ULTRASONIC STONE CUTTING DEVICE

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This invention relates to the art of stonecutting and particularly concerns a tool for cutting rocks and stones in large quantities or masses by utilizing a cutting blade reciprocated at speeds from 10,000 to 100,000 vibrations per second.

It has been known heretofore to provide a tool including an electrically excitable vibratory element which is caused to vibrate at supersonic frequencies. The tool is mounted in a tool holder like a lathe or drill press and the vibratory element is applied to small articles to be worked. The tool of the present invention needs no extraneous abrasive compounds between the vibratory element and the work as the stone becomes its own abrasive agent during the cutting operation. Cutting, drilling, and the like take place by cavitation.

Prior known tools of the character described have only been adapted for working small pieces of metal, ceramics, gems, and the like. These tools have required the use of costly abrasives coating with the cutting element which vibrate at supersonic speed.

The present invention is directed to a tool which dispenses with special granular abrasive in a supersonic cutting device. The tool is particularly applicable to processes requiring a high quantity of stonecutting in a minimum time. The tool is particularly useful in quarrying, veneer stone, tunnel and shaft construction projects, mining, excavating, and the like.

It is, therefore, a principal object of the invention to provide a stonecutting device provided with a vibratable cutting element operated at sonic and/or supersonic speeds.

It is a further object to provide a stonecutting device with a blade having a cutting edge a foot or more in length, the blade being vibratable at high speeds and cooled by liquid during operation thereof.

It is a further object to provide a supersonic cutting device employing only a liquid as a cavitating agent.

It is a further object to provide a stonecutting device having a body provided with a pair of handles including trigger operated members for controlling the flow of a coolant through the body and the application of electrical energy to a vibratable cutting blade actuated in the device.

For further comprehension of the invention, and of the objects and advantages thereof, reference will be had to the following description and accompanying drawings, and to the appended claims in which the various novel features of the invention are more particularly set forth.

In the accompanying drawings forming a material part of this disclosure:

Fig. 1 is a side elevational view of the device embodying the invention.

Fig. 2 is a sectional view on an enlarged scale taken on line 2—2 of Fig. 1.

Fig. 3 is a vertical sectional view taken on lines 3—3 of Fig. 2.

Fig. 4 is a top plan view of the device.

Fig. 5 is a sectional view taken on lines 5—5 of Fig. 1.

Fig. 6 is a diagram of one form of electrical circuit which may be employed to energize and control the device.

Fig. 7 is a fragmentary sectional view showing a modified cutting blade on an enlarged scale.

Referring to Figs. 1—4, there is shown a generally cylindrical elongated hollow body 10. At the bottom of the body, as viewed in Fig. 1, there is a forwardly disposed handle 11. A pipe 12 is connected to the handle for conveying a liquid coolant, such as water, through a passage 14 in the handle and leading into the body 10. Attached pivotally to the handle is a trigger or lever 15. A pin 16 is disposed to move transversely in a bore in handle 11 to open and close passage 14. The pin 16 is actuated by trigger 15 to which the pin is pivotally attached. A spring 17 is coiled on pin 16 and normally retracts the trigger and pin to leave the passage 14 clear. A trigger guard 18 in the form of a curved metal bar is attached between the body 10 and handle 11 at the forward end of the body web-like plate 19. Dashes or serrations 19 for convenience in holding the device.

An elongated rod 20, round in cross section and formed of ferromagnetic laminated material, such as nickel or nickel alloys is oscillably mounted axially in the body 10. The forward end of the rod is tapered and extends through and is supported by a rubber or elastomeric bushing 21 plugged in the restricted or nipple-shaped open end 22 at the front of the body. The rear end of the rod seats in a central recess in a rubber or elastomeric block 24 seated and secured on the rear end of the body 10. The tapered front end of the rod 20 terminates in a narrow externally threaded extension 25, round in cross-section, which is threaded into a threaded socket 23 provided in the apex end of a triangular-shaped plate 26 as shown in Figs. 1 and 3 for detachably connecting the plate to the rod. Plate 26 constitutes the cutting or cavitating blade for agitating the rock or stone particles whereby the rock or stone is cut. By "cavitation" as used herein is meant agitation of rock particles whereby the rock is cut. This phenomenon is described in Letters Patent 2,580,716. The blade is of one-piece construction and may be formed of high quality steel.

The plate 26 is triangular or fan-shaped with its side edges 27, 27 slightly curved and outwardly flared, and its inner free edge working end edges 28 slightly curved as shown in Figs. 1 and 3. Edge 28 may be slightly thicker than the rest of the plate. The curved design of the plate is of utmost importance and satisfactory curvatures of the plate for use in cutting or cavitating stone or rock, giving optimum results, have been obtained by using the hyperbolic and parabolic formulas of mathematics or geometry. It will be understood of course that the invention is not restricted to these formulas and any other suitable formula may be used. The plate preferably is a foot or more wide at its outer curved end and from one-eighth to three-eighths of an inch thick.

A pair of narrow web-like plates 30, 31 are suitably secured to the forward end of the body 10 by welding or the like and are disposed on both sides of the nipple end 22 thereof extending forwardly on both sides of the plate 26 to the outer edge thereof and being disposed in the same plane therewith.

Plates 30 and 31 are formed with straight outer edges 29, 29 and with longitudinally curved inner edges 32, which conform in curvature to the curvature of edges 27, 27 of plate 26. The curved edges 32 may be curved in accordance with the formulas used for curving the edges 27, 27. The inner edges 32 of the plates 30 and 31 are also tubular in formation as indicated at 33 and 34, respectively, thereby providing passages 37, along said inner edges. The tubular formations have spaced aper-
2,831,668

The passages communicate through openings 37', 37" in the front end of the body 10 with a chamber 36 in the body 10 formed by the outer wall thereof and the wall of a tubular member 40 extending axially of the body 10. Chamber 36 holds a quantity of coolant which enters the pipe 12 connected to passage 14 in handle 11 at the front of the body, and leaves the chamber by an outlet tube 39 at the rear end of the body 10.

A multifilar coil 41 of insulated wire surrounds rod 20 and is separated therefrom by a hollow cylindrical wall 44 made of insulation material, and is spaced from the rod 20 so that the rod can expand and contract magnetostrictively in the magnetic field generated by means of the coil 41. The coil terminates in leads 45 and 46. The leads 45, 46 pass through block 24 at the rear of the body 10. Lead 45 is connected to a movable switch contact 47 disposed at the end of a pin 48. Pin 48 is pivotally attached to the trigger or lever 49. Trigger 49 is pivotally mounted on a handle 50 at the rear end of the body 10. A trigger guard 51 is attached between handle 50 and body 10. A coil spring 53 normally holds trigger 49 and pin 48 retracted from movable switch contact 47. Lead 46 is disposed in cavity 55 in handle 50. Lead 57 is attached to the fixed contact and passes out of the body together with lead 46 through block 24 and cable housing 58.

In Fig. 6 is shown an electrical circuit which may be used in energizing the device. A suitable alternating current source, generator, oscillator, or the like 60 is connected in circuit with leads 45, 46 and coil 41. The rod 20 expands and contracts magnetostrictively as the magnetic field set up by coil 41 alternates periodically. A capacitor 61 is shown in series with generator 60. This capacitor is a variable tuning element which may be used to vary the frequency of oscillation of generator 60.

In operation of the device, the operator will hold the body 10 by means of handles 11 and 50. By pressing trigger 49 the circuit through coil 41 will be closed and the coil 41 energized so that the rod 20 is caused to vibrate at whatever frequency the applied electrical energy oscillates. The rod 20 will vibrate in the resiliently cushioned block 24 and brushing 21, thereby vibrating plate 26 with its edge 28 backward and forward a very short distance. By squeezing trigger 15, the coolant 38 will be caused to circulate through chamber 36. The liquid will also pour out in streams through apertures 35 onto plate 26 and its edge 28. This liquid will not only wet the blade members, but will also serve as a cooling medium. As the blade edge is applied to a rock or stone surface, the freed granules of stone resulting from such application will serve as an abrasive in the presence of the coolant liquid so that no supplementary abrasive is required. The extended length of the blade makes it possible to split or shatter large rocks and stones in a very short time. It is only necessary for the operator to support the tool at the worked stone surface. No pressure need be exerted by the operator since the exceedingly rapid blows of the working blade will impart the necessary working forces. The flowing coolant will be 50. A few excess stone granules.

As the edge 28 enters a long cut in a rock, the plate 26 and webs 30, 31 with tubes 33, 34 enter with the edge 28. All members are coplanar and all are of equal or lesser thickness than edge 28 so that they readily follow the edge. Members 47 and 54 serve as a convenient electrical switch to start and stop the vibration of the tool instantly. As the cutting edge 28 produces a quantity of granular cut stone at its working face, the face of the edge need not be held in actual contact with the stone surface being cut since by cavitation the stone granules and freely flowing coolant liquid form a shurry or mud which serves as an effective abrasive cutting material.

If desired, the outlet tube 39 may be omitted to permit the tubular edges 33 and 34 to serve as the sole means to discharge the coolant from the body. Thus in this manner all the liquid passing out of the body will pass over the cutting blade of the device.

If desired, the working edge of the blade 26 may be formed by a separate removable bar 70 as shown in the modified form of the device. Bar 70 is curved similar to edge 28 and formed of hardened tool steel, silicon carbide, a cementitious material embedded with granular diamonds, etc. Bar 70 may be provided with a curved tenon or bead 71 which is inserted into a corresponding mating grooved recess or slot 72 in plate 26.

The rod 20 will be curved similar to edge 28 and made of vibration at its natural mechanical resonant frequency. It is not necessary that the frequency of vibration of the tool be set at this frequency since this may not be the most effective cutting rate. On the contrary the mechanical resonant frequency of the rock mass may be the optimum working frequency and the tool may be adjusted to this frequency by adjusting capacitor 61 or otherwise tuning generator 60 until an optimum rate of cutting is obtained.

The tool described is intended for cutting large masses of stone and rock such as are necessary in mining, quarrying, road and tunnel construction, digging of building foundations, etc. Since the device is wholly portable it can be used to cut in any desired direction depending on the disposition of the stone surface to be worked. The tool can also be used to cut through hard packed earth and through any materials having a limited consistency. The device is of particular value in breaking up masses of metal ore, coal, etc.

The device contains only a single vibrating working element in the body 10. It is rugged in structure, simple, and relatively inexpensive. The working edge of the blade is provided by the curved outer edge 28. This edge will have a very long life since, as explained above, the cavitation effects will minimize the amount of actual contact between the working blade and the stone surface being abraded.

While I have illustrated and described the preferred embodiments of my invention, it is to be understood that I do not limit myself to the precise constructions herein disclosed and that various changes and modifications may be made within the scope of the invention as defined in the appended claims.

Having thus described my invention, what I claim as new, and desire to secure by United States Letters Patent is:

1. A stonecutting device, comprising a hollow cylindrical body, a hollow cylinder, said hollow cylinder being formed concentrically with and spaced inwardly from the body and said body defining an annular chamber, a cylindrical coil of wire disposed radially inwardly of said wall, a ferromagnetic movable rod disposed axially within said body and arranged to expand and contract magnetostrictively within said wall, resilient means supporting said rod at opposite ends of the body, one end of said rod projecting from the body, a blade secured to said one end for reciprocation by said rod, said blade having a hardened edge on its forward end, a tube attached to said body, a handle attached to said body, a pipe attached to said handle, said tube and pipe communicating with said chamber providing an outlet and inlet, respectively, for liquid for said chamber, a pair of tubes attached to said body and opening at one end into said chamber, said pair of tubes having spaced apertures therealong, said pair of tubes being disposed in coplanar relationship with said blade discharging liquid thereon, a first trigger means carried by said handle for controlling the flow of liquid through said tube and an other handle carried by said body, another trigger means carried by latter handle, and electric switch means operatively connected with said last-named trigger means, said switch means being in circuit with ends of said coil, said coil and switch means being in circuit with means for supplying oscillating electrical energy to said coil, for generating an alternating magnetic field around said rod,
whereby the rod may be caused to vibrate magnetostrictively and thereby reciprocate said blade, while said coolant is being discharged upon said blade under control of said first trigger means.

2. A stonecutting device, comprising a hollow cylindrical body, a hollow cylindrical wall disposed concentrically with and spaced inwardly from the body and with said body defining an annular chamber, a cylindrical coil of wire disposed radially inward of said wall, a ferromagnetic movable rod disposed in said body and arranged to expand and contract magnetostrictively within said coil, resilient members supporting said rod at opposite ends of the body, one end of said rod projecting from the body, a further pair of tubes attached to said body and opening into said chamber, said tubes having spaced apertures, said pair of tubes being disposed in coplanar relation with said blade discharging liquid thereon, a first trigger means carried by said handle for controlling the flow of liquid through said pipe, another handle carried by said other handle, and electrical switch means operatively connected with said other trigger means, said switch means being in circuit with said blade discharging liquid thereon, whereby the rod may be caused to vibrate magnetostrictively and reciprocate said blade, while said coolant is discharged upon said blade under control of said first trigger means.

3. A stonecutting device, comprising a hollow cylindrical body, a hollow cylindrical wall disposed concentrically with and spaced inwardly from the body and with said body defining an annular chamber, a cylindrical coil of wire disposed radially inward of said wall, a ferromagnetic movable rod disposed axially within said body and arranged to expand and contract magnetostrictively within said coil, a resilient bushing and a resilient block supporting said rod at opposite ends of the body, one end of said rod projecting from the body, a blade secured to said one end for reciprocation by said rod, said blade having a blunted edge on its forward end, a tube attached to said body, a handle attached to said body, a pipe attached to said handle, said tube and pipe communicating with said chamber, a further pair of tubes attached to said body and spaced apart from the body, said tubes having spaced apertures, said pair of tubes being disposed in coplanar relation with said blade discharging liquid thereon, a first trigger means carried by said handle for controlling the flow of liquid through said pipe, another handle carried by said body, another trigger means carried by said other handle, and electrical switch means operatively connected with said other trigger means, said switch means being in circuit with ends of said coil, said coil and switch means being in circuit with means for supplying oscillating electrical energy to said coil for generating an alternating magnetic field around said rod, whereby the rod may be caused to vibrate magnetostrictively and reciprocate said blade, while said coolant is discharged upon said blade under control of both of the trigger means.

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