SURFACE-TREATING DEVICE

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ABSTRACT OF THE DISCLOSURE

The abrasion, grinding or polishing of a work piece or material is accomplished by exposing the work piece or material to a particulate abrasive and a plurality of permanent magnet elements exceeding 50 oersteds located in a fluid and subjected to a magnetic field varying in direction with time to effect the mutual spacing of and impart motion to the magnetic elements. The motions of the magnet elements are rotational and translational and effect the individual movements of the abrasive particles against the work piece or material.

The present invention relates generally to an improved method and apparatus for the treatment of materials and it relates more particularly to an improved method and apparatus for various degrees of material abrading from the polishing of the surface of a work piece of a particulate material to comminuting or size reduction of materials.

In the mechanical treatment of material of the nature of abrasion, attrition and impact, a large variety of devices and procedures are employed depending upon the precise nature of the treatment and the configuration state, size, hardness and other physical properties of the material being treated. Among the treatments of an abrasive nature effected are grinding, engraving, drilling, milling, polishing, burnishing, comminution, particle size reduction and the like. Although each device is peculiarly suited to the specific treatment effected, those conventionally employed possess disadvantages and drawbacks for their particular purpose and are generally unsuited for other uses. Thus, for example, in the case of particle size reduction, ball mills, hammer mills, impact mills and turbo mills are each adapted for materials of specific properties and are unsuitable for use with other materials. Moreover, grinding, engraving, drilling, milling and polishing operations each require procedures which are designed for the particular process and are not only unsuitable for other processes but leave something to be desired for the process for which it is designed.

It is thus a principal object of the present invention to provide an improved method and apparatus for the treatment of materials.

Another object of the present invention is to provide an improved abrading method and apparatus.

Still another object of the present invention is to provide an improved method and apparatus for abrading the surface of a work piece or a plurality of pieces or a particulate or divided material to various degrees of working and fineness such as grinding, engraving, drilling, milling, polishing, burnishing, comminution, particle size reduction and the like.

A further object of the present invention is to provide an improved abrading apparatus of simple and rugged construction which is simply adjustable to varying conditions.

Still a further object of the present invention is to provide a method and apparatus of the above nature characterized by their versatility, adaptability, reliability, efficiency, economy and low cost.

The above and other objects of the present invention will become apparent from a reading of the following description taken in conjunction with the accompanying drawing wherein:

FIGURE 1 is an end elevational view, partially in section, of an apparatus embodying the present invention;
FIGURE 2 is a top plan view thereof;
FIGURE 3 is a view similar to FIGURE 1 of another embodiment of the present invention;
FIGURE 4 is a longitudinal sectional view of a magnet element advantageously employed in the present apparatus;
FIGURE 5 is another fragmentary sectional view similar to FIGURE 3 of another embodiment of the present invention; and
FIGURE 6 is a view similar to FIGURE 5 of a further embodiment of the present invention.

In the copending patent application Ser. No. 133,215 of Abe Hersher, filed Aug. 22, 1961, now Patent No. 3,219,318, dated Nov. 23, 1965, there is disclosed a method and apparatus for treating or agitating a liquid in which a plurality of permanent magnet elements are distributed in the fluid and are subjected to a magnetic field varying with time in direction and intensity. The varying magnetic field maintains the magnet elements in spaced positions and imparts intense motions thereto, both translatory and rotational, such motions in turn effecting the agitation of the liquid.

It has been found that a highly effective abrading action may be achieved by providing a system of magnetic elements and a direction varying magnetic field of the nature disclosed in the above identified Hersher application relatively hard abrasive elements which may be in a finely divided state separate from the magnet elements or may form coatings on the magnet elements or both. The material to be treated, whether unitary, multiple or particulate is exposed to the abrasive elements to which motion is imparted by the varying magnetic field through the magnet elements to effect the surface abrasis of the treated material.

Accordingly, the present invention contemplates the provision of a material treating apparatus comprising a receptacle containing a plurality of magnetic elements disposed in said receptacle, a plurality of abrasive elements disposed in said receptacle and means for establishing through said receptacle a magnetic field varying in direction with time to effect the mutual spacing of and impart motion to said magnetic elements. The invention also contemplates the method of exposing a material to a plurality of abrasive elements in the presence of a plurality of magnetic elements and establishing in the area of said abrasive elements a magnetic field varying in direction with time.

The magnet elements are highly advantageously permanent magnets having strengths of at least 50 oersteds and preferably at least 200 oersteds and of a size no smaller than that of the single magnetic domain of the magnet material and advantageously of a dimension in any direction between 0.1 micron and 2 inches, the dimensions of the optimum magnet elements depending upon the type of operation being performed and the nature of the material being treated. The magnet elements are advantageously of non-spherical shape and of configurations which also depend on the specific object process. For example, the large dimensioned magnet elements are employed for crushing, whereas the smaller dimensioned magnet elements are preferred for grinding and polishing. Magnet elements of short flat configuration are preferred for drilling and material removal whereas long narrow magnet elements are preferred for polishing and burnishing. It should be noted that where the magnetic elements are provided with flat planar surfaces these surfaces are advan-
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tageously dimpled or ridged to inhibit their inter-engagement to form a unitary magnet. The optimum size and shape of the abrasive particles likewise depend upon the particular application of the process. Thus for crushing or large scale milling the abrasive should be large, preferably between 3/4 inch and 2 inches in maximal dimension, whereas for fine milling and burnishing, the particles should be small, preferably between 0.05 micron and 1/4 inch. For machining, the abrasive particles may be between 0.5 micron and 1/4 inch in maximum dimension, depending upon the desired smoothness of machining desired, that is, engraving or gross drilling. The optimum particle shape also depends on the nature of the abrading operation, for example, round pin-shaped particles for finishing and polishing aluminum castings, random shaped chips for polishing steel, triangular shaped particles for descaling, spherical particles for crushing and grinding and irregular particles with multiple sharp edges for cutting and material removal. It should be noted that the above abrasive elements may be defined by magnet elements coated with or encased by the abrasive material or, in assist applications, they are separable from the magnet elements, for example, that both forms of abrasive elements be employed. The magnet elements are advantageously coated or encased by the abrasive material to minimize the abrasion thereof.

The abrasive elements should be of a material harder than the material being treated, and advantageously of a hardness of at least 5.0 in the Mohs' scale and preferably in excess of 7.0. For example, there may be employed as abrasive elements steel, preferably austenitic stainless, flint pebbles, tungsten, carbide and high density aluminas, of sizes exceeding 3/4 inch diameter, Carborundum and Norbrit of sizes less than 3/4 inch diameter, boron carbide, silicon, carbide, diamond dust and Carborundum of a particle size less than 50 mesh. While the abrading procedure is advantageously affected with the magnet and abrasive elements being disposed in a liquid it may be effective in other fluid material. The liquid serves among other functions as a flushing material for the work piece, supplying fresh abrasive particles to the work piece, increasing the agitation of the abrasive particles to present fresh surfaces to the work piece or material being treated, and assisting the abrading by cavitation. The liquid should be employed in both milling or machining since a more efficient and enhanced abrading results with a fine surface finish. Water or organic liquids may be employed, for example, various alcohols such as methyl, ethyl and propyl alcohol, light oils, acetone and the like. The liquid is advantageously of a low viscosity.

The varying magnetic field likewise depends upon the application of the apparatus and process and may vary sinusoidally with time, reversing direction each half cycle or may be a pulsed or modulated type of magnetic field or other magnetic field varying in direction with time. In general for large crushing forces a high intensity magnetic field is employed, for example, between 100 and 20,000 oersteds which may be in sharp pulses or bursts of magnetic field alternations, whereas for fine abrasion a low intensity magnetic field is employed, for example between 10 and 1,000 oersteds. The frequency of changing direction of the magnetic field likewise varies with the application of the process, a low frequency field, preferably between 1 and 100 c.p.s. being preferred for crushing, whereas a high frequency field is preferred for cutting and engraving, for example between 100 and 100,000 c.p.s. A sinusoidal frequency of 60 c.p.s. has wide application since the field producing current is directly available from commercial power lines.

The frequency of pulsing, in a pulsed alternating magnetic field, also varies with the application. In general, pulsing is very useful in limiting the average power in cases where the use of high peak power is required. For example, a large scale milling operation could utilize very high peak bursts of input power to achieve extremely intense magnetic fields and still maintain a low average power for high efficiency.

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The receptacle for holding the magnet and abrasive elements and the liquid, in which such is employed, is advantageously non-magnetic and is formed of or lined with a material which depends upon the application. A hard lining such as austenitic stainless steel or porcelain should be provided where crushing is being effected while a rubber lining should be used where polishing is being practiced. The receptacle may be open or closed in the form of a pipe through which a fluid may circulate and may be provided with lids, inlet and outlet pipes, and the like.

Referring now to the drawings, and particularly FIGURES 1 and 2 thereof which illustrate a preferred embodiment of the present invention, the reference numeral 10 generally designates the improved apparatus which is highly useful in abrading the surfaces of objects to any desired degree and fineness. The apparatus 10 includes a base member 11 which may be made of a non-magnetic material on which is mounted a vertical hollow solenoid or multiturn coil 12. Mounted on the base 11 within the lower part of the solenoid 12 is a lami nated soft iron core 13 having a cylindrical cradle formed in its upper face. A horizontally extending cylindrical processing tank 14 rests in the cradle of the core 13 and is formed of a non-magnetic material. In the present application, the tank is formed of a ceramic provided with a hard rubber inner liner 16. The tank 14 is provided with a lid 17 affording access to the interior thereof and with inlet and outlet pipes permitting the circulation of a slurry processing liquid and material to be treated. A slurry and mixture 17 is located in the tank 14 and preferably only partially fills the tank. The slurry 17 contains for machining operations. The apparatus includes a base member 11 in which is located a vertical solenoid 19 connected to a
source of alternating current. Located on the base 18 coaxial with the solenoid 19 is a tubular mounting cylinder 20 of non-magnetic material in the lower section of which is nested a laminated iron core 21 having a lower cylindrical section and an upper frusto-conical upper section 22 terminating in a horizontal flat top face. A circular work piece 23 is supported on the top face of the core 21 by an intervening rubber gasket 24. A non-magnetic ring or annulus 26 rests on the peripheral border of the work piece 23, telescoping the tube 20, the upper opening in the annulus 26 being closed by a rubber gasket 27. A laminated soft iron cylindrical plug 28 telescopes the upper end of the tube 20 and rests on the gasket 27. The gasket 27, annulus 26 and work piece 23 delineate a work cell 29, which is partially filled with the working slurry including the abrasive and the magnet elements.

As a specific example of the application of the apparatus last described, the solenoid 19 was 250 turns of No. 12 insulated copper wire connected to a 50 volt, 60 c.p.s., voltage source. The core 21 was 3 inches high and had a 2 1/8 inch diameter base and a 1 inch diameter top face and the plug 28 was 2 inches long and of 2 1/8 inch diameter. The cell 29 was 2 1/8 inch high and of 1 inch diameter and was half filled with a water or ethyl alcohol slurry containing 5 grams of No. 240 Norbite abrasive powder and 16 anisotropic barium ferrite cylindrical permanent magnets 5/8 inch long and 3/8 inch diameter. The work piece 23 was glass and 0.0012 cubic inch of glass was drilled out or removed in 2 minutes at a 500 watt consumption. A 1 inch diameter hole was drilled through the work piece in about 80 minutes at 850 watts input power.

The apparatus illustrated in FIGURES 1 and 2 may be employed for dry milling by substituting for the slurry 17 in the tank 14 a dry mixture of magnet elements, abrasive and active materials and articles to be worked on or treated. In the dry milling procedure it is highly advantageous that the ratio of the number of abrasive elements to magnet elements be very high, of an order much greater than 1, the volume of the magnetic elements and abrasive material be approximately equal, the mass of the magnetic elements preferably is not less than that of the abrasive elements and the size of the individual magnet elements is much greater than that of the abrasive elements.

In FIGURE 4 of the drawing there is illustrated a form of abrasive encased magnet element 32 which may be employed to great advantage. The magnet element 32 includes a cylindrical permanent magnet 33 having poles at opposite ends thereof. The magnet 33 is coated with a layer 34 of a silicone adhesive which functions as a cushion as well and coaxially rests in a tube 36 of a hard, non-magnetic material and somewhat longer than the magnet 33. The ends of the tube 36 are closed by abrasive discs 37 which may have tapered peripheral edges so as to be forced fitted into the tube 36. The end discs 37, tube 36 and magnet 33 are maintained in an assembled condition by the adhesive 34, the magnet 33 being cushioned therein. The material forming the magnet 33 advantageously has a high Hcb, very low Hk, high (BH) for example, anisotropic barium ferrite or Alnico 8 and the tube 36 and end discs 37 may be of any suitable nonmagnetic hard abrasive material, for example, tungsten carbide or ceramic. The magnet elements may be of other shapes and the abrasive jackets may be omitted.

The magnet elements may be coated with hard metals or ceramics by means of several known techniques, for example, flame-spray coatings. The magnet elements may be advantageously coated in the unmagnetized state and then magnetized.

It should be noted that the magnetic field may be directed or concentrated in any manner, for example, as disclosed in the above identified Hershler patent application, to direct the abrasive action to a predetermined area. Thus, as seen in FIGURE 5 of the drawing which illustrates an apparatus similar to that shown in FIGURE 3 except that the plug 28 is omitted and the work piece 38 forms the top of the work cell and is suitably retained in position, a magnetic field concentrating and directing member 39 in the form of a soft iron bar is supported in the vicinity of the workpiece 38 to concentrate the magnetic field intensity in a corresponding area thereof and hence the abrasive activity.

Besides the use of passive flux magnetic field directors (soft iron rods or cores) active flux directors may be used in the form of small sources 40 of alternating magnetic fields as shown in FIGURE 6 which illustrates an apparatus similar to that shown in FIGURE 5 except for the provision of one or more AC energized solenoids 40; for example, instead of using a single source of alternating magnetic field several sources can be utilized in order to direct and concentrate the particle action to specific areas of a work piece. The use of flux directors, passive or active, is particularly useful in pin-pointing the abrasion of materials in one or more selected areas of a work piece.

Frequently, in addition to the activating magnetic field a direct current polarizing or alignment magnetic field may be used to focus or concentrate the abrading action to close tolerances such as in drilling. For example, in the apparatus shown in FIGURE 6, the solenoids 40 are connected to alternating current as shown, and function to produce the magnet element driving field, and the solenoid 12 is connected to a source of DC current and functions to produce the polarizing or alignment magnetic field. As opposed to this method it is also useful to utilize two alternating magnetic fields with a small difference in their frequencies to cause a gross periodic motion at the difference or beat frequency superimposed onto the basic propulsion motions. This is advantageous in milling operations. It is also useful where the frequency is controllable, to adjust the frequency for maximum particle acceleration in order to maximize the abrading forces of the particles.

While there have been described and illustrated preferred embodiments of the present invention, it is apparent that numerous alterations, omissions and additions may be made without departing from the spirit thereof.

What is claimed is:

1. A material treating apparatus comprising a receptacle containing a fluid, a plurality of permanent magnet elements having strengths of at least 50 oersteds disposed in said fluid, and means for establishing through said fluid a magnetic field varying in direction with time to effect the mutual spacing of and impart motion to said magnet elements.

2. The apparatus of claim 1 wherein said abrasive elements have a hardness exceeding 5.0 in the Mohs' scale.

3. The apparatus of claim 1 wherein said abrasive elements have a particle size not exceeding 2 inches in their maximum dimensions.

4. The apparatus of claim 1 wherein at least some of said abrasive elements are defined by magnet elements having hard coatings.

5. The apparatus of claim 4 wherein said coating elements have a hardness of at least 5 Mohs.

6. The apparatus of claim 1 wherein said receptacle is formed of a non-magnetic material.

7. The apparatus of claim 1 including means for concentrating said magnetic field in a predetermined area of said fluid.

8. The apparatus of claim 1 wherein said magnet elements have a particle size of between 0.1 micron and 2 inches in their maximum dimensions.

9. The apparatus of claim 1 wherein said abrasive elements are in the finely divided form and said magnet elements are of greater dimensions than said abrasive elements.
10. The apparatus of claim 9 wherein said fluid is a liquid.

11. The apparatus of claim 1 wherein said means for producing said magnetic field comprises a hollow solenoid surrounding said receptacle.

12. The apparatus of claim 1 wherein said magnetic field establishing means comprises means for establishing a plurality of alternating magnetic fields of different frequencies.

13. The apparatus of claim 1 including means for establishing a stationary magnetic field in said receptacle.

14. The method of treating a work piece comprising immersing said work piece into a fluid having disposed therein a plurality of permanent magnet elements having strengths of at least 50 oersteds and of a size between 0.1 micron and 2 inches in any dimension and abrasive elements and establishing in said fluid in the area of said work piece a magnetic field varying in direction with time to effect the mutual spacing of and impart motion to said permanent magnet elements whereby to bombard the surface of said work piece with said abrasive elements.

15. The method of claim 14 comprising concentrating said magnetic field in a predetermined area proximate to said work piece.

16. The method of claim 14 wherein said abrasive elements have a hardness exceeding 5.0 on the Mohs' scale and a particle size not exceeding ¼ inch in maximum dimension.

17. The method of claim 14 wherein said abrasive elements are non-magnetic.

18. The method of claim 14 wherein said abrasive elements are defined at least in part by magnet elements having abrasive hard coatings.

19. The method of claim 14 wherein said fluid is a liquid.

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LESTER M. SWINGLE, Primary Examiner.

U.S. Cl. X.R.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,423,880 Dated January 28, 1969

Inventor(s) Abe Hershler

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

Claim 1, line 4, after "fluid," should be
inserted --a plurality of abrasive elements
disposed in said fluid,--.

Signed and sealed this 8th day of October 1974.

(SEAL)
Attest:

McCoy M. Gibson Jr.
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Commissioner of Patents