Jan. 29, 1963 A. E. DILLIARD ETAL 3,075,318

ABRASIVE DRILLING APPARATUS

Filed Sept. 28, 1960 3 Sheets-Sheet 1

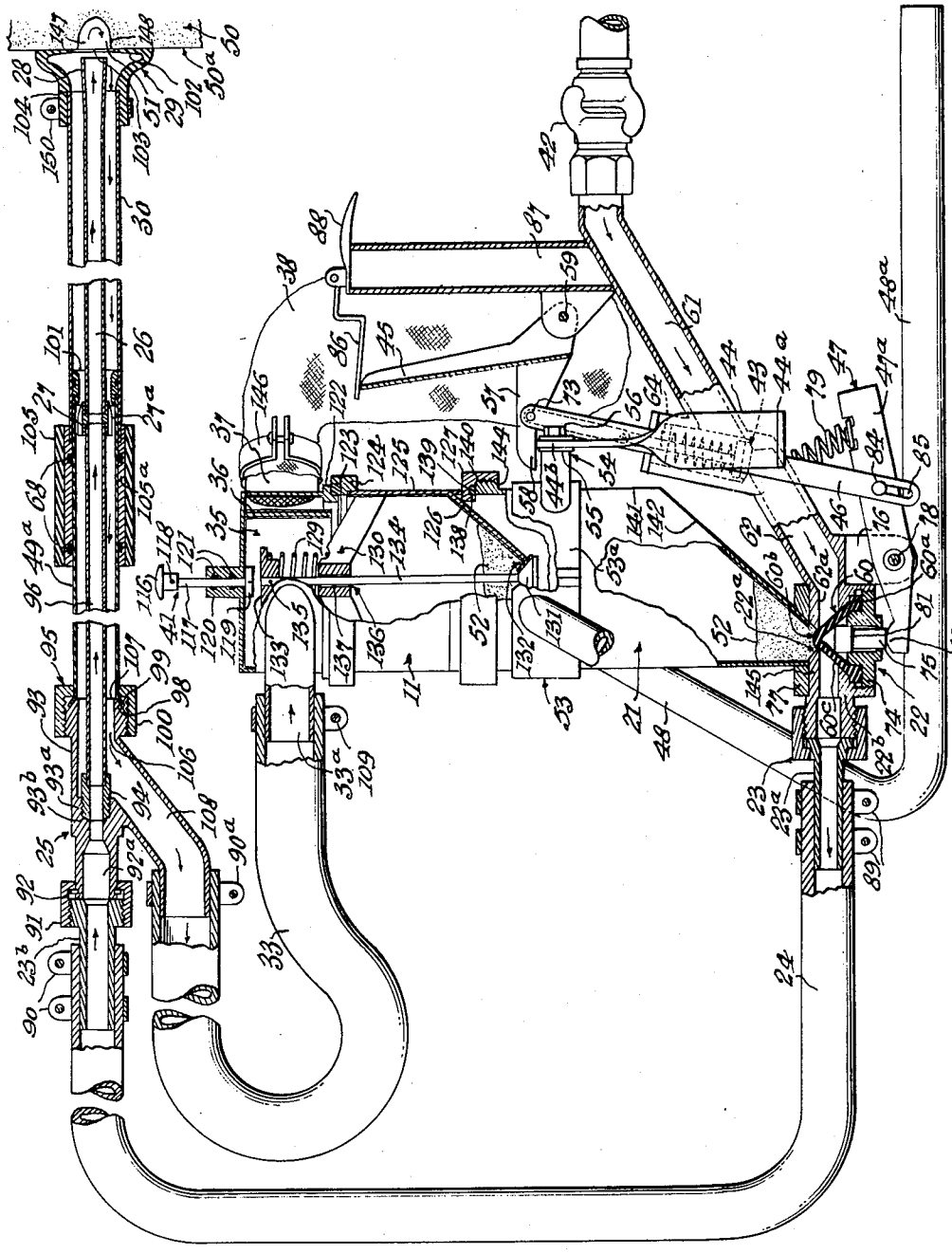


Fig. 1.

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ABRASIVE DRILLING APPARATUS

Filed Sept. 28, 1960 3 Sheets-Sheet 2

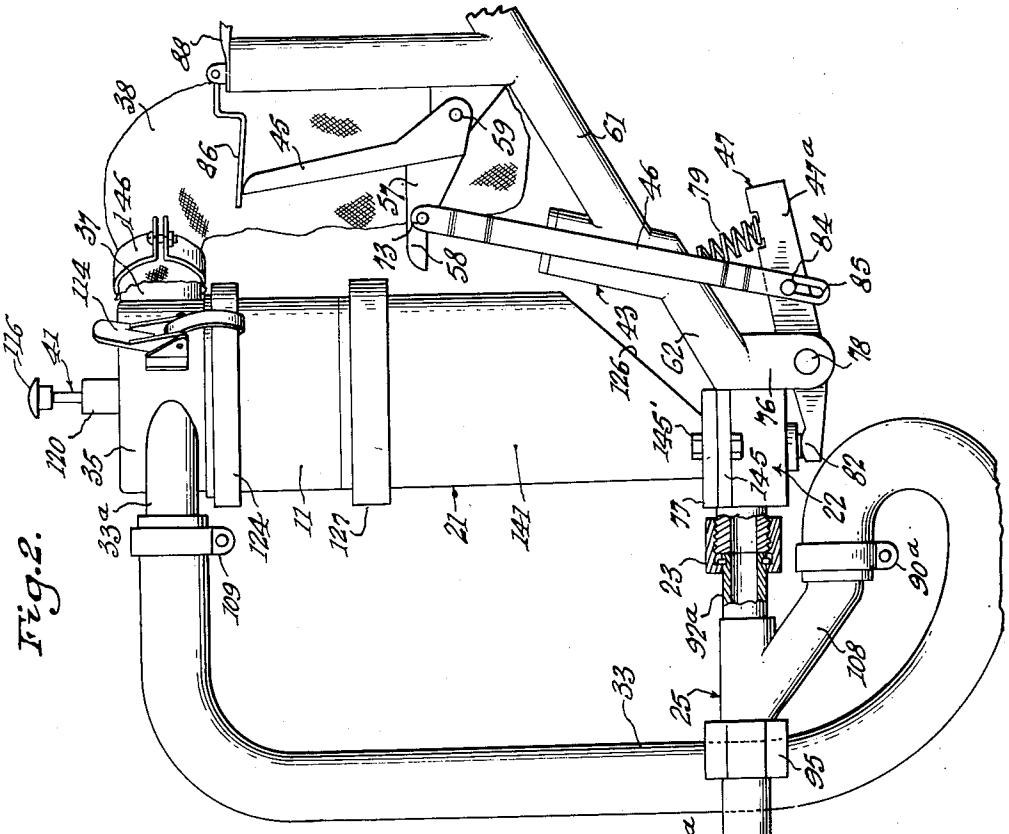


Fig. 2.

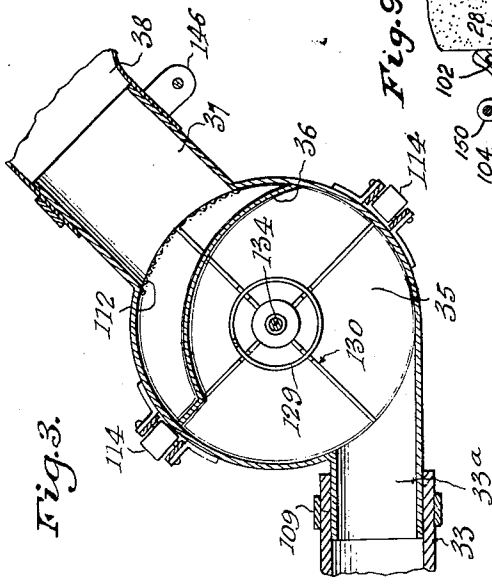


Fig. 3.

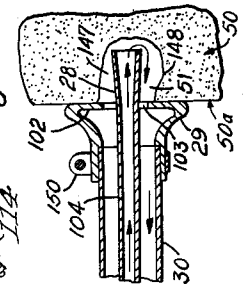


Fig. 9.

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ABRASIVE DRILLING APPARATUS

Filed Sept. 28, 1960 3 Sheets-Sheet 3

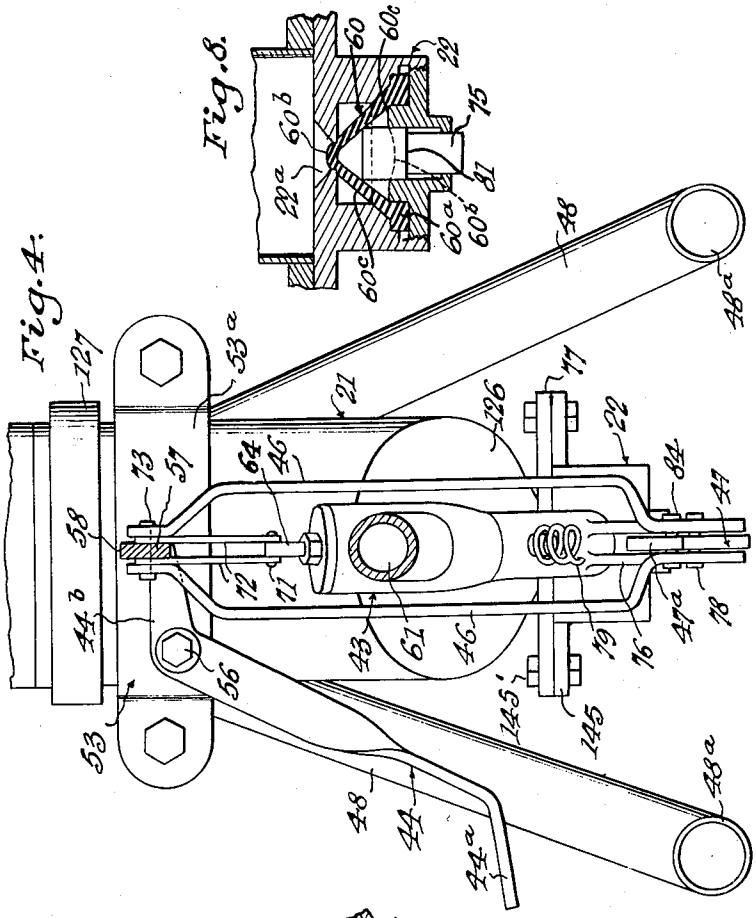


Fig. 8.

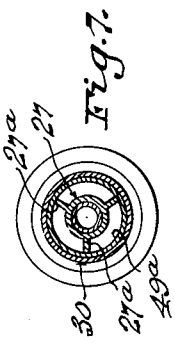


Fig. 7.

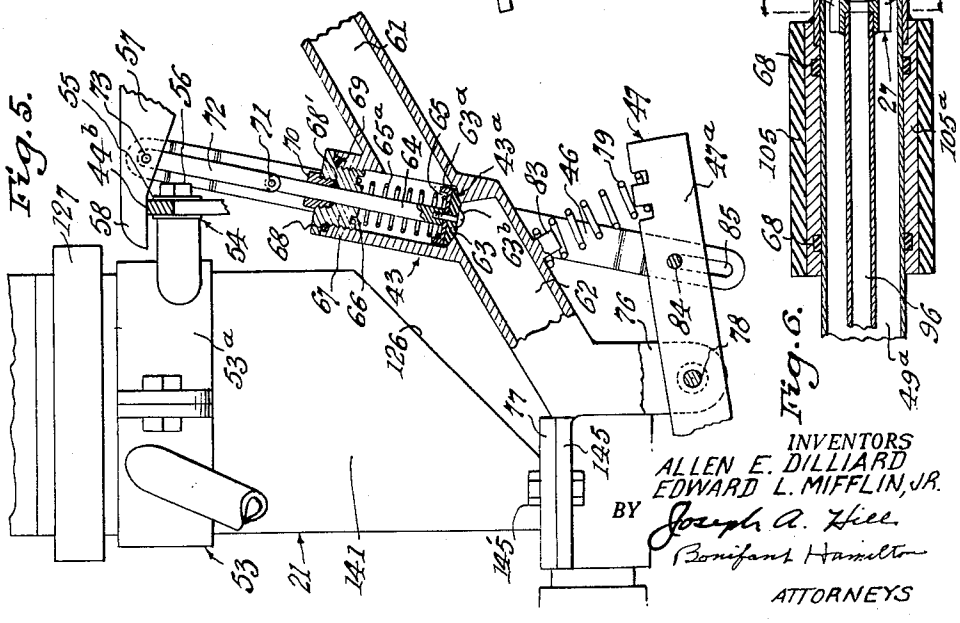


Fig. 5.

Fig. 6.

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3,075,318
ABRASIVE DRILLING APPARATUS

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Filed Sept. 28, 1960, Ser. No. 59,125
6 Claims. (Cl. 51—8)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to a novel method and apparatus for drilling holes in concrete, stone, glass, ceramic, brick, masonry and like materials by employing a high velocity stream of air or fluid containing abrasive particles and having suction retrieving means for separating the used abrasive particles and accumulated particles of drilled aggregate material for re-use during the piercing of a material with a drilled hole.

This invention provides a portable, lightweight, hand-held, or base mounted self-contained unit to drill holes in the afore-mentioned materials.

A primary object of this invention is to provide the capability of the device to drill holes in varied directions through a drilled material ranging from vertically downward through horizontal to vertically upward in position with respect to the drilled material.

Another object of this invention is to provide the capability of a machine for drilling holes in various materials with a minimum accumulation of dirt, dust, spoil or abrasive material in the work area and ambient atmosphere.

Another object of this invention is to provide the means whereby holes can be drilled without the high noise level generally attending such operations when accomplished by star-drills and hammer or pneumatic powered reciprocating drills or air hammers.

A further object is to drill holes without the mechanical vibrations that accompany conventional star-drills and hammer or pneumatic drills.

Another object of this invention is to provide an abrasive and air blasting cleaning and drilling system embodying adjustable nonvibratory gun means, flexible hood means for sealably contacting the work area of a material while enclosing said gun means; and aggregate material recovery means communicating with said hood means and separating means for automatic re-use of said abrasive means.

Another object of this invention is to provide a sandblasting equipment comprising in a single unit a closed supply and recovery system having the capability of instantly starting and stopping when used for either cleaning or drilling purposes.

Still another object of this invention is to drill holes to at least a depth of fifty or more diameters in the aforementioned materials.

Another object of this invention is to provide mutually cooperating air valve means and grit dispensing valve means whereby, the operator may actuate both valves simultaneously in different modes of operation by one control means, for example, only air may be passed through the device for cleaning purposes and/or the air and grit may be intermixed and dispensed by gun under pressure during a combined cleaning or drilling operation.

Another object of this invention is to provide a pneumatic sandblasting apparatus which employs nozzle blasting velocities of supersonic speed for cutting action during drilling operation.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows,

taken together with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

FIG. 1 is a view of the general assembly of the apparatus being applied to a vertical masonry wall, in which the drawing is sectionalized where necessary to expose internal working parts of the apparatus including a sectionalized portion of the wall of material being drilled by the apparatus to more fully show the mode of operation of the invention;

FIG. 2 shows a modified version of the apparatus arranged as a hand-held tool in which the grit and air valves are manually controlled during drilling operations;

FIG. 3 shows a sectional view in plan of the upper portion of the separating chamber of the invention;

FIG. 4 shows an elevation view of the air and grit control valve interlock disclosing how the foot pedal is arranged to form a master control for both valves;

FIG. 5 shows a sectional view of the gas valve with external linkage connecting the grit and gas valves with the linkage as an interlock means;

FIG. 6 is an end and longitudinal sectional view taken of the telescoping coaxial coupling of the gun nozzle structure which concentrically supports the air and grit nozzle supply concentrically within the waste return tube of the invention;

FIG. 7 is a sectional view taken on the line 7—7 of FIG. 6;

FIG. 8 is an enlarged detail view of the grit valve of the drilling gun; and

FIG. 9 is an enlarged detail view of the nozzle advancing within the drilled workpiece.

In all figures of the drawings, similar reference characters indicate like parts.

Referring to FIGS. 1, 2 and 3, an abrasive drill embodying the principles of the invention is shown. The drill includes in general, a connection 42, to a compressed air or gas supply, not shown, grit supply chamber 21, grit dispensing valve 22, grit delivery tube connector 23, flexible delivery tube 24, a flow divider 25, a nozzle extension 26, nozzle coupling spacer 27, nozzle 28, air seal or hood 29, telescoping spoil and grit return tube 30, a stationary spoil and grit return tube 49*a*, a flow divider 25, flexible spoil and grit return tube 33, separating chamber inlet 33*a*, a separating chamber 35, separator chamber baffle 36, separator chamber outlet 37, spoil material collector bag 38, grit collector chamber 11, grit supply chamber filler valve 131, filler valve actuator 41, gas or air valve 43, gas valve foot control pedal 44, gas valve hand control lever 45, connecting link means 46, grit valve operating lever 47 and support means 48.

For purposes of this specification, "grit" is defined as any abrasive media normally used in so-called sandblasting whether it be of a metallic, artificial, natural or agricultural base regardless of size or shape. Also use of the word "air" is meant to include the use of gases, inert or otherwise, in those instances of application where air would be detrimental to the successful completion of a drilling operation.

In general use, the drilling gun is held up to and against the surface of the material 50 into which a hole 51 is to be drilled. The apparatus is then put in operation by opening the air valve 43 and grit valve 22. The flow of air entrains the grit 52 as it falls through orifice 22*a* of grit valve 22 and is delivered to the drilling gun by grit delivery tube 23*a*. The grit is then projected from the nozzle 28 of the drilling gun against the surface 50*a* of material 50 and after impinging upon surface 50*a*, the grit is again entrained along with material spalled from surface 50*a* into the return channel 30 of the drilling gun

and is carried to the grit separating chamber 35 by the grit, spoil and air return line 33.

Referring to the drawings in more detail, 50*a* indicates the surface of material 50 in which a hole 51 is to be drilled. This material may be glass, cement, concrete, ceramic, brick, stone or other material.

The apparatus as disclosed in FIGS. 1 and 4 is mounted on a light frame support 48 of aluminum or other suitable material comprised of two support skids 48*a*, a clamp 53 that grips and holds the support about the outside of the grit chamber 21, and a foot control lever 44 pivotally mounted on a stub shaft 54. Stub shaft 54 is rigidly fixed to the loose half 53*a* of clamp 53. Items 55 and 56 are washers and a nut, respectively, arranged to hold the foot control lever 44 on the stub shaft 54 and yet be free to rotate about stub shaft 54. The foot control lever 44 is located and so formed that the outer lower end 44*a* is approximately four inches above the floor and arranged to accommodate the toe of an operator's shoe. The inner and upper end 44*b* of the foot control lever 44 is arranged so as to engage the under side of toe 58 of the lower portion 57 of hand control lever 45. Thus, depressing the outer lower end 44*a* of the foot control lever 44 rotates lever 44 about stub shaft 54 elevating its inner, upper end 44*b* which in turn contacts the under side of toe 58 of hand control lever 45 causing the hand control lever 45 to rotate about the pivot 59. This rotation operates the air valve 43 and grit value 22 through suitable connecting linkages 46 and 72 and interlocking linkage connections 73 and 84.

Referring to FIGS. 4 and 5, the air valve 43 consists of an inlet air passage 61 and an outlet air passage 62 arranged parallel to each other and offset sufficiently to provide a valve seat 43*a* of a suitable size. This arrangement of the air passages and valve seat provides the most direct air passage and offers the least resistance and constriction of air flow through the valve and permits jet induction of abrasive particles into the air flow. Air valve 43 also consists of a disc face 63 of a rubber-like or semi-rigid plastic material, a valve disc 63*a*, a disc face screw 63*b*. The valve disc has a valve stem 64 and valve spring seat 65 to accommodate one end of valve spring 65*a*. The other end of valve spring 65*a* is seated in an annular groove 66 of valve bonnet 67 which is screwed into the valve body 43. To prevent air leakage at this point, a rubber O ring 68 is placed between the valve bonnet 67 and valve body 43 in a suitable seat 69 in valve body 43. The valve stem 64 passes through the valve bonnet 67 and a suitable packing gland 70. Here again a rubber O ring 68' is seated between the packing gland 70 and the valve bonnet 67 to prevent air leakage. Close to its upper end the valve stem 64 has a hole to receive a rivet or other suitable pivot such as a bolt or screw 71 to which a pair of connecting links 72 are connected. To join the valve stem 64 to the hand control lever 45, the upper ends of the connecting links 72 are connected to a pivot 73 located on the toe 58 of the hand control lever 45. The connecting links 72 are in effect motion translating links, that is, they convert the rotary motion of the hand control lever 45 into linear motion required to actuate the valve stem 64. Valve spring 65*a* is a compression type spring installed into the valve 43 with an initial compressive force sufficient to hold, and return, the valve disc 63*a* to the valve seat 43*a* and prevent air leakage through air valve 43.

Referring now to FIGS. 1 and 2, the outlet air passage 62 of air valve 43 proceeds to and through the grit valve 22 which is composed of diaphragm 60, a valve bonnet 74, a valve stem 75, an actuating lever 47 and an actuating lever support 76. Grit valve 22 also has a mounting flange 145, a grit entrance 22*a*, a coupling means 23, an actuating lever pivot 78 and a closing spring 79. The diaphragm 60 is provided with an annular shoulder 60*a* whose basic section is rectangular providing a simple clamping means when assembled into the valve body 22*b* and held in position by the valve bonnet 74. In its free position (when not under stress), see dotted outline FIG. 8, the diaphragm 60 has a heavier section at the center 60*b* than at the inner diameter 60*c* of the shoulder 60*a*. The ratio of these two thicknesses is related to the inside diameter of annular shoulder 60*a* and the distance from the bottom face 62*a* of the passage 62 to the grit entrance 23*a* so that in operation when the grit valve 22 is closed and the diaphragm 60 is extended across the passage, the section of diaphragm is approximately of equal thickness and is equally stressed throughout.

The valve stem 75 embodies a blunt pointed conical upper end to preclude penetration of diaphragm 60 as the valve stem 75 extends the diaphragm 60 to close grit entrance 22*a*. The lower end of the valve stem 75 is of a reduced diameter to provide a shoulder 81. Valve bonnet 74 is provided with two internal diameters to accommodate valve stem 75; one diameter accommodates the upper end of valve stem 75 and the second reduced diameter keeps the valve stem 75 from falling out of the grit valve 22 and provides means for holding the valve stem 75 in proper alignment when it is pushed upward by the actuating lever 47.

The actuating lever 47 consists of a bearing end 82, a pivot bearing 78, a projection 47*a* which provides a means of holding the closing spring 79. Closing spring 79 is a compression type spring installed with an initial compressive force great enough to extend the diaphragm across the air passage 62 and into the grit entrance 22*a*. The valve body 22*b* also has a projection 83 to provide a means of holding the upper end of the closing spring 79.

The shoulder 60*a* of the diaphragm 60 acts as the valve packing preventing air leakage around the valve bonnet 74 and also as an anchor for diaphragm 60. Diaphragm 60 in itself acts as a valve disc and as a seal to protect the moving parts of the valve from the abrasive effects of grit and/or spoil that has entered the system. A soft, elastic, nonporous, rubber-like, material will serve best for diaphragm 60.

FIG. 1 shows the diaphragm 60 in its extended position, closing the grit entrance 22*a*, and the remainder of the air passage 62 on both sides of diaphragm 60 always remains open to pass air. This feature is required to fulfill functions that will be more fully discussed hereinafter.

Referring to FIGS. 1, 4, and 5, the actuating lever 47 has an interlocking link pin 84, located approximately midway between the lever pivot 78 and the projection 47*a*, to which the interlock links 46 are slidably connected by virtue of the slotted recess 85. The upper end of the interlock links 46 and connecting links 72 are pivotally mounted to the toe 58 of the hand lever 45. The position of the slotted recess 85 is such that the hand lever 45 must have the air valve 43 approximately half open before the lower end of the slotted recess 85 engages the interlock link pin 84. Opening the air valve 43 to its full open position will then open the grit valve 22 to its fully open position. The interlock connecting links 72 between the air valve 43 and the grit valve 22 is required to provide a valving sequence of (open air valve-open grit valve) and (close grit valve-close air valve) that is necessary to clear both the lines and the hole being drilled of any residual grit or spoil.

A keeper 86 of lever 45 is pivotally attached to the upper end of the handgrip 87. The function of the keeper 86 is to hold the hand control lever 45 in such a position that both the air valve 43 and the grit valve 22 are in full open positions. Locking the hand control lever 45 in the manner shown relieves the operator of the constant strain of holding the lever 45 in the open position by hand. The appendage 88 attached to the uppermost end of the hand grip 87 is provided to transfer the weight of the apparatus, when the apparatus is used as a handheld tool, from the fingers and palm of the operator's hand to the back of the hand on the bridge formed between the thumb and index finger. This allows the op-

erator free use of his fingers to manipulate the hand control lever 45.

The grit delivery line 24 is connected to an adapter 23*a* and held thereto by clamps 89. The adapter 23*a* and the female shoulder nut 23 are components of the coupling means. The gun end of the grit delivery line 24 is coupled to the flow divider 25 with a coupling means consisting of clamps 90, a female shoulder nut 91 and an adapter 23*b*. A retaining ring 92 assembled to the flow divider 25 provides the clamping means for the female shoulder nut 91.

The drilling gun includes the flow divider 25, a nozzle extension coupling 93, a nozzle extension 96, a nozzle coupling 27, a nozzle 28, an air seal 29, the telescoping return tube 30, a stationary return tube 49*a*, and a return tube coupling 95.

Because of the unduly great length of nozzle extension 96 and nozzle 28 required to drill a hole and the flow resistance encountered therein, it is important that the air supply line 42, air valve 43, grit valve 22 and grit delivery line 24 be of such a size as to offer the least flow resistance within limits of the design.

The air and grit passage 92*a* of the flow divider 25 is reduced to the inside diameter of the nozzle extension 96. The female portion 93*a* of the nozzle extension coupling 93 is provided with a tapered seat 93*b* upon which the end of the threaded end 94 of the nozzle extension 96 seats to provide an air tight joint. The exit end of the nozzle extension 96 terminates in a coupling-spacer 27. The coupling-spacer 27 serves two functions: the first, as a coupling for the nozzle extension 96 and member 26 of nozzle 28; the second, as a spacer to hold the nozzle centrally in the stationary return tube 49*a*. To perform this second function, the coupling-spacer 27 is provided with three fins 27*a* equally spaced about the outer periphery of the coupling-spacer 27 and extending to the inner wall of stationary return tube 49*a*, see FIGS. 1, 6 and 7.

The nozzle extension 96 and nozzle 28 are abutted together within the coupling-spacer 27 so as to provide a joint that will provide smooth flow of air and grit.

The delivery end of nozzle 28 is flared outwardly to provide greater dispersion of the gas and grit particles and provide greater impinging velocity to abrasive cutting particles issuing between the greatest outside diameter of divergently expanded nozzle 28 and more immediate adjacent side walls of hole 51 during drilling operation. The air and grit velocities issuing from nozzle 28 during drilling operation may be either of sonic or supersonic velocities, as desired.

The air passage 92*a* of the flow divider 25, nozzle extension 96 and the nozzle 28, in combination provide a convergent-divergent nozzle where the nozzle extension 96 and the greater part of the nozzle 28 make up the throat portion.

The forward end of the flow divider 25 is provided with a taper 98 to accommodate the flared end 99 of the stationary return tube 49*a* and in combination with the female shoulder nut 100 provides a suitable airtight joint.

The forward end of the stationary return tube 49*a* telescopes in member 105*a*. Member 105*a* is welded to member 30 and is fitted with a rubber grommet 101 to prevent the end of the stationary return tube from damage due to the peening and abrading effect of the transported grit. The grommet 101 can be a soft rubber-like material cemented or bonded to the stationary return tube 49*a*.

The sliding or telescoping return tube 30 is comprised of an air seal 29, a hand grip 105, and O ring packing means 68. The air seal 29 is made of a medium soft rubber-like material, neoprene or other suitable material varying in thickness to provide the desired rigidity or flexibility where required. The annular lip 102 adjoining the mouth 103 is relatively thin in cross-section, but thickens progressively toward the outer limits of the air seal 29. A shoulder 104 is provided to prevent the telescoping return tube 30 from being pushed through the air seal 29 when the drilling gun is placed in position to drill a hole. The shoulder 104 also protects the telescoping return tube against damage due to grit abrasion or peening. The air seal 29 is attached to the telescoping return tube 30 by a suitable clamp means 150 or, it may be bonded or cemented thereto.

The air seal 29 is also a safety device in that it restricts and directs the returning grit, spoil and air into the return tubes 30 and 49*a* and prevents the scattering of grit, spoil and air about the work area.

The hand grip 105 in this instance is a rubber tube which is attached to 105*a* which is welded to return tube 30.

In operation, the operator places and pushes the air seal 29 against the surface 50 of the material to be drilled. Because the air seal 29 is flexible, it will conform to any surface irregularities present and form a seal. When the air pressure in the system builds up to the operating pressure, the annular lips 102 are forced to conform more closely (because of the varying degree of flexibility of the lips 102) to the surface 50*a* producing a greater sealing effect.

Because the grit, spoil and air are retrieved from the drilled hole under annular flow conditions it becomes necessary to convert the return annular flow to return solid stream flow. The flow divider 25 performs this function. The return flow passage 106 is annular at the entrance 107 and is converted to a solid stream passage by the branch 108 of divider 25. The grit, spoil and air return line 33 is fixed to the branch 108 of the flow divider 25 by a suitable clamp 90*a*. The terminal end of the return line 33 is secured to the entrance 33*a* of the separating chamber 35 by a suitable clamp 109.

Referring to FIGS. 1 and 3 the separating chamber 35 is comprised of an entrance 33*a*, a baffle 36, an exit screen 112, exit 37, catches 114 and a grit valve control 41. All internal surfaces of the separating chamber 35 are covered with a bonded rubber-like or similar material of a suitable thickness to reduce the noise level and the abrading effect of the grit and spoil.

The separating chamber 35 allows the air passing through to expand causing a reduced air velocity. The reduced air velocity allows the grit particles to drop into the grit collecting chamber 11 while the air and spoil flow around and under the baffle 36 and out the exit 37. The baffle 36 is provided to deflect the flight path of the grit and to absorb the energy of the transported grit. The exit screen 112 is provided to prevent the grit particles from passing through the exit into the air and spoil collector 38. The mesh size of the exit screen 112 is such that the grit is retained and air and light spoil are passed through.

The grit valve control 41 consists of a knob 116 fixed to a shaft 117 by a pin 118 and a pad 119. The shaft 117 slides in the gland 120 that is permanently fixed to the top side of the separating chamber 35. To make an air tight seal between the shaft 117 and gland 120 two O rings 121 are provided. The function of the grit valve control 41 will be described hereinafter.

The separating chamber 35 is held to the grit collecting chamber 11 by trunk catch means 114 diametrically opposed and fixed to the outer side of the separating chamber 35. The bottom edge 122 of the separating chamber 35 is shaped to receive an O ring 123 that is provided to effect an air seal when the separating chamber 35 is attached to the grit collecting chamber 11. The air and dust collector bag 38 offers very little resistance to air flow. The air pressure in the air and dust separator 38, the air pressure in separating chamber 35 and the grit collecting chamber 11 is just a bit greater than atmospheric pressure. Also, the air pressure in these three chambers is equal because they are interconnected.

Referring again to FIG. 1, the grit collecting chamber 11 receives the grit separated from the mixture of grit,

spoil and air delivered to the separating chamber 35 by the grit, spoil and air return line 33.

The grit collecting chamber 11 is comprised of an upper lip 124 shaped to receive the O ring gasket 123, a cylindrical side wall 125, a conical bottom 126, a coupling means 127, a grit valve 131, a grit valve spring 129 and a grit valve guide 130.

The underside of the upper lip 124 is shaped so as to accept the locking tongue of the trunk catch means 114.

The grit valve 131 is provided with a conical valve disc that has a soft, rubber-like material bonded to the conic surface to insure complete peripheral sealing when the valve 131 is drawn into the grit passage 132 by the grit valve spring 129. The grit valve spring 129 is a helically wound compression type spring that is installed between the grit valve guide 130 and grit valve biased keeper 133 with a compressive force great enough to seat the valve 131 into the grit passage 132 and prevent leakage of grit into the grit dispensing chamber 21 or air passage from the grit chamber 21 into the grit collecting chamber 11. The grit valve keeper 133 is fixed to the valve stem 134 by a pin 135. The clearance 136 between the valve stem 134 and the hole 137 in the valve guide 130 is large enough that grit particles will not lodge therein and prevent the valve from functioning properly.

The coupling means 127 is provided with a groove 138 to accommodate an O ring 139 and a female screw thread 140 to provide a high pressure air tight joint when the grit collecting chamber 11 is coupled to the grit dispensing chamber 21.

All internal surfaces of the grit collecting chamber 11 are covered with a bonded soft, rubber-like material of a suitable thickness to reduce noise level and to increase wear resistance.

Referring to FIGS. 1 and 4, the grit dispensing chamber 21 is comprised of a cylindrical body 141 with a diagonally placed plane bottom 142 terminating in a flange 77. The top of the cylindrical body 141 has a male screw thread 144 attached thereto that mates with the female screw thread 140 to provide a high pressure air tight joint. The flange 77 is attached to the flange 145 of the grit valve 22 with bolts 145'.

The spoil and air separator 38 is attached to the exit 37 of the separating chamber 35 by a suitable clamp 146. The spoil and air bag 38 is made of a filter cloth suitable to retain the light spoil without maintaining a back pressure detrimental to the drilling operation.

To convert the apparatus of FIG. 1 from a base mounted to a hand-held tool of FIG. 2, the female shoulder nuts 91 and 23 are unscrewed (one located at the flow divider 25, the other at the grit valve 22) and the adapter 23*b*, grit delivery line 24, and the adapter 23*a* are removed from the system. The flow divider 25 is then coupled to the grit valve 22 by the female shoulder nut 91 attached thereto. The grit, spoil and air return line 33 is replaced by a shorter length of the same size tubing 33. The frame support 48*a* is then removed from the grit chamber 21 to complete the conversion.

The hand-held apparatus has the advantage of having less overall weight and the disadvantage of limiting the angle at which a hole can be drilled to the range between approximately minus 45 degrees to plus 45 degrees from the horizontal.

In operation the grit chamber 21 must first be charged with grit and the apparatus then connected to a compressed air supply. By unlocking the trunk catches 114, the separating chamber 35 can be removed from the grit collecting chamber 11. The grit can then be placed in the grit collecting chamber 11 and the separating chamber 35 replaced and locked into position. By pushing down on the knob 116 of the grit valve control 41, the pad 119 comes in contact with grit valve keeper 133 and displaces the valve disc 131 downward opening the grit passage 132 allowing the grit to pass by gravity into grit dispensing chamber 21. The compressed air supply may be either from a high velocity turbine, an air compressor, the plant air system, charged gas cylinders or other suitable sources of supply.

The drilling gun is held at the hand grip 105 with one hand while, in the case of the base mounted apparatus, the other hand grasps the flow divider 25. The telescoping return tube 30 is then positioned so that the air seal 29 extends approximately 1¼ inch beyond the end of the nozzle 28. The dimension, here called the "stand-off" distance, will vary as to the diameter of the hole being drilled and is also dependent upon the diameter and angle of divergence of the nozzle. The air seal is then pressed against the surface of the material to be drilled. The operator then places a foot on the lower end 44*a* of the foot control lever 44 and depresses it to open the air valve 43 and the grit valve 22. Depressing the foot control lever 44 approximately halfway opens the air valve 43 and allows the grit valve 22 to remain closed. Thus air can be circulated through the apparatus without feeding grit.

When the grit and air valve 22 and grit charging valve 131 are open, the air pressure in the grit chamber 11 approaches the pressure of the grit delivery line 24. The grit is gravity fed into the grit delivery line at a rate determined by the distance that the diaphragm 60 of the grit valve 22 is moved from the grit entrance 22*a*. The grit is entrained in the air stream and passes through the grit delivery line 24, nozzle extension 96, nozzle 28, and is projected toward the surface of the material 50 to be drilled.

As the grit impinges upon the surface of the material 50, a cleavage or separation of particles from the base material 50 results, which is referred to as spoil.

The cutting compound of high velocity grit and gas after having passed to the surface of the material reverses its flow and passes over the outer edge of the nozzle 28 into the telescoping return tube 30. The air seal 29 prevents air leakage and dispersion of grit about the work area. When the grit bounces or ricochets off the material, it is re-entrained into the air stream. The spoil is also entrained in the air stream as it is cleaved from material 50.

The grit, spoil and air are transported through the telescoping return tube 30 and the stationary return tube 49*a* in an annular fashion to the flow divider 25. The flow divider 25 converts the annular flow into a solid stream flow by directing the air stream into the branch 108. The grit, spoil and air are then passed through the grit, spoil and air return line 33 and into the grit separating chamber 35 where the air is expanded to reduce the velocity of the flow of material to a point where the grit is dropped out of the air stream, but the light spoil is allowed to remain entrained in the air flow. The baffle 36, of the grit separating chamber 35 directs the air flow into a circular path causing a centrifugal reaction which also assists the grit to be separated from the spoil and air permitting the grit to be re-used over and over again after each cycle of the grit through the system.

The air flow then continues under and around the baffle 36 through the exit screen 112 and the exit 37 into the spoil collector bag 38 where a further expansion of the air takes place to reduce the velocity to a point where the spoil drops out of the flowing air. The filter cloth of the spoil collector bag 38 retains the light spoil particles as the air passes therethrough to the atmosphere.

Referring to FIGS. 1, 2, 3, 4 and 5, it can be seen that as the depth of the hole is increased the nozzle 28 is advanced into the hole. During nozzle advancement the "stand-off" distance is maintained. The "stand-off" distance is determined by the angle of divergence of the nozzle 28 and the diameter of the hole. The rate of nozzle advancement is dependent upon the hardness and/or composition of the material being drilled, the type of grit being used, the diameter of the hole and the amount of grit impinging upon the surface per unit time. The nozzle 28

is advanced by pushing the stationary return tube 49*a* into the telescoping return tube 30. After the nozzle 28 enters the hole the annular space 147 between the outside of the nozzle 28 and the wall 143 of hole 51 becomes the grit spoil and air return line.

The depth of the hole is limited to the amount of telescoping action between the stationary return tube 49*a* and the telescoping return tube 30, when using nozzle 28. To drill a hole to a depth greater than the capabilities provided by the telescoping action, the nozzle 28 can be replaced by a nozzle equivalent in length to the length of the nozzle 28 plus the length of necessary telescoping action. To replace nozzles, the nozzle 28 is removed from the nozzle coupling 27 and the longer nozzle is inserted therein. Hole 51 of any depth can be drilled by utilizing replacement nozzles of incremental lengths.

To stop the drilling operation the operator relieves the applied foot pressure on the end 44*a* of the foot control lever 44 which in turn allows the valve spring 65 to start closing the air valve 43. The interlocking links 72 are thus displaced downwardly allowing the actuating lever 47 to rotate about its pivot 78, as the closing spring 79 takes over, closing the grit valve 22 by extending the diaphragm 60 across the air passage 62 into the grit entrance 22*a*. With the grit valve 22 closed the operator then allows the air valve 43 to remain open for one or two seconds which permits a flow of air only which clears the lines and hole of any grit or spoil. After the air valve 43 is closed the nozzle 28 can then be drawn from the hole without dispersing grit, spoil or compressed air about the work area.

It is important that the hole be free of grit before attempting to withdraw the nozzle 28 from the hole, otherwise, the grit could pile up on the backside of the flared end of the nozzle 28 and prevent withdrawal or cause distribution of grit and spoil about the work area.

From the foregoing it can be seen that the method and apparatus make possible a light weight, safe, small, drilling tool that can be used in confined spaces, closed room, outdoors, around delicate machinery, with complete control over the materials and waste involved, minimum audible or mechanical noise vibrations and a high degree of cleanliness.

Although particular embodiments of this invention have been shown and described, it will be understood, that such disclosure is by way of illustration only and that various changes and modifications may be made within the contemplation of this new apparatus and method without departing from the broader aspects of this invention as more specifically covered by the following appended claims.

We claim:

1. An abrasive gun adapted for drilling various materials comprising a telescoping divergent discharge nozzle means adapted to be advanced within a hole being drilled in a workpiece, a compressed air supply means, independent air valve means controlling said air supply means, a grit supply means; common unitary air bleeding and grit dispensing diaphragm valve means, manually actuated interlock means interconnecting and sequentially controlling said air and grit valve means, a flexible hollow hood means adapted to sealably inclose a drilled material surface, said nozzle means and a work area; coaxial conduit means adapted to communicate concentrically with said air and grit supply means and said nozzle means, said coaxial conduit means including a concentric retrieving conduit passage surrounding said grit supply means and communicating with said hood for collecting abrasive aggregate; and recovery means connected to said hood and said retrieving conduit to retrieve said abrasive material.

2. An abrading equipment comprising in combination, a telescoping jet nozzle for dispensing at high velocity intermixed compressed air and grit to drill a surface; said nozzle being adapted to be advanced within said drilled surface; a flexible hollow hood adapted to surround said nozzle and to be sealably positioned against a surface; grit supply means, and compressed air supply means communicating with said nozzle; air control valve means interconnected between said air supply and said nozzle; aggregate material retrieving means including separating means and conduit means communicating with said hood interior and concentrically surrounding said nozzle and cooperatively connected to said grit supply for re-use of said grit means; common unitary air bleeding and grit dispensing diaphragm valve means in said air and grit supply means; and an interlock linkage means operably connected to said common valve means and said air control valve means to sequentially control said grit and air supply means.

3. An abrasion drilling gun adapted for drilling various materials comprising a flexible hollow hood, a nozzle adapted to drill a surface and advance within a workpiece; a compressed air supply means including conduit means communicating with said hood, air control valve means in said conduit means, abrasive supply means for intermixing grit with said air supply means, common air bleeding and grit dispensing diaphragm valve means for said air and abrasive supply means interconnected to said air control valve by an interlock delay linkage means for sequential operation of said air and abrasive supply means, a conduit connected to said hood, said nozzle operatively connected to said air and abrasive supply and said hood, flexible joint means for adjustably mounting said nozzle concentrically within said hood, said nozzle being adapted to discharge abrasive material at high velocities against a surface being drilled within said hood forming aggregate waste therein, said hood having aperture means for communicating with a waste recovery conduit system adapted to recover and re-use said abrasive material, and centrifugal recovery container means connected to said system to collect aggregate waste for disposal during operation.

4. In combination, a portable self-contained nonvibratory pneumatic apparatus for drilling various thicknesses of materials comprising an inclosed air blasted abrasive material for drilling a surface of various materials; an adjustable and telescoping divergent discharge nozzle means for directing the abrasive against the surface to drill a workpiece; said nozzle being adapted to advance within said workpiece during drilling; a flexible hood means sealably inclosing said nozzle having an open end to inclose the surface; a telescoping coaxial concentric reclaiming and supply conduit means respectively cooperatively connected to said hood for directing the abrasive at the surface to pierce an aperture therethrough in various positions with relation to the surface and forming aggregate waste within said hood means; said hood means sealably inclosing said nozzle and having an open base to sealably inclose the surface; valved abrasive supply means communicating with said hood; pressurized air supply means including air valve means communicating with said hood means; a first conduit operably connecting said grit and air supply to said nozzle including an air bleeding and grit dispensing diaphragm valve means for intermixed high velocity fluid flow within said nozzle; a second conduit concentrically surrounding said first conduit and communicating with said hood means for reclaiming said aggregate waste; expanding air jet means in said nozzle producing an impelling force in said nozzle means whereby abrasive aggregate waste will be caused to flow in said second conduit; aggregate separating means and abrasive reclaiming means cooperatively interconnected by a bypass conduit system which redirects the flow of aggregate waste away from said hood into an abrasive recycling stage of operation for re-use of the abrasive; and a unitary interlock linkage means for interconnecting and cooperatively controlling said air valve means and said

diaphragm valve means permitting sequential control thereof and substantially instantaneously starting and stopping of the drilling action.

5. An apparatus for drilling a workpiece by continuous abrasive blasting comprising, in combination, an air supply means including air control valve means therein, a container for receiving and storing drilling abrasive and waste material and means for dispensing an abrasive material; abrasive supply conduit means; abrasive return conduit means; common unitary continuous air bleeding and diaphragm valve means for dispensing abrasive and sequentially admitting compressed air and entrained abrasive from said container to a supply abrasive conduit; flexible hood means adapted for sealable contact with a workpiece to be drilled; a telescoping blasting nozzle adjustably and sealably extending within said hood, said blasting nozzle being adapted for directing said abrasive material within the surface of a workpiece and to advance within a drilled workpiece; an adjustable reciprocating recovery nozzle concentrically and coaxially surrounding said drilling nozzle in fixed relationship with said drilling nozzle and extending externally of said hood for recovering expended abrasive particles in the drilling work area; a flow divider means having Y-conduit connections adapted to connect said recovery nozzle by said abrasive return conduit to the separating chamber of said container; and connecting conduit fitting means for connecting said drilling nozzle by said abrasive supply conduit to said unitary supply valve; and manual actuating interlock linkage means for sequentially interconnecting said air and abrasive valve dispensing means to insure instantaneous operation and nonclogging of the apparatus during operation.

6. An apparatus for drilling a workpiece by continuous abrasive blasting comprising, in combination, a telescoping blasting and drilling nozzle means adapted to advance within a hole being drilled in a workpiece; a container for receiving, storing and dispensing an abrasive material having a separating chamber and an abrasive supply chamber; compressed air supply conduit means including an air control valve; abrasive supply conduit means; abrasive return conduit means; common air bleeding and abrasive dispensing diaphragm valve means for sequentially admitting compressed air and entrained abrasive from said container to said drilling nozzle; flexible hood means adapted for sealable contact with a workpiece to be drilled; said telescoping blasting and drilling nozzle means adjustably and sealably extending within said hood, said drilling nozzle being adapted for directing said abrasive material at the surface of a workpiece; an adjustable reciprocating abrasive recovery conduit means concentrically and coaxially surrounding and being fixedly secured to said drilling nozzle and extending coextensive with said drilling nozzle externally of said hood for recovering expended abrasive particles in the drilling work area; a flow divider means consisting of a Y-conduit fitting including connections adapted to connect said abrasive recovery nozzle by said abrasive return conduit to the separating chamber of said container, and connecting conduit fitting means for connecting said drilling nozzle by said abrasive supply conduit to said abrasive diaphragm valve and said compressed air control valve; a spoil collector means adapted to be connected to the separating chamber of said container; and manual actuating interlock linkage means interconnecting said abrasive valve and said air valve adapted to actuate said abrasive dispensing valve for instantaneous start or stop operation of said apparatus.

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