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P. BLUM

3,606,470

ROCK SAMPLING

Original Filed Jan. 24, 1967

2 Sheets-Sheet 1

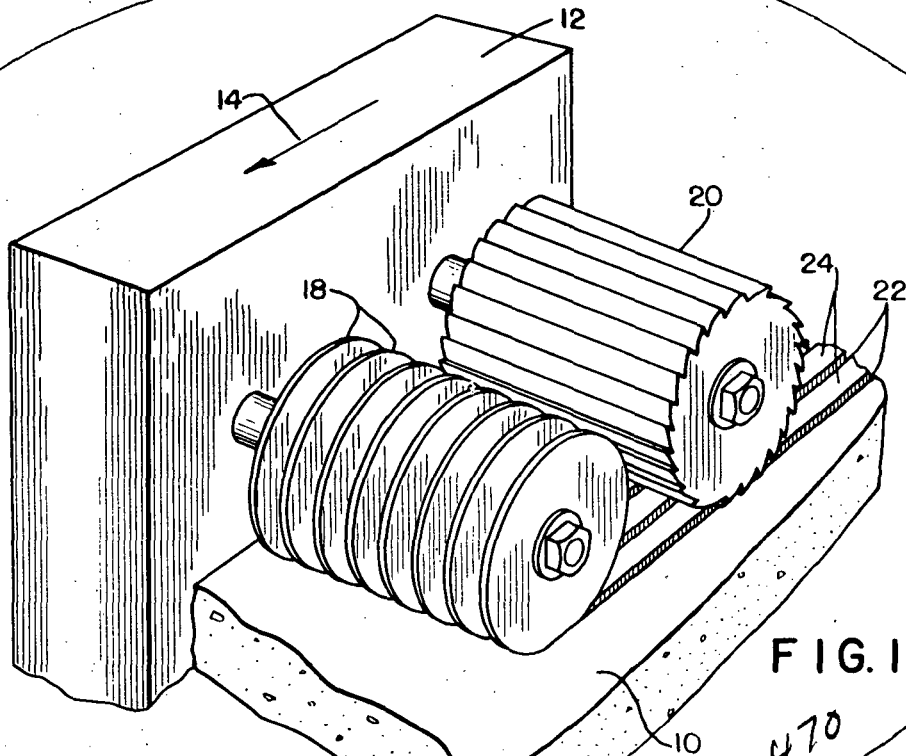


FIG. 1

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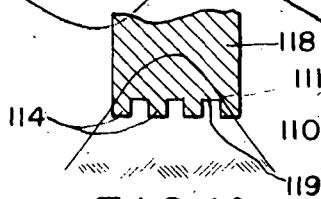


FIG. 1A

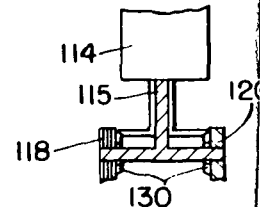


FIG. 1B

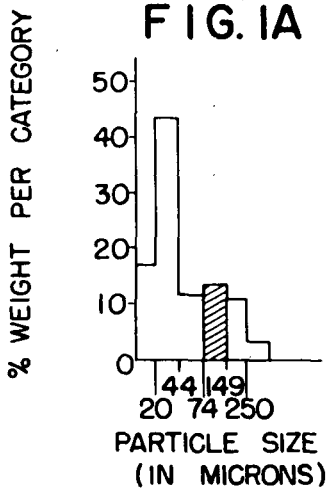


FIG. 2

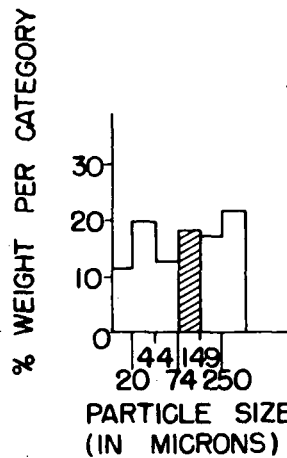


FIG. 3

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(NASA-Case-XNP-10007-1) ROCK SAMPLING  
Patent (NASA) 4 p  
CSCL 131

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Unclas  
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ROCK SAMPLING

Original Filed Jan. 24, 1967

2 Sheets-Sheet 2

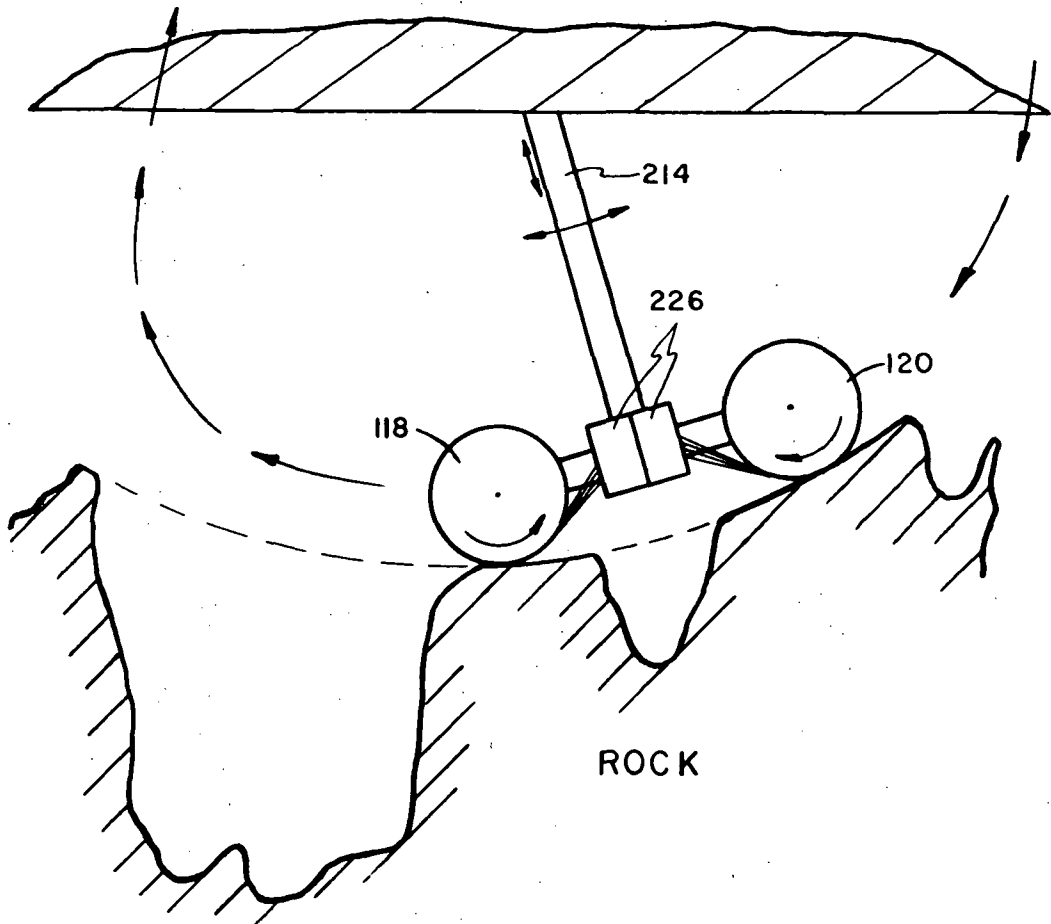


FIG. 1C

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**ROCK SAMPLING**

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Original application Jan. 24, 1967, Ser. No. 611,414.

Divided and this application Aug. 6, 1968, Ser.  
No. 768,942

Int. Cl. B28d 1/18; E21c 13/00

U.S. Cl. 299-67

4 Claims

**ABSTRACT OF THE DISCLOSURE**

An apparatus for sampling rock and other brittle materials and for controlling resultant particle sizes. The device includes grinding means for cutting grooves in the rock surface and to provide a grouping of thin, shallow, parallel ridges and cutter means to reduce these ridges to a powder specimen. Collection means is provided for the powder.

The present invention relates to rock grinding and particularly to the sampling of rock specimens with good size control. The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 426; 42 U.S.C. 2451) as amended. A license has been granted to the United States Government for practice of the invention and title to the invention and this patent has been reserved to the assignee, subject to voidability by NASA.

The present invention relates to abrasive sampling of rock and other brittle materials which shatter during grinding due to a lack of plasticity.

This application is a division of application Ser. No. 611,414, filed Jan. 24, 1967, now abandoned.

There is a need in geological sampling for an apparatus which will grind a rock surface and give high yields in any desired particle size range without recourse to classification or sieving techniques. An important reason for avoiding classification or sieving techniques is that they yield mineralogically unrepresentative powder specimens. The latter results from the fragmentation of each mineral in a rock into a separate size distribution.

It has been discovered that known grinding techniques do not afford adequate yield in coarse size ranges, e.g. particle sizes between 75 and 150 microns, a range suitable for analysis by a petrographic microscope. Conventional grinding, e.g., of basalt, tends to produce particles with sizes predominantly below 44 microns. Variation of conventional grinding parameters such as wheel speed and grit size, does little to increase the yield above this range or to change the shape of the size distribution curve.

The present invention gives a two step treatment to rock or other brittle material. This consists of cutting a series of adjacent grooves on the surface of the brittle material to form a grouping of thin, shallow, parallel, closely spaced ridges. The ridges are subsequently machined, preferably by milling. Control over particle size distribution is effected by altering the thickness and height of these ridges, as well as by altering conventional milling parameters, such as wheel speed and traverse speed.

The use of the invention is now described with reference to the accompanying drawings wherein:

FIG. 1 is a schematic sketch of an improved sampling apparatus;

FIG. 1A is a diagram showing a variation of the ridge cutter and FIGS. 1B and 1C show other variations of the apparatus;

FIG. 2 is a bar graph showing size distribution of rock

particles obtained using prior art grinding techniques; and

FIG. 3 is a bar graph showing the improved distribution obtained in one example of use of the present invention.

Referring to FIG. 1 there is shown a rock 10 to be sampled, a tool carriage 12 traversing in the path and direction indicated by the arrow 14. Mounted on the carriage are a group of diamond surface cut-off wheels 18 and a milling cutter 20 with wedge shaped teeth. The wheels 18 and miller 20 are driven by a motor (not shown) mounted in the carriage 12. The wheels 18 cut closely spaced parallel grooves 22 thus forming ridges 24. The milling cutter cuts the ridges down partially (but not fully) to produce a more controllable yield in terms of particle size. Only the milled powder is collected. A collection cup (not shown) is mounted on the apparatus for this purpose.

FIG. 1A shows a variation of the apparatus in which a single rotary wheel with several parallel lands 114 is used instead of several grouped cut-off wheels. It should be noted that here the rock sample 110 has a narrow profile. The profile should preferably be preground (by the wheel 118 with abrasive on the flats 119 or a separate grinder) to the level 111 to provide a common level for groove and ridge formation.

FIG. 1B shows a variation of the apparatus formed as a rock drill for taking a sample in a pre-drilled hole. A wheel 118 (similar to the wheel 118 of FIG. 1A) and a milling cutter 120 are mounted on a common shaft 115. They are driven from support 114 for traversing on the same rotary path and they are individually rotated by gears 130.

FIG. 1C shows another version of the apparatus on a pendulum mount with cutoff wheels 118 and a milling cutter 120 and collection boxes 226. The wheels 118 and 120 again travel the same path and same direction. The wheel drive transmission is not shown.

The pendulum continually swings around with the cut-off wheel 118 lowering the rock contour until a suitable level is obtained. Then the collection means 226 collects a sample from the milling cutter 120 for use in analytical processes.

FIG. 2 is a bar graph showing the highest yield of particles and in about the 74-149-micron range obtained by conventional grinding of basalt. (The particle sizes indicated on the abscissa between 0 and  $\infty$  are the sieve sizes used.) The distribution shown was obtained by traversing the rock at 12 inches per minute, using a 16-grit diamond wheel run at 440 revolutions per minute, and taking off 0.005 inch of rock per traverse.

FIG. 3 shows the improved sample distribution obtained from the same rock using the method of the present invention. Besides the improvement in immediate range of interest, which is shown shaded, there is a sizeable increase in the adjacent 149-250-micron range and a marked reduction in the under 44 micron range. Further peaking of the distribution about the desired 74-149 range can be obtained with further adjustment of ridge widths and heights as described below. The results shown in FIG. 3 were obtained using the following conditions: The previously described grooves were cut with a 60-mil width and 35-mil depth producing intervening ridges of 15-mil width and 35-mil height. The preformed surface was traversed by a flat tooth milling cutter rotating at 440 revolutions per minute and traversing at 30 inches per minute. The milling cutter took 0.008 inch off the ridges per traverse.

The reasons for the size control using the present invention are the following: The production of grooves removes considerable support from the remaining ridge material. As a result a reduction is effected in the amount of mechanical crushing pressure required to remove the

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ridge material. A reduction in the number of fine particles therefore results. Within limits, the thinner are the ridges, the fewer are the number of fines that result. The ridge width is preferably about equal to the desired particle size or in the range of the desired particle size. The ridge height is usually larger than the width and therefore the upper size of the particles is primarily governed by, although not limited to, the height of the ridges.

Several variations can be made from the above-described embodiments. It is therefore intended that the above disclosure shall be read as illustrative and not in a limiting sense.

What is claimed is:

1. An apparatus for geological rock sampling or the like comprising a combination thin wheel grinding means for cutting closely spaced grooves in the surface to create the elevated ridges and a milling cutter means for machining said elevated ridges simultaneously with a common tooth cut of said multiple ridges and means for collecting the loose particles produced by said milling cut, the said grinding means and milling means being supported on a common pendulum mounting structure to sweep along a rock in a common path and common direction and spaced apart from each other on said mounting structure, said collection means being mounted on said mounting structure and constructed and arranged to collect rock particles removed by said milling means.

2. Apparatus for geological rock sampling comprising,

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a frame means, a pair of spaced parallel rotary shafts mounted on said frame means, a plurality of thin grinding wheels mounted in spaced apart relation on one of said shafts for cutting a plurality of closely spaced grooves in the surface of said rock and for creating elevated ridges between said grooves, a toothed milling cutter mounted on the other of said shafts and arranged to simultaneously reduce said plurality of ridges into a powder specimen, and collection means carried on said frame for collecting said powder from said cutter.

3. The apparatus of claim 2 wherein said grinding and milling means are constructed to sweep along the work in the same path.

4. The apparatus of claim 3 wherein said grinding and milling means sweep along the work in the same direction.

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U.S. Cl. X.R.

125-3; 175-58, 308

