

Sept. 11, 1945.

A. G. BODINE, JR
PORTABLE CUTTING TOOL
Filed Dec. 18, 1942

2,384,435

Fig. 1.

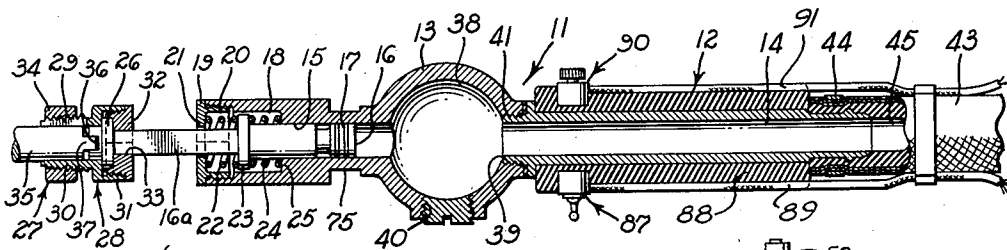


Fig. 9.

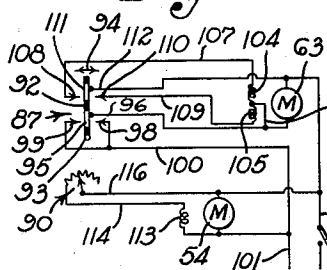


Fig. 2.

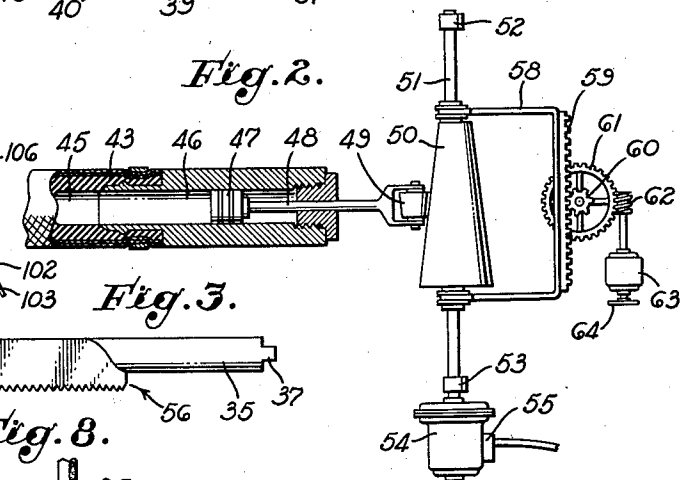


Fig. 3.

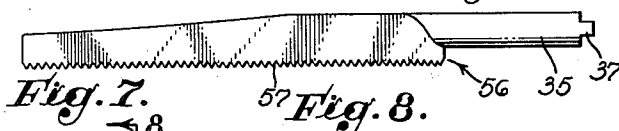


Fig. 7.

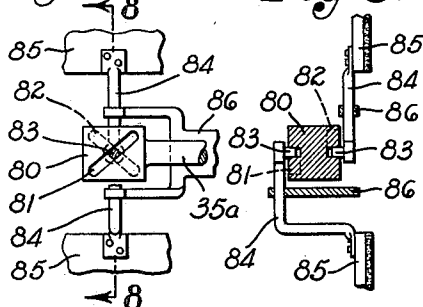


Fig. 10.

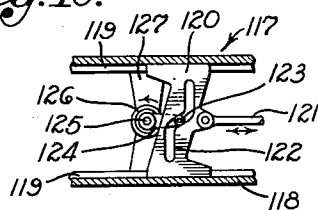


Fig. 6.

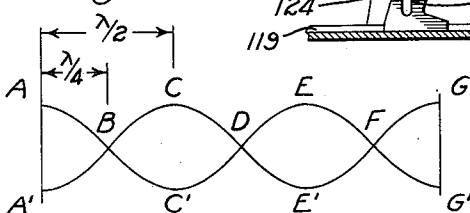


Fig. 4.

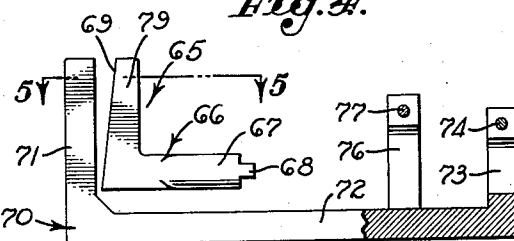
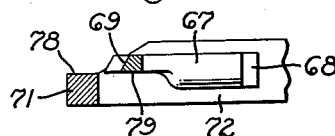


Fig. 5.



INVENTOR
ALBERT G. BODINE, JR.
BY
HARRIS, KIECH, FOSTER & HARRIS
Harold R. Foster
FOR THE FIRM
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,384,435

PORTABLE CUTTING TOOL

Albert G. Bodine, Jr., Burbank, Calif., assignor to
The Calpat Corporation, Los Angeles, Calif., a
corporation of California

Application December 18, 1942, Serial No. 469,741

36 Claims. (Cl. 164—34)

My invention relates to a portable tool, and, since it finds particular utility in cutting operations, embodiments of my invention well adapted for such use will be hereinafter described, it being understood that my invention is not limited to such use.

This application is a continuation-in-part of my copending application Serial No. 397,252, filed June 9, 1941, for Method and apparatus for cutting pipe.

Power driven hand tools now available are either driven by an electric motor portable with the tool or driven through a flexible mechanical connection, such as a cable rotating in a conduit and connected to a motor remote from the tool. Tools of the former class are necessarily bulky and heavy, preventing their use in many places, such as corners, and causing early fatigue to the operator. Tools of the latter type are restricted in their use by the lack of complete flexibility in the driving connection and require frequent repairs due to the considerable number of their moving parts.

It is an object of my invention to provide a portable tool which is light in weight, compact in form, and which utilizes relatively few moving parts, none of which is so delicate as to require frequent repair or replacement. It is another object of my invention to provide such a portable tool with its source of driving energy remote from the tool, so that the driving means need not be carried by the operator, and with energy transmitting means connecting the source of the energy to the tool, which means is completely flexible.

It is still another object of my invention to provide such a tool and drive means therefor in which a large amount of energy can be transmitted and expended in the performance of work with a high degree of efficiency.

In the performance of different kinds of work, for example, in the cutting of different materials, it is desirable that the amplitude and speed of movement of the cutting tool be varied. It is an object of my invention to provide a portable tool in which the speed and amplitude of movement of the driven member may be quickly and easily varied between wide limits while the tool is being operated.

It is another object of my invention to provide a portable tool in which the force applied to the driven member is automatically increased when the resistance to motion of the driven member is increased and in which the motion of the driven member is substantially simple harmonic mo-

tion, whereby the driven member may be reciprocated at extremely high velocities without damaging it.

My invention contemplates the utilization of sonic and supersonic energy in the accomplishment of the foregoing objects.

During the transmission of sound waves through an elastic medium, the movement of the particles of the medium is a local movement consisting of small reciprocations in the direction of transmission of the sound waves in a manner similar to the reciprocation of the sound wave generating devices. My invention contemplates the amplification of such movement of the particles so that their movement is greater than the movement of the sound generating devices. This is accomplished in accordance with my invention by establishing within the transmitting medium a resonant condition in which a large portion of the energy generated is stored in the medium by the reflection of the sound waves in a manner to reinforce those originating with the generator and thus establish within the medium a standing or stationary wave. Such a standing wave has considerably larger amplitude than the single sound waves transmitted, so that its wave fronts are very steep, and the velocity and acceleration of the particles of the wave-transmitting medium at the maximum velocity variation zones are very great, and the rate of change of pressure within the wave-transmitting medium at the pressure variation zones is greatly enhanced in value.

My invention contemplates that the sound wave generator shall be located remote from the tool and the sound waves transmitted to the tool through an elastic medium, such as a fluid, for example, oil or water, in a flexible conduit, and that the sound wave generator shall be readily adjustable as to both the frequency and amplitude of the sound waves generated, so that a condition of resonance can be established within the fluid column and the driven member reciprocated with the desired amplitude.

Embodiments of my invention capable of accomplishing the objects and providing the advantages herein stated and others which will be made apparent hereinafter are described in the following specification, which may be better understood by reference to the accompanying drawing, in which

Fig. 1 is a longitudinal sectional view partially diagrammatic of the portable cutting tool;

Fig. 2 is a longitudinal sectional view of the

actuating means for the cutting tool shown in Fig. 1;

Fig. 3 is a side elevational view of one form of cutting or driven member which may be employed in the use of my invention;

Fig. 4 is a side elevational view of another form of cutting or driven member which may be employed in the use of my invention;

Fig. 5 is a sectional view taken as indicated by the line 5—5 of Fig. 4;

Fig. 6 is a diagrammatic view of a stationary or standing sound wave in a fluid column;

Fig. 7 is a fragmentary plan view of a modified form of driven member connection for the tool of my invention;

Fig. 8 is a sectional view taken as indicated by the line 8—8 of Fig. 7;

Fig. 9 is a wiring diagram of the control means by which the frequency and amplitude of the sound waves generated may be varied; and

Fig. 10 is a fragmentary plan view of a second modified form of driven member connection for the tool of my invention.

Referring to the drawing, which is for illustrative purposes only, the numeral 11 indicates a tool, which includes a handle 12 and a body 13. The handle 12 is provided with a fluid passage 14, preferably cylindrical in cross section, and the body 13 is provided with a cylinder 15 of the same cross-sectional area and form as the passage 14 and, as illustrated in Fig. 1, coaxial therewith.

Positioned within the cylinder 15 is a piston 16 provided with annular sealing passages 17 in which rings adapted for sliding engagement with the wall of the cylinder 15 may be installed if desired. The piston 16 extends outwardly of the cylinder 15 through an enlarged cylindrical chamber 18 formed in the outer end of the body 13. A cap member 19 formed of two semi-cylindrical portions and having a cylindrical bore 20 of the same diameter as the cylindrical chamber 18 is threaded upon the end of the body 13 and is provided with an inwardly extending flange 21 defining a central opening, square in outline, through which an extension 16a of the piston 16 projects, such extension being square in cross section.

A first compression spring 22 is positioned in the cylindrical chamber 18 with one end engaging the flange 21 and the other end engaging a collar 23 formed on the extension 16a. A second compression spring 24 is positioned in the cylindrical chamber 18 with one end engaging the collar 23 and the other end engaging an annular wall 25 separating the chamber 18 from the cylinder 15.

Outwardly of the collar 23 the extension 16a is provided with a second collar 26 adapted for retaining a chuck 27 on the end of the piston 16. The chuck 27 includes a sleeve 28 having slots 29 therethrough at its forward end providing gripping members 30. The sleeve 28 includes an enlarged portion 31 at its opposite end into which a locking collar 32, consisting of two semi-cylindrical portions, is threaded so that the second collar 26 is locked between the sleeve 28 and the collar 32. The locking collar 32 is provided with a central opening 33, square in outline, through which the extension 16a projects. An adjusting collar 34 is threaded upon the outer tapered surface of the gripping members 30 so that they may be moved towards each other to clamp a shank 35 of a driven member.

The extension 16a may be provided with a central opening 36, preferably of cross section other than circular, for the reception of a central pro-

jection 37 of cross section of similar outline upon the shank 35 for centering the shank relative to the extension 16a and preventing their relative rotation.

5 Formed in the tool body between the liquid passage 14 and the cylinder 15 is a spherical chamber 38, the radius of which is preferably considerably greater than the radius of the cylindrical liquid passage 14 and the radius of the cylinder 15.

10 As illustrated in Fig. 1, the tool 11 may be provided with a plurality of threaded openings 39 and 40 for the reception of a reduced end 41 of the handle 12, so that the handle 12 may be secured at various angles with respect to the axis of the cylinder 15, and so that two handles may be secured to the body 13 if desired. A plug 42 is threaded into the opening 39 and 40 when a handle is not installed therein.

20 Secured upon the end of the handle 12 by a collar 44 is a conduit means 43 having therein a liquid passage 45, preferably of the same cross-sectional area and form as the liquid passage 14. The conduit means 43 is flexible and resistant to longitudinal or radial deformation. Suitable conduit means comprises a hose of fabric or rubber or a combination of fabric and rubber reinforced by metal strands embedded therein or wrapped therearound. The conduit means 43 is connected remote from the tool 11 to a cylinder 46 in which a piston 47 is mounted for reciprocation. The bore of the cylinder 46 is preferably of the same diameter as the liquid passage 45 of the conduit means 43. Attached to the piston 47 and extending from the cylinder 46 is a piston rod 48 having at its outer end a roller 49 adapted for rolling upon the surface of a cone 50 eccentrically mounted for rotation with and movement axially of a shaft 51. The shaft 51 is supported for rotation in bearings 52 and 53 and is driven by a motor 54 having suitable control means 55 for controlling the starting and speed of the motor 54, which may be carried by the tool 11 as hereinafter described.

45 The conduit means 43, liquid passage 14, spherical chamber 38, and the portions of the cylinders 46 and 15 inwardly of the pistons 47 and 16, respectively, are filled with a fluid, preferably a liquid such as water or oil.

50 The driven members which are removably secured in the chuck 27 may be of a variety of forms adapted for a variety of uses. The numeral 56 indicates a driven member in the form of a saw having teeth 57 adapted for cutting metal. When the shank 35 is centered in the tool 11 by the insertion of the projection 37 into the central opening 36 of the piston extension 16a, the sleeve 34 is rotated to clamp the gripping members 30 and thus lock the driven member 56 to the tool 11.

60 When the motor 54 is energized, the shaft 51 and the cone 50 thereon are rotated. The engagement of the surface of the eccentrically mounted cone 50 with the roller 49 reciprocates the piston rod 48 and the piston 47. The reciprocation of the piston 47 in the cylinder 46 imposes upon the liquid in the cylinder alternate condensation or compression impulses and tension or rarefaction impulses which are transmitted through the liquid column in the conduit means 43 to the spherical chamber 38. These impulses or sound waves are sinusoidal in form, since the piston 47 is reciprocated with simple harmonic motion. The sound waves transmitted to the spherical chamber 38 are transmitted therefrom to the piston 16 as if originating at a

point source which is the center of the spherical chamber 38.

The piston 16 is thus subjected to sound waves generated by the piston 47. The length of the liquid column between the pistons 47 and 16 may be, and preferably is, so related to the frequency with which the piston 47 is reciprocated that a condition of resonance is established within the liquid column whereby the impulses reflected from the piston 16 reach the piston 47 and are reflected therefrom as like impulses at that instant when a like impulse is generated within the liquid column by the piston 47.

When such a condition of resonance is established, there is a standing sound wave in the liquid column with maximum pressure variation zones occurring at distances from the ends of the pistons 47 and 16 equal to multiples of a half wave length of sound in the liquid constituting the column and maximum velocity variation zones occurring at distances from the ends of the pistons 47 and 16 equal to odd multiples of a quarter wave length of sound in the liquid constituting the column.

This is illustrated diagrammatically in Fig. 6 in which the distance between the ends of the pistons 16 and 47, represented as AA' and GG', respectively, is indicated for illustrative purposes to be one and a half wave lengths of sound in the liquid column.

Zones of maximum pressure variation occur at CC' and EE' distant from the ends of the pistons 16 and 47 a half wave length. In these zones the velocity variation of the particles of liquid is at a minimum, and the velocity is substantially zero. Distant a quarter wave length from the ends of the pistons 16 and 47 and from the maximum pressure variation zones are zones of maximum velocity variation, indicated as B, D, and F, at which the velocity variation of the molecules of liquid is a maximum, and the pressure variation is a minimum and substantially equal to the pressure caused by the static head upon the liquid in the column.

These zones AA' and GG' adjacent the ends of the pistons 16 and 47 are not purely zones of maximum pressure variation, since some movement of the liquid molecules at these zones is caused by the movement of the pistons, but they are zones predominantly of pressure variation, as contrasted with velocity variation, and may be termed zones of predominant pressure variation.

It will be seen that, when a condition of resonance is established within the liquid column, the inner end of the piston 16 is at a zone of predominant pressure variation and is therefore subjected to approximately the maximum pressure variation developed in the liquid column. In response to the variations in pressure thereon that is the effect of the alternate condensation or compression impulses and tension or rarefaction impulses transmitted to it through the liquid column, the piston 16 is caused to reciprocate in the cylinder 15 with a frequency the same as the frequency of reciprocation of the piston 47 and an amplitude that may be very considerably greater than, and if desired, a multiple of the amplitude of movement of the piston 47.

This condition of resonance may be readily established by varying the frequency of the sound waves generated by the piston 47 by varying the speed of the motor 54 by employing the control means 55. The amplitude of movement

of the piston 16 may likewise be readily varied by sliding the cone 50 along the shaft 51 relative to the roller 49, and for this purpose a yoke 58 is rotatably mounted upon the shaft 51 and provided with a rack 59 engaged by a pinion 60. The pinion 60 is rotated by a driven gear 61 rotated by a worm gear 62 turned by a motor 63. The motor 63 is energized to rotate the worm gear 62 in either direction by suitable means carried by the tool 11 and hereinafter described. The worm gear 62 may be manually turned by a hand-wheel 64.

It will be obvious that the driven member 56 is reciprocated with the same amplitude and frequency as the piston 16 to which it is connected by the chuck 27 and piston extension 16a. This frequency will vary with the type of work performed by the driven member 56. In use employing the saw illustrated in Fig. 2 a frequency of 100/sec. to 1,000/sec. may with advantage be employed the exact frequency depending upon the material being cut.

In the transmission of the sound waves through the liquid column the spring 22 acts as a capacitance and has the effect of a continuation of the liquid column equal to a quarter wave length of the sound waves in the liquid column. The spring 24 is identical with the spring 22. The spherical chamber 38 likewise acts as a capacitance and limits the peak or maximum wave pressure in the system.

Since the potential energy available for actuating the piston 16, and hence the driven member 56 adjacent the end of the piston 16, is the sum of the energy due to pressure variation upon the liquid molecules and the energy due to the velocity variation of the molecules, it will be understood that, as the resistance to motion of the piston 16 is increased, and hence the velocity variation of the piston 16 is decreased, the pressure variation is correspondingly increased, causing the end of the piston 16 to assume a position more nearly one of an exact pressure variation zone in the standing wave in the liquid column. Thus any resistance to the reciprocation of the driven member 56 afforded by its use is immediately and automatically met by an increase in that pressure variation tending to move it in that direction in which its movement is resisted.

Furthermore, the driven member 56 is caused to reciprocate with simple harmonic motion, which is that motion best adapted for the maximum velocity and cutting action with the minimum destructive stress upon the driven member and the other reciprocated parts. With such a type of motion it is possible to reciprocate the driven member 56 with a maximum speed without damage to the driven member impossible of attainment with any other form of motion. The saw illustrated in Fig. 2 can therefore perform a cutting operation upon metal, wood, stone, or any desired substance at an extremely high rate.

I have illustrated in Figs. 4 and 5 another form of driven member or tool 65, which may be employed instead of the driven member 56. The driven member 65 includes a shear member 66 having a shank 67 with a central projection 68 for reception in the chuck members 33 and in the central opening 36 of the extension 16a. The shear member 66 includes also a blade 69, the axis of which is substantially at right angles to the shank 67.

The numeral 70 indicates an anvil member which includes a work-engaging portion 71 and a connecting portion 72. The connecting portion

72 is secured to the tool 11 by a first collar 73 which is releasably secured as by a bolt 74 in an annular recess 75 in the tool 11. A second collar 76 is releasably secured by a bolt 77 around the tool 11 adjacent the end thereof.

As illustrated in Fig. 5, the work-engaging member 71 is provided with a surface 78 in substantial alignment with a surface 79 of the blade 69, so that, as the blade 69 is reciprocated, a sheet of metal or the like between the blade 69 and the work-engaging member 71 is subjected to shear. If desired, the shear member 66 and anvil member 70 may be of such dimensions and the amplitude of movement of the shear member 66 of such magnitude that the surfaces 78 and 79 not only approach, but overlap each other at the end of the stroke of the blade 69, although such overlapping relationship is not necessary in order to accomplish the shearing action. The movement of the shear member 66 is accomplished in the same manner and has the same advantages as described in connection with the driven member 56.

The portable tool of my invention is not limited to use as a saw or shearing member, for there may be substituted for the driven members 56 and 65 other driven members adapted for performing many kinds of cutting or other work, such as files, abrasive stones, punches, knives, mica splitting knives, hammers, peening tools, chisels, riveting tools, and the like. Driven members such as sanding, polishing, abrading tools, or the like may with advantage be driven with a reciprocating motion at right angles to or at any desired angle with the axis of the piston 16.

This may be accomplished by a variety of means, one of which is illustrated in Figs. 7 and 8, in which the numeral 35a indicates a shank similar to the shank 35 of the driven member 56 but provided at its outer end with a head 80 having in opposite faces slots 81 and 82 disposed in opposite angular relationship with the axis of the shank 35a. Each of the slots 81 and 82 is adapted for the reception of a pin 83. Each pin 83 is connected to a transverse member 84 to which is secured a driven member 85. The transverse members 84 are retained against movement longitudinally of the tool 11 by a yoke 86 secured to the tool 11 in any suitable manner, as for example, in the manner illustrated and described for the anvil member 70.

It will be seen that, as the shank 35a and head 80 are reciprocated longitudinally of the tool 11 in response to sound waves, the transverse members 84 and the driven members 85 which they carry are reciprocated transversely of such axis with an amplitude varying with the amplitude of longitudinal oscillation of the head 80 and with the angular relationship of the slots 81 and 82 with the axis of the shank 35a. By forming the slots 81 and 82 in opposed angular relationship, the driven members 85 are caused to move in opposite directions, so that the forces upon the head 80 and the tool 11 tending to cause movement of the tool transversely of its longitudinal axis are equal and opposed.

In the preferred embodiment of the invention, I prefer to control, from a position adjacent the tool 11, both the speed of the motor 54 and the operation of the reversible motor 63, thus respectively controlling the rate of sonic impulses and the stroke of the piston 47. Fig. 9 shows very diagrammatically one method of accomplishing this, illustrated for simplicity as being a system

particularly adapted to direct current operation, though it will be apparent that alternating current operation can be used by substitution of remote controls on the tool 11 capable of changing the speed of the motor 54 or operating the motor 63 selectively in either direction.

As illustrated in Fig. 1, a multiple contact switch 87 may be recessed in a rubber grip 88 of the handle 12 and connected to the reversible motor 63 by conductors in a cable 89 carried in a groove in the grip 88, and a variable resistance 90 may in a similar manner be installed in a recess in the grip 88 and connected to the motor 54 by conductors in a cable 91 likewise positioned in a groove in the grip 88.

Referring particularly to Fig. 9, the multiple contact switch 87 is shown as including an arm 92 formed of insulating material and pivoted at 93, the free end of this arm forming or being connected to a thumb control permitting it to be moved in either direction, as indicated by the double-headed arrow 94. This arm 92 carries a main contact 95 connected by conductor 96 to one terminal of the motor 63. The contact 95 is adapted to engage selectively contacts 98 and 99, which are electrically connected together and connected by conductor 100 to a conductor 101 of the incoming line, the other conductor of this line being indicated by the numeral 102 and including a main control switch 103. The conductor 102 is connected to the other terminal of the motor 63. Correspondingly, movement of the arm 92 in either direction will close a circuit from the conductor 101 through the conductor 100, one or the other of the contacts 98, 99, the conductor 96, and the armature of the motor 63, thus completing the circuit to the conductor 102 when the main switch 103 is closed.

Merely as representative of one method of reversal of the motor 63, I have shown this motor as including opposite-wound field windings 104 and 105 connected together and to the conductor 96 by a conductor 106. The remaining terminal of the winding 104 is connected by a conductor 107 to a contact 108, while the remaining terminal of the winding 105 is connected by conductor 109 to a contact 110. The windings 104 and 105 are oppositely wound so that selective energization will operate the motor 63 in one or the other direction. The arm 92 carries a contact 111 connected by conductor 112 to the line conductor 102. If the arm 92 is moved to bring the contacts 108 and 111 into engagement, current will flow in parallel with the armature of the motor 63 to traverse the field winding 104. This current will flow through conductor 106 through the field winding 104, the conductor 107, the contacts 108, 111, and the conductor 112.

Similarly, if the arm 92 is moved to bring the contacts 110, 111 into engagement, a similar circuit will be completed through the field winding 105. The arm 92 normally rests in a central position, with none of the circuit-closing contacts in engagement, until the operator desires to increase or decrease the stroke of the piston 47 of the sound-generating means. At this time, he moves the arm 92 to one position or the other and retains it in this position until the stroke is changed to the desired amount, whereupon release of the arm 92 will cause return to its central position. It should be understood that the switch elements are shown merely diagrammatically and that various types of compact switches can be employed in this connection.

To control the speed of the motor 54 and, correspondingly, the frequency of sonic impulses supplied to the sonic tool, I can employ any suitable speed-changing means for the motor 54. Fig. 9 shows in this connection a shunt-wound motor with an armature connected between line conductors 101 and 102 so as to be energized upon closing of the main switch 103. The field winding is indicated by the numeral 113, one terminal being directly connected to the armature and the other terminal being connected to a conductor 114 extending to one terminal of a variable resistance 90. The other terminal of this variable resistance is connected by a conductor 116 to the remaining armature terminal so that the field winding 113 is in series with the variable resistance 90 across the armature. The variable resistance 90 is preferably connected on the handle 12 of the tool 11, as illustrated in Fig. 1. By changing the variable resistance, the operator can change the speed of the motor 54. The conductors 96, 100, 107, 109, 112, 114, and 116 are preferably provided by cables 89 and 91, illustrated in Fig. 1.

In Fig. 10 is illustrated a connection 117 for translating the reciprocating motion of the piston 16 into rotary motion which may be oscillating or continuous. The connection includes a carriage member 118 which is connected to and supported by the tool body 13 in any suitable manner, such, for example, as employed for the anvil member 70. The carriage member 118 provides ways 119 in which a head 120 is mounted for sliding movement. The head 120 is reciprocated by a rod 121 which is clamped in the chuck 27 and has formed therein a cam slot 122 for the reception of a pin 123. The pin 123 is attached to one end of a crank 124, the other end of which is secured to a shaft 125 mounted for rotation in a bearing 126 supported by arms 127 attached to the carriage. The shaft is provided with a suitable chuck, not shown, for clamping a tool.

The amplitude of the piston 16 may be varied so that the shaft 125 is oscillated through as many degrees as desired or rotated continuously.

Whatever form of driven member is employed, its frequency of reciprocation can be readily varied to the desired value, and resonance within the liquid column can be established by varying the speed of the motor 54 through the motor control 55. Likewise the amplitude of movement of the driven member can be readily varied to the desired value while the tool is being actuated, by shifting the cone 50 along the shaft 51 by rotation of the hand-wheel 64 or by operation of the motor 63.

In all such uses of the tool of my invention there are attained the advantages of the transmission of a relatively large amount of power with a compact, light weight apparatus, the transmission of such power with a high degree of efficiency, the exertion of an increased pressure upon the driven element urging its movement automatically as resistance to such movement is increased, the utility of the tool in performing work in confined spaces, corners, and the like, the easy adaptability of the frequency and amplitude of reciprocation of the driven element to the desired values, and the movement of the driven element at extremely high speeds with simple harmonic motion.

While I have illustrated and described the sound wave generator as comprising a motor driven eccentric actuating a piston in a cylinder,

any suitable means of generating sound waves may be employed, such as a piezo-crystal or a plunger or diaphragm actuated by a magnetostriction bar or electromagnet energized by alternating current of the desired frequency, and, while I have described the tool of my invention as actuated by sound waves under conditions of resonance, when it is desired for any reason to move the driven member with random varying amplitudes, the frequency of vibration of the sound wave generator may be varied so that resonance does not exist.

While those embodiments of my invention hereinbefore illustrated and described are capable of performing the objects and providing the advantages primarily stated, there are various other embodiments of my invention likewise capable of performing the objects and providing the advantages stated, and I therefore wish my invention to be understood as not restricted to the specific embodiments of my invention hereinbefore described but as including all of the modifications thereof which come within the scope of the claims which follow.

I claim as my invention:

1. In a portable cutting tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; and a cutting tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column from said primary piston under conditions of resonance.

2. In a portable cutting tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; and a cutting tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column from said primary piston.

3. In a portable tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; and a tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves of substantially sine form transmitted through said liquid column from said primary piston.

4. In a portable tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; walls defining a capacitance chamber; flexible conduit

means connecting said cylinders to said chamber; a liquid column in said conduit means connecting said pistons and said chamber; and a tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column from said primary piston under conditions of resonance.

5. In a portable tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; a tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column from said primary piston under conditions of resonance; and a handle associated with said body coaxial with said tool.

6. In a portable tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; a tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column from said primary piston under conditions of resonance; and a handle so associated with said body that its axis is angularly related to the axis of said secondary piston.

7. In a portable tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; a tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column from said primary piston under conditions of resonance; and a handle adapted for connection to said body in various angular relationships.

8. In a portable tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders, said conduit means having a liquid passage of a cross-sectional area substantially equal to the cross-sectional area of said primary cylinder; a liquid column in said conduit means connecting said pistons; and a tool associated with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column from said primary piston under conditions of resonance.

9. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator; walls defining a capaci-

5 tance chamber; conduit means connecting said generator and said chamber; a driven member carried by said body and adapted for reciprocation relative thereto; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said driven member.

10. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator and having a capacitance chamber therein; flexible conduit means connecting said generator and said chamber; a driven member carried by said body and adapted for reciprocation relative thereto; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said driven member.

11. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator; walls defining a capacitance chamber; conduit means connecting said generator and said chamber; a driven member carried by said body and adapted for reciprocation relative thereto; a handle for said body; means adapted for securing said handle to said body in various angular relationships with said driven member; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said driven member.

12. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator and having a cylinder therein; walls defining a capacitance chamber communicating with said cylinder; a piston in said cylinder; conduit means connecting said generator and said chamber; a driven member connected to said piston and adapted for reciprocation therewith; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said piston.

13. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator and having a substantially spherical capacitance chamber therein and a cylinder communicating therewith; a piston in said cylinder; conduit means connecting said generator and said chamber; a driven member detachably connected to said piston and adapted for reciprocation therewith; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said piston.

14. In a portable tool, the combination of: a portable tool body; walls defining an enlarged chamber; a handle adapted for connection to said body in various angular relationships, said handle having a fluid passage therein for communication with said chamber; a sound wave generator remote from said body; conduit means connecting said generator to said passage in said handle; a fluid in said conduit means, said passage, and said chamber, said chamber acting to transmit sound waves as if originating from its center; and a tool carried by said body and adapted for reciprocation in response to sound waves transmitted through said fluid from said generator to said chamber.

15. In a portable tool, the combination of: a portable tool body having therein a substantially spherical chamber; a handle adapted for connection to said body in various angular relationships, said handle having a fluid passage therein for communication with said chamber; a sound wave generator remote from said body; conduit means connecting said generator to said passage in said handle; a fluid in said conduit means, said passage, and said chamber, said chamber acting

to transmit sound waves through said fluid as if originating at its center; a tool carried by said body and adapted for reciprocation in response to sound waves transmitted through said fluid from said generator to said chamber; and means associated with said body and resiliently resisting movement of said tool relative to said body.

16. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator; walls defining a capacitance chamber; conduit means connecting said generator and said chamber; a driven member carried by said body and adapted for reciprocation relative thereto; a fluid in said conduit means and said chamber in sound wave transmitting relationship with said driven member; and means adapted for varying the frequency and amplitude of the sound waves generated by said generator.

17. In a portable tool, the combination of: a primary cylinder; a primary piston reciprocable therein; drive means adapted for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and drive means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; a driven member connected with said secondary piston and adapted for reciprocation therewith in response to sound waves transmitted through said liquid column by the reciprocation of said primary piston; and control means associated with said drive means and adapted for varying the amplitude of movement of said primary piston.

18. In a portable tool, the combination of: a portable tool body having therein a fluid passage; a handle adapted for connection to said body in various angular relationships, said handle having a fluid passage therein for communication with said passage in said tool body; a sound wave generator remote from said body; conduit means connecting said generator to said passage in said handle; a fluid in said conduit means and said passages; a driven member carried by said body and adapted for reciprocation in response to sound waves transmitted through said fluid from said generator; and means associated with said generator for varying the frequency and amplitude of the sound waves generated thereby.

19. In a portable cutting tool, the combination of: a primary cylinder; a primary piston reciprocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; and a liquid column in said conduit means connecting said piston and adapted for transmitting sound waves from said primary piston to said secondary piston under conditions of resonance.

20. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator; walls defining a substantially spherical capacitance chamber; conduit means connecting said generator and said chamber; a piston carried by said body and adapted for reciprocation relative thereto; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said generator and said piston.

21. In a portable cutting tool, the combination of: a primary cylinder; a primary piston recip-

rocable therein; means for reciprocating said piston in said cylinder; a portable tool body remote from said cylinder, piston, and means and having a secondary cylinder therein; a secondary piston reciprocable in said secondary cylinder; flexible conduit means connecting said cylinders; a liquid column in said conduit means connecting said pistons; and control means associated with said tool body and operable by the tool operator for varying the frequency and amplitude of movement of said primary piston.

22. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator; walls defining a capacitance chamber; conduit means connecting said generator and said chamber; a piston carried by said body and adapted for reciprocation relative thereto; a fluid in said conduit means and said chamber in sound wave transmitting relationship with said generator and said piston; and control means carried by said tool body and adapted for varying the frequency and amplitude of the sound waves generated by said generator.

23. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator and having therein a cylinder; a piston in said cylinder; conduit means connecting said generator and said cylinder; a saw operably connected to said piston and adapted for reciprocation therewith; and a fluid in said conduit means and said cylinder in sound wave transmitting relationship with said generator and said piston.

24. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator and having therein a cylinder; a piston in said cylinder; conduit means connecting said generator and said piston; motion translating means operably connected to said piston and carried by said tool body and adapted for translating longitudinal reciprocatory motion of said piston into transverse reciprocatory motion; and a fluid in said conduit means and said cylinder in sound wave transmitting relationship with said piston and said generator.

25. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator and having therein a cylinder; a piston in said cylinder; conduit means connecting said generator and said piston; motion translating means operably connected to said piston and carried by said tool body and adapted for translating longitudinal reciprocatory motion of said piston into rotary motion; and a fluid in said conduit means and said cylinder in sound wave transmitting relationship with said piston and said generator.

26. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator and having a cylinder therein; a piston in said cylinder; conduit means connecting said generator and said chamber; a work supporting member so connected to said tool body as to be restrained against movement relative thereto; a shearing member operably connected to said piston and adapted for reciprocation therewith in shearing relationship with said work supporting member; and a fluid in said conduit means and said cylinder in sound wave transmitting relationship with said piston, whereby said shearing member is reciprocated in shearing relationship with said work supporting member.

27. In a tool, the combination of: a sound wave generator; a portable tool body; a movable mem-

ber associated with said tool body and adapted for reciprocation relative thereto; conduit means connecting said generator and said movable member; a capacitance chamber in said conduit means; a saw operably connected to said member; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said generator and said member.

28. In a tool, the combination of: a sound wave generator; a portable tool body; a movable member associated with said tool body and adapted for reciprocation relative thereto; conduit means connecting said generator and said movable member; a saw operably connected to said member; control means adjacent said tool body and adapted for varying a characteristic of the sound waves generated by said generator; and a fluid in said conduit means in sound wave transmitting relationship with said generator and said member.

29. In a tool, the combination of: a sound wave generator; a portable tool body; a movable member associated with said tool body and adapted for reciprocation relative thereto; conduit means connecting said generator and said movable member; a capacitance chamber in said conduit means; motion translating means operably connected to said member and associated with said tool body and adapted for translating longitudinal reciprocatory motion of said member into transverse motion; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said member and said generator.

30. In a tool, the combination of: a sound wave generator; a portable tool body; a movable member associated with said tool body and adapted for reciprocation relative thereto; conduit means connecting said generator and said movable member; motion translating means operably connected to said member and associated with said tool body and adapted for translating longitudinal reciprocatory motion of said member into transverse motion; control means adjacent said tool body and adapted for varying a characteristic of the sound waves generated by said generator; and a fluid in said conduit means in sound wave transmitting relationship with said member and said generator.

31. In a tool, the combination of: a sound wave generator; a portable tool body; a movable member associated with said tool body and adapted for reciprocation relative thereto; conduit means connecting said generator and said movable member; a capacitance chamber in said conduit means; motion translating means operably connected to said member and associated with said tool body and adapted for translating longitudinal reciprocatory motion of said member into rotary motion; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said member and said generator.

32. In a tool, the combination of: a sound wave generator; a portable tool body; a movable member associated with said tool body and adapted for reciprocation relative thereto; conduit means connecting said generator and said movable member; a capacitance chamber in said conduit means; a work supporting member so associated with said tool body as to be restrained against movement

relative thereto; a shearing member operably connected to said movable member and adapted for reciprocation therewith in shearing relationship with said work supporting member; and a fluid in said conduit means and said chamber in sound wave transmitting relationship with said movable member and said generator.

33. In a tool, the combination of: a sound wave generator; a portable tool body; a movable member associated with said tool body and adapted for reciprocation relative thereto; conduit means connecting said generator and said movable member; a work supporting member so associated with said tool body as to be restrained against movement relative thereto; a shearing member operably connected to said movable member and adapted for reciprocation therewith in shearing relationship with said work supporting member; control means adjacent said tool body and adapted for varying a characteristic of the sound waves generated by said generator; and a fluid in said conduit means in sound wave transmitting relationship with said movable member and said generator.

34. In a device of the character described, the combination of: a cam member eccentrically mounted for rotation and having circular outline varying in diameter longitudinally of said member; a driving member mounted for reciprocation responsive to the rotation of said cam member; a driven member remote from said driving member; conduit means connecting said driving and said driven members; a fluid in said conduit means in sound wave transmitting relationship with said driving and said driven members; means for rotating said cam member whereby sound waves are generated in said fluid; and means for inducing relative movement of said cam member and said driving member longitudinally of said cam member to vary the amplitude of the sound waves generated in said fluid.

35. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator; conduit means connecting said generator and said body; a driven member carried by said body and adapted for reciprocation relative thereto; a fluid in said conduit means in sound wave transmitting relationship with said driven member and said generator; and means operable from adjacent said tool body adapted for varying a characteristic of the sound waves generated by said generator.

36. In a portable tool, the combination of: a sound wave generator; a portable tool body remote from said generator; a driven member carried by said body and adapted for reciprocation relative thereto; flexible conduit means connecting said generator and said body; a fluid in said conduit means in sound wave transmitting relationship with said driven member and said generator; and reinforcing means associated with said conduit means and restraining said conduit means against radial and longitudinal deformation in response to sound waves in said fluid therein.

ALBERT G. BODINE, JR.