure was the same as in Table I.

Although flap wheels are desirably bonded together at the radially inner end of the flaps, it has been found that the present invention permits making narrow (1-inch wide) wheels without such bonding. In the absence of elastomeric material in the groove area, 1" wheels having no core bonding resin fail by disintegration in less than one minute when subjected to the test heretofore described. The following table sets forth a series of 1" x 6" wheels, made in the same manner as the wheels in Table I except for omission of the epoxy core adhesive. The wheels were tested in the same manner as the wheels of Examples 2–11 inclusive, except that they were driven at 4560 r.p.m. and the force urging the wheel against the workpiece was about 10% less.

Although the foregoing examples are only illustrative, it is believed that they clearly indicate the wide range of elastomeric materials which can be employed in practicing the invention. These materials may be preformed or applied in solutions or 100% solids fluids which solidify at room or elevated temperature. The elastomers need not be extremely strong, but either they should maintain their integrity or possess sufficient adhesion to the abrasive flaps to remain in place during abrading operations. Elastomers may be compounded to obtain desired characteristics; it is likewise true that initially effective elastomeric materials may be rendered ineffective by excessive filling, heating, or crosslinking.

For convenience, it is preferred to employ elastomers which are initially solvent-free fluids, which solidify at room temperature, which are relatively soft when cured, and which neither embrittle nor flow when subjected to temperatures in excess of 150° F. Since it is desirable to preserve the integrity of flap wheels during shipping and storage, it is likewise desirable for the elastomer to have sufficient adhesion to metal to maintain the side plates snugly adhered to the sides of the wheel. I have found that polyurethane and room temperature vulcanizing silicone elastomers possess such characteristics and hence are particularly attractive. I am, of course, aware that others have heretofore adhered side plates to the lateral surfaces of abrasive flap wheels (see, e.g., U.S. Patent No. 2,749,-224), and my invention is not directed to that concept per se.

What I claim is:

1. A coated abrasive flap wheel assembly having outstanding resistance to failure by flap loss, eccentricity, or heat distortion, comprising in combination: an annulus of radially disposed flaps of coated abrasive sheet material, an annular groove on each side of said annulus adjacent the radially inner ends of said flaps, an annular side plate having on its laterally inner aspect an annular flange complementary to and positioned within said groove, and, between said side plate and said annulus at and adjacent the radially outer area where said side plate contacts said annulus, a concentric ring of resilient elastomer which extends between said flaps when said assembly is subjected to axial compression in mounting, said ring being located radially outward of any other flap-contacting means unifying the radially inner ends of said flaps.

2. The product of claim 1, wherein said elastomer has a Shore A hardness in the range of 20 to 50.

3. The product of claim 1, wherein said elastomer is a room temperature-vulcanized silicone.

4. The product of claim 1, wherein said elastomer is a polyurethane.

5. A coated abrasive flap wheel assembly having outstanding resistance to failure by flap loss, eccentricity, or heat distortion, comprising in combination: an annulus of radially disposed flaps of coated abrasive sheet material, an annular groove on each side of said annulus adjacent the radially inner ends of said flaps, an annular side plate having on its laterally inner aspect an annular flange complementary to and positioned within said groove, and, between said side plate and said annulus at and adjacent the radially outer area where said side plate contacts said annulus, a resilient elastomer which extends between said flaps to form therewith a ring composed of contiguous alternate sections of flaps and elastomer, said ring being located radially outward of any other flap-contacting means unifying the radially inner ends of said flaps.

6. A coated abrasive flap wheel comprising in combination: an annulus of radially disposed flaps of coated abrasive sheet material firmly bonded together at their radially inner end portions by a matrix of rigid polymeric material, an annular groove on each side of said annulus adjacent the radially inner ends of said flaps, the radially outer portion of said groove lying radially outward from said matrix, and at each side of said annulus at the radially outer portion of said groove, a resilient elastomer which extends between said flaps to form therewith a ring composed of contiguous alternate sections of flaps and elastomer.

7. In a coated abrasive flap wheel comprising an annulus of radially disposed flaps of coated abrasive sheet material firmly bonded together at their radially inner end portions by a matrix of rigid polymeric material, said annulus being adapted for mounting between a pair of laterally positioned side plates, the improvement which comprises providing substantially only at and adjacent the radially outer lateral area where said wheel is to be contacted by said side plates a resilient elastomer which penetrates between said flaps to form therewith a continuous ring, said ring being located radially outward of any other flap-contacting means unifying the radially inner ends of said flaps.

8. In a coated abrasive flap wheel comprising an annulus of radially disposed flaps of coated abrasive sheet material held firmly together at their radially inner end portions, said annulus being adapted for mounting between a pair of laterally positioned side plates, the improvement which comprises providing substantially only at and adjacent the radially outer lateral area where said wheel is to be contacted by said side plates a resilient elastomer which penetrates between said flaps to form therewith a continuous ring, said ring being located radially outward of any other flap-contacting means unifying the radially inner ends of said flaps.

9. The product of claim 1 wherein the ring of resilient elastomer is preformed.

10. The flap wheel of claim 6 wherein the resilient elastomer is a preformed ring.

References Cited

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,406,488 October 22, 1968

Kenley J. Rykken

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 10, "One" should read -- On --; line 12, "1-3/32" should read -- 13/32 --. Column 5, line 47, "abut" should read -- about --.

Signed and sealed this 7th day of April 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents