

Sept. 7, 1943.

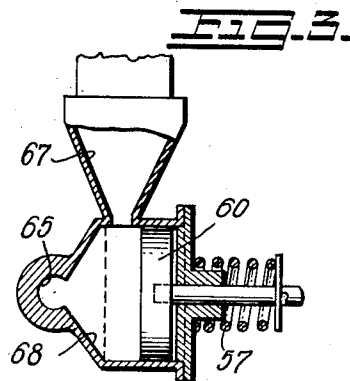
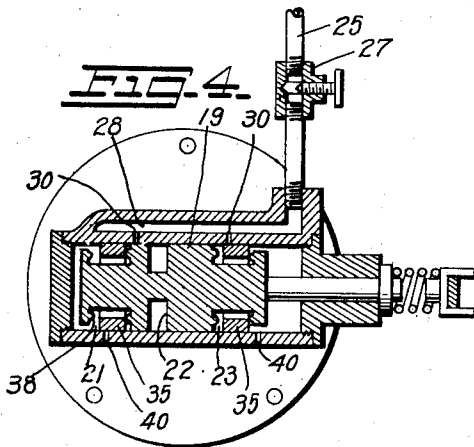
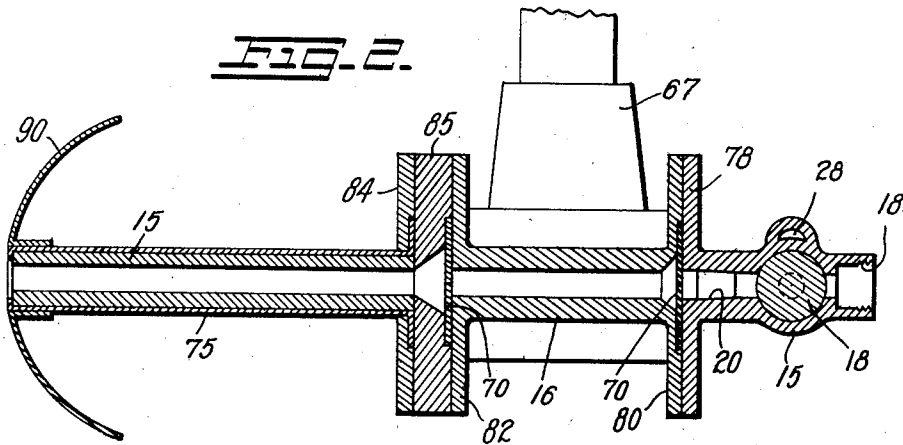
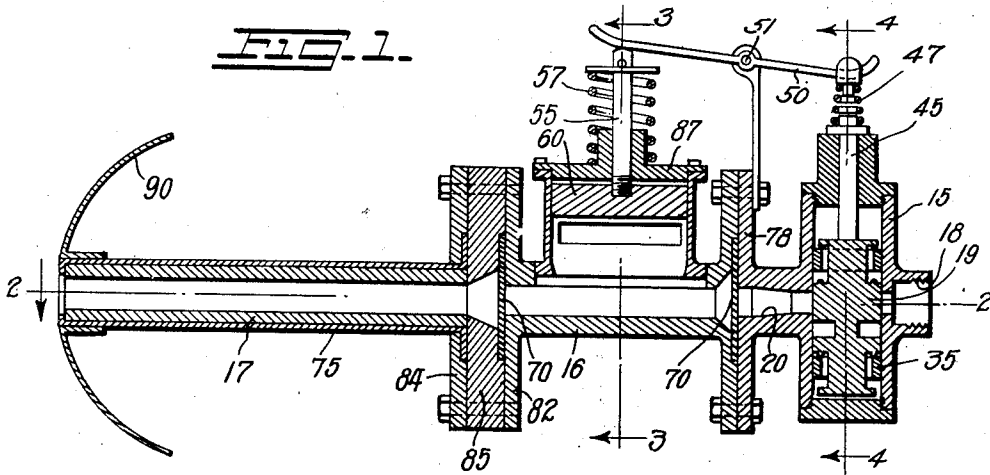
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2,328,581

ABRASIVE PROJECTING APPARATUS

Filed Nov. 8, 1940

4 Sheets-Sheet 1



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ABRASIVE PROJECTING APPARATUS

Filed Nov. 8, 1940

4 Sheets-Sheet 2



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ABRASIVE PROJECTING APPARATUS

Filed Nov. 8, 1940

4 Sheets-Sheet 3

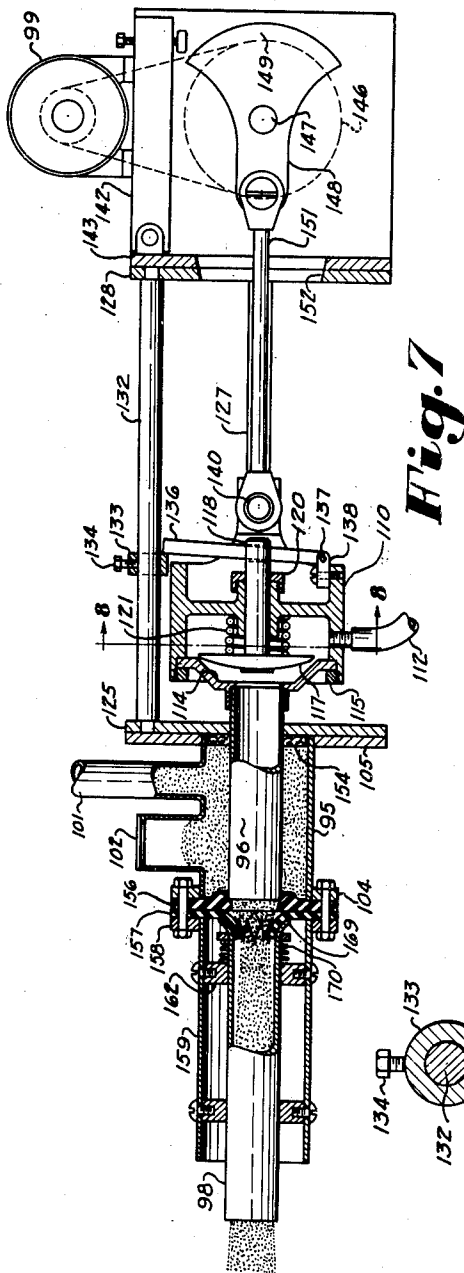


Fig. 7

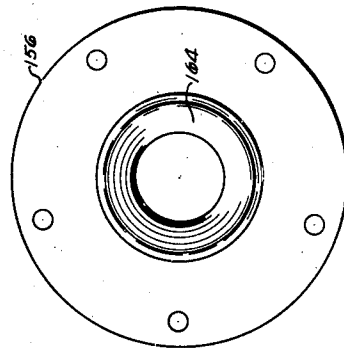


Fig. 10

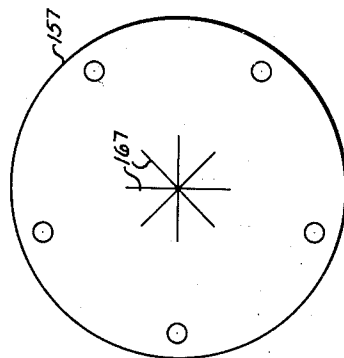


Fig. 9

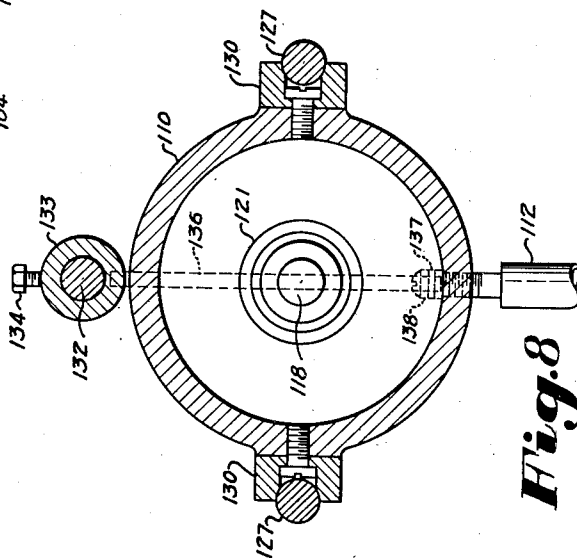


Fig. 8

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4 Sheets-Sheet 4

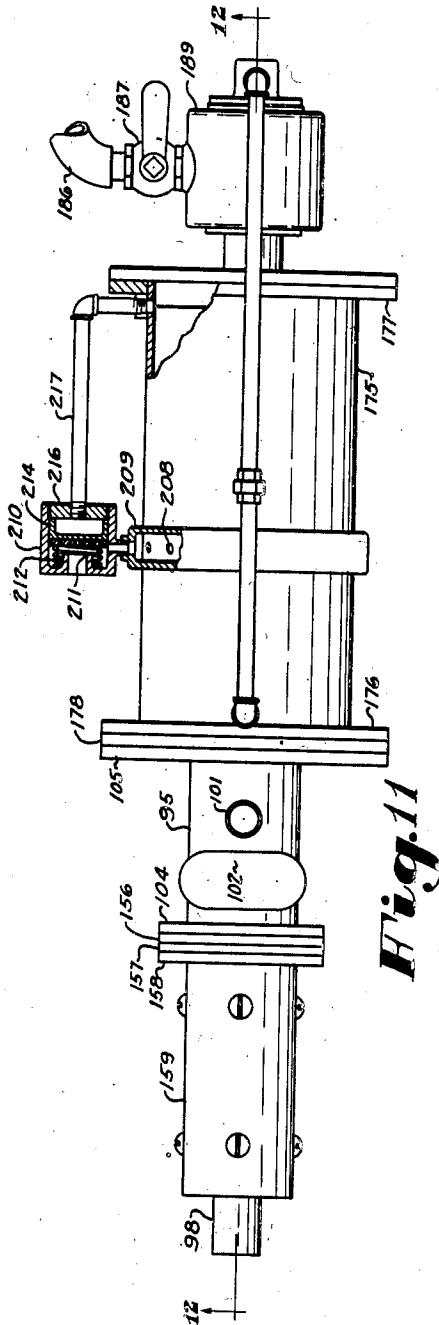


Fig. 11

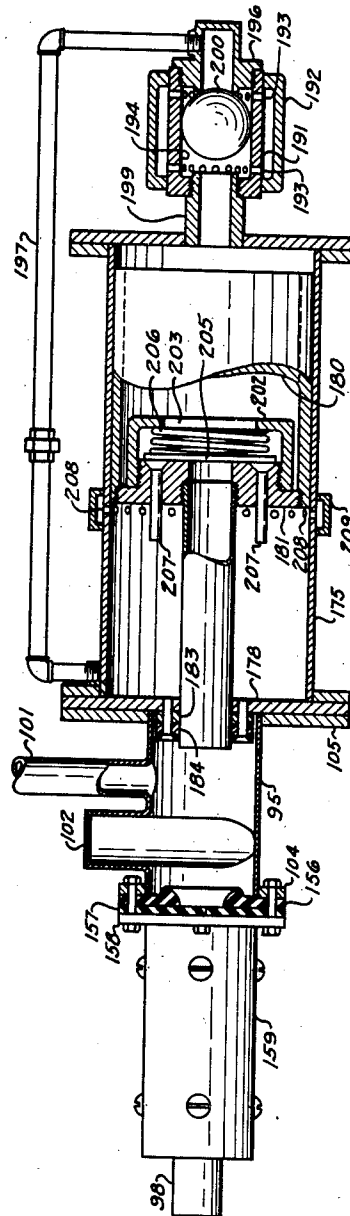


Fig. 12

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UNITED STATES PATENT OFFICE

2,328,581

ABRASIVE PROJECTING APPARATUS

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Application November 8, 1940, Serial No. 364,931

25 Claims. (Cl. 51—8)

This application is a continuation in part of my co-pending application Serial No. 166,082, for "Abrasive projecting apparatus," filed September 28, 1937.

The present invention, relating as indicated, to a method of and apparatus for projecting abrasives, is more particularly directed to a method of and apparatus for projecting successive charges of abrasive at a high speed by means of fluid pressure released in small increments or charges to reduce the consumption of the same and produce explosive-like propulsion of the abrasive charges against the work. A further object of the invention is the provision of a method and apparatus that will reduce the cost of abrasive cleaning and increase the efficiency. Another object is the provision of a simple and inexpensive mechanism for carrying out the method referred to above and one that will have a minimum of working parts and greatly reduce the destructive and rapid wear of the abrasive on the propelling mechanism.

The cleaning of castings is today carried out by three methods, (1) tumbling, (2) propelling abrasive against them by feeding the same into an air blast and (3) directing abrasive against them by a centrifugal wheel. Tumbling is slow and applicable only to certain types of castings. An air blast is extremely wasteful of air and a relatively small amount of abrasive can be carried by the air stream. Centrifugal wheels are a development, commercially at least, of the last few years and while very effective are expensive to maintain because of the high wear on the blades and means for feeding abrasive to the blades. In addition the propulsion speed of abrasive thrown by a wheel must be kept much lower than from an air blast to prevent excessive wear on the blades and to avoid still other difficulties in operation.

The present invention provides a method and apparatus the cleaning operation of which is more efficient than any of those now in use.

As will be hereinafter more particularly explained, my projecting apparatus has been designed to be operable entirely by means of a single supply of compressed air, which acts also as the propelling agency for the slugs of abrasive. Other features and objects of my invention will appear from the detailed description following as construed in the light of the drawings appended hereto. The novel features of the invention will be summarized in the claims.

Referring now to the drawings:

Fig. 1 is a longitudinal cross-section of one form of my abrasive projecting gun;

Fig. 2 is a longitudinal section along the lines indicated by 2—2, Fig. 1;

Fig. 3 is a transverse section as indicated by the lines 3—3 of Fig. 1;

Fig. 4 is a transverse section as indicated by the lines 4—4 of Fig. 1;

Fig. 5 is a side elevation of an alternative form of my abrasive projecting gun;

Fig. 6 is a section taken substantially along the line 6—6 of Fig. 5;

Fig. 7 is a partially sectional view similar to Fig. 5 but with the device seen therein in another step of operation;

Fig. 8 is a section taken on the line 8—8 of Fig. 7;

Fig. 9 is a side elevation of one of the elements of the device seen in Fig. 5;

Fig. 10 is a side view of another element of the device seen in Fig. 5;

Fig. 11 is a side elevation partially in section of another alternative form of my abrasive projecting gun; and

Fig. 12 is a fragmentary cross-sectional view taken substantially on the line 12—12 of Fig. 11.

In general, my invention may be said to comprise three parts; one, a suitable form of the air metering valve 15; two, the feed valve for abrasive 16; and three, the barrel mechanism 17. These parts are bolted together to form a continuous unit and supplied with compressed air which not only furnishes the propelling force for the abrasive but controls the operation of the device.

Air is admitted to the metering chamber through a compressed air nipple 18 and thence metered by the reciprocating piston 19, after which it passes through the chamber 20 into contact with the abrasive.

In operation the metering piston 19 lies horizontally, but for convenience is described as it appears in Fig. 1. It is circular in cross-section and is provided with three annular recesses 21, 22 and 23 (Figs. 1 and 4). The recess 22, when positioned in line with the nipple 18 and the passage 20 permits passage of the air column to the abrasive feed chamber. The feeding of air is cut off when the annular opening 22 occupies the position shown in Fig. 1, at which time it is out of line with the aforesaid openings. Piston 19 is reciprocally carried in a chamber of the casing of the valve 15 and normally retained in the position in Fig. 1 by suitable spring mechanism hereafter to be described.

Reciprocation of the piston 19 is controlled by an auxiliary line 25 which meets the main line at a convenient distance away from the device. In practice, I have found six feet to be a good dis-

tance as this prevents surging in the main feed line from being transferred to the auxiliary line 25 and affecting the control of the piston 19. A needle valve 27 is inserted in the auxiliary line to control the amount of air passing there-through. As the auxiliary air column leaves the needle air valve 27, it enters a jacket 23 integral with the chamber of the valve 15, as shown in Fig. 4. Openings 30 lead from the jacket 23 to the interior of the piston chamber. Valve rings 25 carried slidably in the openings 21 and 23 serve to open and close the intake ports 30. Abutting pins 38 carried by the piston 19 prevent the valve rings 35 from forming a seal against the flanges acting to limit their movement.

When the piston is in the position shown in Fig. 1 the lowermost valve ring 35 has been pushed down by the upper flange of the opening 21 to a position opening the adjacent intake ports 30. Air rushes through the ports from the auxiliary line 25 filling the chamber formed adjacent the recess 21 and as a suitable pressure is built up, forces the piston 19 upwardly (as shown in this figure) to bring the annular opening 22 in line with the nipple 18 and the passage 20. At this time a charge of air under a pressure of approximately 60 to 100 pounds per square inch gauge rushes through the metering valve into the abrasive feed chamber to propel the abrasive as hereafter described.

The action of the piston 19 in opening the port 22 moves the lowermost valve ring 35 (as appears in Fig. 1, upwardly) to close the intake ports 30 and open exhaust parts 40 discharging to the atmosphere. Simultaneously the upper valve ring 35 has closed the upper exhaust ports 40 and opened the upper intake ports 30. Air then enters the upper intake ports from the auxiliary line 25 and in the manner already described forces the piston back down into the position shown in Fig. 1, closing the main air feed line to the abrasive feed chamber. As the piston 19 is forced downwardly to this position, the valve rings 35 position themselves to again force the piston 19 upwardly repeating the operation of feeding air intermittently to the abrasive chamber.

Each time the piston 19 is forced upwardly in Fig. 1, mechanism is operated to feed a corresponding amount of abrasive into position to be thrown through the barrel 17. This mechanism is best shown in Figs. 1, 2 and 3. As there shown upward movement of the piston 19 forces the valve pin 45 upwardly against a stiff compression spring 47 which, in turn, rocks the rocker arm 50 about its pivot 51. This movement, in turn, forces the valve pin 55 downwardly against the action of a compression spring 57 to reciprocate the valve plug 60 integral with the pin 55. As the plug 60 is shifted, abrasive is fed to the ejecting breech 65. A suitable supply of abrasive is normally fed to the funnel 67 through which it falls to fill the chamber 63. As the plug 60 is shifted by the piston 19, it assumes the dotted line position shown in Fig. 3 to close off the funnel 67 and at the same time pack the abrasive charge in the breech 65. It will be noted that a layer of abrasive stands between the radial face of the plug 60 and the breech, preventing wear on the plug resulting from the air column throwing the abrasive from the barrel. Similarly, the position of the plug closing the feed funnel prevents the air fed from passing up through the funnel 67. As the piston 19 moves to the position shown in Fig. 1, the spring 57 forces the plug 60 outwardly

and rocks the arm 50 to push the pin 45 against the piston 19.

If desired, I could employ this spring action to return the piston to its inactive position; although from the standpoint of better timing, I prefer to make use of the double valve ring mechanism heretofore described.

To prevent the abrasive moving either way from the breech zone I may provide radially split diaphragms 70, preferably formed of rubber or other suitable resilient material and positioned as shown. The pressure of the air ejecting the abrasive is sufficiently strong to easily displace the diaphragms during the ejecting operation. As the first of the column of the compressed air passes the passage 20, through the adjacent diaphragm 70, it encounters the abrasive just deposited into breech 65 and blows the same the mass of abrasive in line with the barrel through the second diaphragm 70 and out the barrel 17 as a compact slug.

It is a very important characteristic of my invention to eject the charge of abrasive as a compact slug and not intermingle relatively widely separated particles of abrasive in an air stream as is done in the ordinary type of air blast.

The barrel 17 as shown in Figs. 1 and 2 is surrounded by an outer shell 75 and is preferably made of very hard cast iron to resist as well as possible the abrasive effect of the charges shot therethrough. Even with the hardest material now known, the barrels wear very rapidly and must be continually replaced. The same is true of the breech portion 65 and in lesser degree of any other portion of the machine handling abrasive.

To effect ready interchange of parts due to this wear, the device is built in sections. As shown in Fig. 1, the valve is provided with a flange 73 which is bolted to a similar flange 80 carried by the abrasive feed valve mechanism 16 and which clamp between them the adjacent diaphragm 70. At the other end of the abrasive feed mechanism are similar flanges 82 which are bolted to corresponding flanges 84 securing the barrel to the rest of the device as shown. Similarly, the flanges 82 and 84 maintain the adjacent diaphragm 70 in place and position a member 85 with a conical opening adjacent the barrel to permit room for displacement of the adjacent diaphragm.

The plunger or plug member 60 wears very rapidly due to intimate sliding contact with abrasive fed to the breech and is readily replaced by removal of the cover 87. A shield 90 is mounted on the outer barrel member 75 adjacent the end to deflect abrasive bouncing back from the work and protect the machine and the operator.

The speed of operation of the device is readily adjusted by the needle valve 27 and the spring pressure of the springs 47 and 57. As the needle valve is opened, air fed through the auxiliary line 25 more rapidly fills the chambers adjacent the respective valve rings and thus reciprocates the piston 19 more rapidly. In a similar manner, the pressure of the spring 57 as compared with the pressure of the spring 47 will, if increased, tend to move the plug 60 to open the funnel 67 more rapidly and further will aid the air from the auxiliary line in returning the piston 19 to its initial position.

It will be seen from the foregoing description that I have provided a new means of projecting abrasive onto surfaces to be cleaned. By the term "abrasive" I means any material of granu-

lar nature which it is desired to project onto an object. It will further be apparent that my device projects such abrasive in compact slugs as distinguished from mixtures of air and scattered abrasive, with the result that very much less air is used for a given amount of abrasive thrown. A further result is that the abrasive is projected with much more force onto the surface desired because of its compact nature, and because the particles travel under the momentum given them by the force of the ejection. It will also be apparent that my device is operable entirely from the single column of air used to provide the propelling force and that each mass or slug of abrasive is propelled ahead of an air column and through comparatively still air. The various parts of the device are automatic in operation. The entire assembly is simple in construction and readily disassembled for cleaning and for replacement due to wear.

The modification seen more particularly in Figs. 5, 6, and 7 comprises, in general, a receptacle 95 for receiving abrasive, a reciprocating firing tube 96 which projects into the receptacle and segregates a slug of abrasive within the receptacle, a valve indicated generally by the reference character 97 for controlling admission of fluid under pressure to the firing tube, a barrel 98 for directing the slug after the same is blown out of the firing tube, and a source of power 99 for reciprocating the firing tube and actuating the valve.

The receptacle 95 is cylindrical and is provided with a suitable intake 101 and an expansion chamber 102. With reference to the barrel as the front end of the device, the receptacle is provided with a front flange 104 and a rear flange 105, the purposes of which will hereinafter appear.

The firing tube which, as is above noted, is reciprocable within the receptacle and is made of suitable wear-resisting material. For facilitating the cutting or segregating of a slug of abrasive, the front end of the firing tube is interiorly chamfered as at 107 to make it sharp or, if desired, the same may be exteriorly chamfered. This is seen in Fig. 6. The rear end 108 of the firing tube threadingly engages the valve, the latter being part of the firing tube reciprocating means.

This valve will now be described in detail, reference being had more particularly to Figs. 6 and 7. A cylindrical valve casing 110 is provided with a transverse wall 111 so as to present a front chamber which is supplied with compressed fluid from a flexible conduit 112. The front end of the casing is interiorly recessed for accommodating an annular valve seat 114 which is retained therein by an exteriorly threaded nut 115, and which presents a forwardly extending interiorly threaded nipple for engaging the threads of the end 108 of the firing tube.

Adapted for coaction with the valve seat 114 is the head 117 of a valve, the stem 118 of which is slidingly engaged by an apertured boss 119, the latter extending on either side of the wall 111. Leakage of the compressed fluid from the front chamber of the casing through the aperture of the boss is prevented by suitable packing means 120.

For normally urging the valve closed, suitable means such as a spring 121 surrounds the stem of the valve and is interposed between the head of the valve and the wall 111. For opening the valve, the rear end of the stem 118 is provided

with a slot 123 which cooperates with means hereinafter described.

Structure will now be described for supporting the valve and consequently the firing tube, such structure being connected to the rear flange 105 of the receptacle 95. Connected to the flange 105 as by welding or bolting is a plate 125 which is provided with a central aperture for slidingly engaging the firing tube 96. One end of a pair of cylindrical slideways 127 is of reduced diameter and is accommodated by an opening in the plate 125 and secured in such opening by set screws. The other end of each of the slideways is similarly connected to a plate 128. Bolted to the casing 110 and slidingly engaging the slideways 127 is a pair of slideblocks 130 (see Fig. 8). Connected to the plates 125 and 128, in a manner similar to that in which the slideways 127 are connected thereto, is a spacer rod 132 which slidingly accommodates a collar 133, the latter being provided with a set screw 134. This collar actuates the valve opening means heretofore referred to.

Such valve opening means comprise an arm 136 which projects through the slot 123 of the stem 118. As is more clearly seen in Fig. 7 the upper end of this arm is adapted for engaging the collar 133 and the lower end of this arm pivots about a pin 137 which is carried by a block 138, the latter being suitably bolted or otherwise secured to the rear of the skirt of the casing 110.

From the foregoing it will be seen that as the valve reciprocates on the slideways 127, the arm 136 will engage the collar and pivot about the pin 137 thereby opening the valve. The slideblocks 130 project rearwardly of the casing and are interconnected by a bar 140 to which reciprocating forces are transmitted for reciprocating the casing and the firing tube.

For imparting such reciprocating forces, the source of power 99, heretofore mentioned, is provided and is, by way of illustration, an electric motor suitably mounted on a plate 142, the latter being pivotally carried by a plate 143 which is bolted or otherwise secured to the plate 128. A vertical plate 144 is secured to one side, as is seen in Figs. 5 and 6, of the center of plate 143 and is provided with a detent 145. Threadingly carried by the plate 142 is a screw, the bottom of which engages the detent for retaining plate 142 in any desired pivotal position. The motor, by suitable means such as a belt indicated by a dotted line, rotates a pulley 146 (Fig. 6) which is connected to one end of a stub shaft 147, the other end of which is provided with a crank arm 148, the stub shaft being suitably rotatably journaled in the vertical plate 144. The crank arm is provided with a counter balance 149. A connecting rod 151 pivotally interconnects the crank arm and the said bar 140. As is better seen in Fig. 7 the plates 128 and 143 present a vertical slot 152 for accommodating the connecting rod.

Thus, rotation of the pulley 146 reciprocates the valve casing and the firing tube. It has been found that very little power is required to rotate the pulley and that a fractional horsepower motor is entirely suitable.

For preventing seepage of abrasive and to prevent wear of the firing tube as it slides through the opening of the plate 125, a suitable wiping washer 154 is provided and is preferably connected to the plate 125.

It has been indicated above that the slug of abrasive upon leaving the firing tube enters and is projected out of the barrel 98. This barrel and

its immediately cooperating elements are supported by the front face of the front flange 104 as by bolting and will now be described. Such bolting interconnects the flange 104, a washer 156, a diaphragm 157, and a flange 153 of a guard tube or shell 159. The barrel is longitudinally movably supported within the shell 159 and for this purpose the barrel slidably engages apertured guide block 162, the latter being suitably secured to the shell.

The aperture of the washer 156 is convex rearwardly and outwardly as at 164. The washer is of a composite structure, and that portion thereof which is convex is made of a very tough wear-resisting stiff material and the flat body portion thereof is made of relatively flexible material. The purpose of such composite structure will hereinafter appear.

The diaphragm 157 is similar to the diaphragms 70 and is best seen in Fig. 9. It is a flat disc provided with any desirable number of slits 167 which radiate from a central point. As is seen in Fig. 7, when pressure is exerted on the rear face of the diaphragm the slitted portion thereof deforms or projects forwardly and presents a plurality of lips which enter the rear end 169 of the firing tube. This end flares outwardly and is urged against the diaphragm by washer and spring means 170.

The operation of this alternative embodiment is as follows:

Abrasive is supplied to the receptacle 93 through the intake 101 and substantially completely fills the former so that when the firing tube is in the position seen in Fig. 5, upon application of power, the firing tubes will be driven or pushed through the abrasive so as to segregate therefrom or cut thereout of and completely surround and enclose a slug of abrasive. During the segregating action the abrasive displaced by the firing tube backs up into the expansion chamber 162 and into the intake. As the firing tube approaches the washer 156, the forward portion of the abrasive within the tube becomes somewhat packed or the individual particles of abrasive constituting such portion become closer together than such particles would if the receptacle were continuous. This packing is more marked when the firing tube projects into the aperture of the washer. The firing tube moves forward until it is in sealing relation with the convex surface of the washer and for insuring a good seal between the firing tube and the washer, the latter, due to the flexibility of the flat outer portion thereof, may be slightly displaced.

By means of set screw 134 the collar 133 may be so adjusted that when such seal is suitably established, the valve is opened by coaction between the arm 136 and the collar. When the valve is opened, live fluid under high pressure rushes behind the slug in the firing tube and due to its initial pressure and expansion the slug is blown or exploded out of the firing tube, through the diaphragm and finally projected out of the barrel 92. The relationship of the various elements when a slug is being ejected or fired, is seen in Fig. 7. The breech member or firing tube 96 is preferably extended outside of the abrasive receptacle 93 so that the valve 117 may be spaced a safe distance from the charge in the breech. Thus when the breech tube has been moved forwardly to firing position as shown in Fig. 7 the length of the slug or mass in the tube does not extend to the valve.

While the slug is passing through the dia-

phragm, the said lips thereof which are formed by the slits 167 flex forwardly into the outwardly flaring end 169 of the barrel 92 and effectively prevent dribbling of abrasive into the shell 159.

The outer portion of the diaphragm at which the lips terminate also flexes forwardly. Such flexing urges the barrel forwardly against the tendency of the spring 170 to urge the barrel rearwardly. Thus during each firing cycle the barrel is reciprocated within the shell 159.

Devices constructed in accordance with this invention have successfully operated at a speed of 500 operating cycles per minute, so that 500 slugs per minute were ejected or blown out of the device. These slugs, it will be noted, are projected intermittently and fly as slugs from the barrel to the surface to be sandblasted. Upon striking such surface the slug will disperse and scatter as if it were a snowball.

Attention is particularly directed to the suddenness with which the air pressure is released into the rear end of the firing tube. The fluid pressure within the firing tube cannot be released except by actuation of the slug because the slug completely fills the firing tube. In other words, the fluid cannot escape around the slug, but must follow the slug. Thus, a very small quantity of fluid is required for each operating cycle to shoot the slug. This quantity may be as small as a few cubic inches as compared to several cubic feet which is required in a conventional sandblast nozzle device having a continuous stream of air passing through an open pipe. The ratio between small quantities of air used by my method and in my guns is as small as $\frac{1}{100}$ part of the air for throwing the same quantity of abrasive by a sandblast.

It is to be noted that the diaphragm 157 forms a seal at the front of the receptacle 93 and that no such seal is necessary at the rear of the receptacle.

When the firing tube is sealed against the washer, a slug within the firing tube is completely segregated from the remainder of the abrasive within the receptacle and such a slug is substantially, completely and entirely projected, all without disturbing such remaining abrasive. The latter is unaffected and unacted upon by fluid pressure.

It is well known that the abrasive contacting parts of abrasive projecting devices are subject to enormous wear. This is particularly true where the relative velocity is high. Thus, in my disclosure the firing tube and barrel are the elements of major wear. By constructing the device in sections and bolting the sections together, these elements may be readily replaced. For instance, by removing the bolting which interconnects the elements 104, 156, 157, and 158, the barrel, the diaphragm, the washer and the firing tube may be replaced in a very short period of time.

When devices of the character described operate at the speed described and project the abrasive upwardly, horizontally or slightly downwardly the diaphragm 157 may be dispensed with because the interval between each cycle of operation is too short for gravity to act on the slug sufficiently to move it materially.

The alternative construction seen in Figs. 11 and 12 is similar to that seen in Figs. 5, 6 and 7, and only the differences therebetween will be described, such differences being chiefly in the provision of pneumatic means for reciprocating the firing tube. In this alternative construction

compressed fluid, preferably air, reciprocates a piston which in turn reciprocates the firing tube. As the firing tube approaches the end of its forward stroke, a valve is opened and admits into the firing tube the compressed fluid which has actuated the piston.

To this end a cylinder 175 is provided with a front flange 176 and a rear flange 177. An apertured bumper plate 178 is interposed between flanges 105 and 176 and is suitably secured between and to these flanges as by bolting, riveting, or welding.

The piston which reciprocates in the cylinder is itself a valve and comprises a relatively thin cylindrical shell 180. The front end of the shell is interiorly threaded for receiving a base 181 which is provided with a threaded central aperture for receiving the threaded rear end of the firing tube. Thus, the piston has an opening extending longitudinally therethrough.

Since fluid pressure must be built up on either side of the piston for reciprocating the same, means for sealing such fluid pressure at the front end of the cylinder is provided. To this end there is secured to the forward face of the bumper plate 178 a wiping washer 184 and a sealing washer 183, the latter engaging the firing tube.

Fluid pressure is supplied to the device from a main source of fluid pressure 186 which, by means of a control valve 187, communicates with an automatic valve indicated generally in Fig. 11 by the reference character 189. This valve alternately directs the fluid pressure to one side and then the other side of the piston. The automatic valve is seen in detail in Fig. 12 and comprises a casing 191 which is surrounded by a jacket 192 so as to provide a space between the casing and the jacket.

The fluid pressure from the control valve 187 is admitted to this space and by means of apertures 193 flows into the interior of the casing. It is to be noted that the interior 194 is cylindrical and that the holes 193 are in two circumferentially extending rows, one at each end of the interior. The rear end of the casing threadingly receives a hollow plug 196 which communicates with the interior 194 and which by means of a conduit 197 communicates with the front end of the cylinder 175 immediately adjacent the flange 176. The inner end of the plug 196 presents a valve seat which in the present instant is preferably spherical. Interconnecting the front end of the casing 194 and the rear end of the cylinder 175 is a conduit 199, the rear end of which presents a spherical valve seat.

Adapted for coaction with these valve seats and disposed within the interior 194 of the casing is a ball 200, the diameter of which is substantially equal to the diameter of the interior 194 so that fluid pressure cannot pass from one of these series of apertures 193 around the ball to the other series of apertures. These apertures are so located that the ball is always between them. Thus, it is seen that when the ball is in the position seen in Fig. 12, fluid pressure is admitted against the rear of the piston and that when the ball moves to the left of Fig. 12 fluid pressure will be admitted against the front of the piston.

Means will now be described for exhausting the fluid pressure built up within the cylinder 175. As was heretofore said, the piston has an opening extending longitudinally therethrough, but it is to be noted that such opening, by means

of the firing tube 96, does not communicate with the forward portion of the cylinder 175. The piston, unless this opening is sealed, cannot be forced forwardly by fluid pressure. According to this invention valve means are provided for sealing this opening and consequently, for permitting fluid pressure to build up behind the piston and force the same forwardly, such means also controlling the admission of fluid pressure to the interior of the firing tube 96.

This valve means, which is built into the piston, comprises a cup-like cap 202 which is threaded to the base 181 and which presents an opening 233. Adapted for seating on the rear surface of the base and consequently for sealing the aperture through the piston is a plate 205. Resilient means in the form of a spring 206 are interposed between the plate 205 and the cup 202 for normally maintaining the opening closed. The base is provided with a plurality of circumferentially spaced openings for accommodating pins 207, the rear side of which are provided with enlarged heads. The heads abut the plate 205 and serve the purpose of preventing the pins from working their way forwardly out of the opening. The pins project forwardly of the base 181 and are adapted for simultaneously engaging or bumping the bumper plate 178 or unseating the plate 205 and consequently permitting the fluid pressure at the rear of the piston to enter the firing tube 96 and expand against the slug of abrasive for projecting the same out of the barrel 98. When the plate 205 is unseated, the pressure at the rear end of the cylinder is less than the pressure at the front end thereof and consequently the ball 200 will move from the position seen in Fig. 12 to the left thereof and seat itself against the conduit 199. Thus the flow of fluid under pressure from the source 186 to the rear of the cylinder will be terminated and fluid under pressure will be admitted to the front of the cylinder.

For exhausting fluid pressure from the front of the piston, the cylinder is provided with a series of circumferentially spaced openings 208. These openings, it will be noted, are uncovered by the piston only when the latter occupies the extreme rear end of the cylinder 175 and are not uncovered when the piston is in the front end of the cylinder. These openings communicate with the interior of a hollow ring 209 which encircles the cylinder and which communicates with the cylindrical interior of a valve casing 210. The front end of this valve casing is centrally bored so that the casing has an opening extending therethrough and presents a valve seat 211 which is surrounded by a coil spring 212. This spring urges rearwardly a piston 214 which is adapted for reciprocation within the said cylindrical interior of the valve casing 210. The piston seats on the seat 211 and seals the hollow interior of the ring 209 from the interior of the valve casing 210. The rear end of the cylindrical interior of the valve 210 threadingly receives a plug 216 which, in turn, threadingly receives a conduit 217, the latter being in communication with the rear end of the cylinder 175.

From the foregoing it will be seen that when the piston which is within the cylinder 175, the former in and of itself being a valve, is actuated forwardly, the fluid pressure so actuating this piston is by means of conduit 217 transmitted to the rear of the piston 214 and forces the latter against the seat 211. When the plate 205 is unseated this pressure is released and the piston 214 is unseated and unseals or opens communi-

cation between the ring 209 and the interior of the valve casing 210.

When the plate 205 is unseated, the ball 200 moves to the left of Fig. 12 and fluid pressure is admitted to the front end of cylinder 175 by conduit 137. When the openings 208 are uncovered the pressure in the front of the cylinder 175 exhausts through these openings into the ring 209, into the interior of the casing 210 and out of the forward end thereof. The uncovering of the openings 208 forces the ball 200 from the left of Fig. 12 to the right thereof, thus sealing the piston 214 against the seat 211 and forcing the piston forwardly.

The moving back and forth of the ball 200 is extremely rapid and due to the unique construction and arrangement of various valves this alternative construction is capable of expelling as many as 500 abrasive slugs or wads per minute. The speed of operation of the device is dependent upon the fluid pressure admitted to the automatic valve 189.

The various elements which comprise a device constructed in accordance with this alternative form of the invention may be very thin and the overall dimensions of such a device are within the limits of portability. The entire device approximates the weight of an ordinary portable electric drill.

The word "abrasive" as used herein is intended to embrace all materials which, when directed against a surface, have an effect thereon. Such material might be sand, metallic shot or grit, other granular material, polishing balls, such as leather pellets, or the like.

It is interesting to note that the slugs or wads of abrasive projected by the alternative forms of this invention are substantially cylindrical. This is because the firing tube is substantially cylindrical. The result is a segregated elongated projectile which flies from the tube nose or end first and strikes the surface to be abraded.

When an open air blast nozzle or a centrifugal wheel is used, the abrasive is projected as individual particles with substantially still air in between the particles, i. e., each particle encounters its own independent air resistance. If No. 50 steel grit is used there are approximately 75,500 particles per pound. With an open air blast or centrifugal wheel there would be 75,500 different .007 gram projectiles spaced at random from each other. It will be obvious that the nozzle velocity is higher than the target velocity even though the projecting range or flying distance is but 2 to 3 feet. The same pound of abrasive would comprise six or less shots for the present invention. It is not difficult to comprehend that abrasive projected by this invention suffers but little loss of velocity due to air friction.

Other forms may be employed embodying the features of my invention instead of the one herein explained, change being made in the form or construction, provided the elements stated by any of the following claims or the equivalent of such stated elements be employed, whether produced by my preferred method or by others embodying steps equivalent to those stated in the following claims.

I therefore particularly point out and distinctly claim as my invention:

1. In apparatus of the class described, a frame, an abrasive breech in said frame, means to intermittently feed abrasive to said breech in compact slugs, a displaceable valve member to retain the abrasive in said breech and a metering device

to intermittently admit charges of air to said breech to expel said intermittent charges of abrasive in the form of compact slugs.

2. In apparatus of the class described, a frame, an abrasive breech in said frame, means to intermittently feed abrasive to said breech in compact slugs, a displaceable valve member to retain the abrasive in said breech, a metering device to intermittently admit charges of air to said breech to expel said intermittent charges of abrasive in the form of compact slugs and feed mechanism operated by said metering device to actuate said abrasive feeding means.

3. In apparatus of the class described adapted to project abrasive in compact slugs, a frame, an abrasive breech in said frame, a feed pipe for abrasive opening into said breech, a valve to intermittently open and close the said opening, power means to operate said valve, an air metering device opening into said breech, a reciprocable piston in said device, power means to operate said piston in timed relation with said valve to admit a charge of air to said breech after a charge of abrasive has been fed thereto.

4. In apparatus of the class described adapted to project abrasive in compact slugs, a frame, an abrasive breech in said frame, a feed pipe for supplying abrasive to the opening into said breech, a valve to intermittently open and close said opening, power means to operate said valve, an air metering device opening into said breech, a reciprocable piston in said metering device, a member connecting said piston and said valve to operate the valve by reciprocation of the piston and power means to reciprocate said piston in timed relation with said valve to admit a charge of air to said breech after a charge of abrasive has been fed thereto in a compact slug.

5. In apparatus of the class described adapted to project abrasive in compact slugs, a frame, an abrasive breech in said frame, a feed pipe for supplying abrasive to the opening into said breech, a valve to intermittently open and close said opening, power means to operate said valve, an air metering device opening into said breech, a reciprocable piston in said metering device, a member connecting said piston and said valve to operate the latter by reciprocation of the former, a source of high pressure air, means actuated by said air pressure source to reciprocate said piston in timed relation with said valve to admit a charge of air to said breech after a charge of abrasive has been fed thereto.

6. In apparatus of the class described adapted to project abrasive in compact slugs, a frame, an abrasive breech in said frame, a feed pipe for supplying abrasive to the opening to said breech, a valve to intermittently open and close said opening, power means to operate said valve, an air metering device opening into said breech, a reciprocable piston in said metering device, a member connecting said piston and said valve to operate the latter by reciprocation of the former, a source of high pressure air, means actuated by said air pressure to reciprocate said piston in timed relation with said valve to admit a charge of air to said breech after a charge of abrasive had been fed thereto, and control mechanism to vary the proportion of air used to operate said piston with respect to the amount of air fed to said abrasive breech.

7. In apparatus of the class described, a frame, an abrasive breech in said frame with a pair of inlet openings and an outlet opening, a barrel

carried by said frame coacting with said outlet opening, a feed pipe for abrasive emptying into one of said inlet openings, a reciprocable plunger to intermittently open and close said opening and feed abrasive to said breech in a compact slug, an air metering device with a hollow cylinder opening into said other inlet to the breech, a piston reciprocable in said cylinder, means to reciprocate said piston, a discharge passage opening in said piston to open and close the second named inlet to said breech, and a source of air under pressure leading to said cylinder and admitted to said breech intermittently of said discharge passage.

8. In apparatus of the class described, a frame, an abrasive breech in said frame with a pair of inlet openings and an outlet opening, a barrel carried by said frame coacting with said outlet opening, a feed pipe for abrasive emptying into one of said inlet openings, a reciprocable plunger to intermittently open and close said opening and feed abrasive to said breech in a compact slug, an air metering device with a hollow cylinder opening into said other inlet to the breech, a piston reciprocable in said cylinder, fluid intake and exhaust ports at each end of said cylinder, an air jacket discharging to each pair of intake ports, an air supply source leading to said jacket, valve mechanism to regulate the amount of air admitted to said jacket, valve rings carried by said piston and adapted to seal said intake and exhaust ports, a discharge passage in said piston to open and close the second named inlet to said breech, and a source of air under pressure leading to said cylinder and metered by said piston discharge passage.

9. In a device of the character described, the combination of an abrasive receptacle, means projecting in said receptacle for segregating and packing a quantity of abrasive so as to form a packed slug, and means for projecting the packed slug as a slug out of the device.

10. In apparatus adapted to project abrasive in compact unsupported slugs against an object, a frame with a discharge passage spaced from said object, an abrasive breech in said frame, positive means to forcibly feed abrasive to said breech in compact slugs, a source of compressed fluid under pressure and a metering device to intermittently admit charges of air to said breech to expel intermittent charges of abrasive.

11. In apparatus adapted to project abrasive in compact unsupported slugs against an object, a frame with a discharge passage spaced from said object, an abrasive breech in said frame, means to feed abrasive to said breech in compact slugs, means to retain said abrasive in said breech when said breech is positioned out of horizontal position, a source of compressed fluid under pressure and a metering device operated by said air blast to intermittently admit charges of air to said breech to expel intermittent charges of abrasive against the work.

12. In apparatus adapted to discharge abrasive in relatively compact slugs toward an object to be cleaned thereby, a frame, an abrasive breech in said frame, positive means to deposit successive charges of abrasive in said breech in compact slugs, means to retain said abrasive in the breech when said apparatus is tilted and a metering device to pass air under pressure through said breech and past said retaining means to discharge abrasive from said apparatus toward an object.

13. In apparatus adapted to discharge abra-

sive in relatively compact slugs toward an object to be cleaned thereby, a frame, an abrasive breech in said frame adapted to receive a charge of abrasive to be projected, positive abrasive feeding means to deposit successive charges of abrasive in said breech, means to retain the charge of abrasive in said breech and means to admit fluid under pressure to said breech to simultaneously open said retaining means and project said abrasive from said apparatus, and timing mechanism interconnecting said abrasive feeding means and fluid admitting means to feed abrasive and fluid to said breech in timed relation to each other.

14. In apparatus adapted to discharge abrasive in relatively compact slugs toward an object to be cleaned thereby, a frame, an abrasive breech in said frame adapted to receive a charge of abrasive to be projected, positive abrasive feeding means to deposit successive charges of abrasive in said breech, means to admit fluid under pressure to said breech to project said abrasive from said apparatus, and timing mechanism interconnecting said abrasive feeding means and fluid admitting means to feed abrasive and fluid to said breech in timed relation to each other.

15. In abrasive projecting apparatus the combination of an abrasive receptacle, an axially reciprocable firing tube one end of which is open and projects in said receptacle, piston and cylinder means for reciprocating said firing tube, said piston having an axial opening therethrough, the other end of said firing tube being open and secured to said piston in communication with the opening of the latter, a cap for covering and uncovering the opening of said piston, and means adapted for abutting one end of said cylinder for actuating said cap into uncovering position whereby fluid under pressure from the firing tube remote side of said piston is admitted to said firing tube for projecting abrasive out of said firing tube.

16. In abrasive projecting apparatus, the combination of an abrasive receptacle, an axially reciprocable firing tube one end of which is open and projects in said receptacle, piston and cylinder means for reciprocating said firing tube, said piston having an axial opening therethrough, the other end of said firing tube being open and secured to said piston in communication with the opening of the latter, a cap for covering and uncovering the opening of said piston and resiliently urged into covering position, means for admitting fluid under pressure to the other side of said piston, and means for intermittently actuating said cap into uncovering position.

17. The combination of an abrasive receptacle provided with a pair of openings the surface of one of which is flexible and convex rearwardly and outwardly, an axially movable firing tube projecting through the other of said openings, the front end of said firing tube being adapted for seating against said convex surface for sealing the interior of said tube from the remainder of said receptacle, and means for admitting fluid under pressure to the rear end of said firing tube.

18. The combination of means including an abrasive receptacle provided with a pair of openings the surface of one of which is flexible and convex rearwardly and outwardly, an axially movable firing tube projecting through the other of said openings, the front end of said firing tube being adapted for seating against said con-

vex surface for sealing the interior of said tube from the remainder of said receptacle, and slitted flexible pressure responsive means for sealing said one of said openings.

19. The combination of an abrasive receptacle having an opening, a flexible slitted washer for closing said opening, a barrel one end of which flares and is adapted for circumscribing the slit of said washer, and means for admitting fluid under pressure to said receptacle whereby abrasive within said receptacle is projected outwardly through said opening, through said washer by displacing the slit thereof with the lip of such slit confined by said end of said barrel, and finally through said barrel.

20. The combination of an abrasive receptacle having an opening, a slitted resilient washer for closing said opening, an axially movable barrel one end of which is adapted for circumscribing the slit of said washer, resilient means for urging said barrel against said washer and means for admitting fluid under pressure against the abrasive within said receptacle whereby such abrasive is expelled through said opening, through said washer by displacing the lips of the slit thereof against said end of said barrel, and finally through said barrel.

21. A method of throwing measured masses of cleaning abrasive in rapid succession, comprising the steps of forcing a measured amount of abrasive through an opening into a breech chamber in a gun and then closing said opening and while closed releasing a sudden charge of compressed air behind the abrasive mass to expel it from the gun and repeating the cycle of said steps in quick succession.

22. An abrasive gun for rapidly throwing separate dense charges of abrasive and having a firing barrel and a charge holding breech, a supply means for bringing abrasive to the breech, coacting elements for loading a dense measured load of abrasive from the supply into the breech and for closing the breech, means responsive to the movement of said elements for releasing a charge

of compressed air behind the load only while the breech is closed.

23. The combination of a gun having a nozzle and charging chamber, a compressed air supply and abrasive supply, means for mechanically charging the chamber while separating a measured mass of abrasive from the supply and for closing the chamber, valve means for suddenly delivering a charge of compressed air to the chamber to eject the charge of abrasive as a mass, and an interconnecting control operating mechanism responsive to the chamber closing means to assure closing of the charge chamber before delivering the compressed air, and means for shutting off the air immediately after each discharge.

24. A repeating abrasive slug throwing gun including a firing tube and a breech load-carrying tube, means for relatively moving said tubes axially, means for presenting a mass of abrasive between the tubes when separated whereby when moved together a measured mass of abrasive is contained in the breech portion and is separated from the mass and the opening between the tubes is closed to prevent escape of abrasive or air, and means responsive to the tube movement for delivering an explosive charge of compressed air to the mass when the tubes are in said closed position.

25. An abrasive throwing gun having an opening breech and an ejecting passage, a repeating mechanism for forcibly moving a mass of abrasive into the breech when open and thereafter closing the gun except for free movement through the throwing passage to prevent lateral movement of abrasive, repeating means for releasing explosive air charges through the passage, and timing means causing such release only when the breech is closed and whereby the mass is forcibly ejected in a dense charge, the time of air flow constituting a small fraction of the time of the cycle including the charging and closing.

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