Jan. 12, 1971 D. H. MABEY ET AL 3,554,606

CUTTERS FOR FORMING HIGHWAY PAINT RECEIVING GROOVES

Filed Jan. 22, 1969 2 Sheets-Sheet 1

FIG. 1.

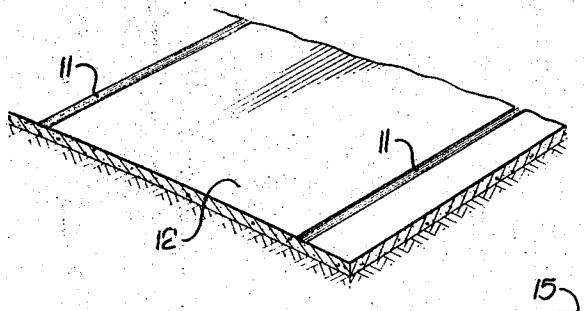

FIG. 2.

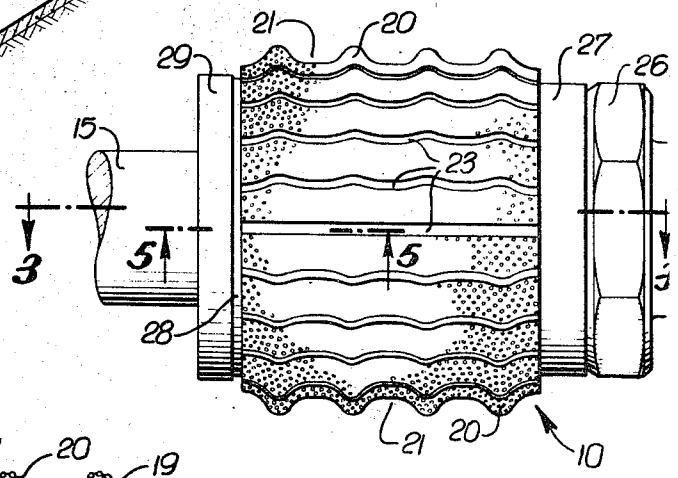

FIG. 3.

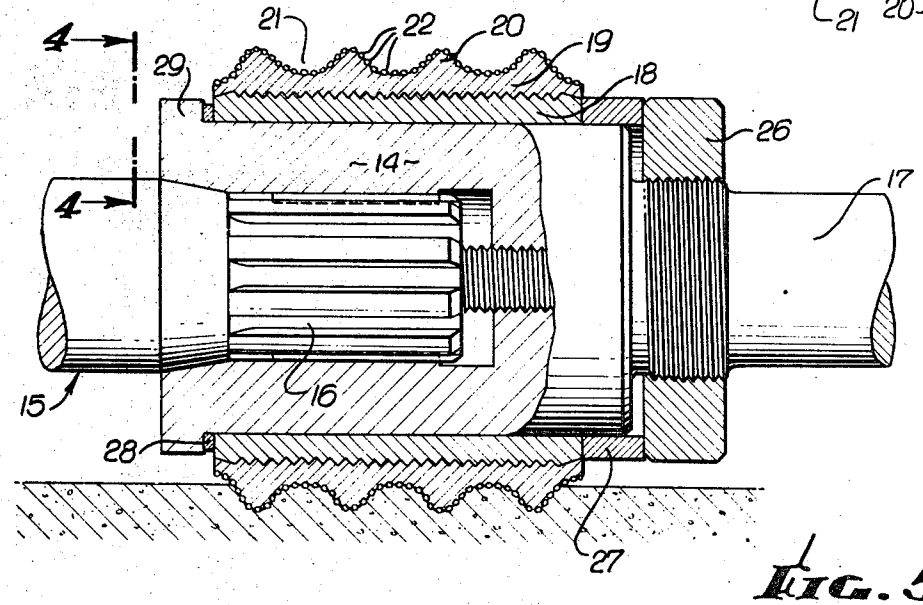

FIG. 5.

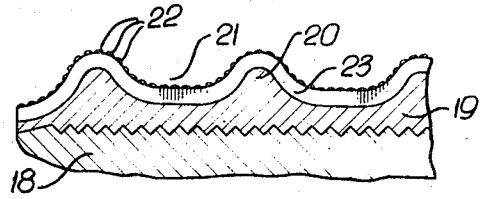

FIG. 4.

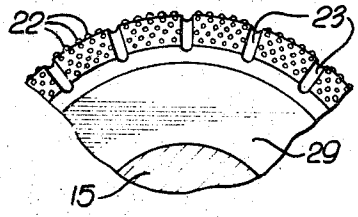

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FIG. 6.

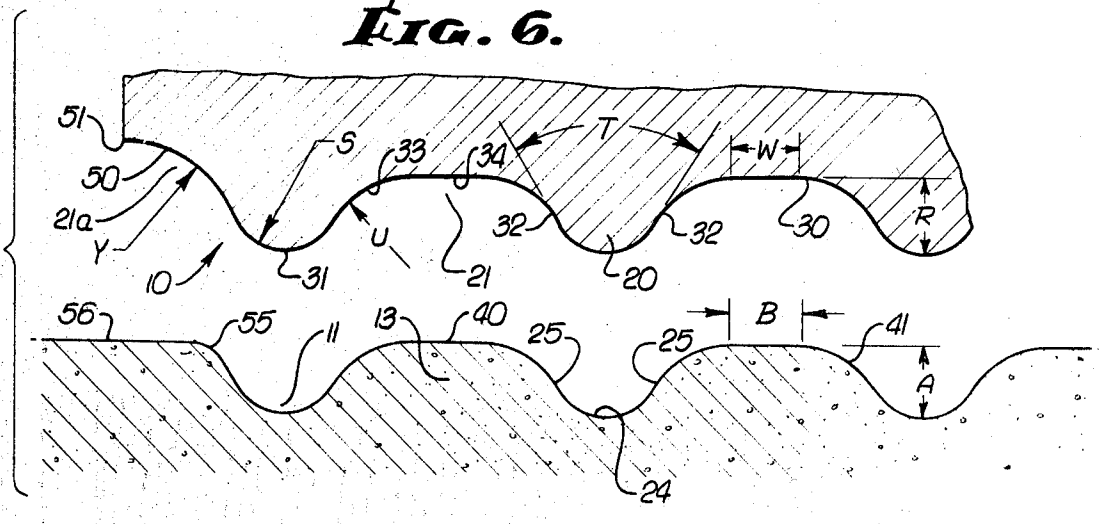
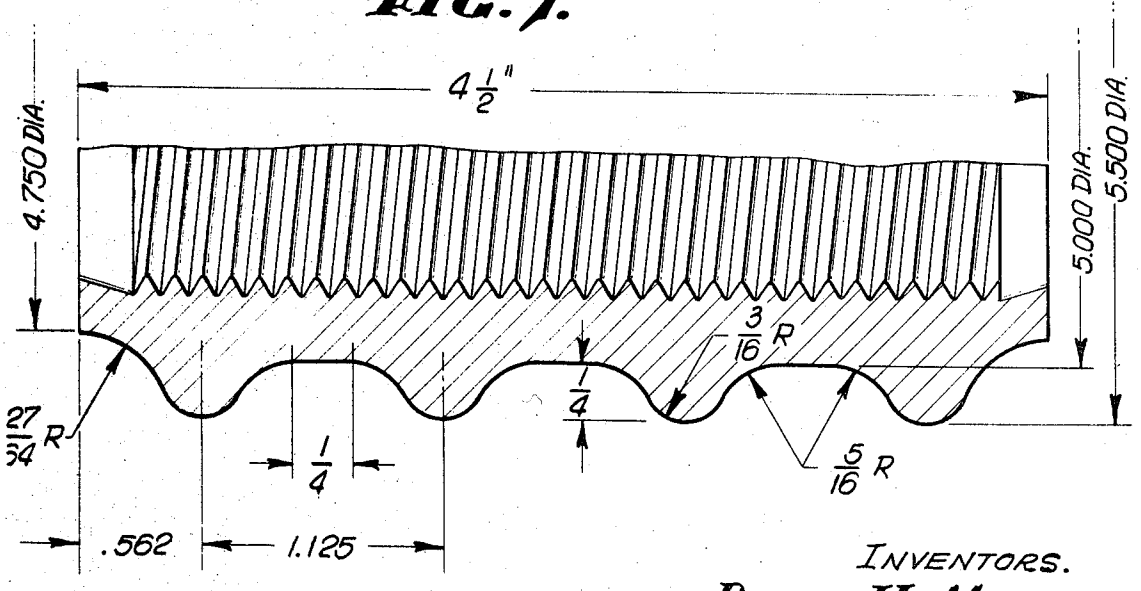


FIG. 7.



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CUTTERS FOR FORMING HIGHWAY PAINT RECEIVING GROOVES

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Int. Cl. E21c 37/26; E01c 23/16
U.S. Cl. 299—89 21 Claims

ABSTRACT OF THE DISCLOSURE

A rotatable cutter to form grooves in highways receiving reflective highway paints to indicate separation between highway lanes. The cutter has longitudinally spaced ridges normal to its aixs with convexly curved crests, tapered sides curving into elongate roots which, preferably, have intermediate cylindrical surfaces, the crest, side and root portions having diamond cutting elements embedded therein. Rotation of the cutter while moving along the highway produces grooves, valleys or troughs in the highway of a depth to rapidly collect and drain rain water and keep it off the upper portions of the reflecting sides of the trough, the highway crests between troughs having flat surfaces insuring vehicle control when its tires pass over the grooved area.

The present invention relates to milling cutters useful in forming uniform grooves or troughs in concrete highways, and more particularly to milling cutters for producing grooves or troughs capable of effectively receiving and retaining highway paints which will be visible to vehicle operators in rainy weather or under wet conditions generally.

The present invention is directed to cutters for grooving roadways to designate separation between traffic lanes. The cutters are specifically designed for providing grooves in concrete highways, as described and claimed in the application of Gordon M. Liddle and Frank L. Christensen, Ser. No. 747,692, filed July 25, 1968, for "Marked Roadway and Method of Making the Same."

Milling cutters embodying diamond cuttng elements therein are known for performing a cutting action on concrete highways. U.S. Pat. No. 3,306,669 discloses diamond milling cutters that will produce grooves in a concrete highway during a cutting action designed to remove bumps from the highway surface. However, such milling cutters cannot accomplish the functions of the cutters embodying applicants' invention, and described hereinafter in this case, since the grooves they form are shallow and cannot drain rain water along the roots of the grooves sufficiently for the purpose of leaving exposed surfaces for light reflection above the water level in the grooves. About all the cutters of Pat. No. 3,306,669 could accomplish is to provide a roughened or skid resistant texture in the surface of the concrete highway.

By virtue of the present invention, grooves are formed in a concrete highway that are deep enough to trap rain water, draining it along the roots of the grooves or troughs to leave exposed surfaces above the water level for light reflection from the highway paints with which the sides and bottom of the grooves are coated. The cutters produce grooves in which the life of the crest of the ridges between the grooves is prolonged, since an essentially flat surface is provided that resist lateral or right angle forces that might tend to break the concrete, furnishing a generally flat surface providing vehicle control when its tires pass over the paint striped area. The strength and enurance of the grooved pavement area is high. The cutters produce grooves in the concrete with upwardly diverging sides so that the highway paint on the sides will be reflected in an

upward direction and will be readly visible to the vehicle operators. All corners of the cutters are rounded, producing grooves in the concrete highways in which the bottoms are concavely curved, merging smoothly into tapered sides of the grooves, which, in turn, merge into convexly curved crests of the ridges between the parallel grooves. These convexly curved portions preferably merge into longitudinal flat surfaces at the upper surfaces or crests of the ridges.

Because the cutters form a grooved highway area in the manner just described, such area is self-cleaning, inasmuch as there are no right angle corners for collection of dirt, salt, and road films, which would obliterate or eliminate the highway marking paint. In addition, ice collection in cold climates is greately minimized since the ice forces itself up and out of the highway grooves as it forms and expands. The cutters produce a grooved striped region in which only a minor portion, which, for example, may be about 35%, of the highway painted strip is exposed to automobile tire wear. The radiused longitudinal grooves and ridges provide for better placement and retention of the reflective beads in highway paint, resulting in a brighter reflectve paint marking. In addition, the cutters produce uniform grooves and intervening ridges in the highway surface of a long, useful life, the cutters themselves being strong and sturdy, and having a comparatievly long life.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIG. 1 is a perspective view of a small section of concrete pavement, with highway striped areas formed therein;

FIG. 2 is a side elevational view of a cutter apparatus embodying the invention;

FIG. 3 is an enlarged longitudinal section taken along the ilne **3—3** on FIG. 2;

FIG. 4 is a fragmentary section taken along the line **4—4** on FIG. 3;

FIG. 5 is an enlarged section taken along the line **5—5** on FIG. 2;

FIG. 6 is an exploded enlarged fargmentary section of the cutter and the grooves formed thereby in the concrete roadway, the cutter diamonds being omitted for purpose of clarity; and

FIG. 7 is an enlarged fragmentary section of an actual cutter design, with diamonds omitted for purpose of clarity.

As disclosed in the drawings, a milling cutter **10** is provided for forming grooves **11** in a concrete highway **12** of an overall width corresponding to the width of a highway paint stripe which serves to separate and define traffic lanes. Grooves are formed in the highway surface to the desired depth, leaving intervening ridges **13**, and such grooves and ridges are then coated with reflective highway paint (not shown) so that the traffic lanes are readily visible to drivers of vehicles traversing the highways.

The cutter assembly **10** includes an arbor **14** of suitable length mounted on a rotatable drive shaft **15**, rotating therewith because of the intervening external and internal meshing splines **16** on the shaft and arbor. The shaft **15** and end portion **17** of the arbor are supported in suitable bearings (not shown) and in the frame of a concrete grooving machine (not shown). The milling cutter itself

includes a sleeve **18**, which may be made of steel, to which a matrix body **19** is bonded, the matrix having the longitudinally spaced, circumferential ribs or ridges **20** formed therein disposed normal to the axis of the matrix and sleeve and defining intervening valleys, troughs or grooves **21** therebetween. In effect, the ridges and grooves form hills and valleys, there being diamond cutting elements **22** molded or otherwise embedded in the matrix **19** in a known manner. Circumferentially spaced, longitudinal waterways **23** are provided in the matrix, such waterways following the hills and valleys of the outer portion of the matrix, as disclosed most clearly in FIG. 5. Water or other flushing fluid is used for cleaning and cooling the cutters during its traverse along the highway. It is to be noted that the diamonds **22** are separated from each other and are distributed in a desired pattern over all surfaces of the grooves **21** and ridges **20** so as to perform a cutting action in the concrete, producing the bottom **24** and sides **25** of the grooves **11**, as well as the intervening ridge portions **13**.

The sleeve **18** and diamond set matrix **19** are clamped to the arbor **14** by a clamp nut **26** threaded on the arbor and engaging a spacer **27**, which bears against one end of the steel sleeve **18**, the other end of the steel sleeve engaging a friction ring **28** abutting a shoulder or flange **29** integral with the arbor. Accordingly, rotation of the shaft **15** will rotate the arbor **14**, sleeve **18**, matrix **19** and the diamond cutting elements **22** as an integral unit, while the assembly is moved bodily along the highway surface, so that the rotating cutter **10** can form the grooves **11** therein.

The bottom or root portions **30** of the cutter grooves **21** are much wider than the intervening ribs **20**, to form grooves **11** in the concrete surface separated by ridges **13** that are much wider than the grooves therebetween. Moreover, the height R of each cutter ridge is such as to form a desired depth of groove in the concrete surface, which, as stated above, is sufficient to effect proper drainage of rain and other waters while leaving the tapered sides **25** of the highway grooves exposed above the water level in the lower portion of the grooves **11**. Moreover, there are no right angle corners present in the ridge and root portions **30** of the cutters, corners being curved to form corresponding curves in the concrete surface.

As specifically disclosed (see FIG. 6 particularly) the height R of each cutter ridge **20**, which is the distance between its root **30** and crest **31**, is about 3/16 of an inch to about ½ inch to produce a corresponding depth A of groove in a concrete highway surface. The radius of curvature S of the crest is from about 1/32 of an inch to about 3/16 of an inch, and this crest portion merges into ridge sides **32** that taper toward each other in a lateral outward direction with an included angle T of from about 20 degrees to about 120 degrees. The sides **32** of each ridge merge concavely into the root portion or bottom **30** of the groove **21** between intervening ridges, the radius of curvature U being from about 1/16 of an inch to about 5/8 of an inch. Such curved root portions **33** merge into the cylindrical bottommost portion **34** of the groove or root which has a flat width W from about 1/16 of an inch to about 1 inch.

With a cutter made within the range of proportions set forth above, the grooves **11** and ridges **13** are formed in the highway surface that have a profile the reverse of the profile of the cutter ridges **20** and grooves **21**; that is to say, the bottom or root portions **24** of the highway grooves will be curved corresponding to the curvature of the crest portions **31** of the cutters; whereas, the crest portions **40** of the highway ridges will have a central flat width B merging smoothly at opposite sides into convex curved surfaces **41** that form a portion of and also merge smoothly into the remaining portion of the sides **25** of the grooves or troughs formed in the concrete, the bottom **24** of the grooves or troughs being concavely curved, the configuration of the grooved concrete

highway surface being illustrated most clearly in FIG. 6. Thus, the grooved portion of the highway has ridges **13** of extended width separated by grooves **11** of a sufficient depth as to carry off rain and other water and insure reflective paint surfaces on the sides **25** of the grooves exposed above the level of the rain water in the lower portions of the grooves.

There are no sharp corners in the concrete highway ridges **13**, which causes them to possess great strength and a long and useful life. In addition, the absence of any sharp corners in the concrete ridges makes the grooves **11** therein self-cleaning, since dirt, salt, and road films do not tend to collect therein which would obliterate or eliminate the highway paint or other visible marking provided by or on the grooves **11** and ridges **13**. Since the sides **25** of the grooves are tapered, highway paint placed thereon will be readily visible to the operators of motor vehicles traversing the highways. The highway grooves **11** themselves will give an audible indication to the vehicle operator that he is on or crossing the grooved or striped lane divider. However, he will still retain control of his vehicle since the essentially flat surface B on the crests of the ridges, when the vehicle tires pass over the grooved area, insures proper vehicle control. Because of the tapered sides **25** of the grooves **11** and the rounded regions **41**, **24**, ice collection and retention in the grooves is eliminated, since the ice forces itself up and out of the grooves as it forms and expands. It is only the crests **40** of the ridges **13** formed in the highway surface that are exposed to automobile tire wear, and such areas are only a minor portion of the entire painted area of the grooved highway stripe, being, for example, about 35% of the total painted area of the lane divider formed in the concrete. The absence of sharp corners, through the provision of the radiused longitudinal grooves and crest portions, enables reflective beads in the highway paint to be placed in better fashion and retained on the groove and ridge surfaces, resulting in a brighter reflective coating in the grooves **11** and on the ridges **13**.

It will be noted that the ends **50** of the cutter terminate in half grooved regions, that is, grooves **21***a* extending about half the axial distance of a full groove **21** between ridges **20**, and that the outer ends **51** of such partial end grooves are disposed radially inwardly of the innermost portions **34** of a full groove. Such grooved portions **21***a* also have a radius of curvature Y extending from the sides **32** of the ridge **20** which is greater than the radius of curvature U of the bottom portion of the grooves **21** between adjacent ridges. Such greater radius of curvature Y insures that the outermost grooves **11** formed in the concrete will not terminate in a sharp corner with the adjacent highway surface **56**, there being a curved corner or radius **55** at the outer side of the outermost groove. The greater radius of curvature Y at the ends of the cutters also provides for a curved or radiused run-out of the sidemost groove into the adjacent concrete surface in the event irregularities in the highway surface cause the cutter to move deeper thereinto than intended. Normally, the extent of penetration of the cutter **10** into the concrete surface is determined by a depth control sensing element, such as a rotating wheel or wheels (not shown) having a bearing shaft elevation fixed with respect to the center line of the arbor and shaft, such rotating wheel or wheels rolling along the highway surface. If the wheel were to move into a shallow depression in the highway surface, the cutter **10** could move deeper into the concrete surface than is actually required. However, with the radius of curvature Y at the ends of the cutter being greater than the radius of curvature U between the sides and bottom portions or roots of the cutter, the deeper penetration of the cutter still results in a curved corner **55** between the outer side of the outermost groove and the adjacent flat pavement surface **56**.

FIG. 7 presents a cutter and its dimensions in inches, for purposes of example only. Such cutter produced

grooves **11** in a concrete highway that were narrower in width than the width of the intervening ridges **13**, all surfaces merging smoothly into one another, providing an absence of right angle or other sharp corners, with the crests **40** of the concrete ridges lying in essentially the same plane as the concrete highway surface **56** on opposite sides thereof. Accordingly, the grooved stripes effect no interference with snow removal equipment operating on the highway.

We claim:

1. In a milling cutter: a body adapted to be rotated about an axis, said body comprising axially spaced circumferential ridges extending around its periphery and disposed normal to the body axis, said body having circumferential grooves between said ridges, the bottoms of said grooves being of substantially greater axial extent than the crests of said ridges, the bottoms of said grooves comprising cutting means for operation upon the work being cut.

2. In a milling cutter as defined in claim **1**; at least a portion of the bottom of each groove being cylindrical.

3. In a milling cutter as defined in claim **1**; said body having circumferentially spaced, longitudinal waterways extending through said ridges.

4. In a milling cutter: a body adapted to be rotated about an axis, said body comprising axially spaced circumferential ridges extending around its periphery and disposed normal to the body axis, said body having circumferential grooves between said ridges, the bottoms of said grooves being of substantially greater axial extent than the crests of said ridges; cutting elements embedded in the crests of said ridges, and side cutting elements embedded in the sides of said ridges, said side cutting elements in confronting sides of said ridges being in opposed relation to each other for simultaneous operation upon the work being cut.

5. In a milling cutter as defined in claim **4**; the sides of each rib tapering toward each other in the direction of the ridge crests.

6. In a milling cutter as defined in claim **4**; and cutting elements embedded in the body at the bottoms of said grooves.

7. In a milling cutter as defined in claim **4**; the sides of each rib tapering toward each other in the direction of the ridge crests, and cutting elements embedded in the body at the bottoms of said grooves.

8. In a milling cutter as defined in claim **4**; the sides of each rib tapering toward each other in the direction of the ridge crests, the outer portion of the sides of each ridge being convexly curved and merging into the crest of said ridge, the inner portion of the sides of each ridge being concavely curved and merging into the bottoms of the grooves on opposite sides of each ridge, the central portion of the bottom of each groove between ridges being cylindrical.

9. In a milling cutter as defined in claim **4**; the sides of each rib tapering toward each other in the direction of the ridge crests, the outer portion of the sides of each ridge being convexly curved and merging into the crest of said ridge, the inner portion of the sides of each ridge being concavely curved and merging into the bottoms of the grooves on opposite sides of each ridge, the inner portions of the outer sides of the end ridges of said being concavely curved at a greater radius of curvature than the radius of curvature of the other concavely cured inner portion of said ridges.

10. In a milling cutter as defined in claim **1**; the sides of each rib tapering toward each other in the direction of the ridge crests, the outer portion of the sides of each ridge being convexly curved and merging into the crest of said ridge, the inner portion of the sides of each ridge being concavely curved and merging into the bottoms of the grooves on opposite sides of each ridge, the inner portions of the outer sides of the end ridges of said body being concavely curved at a greater radius of curvature

than the radius of curvature of the other concavely curved inner portions of said ridges, the central portion of the bottom of each groove between ridges being cylindrical.

11. In a milling cutter as defined in claim **4**; the sides of each rib tapering toward each other in the direction of the ridge crests, said body having circumferentially spaced, longitudinal waterways extending through said ridges.

12. In a milling cutter as defined in claim **4**; the sides of each rib tapering toward each other in the direction of the ridge crests, said body having circumferentially spaced, longitudinal waterways extending through said ridges, the bottoms of each waterway being of undulant form and conforming generally to the shape of the crests and sides of said ridges and the bottoms of said grooves.

13. In a milling cutter as defined in claim **4**; the sides of each rib tapering toward each other in the direction of the ridge crests, the outer portion of the sides of each ridge being convexly curved and merging into the crest of said ridge, the inner portion of the sides of each ridge being concavely curved and merging into the bottoms of the grooves on opposite sides of each ridge.

14. In a milling cutter as defined in claim **13**; said convexly curved outer portions having a radius of curvature from about $\frac{1}{32}$ inch to about $\frac{3}{16}$ inch, said concavely curved inner portions having a radius of curvature from about $\frac{1}{16}$ inch to about $\frac{5}{8}$ inch, the depths of each groove being from about $\frac{3}{16}$ inch to about $\frac{1}{2}$ inch, and the included angle between the tapered sides of each ridge being from about 20 degrees to about 120 degrees.

15. In a milling cutter as defined in claim **13**; the central portion of the bottom of each groove between ridges being cylindrical, said convexly curved outer portions having a radius of curvature from about $\frac{1}{32}$ inch to about $\frac{3}{16}$ inch, said concavely curved inner portions having a radius of curvature from about $\frac{1}{16}$ inch to about $\frac{5}{8}$ inch, the depths of each groove being from about $\frac{3}{16}$ inch to about $\frac{1}{2}$ inch, and the included angle between the tapered sides of each ridge being from about 20 degrees to about 120 degrees, the axial extent of the cylindrical central portion being from about $\frac{1}{16}$ inch to about $\frac{1}{8}$ inch.

16. In a milling cutter as defined in claim **13**; said convexly curved outer portions having a radius of curvature from about $\frac{1}{32}$ inch to about $\frac{3}{16}$ inch, said concavely curved inner portions having a radius of curvature from about $\frac{1}{16}$ inch to about $\frac{5}{8}$ inch, the depths of each groove being from about $\frac{3}{16}$ inch to about $\frac{1}{2}$ inch, and the included angle between the tapered sides of each ridge being from about 20 degrees to about 120 degrees, cutting elements in the body at the bottoms of said grooves, said cutting elements being diamond cutting elements, said diamond cutting elements being spaced from each other and arranged in a predetermined pattern in said body.

17. In a milling cutter as defined in claim **13**; the central portion of the bottom of each groove between ridges being cylindrical, said convexly curved outer portions having a radius of curvature from about $\frac{1}{32}$ inch to about $\frac{3}{16}$ inch, said concavely curved inner portions having a radius of curvature from about $\frac{1}{16}$ inch to about $\frac{5}{8}$ inch, the depths of each groove being from about $\frac{3}{16}$ inch to about $\frac{1}{2}$ inch, and the included angle between the tapered sides of each ridge being from about 20 degrees to about 120 degrees, the axial extent of the cylindrical central portion being from about $\frac{1}{16}$ inch to about $\frac{1}{8}$ inch, said cutting elements being diamond cutting elements, said diamond cutting elements being spaced from each other and arranged in a predetermined pattern in said body.

18. In a milling cutter: a body adapted to be rotated about an axis, said body comprising axially spaced circumferential ridges extending around its periphery and disposed normal to the body axis, said body having circumferential grooves between said ridges, the bottoms of said grooves being of substantially greater axial extent than the crests of said ridges; the sides of each rib tapering toward each other in the direction of the ridge crests,

diamond cutting elements embedded in the crests of said ridges, and side diamond cutting elements embedded in the sides of said ridges, said side diamond cutting elements in confronting sides of said ridges being in opposed relation to each other for simultaneous operation upon the work being cut, said diamond cutting elements being spaced from each other and arranged in a predetermined pattern in said body.

19. In a milling cutter as defined in claim **18**; diamond cutting elements in the body at the bottoms of said grooves, all of said bottom diamond cutting elements being spaced from each other and arranged in a predetermined pattern in said body.

20. In a milling cutter as defined in claim **18**; the outer portion of the sides of each ridge being convexly curved and merging into the crest of said ridge, the inner portion of the sides of each ridge being concavely curved and merging into the bottoms of the grooves on opposite sides of each ridge, diamond cutting elements in the body at the bottoms of said grooves, all of said bottom diamond cutting elements being spaced from each other and arranged in a predetermined pattern in said body.

21. In a milling cutter as defined in claim **18**; the outer portion of the sides of each ridge being convexly curved

and merging into the crest of said ridge, the inner portion of the sides of each ridge being concavely curved and merging into the bottoms of the grooves on opposite sides of each ridge, diamond cutting elements in the body at the bottoms of said grooves, all of said bottom diamond cutting elements being spaced from each other and arranged in a predetermined pattern in said body, said body having circumferentially spaced, longitudinal waterways extending through sadi ridges, the bottoms of each waterway being of undulant form and conforming generally to the shape of the crests and sides of said ridges and the bottoms of said grooves.

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ERNEST R. PURSER, Primary Examiner

U.S. Cl. X.R.

51—206.3; 125—39; 299—39

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,554,606 Dated January 12, 1971

Inventor(s) Donald H. Mabey et al.

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

Column 5, line 63, after "said" insert -- body --; line 6 "1" should read -- 4 --.

Signed and sealed this 29th day of June 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents