

[54] **REVERSIBLE IMPACT DEVICE FOR DRIVING HOLES IN EARTH**

[76] Inventors: **Boris Vasileivich Sudnishnikov**, Krasny prospekt, 56, kv. 59;
Alexander Dmitrievich Kostylev, ulitsa Derzhavina 19, kv. 44;
Konstantin Stepanovich Gurkov, ulitsa Derzhavina 19, kv. 28;
Konstantin Konstantinovich Tupitsyn, ulitsa Novogodnaya, 44, kv. 23; **Vladimir Vasilievich Klimashko**, ulitsa Kamenskaya 84-v, kv. 33; **Vladimir Dmitrievich Plavskikh**, ulitsa Krylova, 3, kv. 37, all of Novosibirsk, U.S.S.R.

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[52] U.S. Cl. 173/91, 173/135

[51] Int. Cl. E21b 1/08

[58] Field of Search 173/91, 92, 135; 175/19

[56]

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Primary Examiner—James A. Leppink

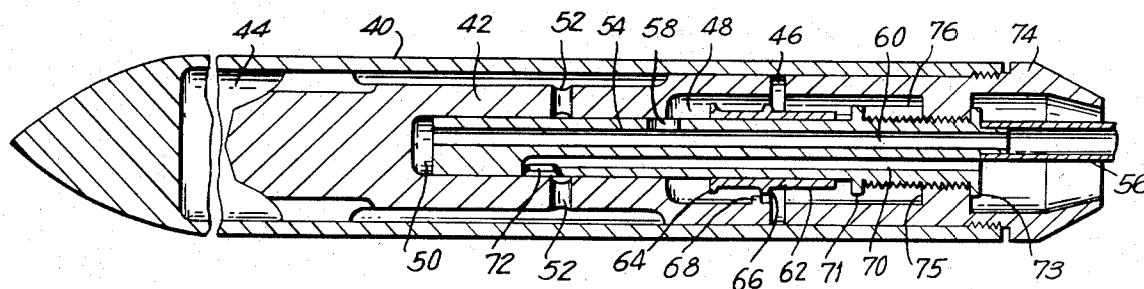
Attorney—Eric H. Waters et al.

[57]

ABSTRACT

A pneumatically operated impact action self-propelled reversible device for driving holes in the earth by compacting the soil around the hole being made includes a housing having a pointed driving end portion and a rear end portion. The impact member is reciprocated interiorly of the housing in operation of the mechanism under the action of compressed air to deliver successive impacts upon the housing. An air distributing mechanism including an air supply sleeve associated with the impact member and connected with an air conduit member is provided to control the supply of air to front and rear working chambers within the housing.

3 Claims, 6 Drawing Figures



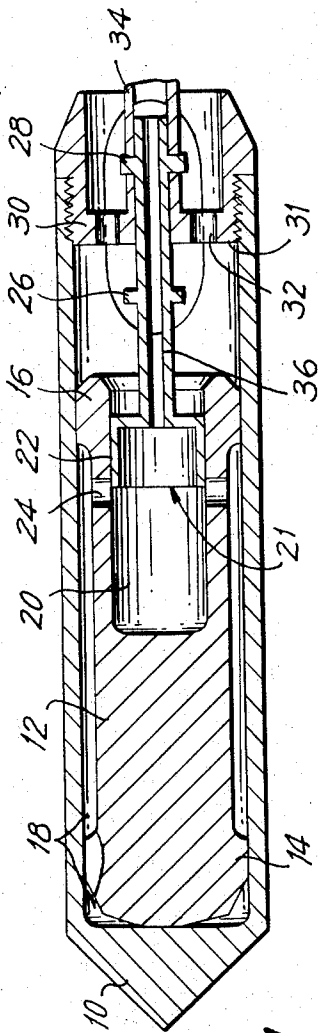


FIG. 1

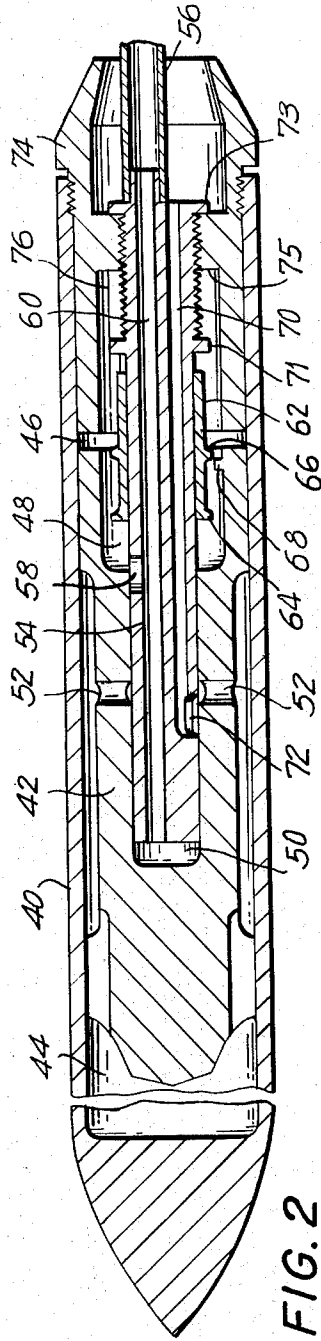


FIG. 2

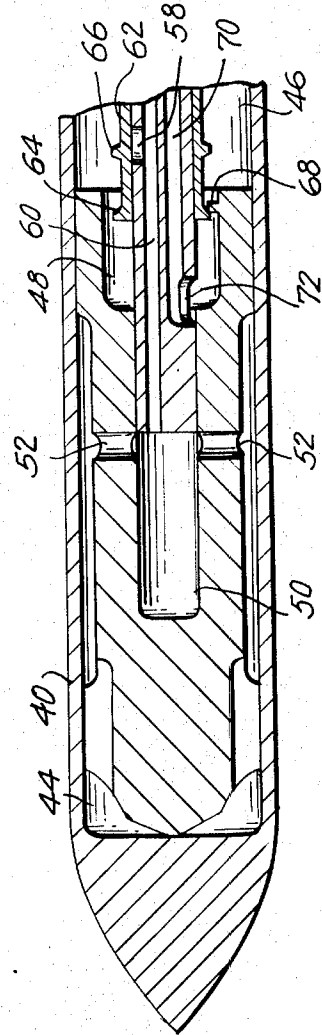
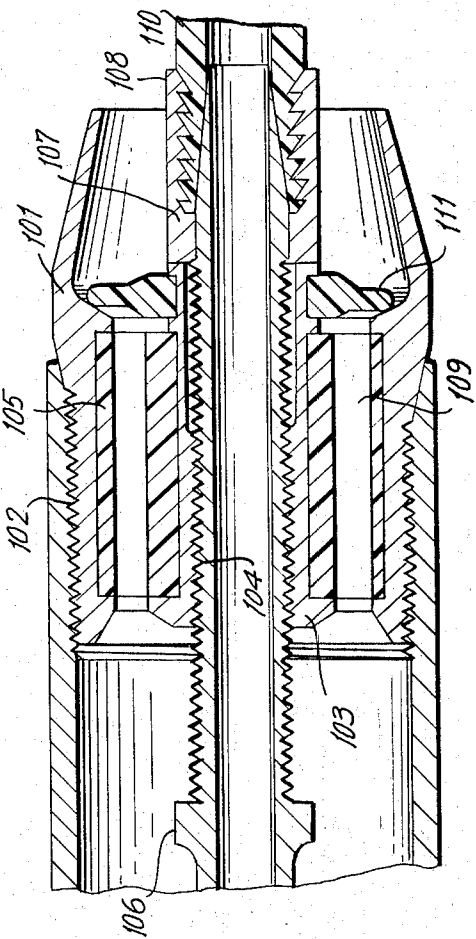
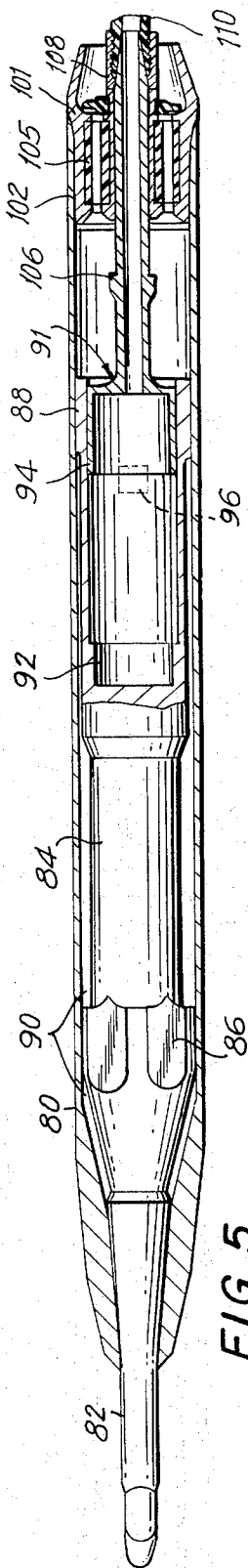
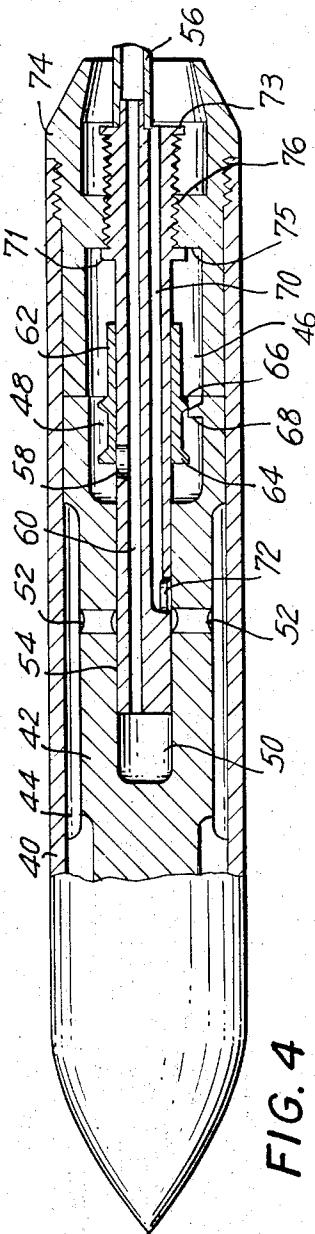


FIG. 3



REVERSIBLE IMPACT DEVICE FOR DRIVING HOLES IN EARTH

This application is a continuation-in-part of our co-pending U. S. Pat. application Ser. No. 12,208, entitled PNEUMATIC PERCUSSION DEVICE FOR MAKING HOLES IN THE GROUND BY PACKING THE LATTER, filed Feb. 19, 1970, and our co-pending U. S. Pat. application Ser. No. 53,216, entitled PNEUMATICALLY OPERATED IMPACT-ACTION SELF-PROPELLED REVERSIBLE MECHANISM, filed July 8, 1970 now U. S. Pat. No. 3,651,874 dated Mar. 28, 1972.

The present invention relates to a pneumatically operated impact-action self-propelled device for driving holes in the earth by compacting the soil around the hole being made and more particularly relates a device of this type which is reversible.

These impact devices, as shown in the above mentioned U. S. Pat. applications, and U. S. Pat. No. 3,410,354, entitled IMPACT DEVICE FOR DRIVING HORIZONTAL HOLES IN SOFT GROUND, issued Nov. 12, 1968, are particularly useful for the trenchless laying of underground communication conduits. Typically such devices comprise a housing with a pointed driving end which receives therein a movable impact member. The interior of the housing is divided by the impact member into front and rear working chambers to which compressed air is supplied by an air distributing mechanism. The impact member is reciprocated in the housing under the action of the compressed air supplied into the abovementioned working chambers and delivers successive impacts upon the housing. The impacts imparted by the impact member on the housing propel the device along a course in the earth to produce the desired hole.

Often it is desirable to extract the mechanism from the hole it has already made back to the surface, such is the case when the mechanism meets along its course an insurmountable obstacle, such as a boulder or the remnants of a foundation, or when the mechanism has completed its course and driven a blind hole of a particular length. Therefore, it is a primary object of the present invention to provide a pneumatically operated impact-action self-propelled device for driving holes in the earth which is reversible.

It is a further object of this invention to provide a pneumatically operated impact device of the type hereinbefore described having a novel air distributing mechanism which controls the supply of compressed air to the working chambers of the device and thereby effects a particular direction of movement of the device in the earth.

In accordance with these and other objects, the present invention is directed to a pneumatically operated impact-action self-propelled mechanism of the type described above including a novel air distributing mechanism. In the present invention the air distributing mechanism briefly comprises an air supply sleeve threadably connected to a rear end portion of the housing for axial displacement therein and cooperating with passages or ports in a shank portion of the impact member for control of the supply of compressed air to the working chambers. The air supply sleeve is secured to the air supply hose and rotates therewith. Rotation of the air supply hose thereby causes the air supply sleeve to be displaced axially within said housing which in turn

changes the relative positions of the sleeve and the passages. This change leads to a change in the pattern of the operative distribution of the compressed air between the abovementioned working chambers of the mechanism and, therefore, to a reverse of the direction of the impact delivered by the impact member, and, hence to a reverse of the direction of movement of the device as a whole.

It is a further object of this invention to provide a simple but effective means for reversing the driving direction of the self-propelled device.

These and other objects and advantages of this invention will be made readily apparent by the following detailed description and the accompanying drawings, wherein:

FIG. 1 is a schematic sectional side view of a pneumatically operated impact-action self-propelled device having an air distributing mechanism for accomplishing a reversal in the direction of movement of the device in accordance with the present invention;

FIG. 2 shows a pneumatically operated impact-action self-propelled device with an alternative form of air distributing mechanism having the proposed reversing means and illustrating the position of the impact member prior to the beginning of its forward stroke during a forward advance of the device;

FIG. 3 is identical to FIG. 2 except the impact member is shown in the position prior to its rearward stroke;

FIG. 4 is identical to FIGS. 2 and 3 except the impact member is shown in the position of delivering an impact upon the rear end portion of the housing during a retreat of the device;

FIG. 5 shows another alternative embodiment of the pneumatically operated impact-action self-propelled device having the proposed reversing means;

FIG. 6 is an exploded view illustrating the reversing means of the air distributing mechanism of FIG. 5.

Referring now in detail to the drawings and in particular to FIG. 1, there is disposed inside a hollow cylindrical housing 10 an impact member 12 engaging the internal cylindrical wall of the housing by a pair of annular projections 14 and 16, respectively.

The space inside the housing 10 defined by the internal surface of the housing and by the external surface of the impact member 12 constitutes a front working chamber 18. Formed within the rear or shank portion of the impact member 12 is a space 20 which constitutes the rear working chamber of the herein disclosed device. The wall of the impact member 12 has made therein passages or ports 24 for fluid communication between the chambers 18 and 20.

The air distribution mechanism, generally designated 21, controls the supply of compressed air to the working chambers 18 and 20 and includes a compressed air supply sleeve 22, the head or greater diameter portion being received by the space 20. The compressed air supply sleeve 22 has its stem (that is the smaller diameter portion) provided with annular abutments 26 and 28, this stem being threadably secured in the threaded passage of a nut 30, the forward face of which forms an end wall 31. This nut 30 in turn is threadably secured to the housing 10 by means of the external cylindrical thread of the nut 30 engaging the internal thread of the housing 10. The nut 30 is provided with outlet passages 32 for exhaust of air there-through. The rear end portion of the compressed air supply sleeve 22 non-

rotatively receives thereabout the end portion of an air supply conduit or hose 34.

When the compressed air is supplied from an appropriate source (not shown) into the supply hose 34, the compressed air finds its way through the axial passage 36 and the sleeve 22 into the rear working chamber 20, whereby the impact member (of which the communication passages are in this position cut off the rear chamber 20 by the head of the sleeve 22) is driven forward into the chamber 18 inside the housing 10 and strikes the latter in the forward direction, and thus the housing 10 is driven forward relative to the sleeve 7.

When the impact member 12 thus moves toward its extreme forward position, that is, the position in which it strikes the housing 10, at a certain point immediately preceding this position (the point being defined by the disposition of the communication ports or passages 24 in the body of the impact member 12) the communication passages 24 establish communication between the front working chamber 18 and the compressed air source through the chamber 20, the passage 36 and the hose 34.

The rebound of the impact member 12 together with the action of the compressed air in the front chamber 18 are responsible for the return stroke of the impact member 12 in the rearward direction. In this return stroke the working surface of the impact member 12 subjected to the action of the compressed air in the front chamber 18 is greater than the working surface of the same impact member subjected to the action of the compressed air in the rear chamber 20 which is continuously communicating with the source of the compressed air.

During the return stroke of the impact member 12, the communication passages or ports 24 at a certain point become closed by the cylindrical external wall of the head portion of the sleeve 22, but the continuing pressure inside the chamber 18 and the momentum gained by the impact member 12 make the latter move on against the action of the pressure of the compressed air in the chamber 20. During the return stroke of the impact member 12 the volume of the chamber 18 expands.

The end of the return stroke of the impact member 12 is defined by the communication passages or ports 24 thereof passing in the rearward direction beyond the head portion of the compressed air supply sleeve 22, whereby there is established communication between the front chamber 18 and the ambient atmosphere through the exhaust passages 32 in the end wall 30. In this manner the used up compressed air is exhausted. If the supply of compressed air into the supply hose 34 is continued, the above described operating cycle repeats itself.

The reaction force produced by the return stroke of the impact member 12 in operation of the herein disclosed device, which acts upon the housing 10 in the direction opposite to the desired direction of the progress of the latter, is taken up, or counterbalanced by the friction between the housing 10 and the surrounding earth, brought about by the resilient properties of the earth.

When the herein disclosed device encounters an insurmountable obstacle (a boulder, the remnants of a foundation, etc.) or when a blind hole of a desired length has been made, the direction of movement of the device can be reversed to permit the device to re-

treat under the action of the compressed air back to the surface along the hole or course it has already made. In order to reverse the direction of movement of the device, the compressed air supply hose 34 is temporarily disconnected from the compressed air source (not shown) and is rotated to transmit the torque to the air supply sleeve 22 of the air distribution mechanism 21 with which the hose 34 is connected non-rotatively. In this manner the sleeve 22 is rotated in the unscrewing direction, that is, is unscrewed from the nut 30 into the rearmost position of the sleeve 22, in which the abutment 26 thereof engages the face of the rear end wall 31. This changes the relative positions of the sleeve 22 and the ports 24 during operation of the device.

With the compressed air supply sleeve 22 being set in the last mentioned position, the supply of the compressed air to the working chamber 18 during the forward stroke of the impact member occurs earlier and its forward stroke is thereby stopped by the pressure of the compressed air in the front chamber 18 before it reaches the internal front end wall of the housing 10, and thus delivers no impact upon the housing 10 in the forward direction. Moreover, the now increased initial volume of the front chamber 18 and the rearmost position of the head of the sleeve 22 are responsible for the impact member 12 reaching the front face of the rear end wall 31 during the return stroke thereof and thus delivering a rearwardly directed blow upon the end wall. These repeated impacts of the impact member 12 upon the end wall 31 drive the entire device for the retreating motion.

The reaction force produced by the forward strokes of the impact member 12 and acting upon the housing 10 in the direction opposing its retreating motion is taken up or counter-balanced (as it has been already described in connection with the forward motion of the device) by the friction between the earth and the housing 10.

Referring now to FIGS. 2 through 4, there is shown a pneumatically operated impact-action self-propelled mechanism similar to the mechanism of FIG. 1 in many respects but provided with a different air distributing mechanism. In FIGS. 2 through 4, there is shown a cylindrical housing 40 pointed in its front portion, accommodating a striker or impact member 42 which divides the inside of the housing 40 into front, 44, and rear, 46, working chambers to which compressed air is intermittently supplied for imparting reciprocation to the impact member 42 which is delivering impacts upon the housing 40.

The impact member 42 in its rear or shank portion has space 48 open from the butt end side, a space 50 of smaller diameter and radial openings or passages 52, while in the shank portion of the housing 40 is secured an air supply sleeve 54 connected to an air supply hose 56. During the movement of the striker or impact member 42, its radial openings or passages 52 are intermittently overlapped by the sleeve 54 entering the space 50, whereby intermittent air supply is attained to the front 44 and rear 46 chambers.

In the side wall of the sleeve 54 provision is made for an aperture 58 serving to connect the rear chamber 46 with an air conduit 60 of the sleeve 54. This latter aperture can only be overlapped during the movement of the impact member 42 toward the front chamber 44 by an outer sleeve or cover member 62 mounted outside the air supply sleeve 54 and connected with the impact

member 42 so as to be movable with respect to the impact member and air supply sleeve 54.

To this end, the outer sleeve 62 is provided with two ribs 64 and 66 spaced from each other, between which there is arranged a pin 68 of the impact member 42, said pin alternately cooperating with the ribs 64 and 66 during the reciprocation of the impact member, whereby the sleeve 62 is caused to move and close or open the aperture 58.

Thus, the air supply sleeve 54, the outer sleeve 62, the openings or passages 52 and the aperture 58, when taken in combination, form the air distributing mechanism. Because of the provision of the aperture 58, compressed air acts through the total cross-sectional area of the impact member 42 from the side of the rear chamber 46, which results in an increase of the percussion energy of the impact member during the forward stroke.

According to the embodiment of this form of the invention shown in FIGS. 2 through 4, the abovementioned air supply sleeve 54 is provided with a channel 70 for removal of exhaust air to the atmosphere and alternately communicating, during the movement of the impact member 42, with the chambers 44 and 46 via exhaust hole 72 provided in the air supply sleeve 54.

As seen from FIGS. 2 and 4, the skin portion of air supply sleeve 54 includes abutments 71 and 73 and is secured in the shank or rear end portion of the housing 40 by means of a nut 74, the forward face of which forms an interior rear end wall 75, relative to which it can be moved along thread 76. By moving the air supply sleeve 54 relative the nut 74 until the abutment 71 contacts the rear end wall 75 and thereby displacing the air supply sleeve 54 axially within the housing 40, the relative positions of the passages and the air supply sleeve will change during operation of the device and the moment of air supply to the working chamber 44 will occur sooner during the forward stroke of the impact member so that the impact member 42 will strike against the rear end wall thereby causing the retreat of the mechanism.

Presented herein below is a description of the principles of operation of the proposed device during the forward and reverse strokes. Considering first the forward stroke of the device from the moment the impact member 42 and the sleeve 62 are in the extreme rear position, the aperture 58 of the air supply sleeve 54 is open, and the openings or passages 52 of the impact member 42 are overlapped by the air supply sleeve 54 as shown in FIG. 2.

The chamber 44 is communicated with the atmosphere via the openings 52 of the impact member 42, exhaust hole 72 in the air supply sleeve and the air discharge channel 70 of the latter. Under the action of compressed air supplied via the conduit 60 into the spaces 48 and 50 of the impact member 42 and through the aperture 58 into the chamber 46, the impact member 42 moves forward. When so doing, the pin 68 of the impact member 42 acts upon the rib 64 of the sleeve 62, displacing the latter along the air supply sleeve 54 so as to overlap the aperture 58, thereby ceasing the supply of air into the chamber 46. Further advance of the impact member 42 takes place under the effect of air expanded in the chamber 46. At the end of the stroke the impact member 42 delivers an impact upon the front portion of the housing 40, causing the latter to intrude into the ground.

Almost simultaneously with the impact, the exhaust hole 72 gets connected with the space 48 of the impact member 42, as shown in FIG. 3, as a result of which exhausted air is discharged into the air from the chamber 46 via the channel 70 of the air supply sleeve 54, while the openings 52 get opened, and compressed air from the space 50 enters the chamber 44, causing a rearward movement of the impact member 42.

The sleeve 62 remains in the extreme front position, that is, the aperture 58 is overlapped by this sleeve. During further movement of the impact member 42 its openings 52 are overlapped by the air supply sleeve 54 entering the space 50, and the supply of air to the chamber 44 is ceased. The impact member 42 moves on owing to the energy of air expanding in the chamber 44.

As soon as the openings 52 of the impact member 42 coincide with the exhaust hole 72, there takes place the discharge of exhausted air to the atmosphere from the chamber 44 via the channel 70 of the air supply sleeve 54. The striker or impact member 42 moving on by inertia, acts with its pin 68 upon the rib 66 of the sleeve 62 which displaces to its initial position leaving the aperture 58 open for the subsequent air intake to the chamber 46. Thereupon, the cycle is repeated.

In order to switch the device over to the reverse stroke, the air supply sleeve 54 is displaced axially within the housing from a front to a rear position, both positions being determined by the abutments 71 and 73, by turning the air conduit or hose 56 until the air supply sleeve is screwed into the nut 74 up to where the abutment 71 engages the end wall 75, as shown in FIG. 4.

With the new position of the air supply sleeve, the openings 52 of the impact member 42 during the latter's advance will open earlier and, consequently, the intake of compressed air to the chamber 44 will take place earlier, therefore, the striker or impact member 42 will brake without having struck against the front portion of the housing 40 and will start moving in the opposite direction. During this latter movement of the impact member 42, the exhaust hole 72 and the aperture 58 will open later, that is, the exhaust of exhaust air from the chamber 44 and the intake of compressed air to the chamber 46 will take place later, and the impact member 42, having no time for braking, will deliver an impact upon the rear end wall 75, as a result of which the housing 40 of the device will move in the opposite direction.

FIGS. 5 and 6 disclose a still further embodiment of a pneumatic percussion device having an air distribution mechanism with reversible means in accordance with the present invention. Referring to these figures, the hollow cylindrical housing 80 of the herein disclosed mechanism has a generally pointed, replaceable, driving forward end 82 and receives therein an axially reciprocable impact member 84 engaging the internal cylindrical wall of the housing 80 with an interrupted annular shoulder 86 and a continuous annular shoulder 88. The space defined by the internal wall of the housing 80 and the external surface of the impact member 84 constitutes a front working chamber 90. The rear of shank portion of the impact member 84 has formed there in a cavity 92 which constitutes the rear working chamber of the herein disclosed device, responsible for forward displacement of the impact member 84 during operation of the device. Passages or ports 96 are made

through the cylindrical wall of the impact member 84, in the area of the rear cavity 92 therein, these passages or ports establishing communication between the chambers 90 and 92.

The air distribution mechanism, generally designated 91, controls the supply of compressed air to the working chambers and includes an air supply sleeve 94, the head portion of which is received by the cavity 92. The sleeve 94, which is of a stepped diameter, is supported along its reduced diameter portion or stem inside a nut assembly 100 at the rear end portion of the housing 80. The nut assembly 100 is integrally molded together and comprises an outer sleeve 101 with external threads 102, and inner sleeve 103 with internal threads 104, and a shock-damping bush 105 molded therebetween. The bush 105 is made of an elastically deformable material and includes a plurality of passageways extending longitudinally the length thereof through which the used air can be exhausted into the atmosphere.

The nut assembly 101 is secured by the external thread 102 to the housing 80 of which the corresponding portion of the internal wall is provided with a matching internal thread. The sleeve 94 is secured to the internal threads 104 for axial displacement within the housing 80. Movement of the sleeve 94 between a forward and rear position is determined by the stop or abutment 106 on one side of the nut assembly 100 and the stop or abutment 107 on the other side of the nut assembly 100. The stop 107 is formed by a clamp member 108 which non-rotatably secures the rear end portion or stem portion of the sleeve 94 to the end portion of an air supply hose 110. A flapper valve member 111 adjacent the outlet end of the exhaust passageways 109 prevents dirt from entering the passageways.

Operation of the device shown in FIGS. 5 and 6 and the control of the supply of compressed air to the working chamber by the air distribution mechanism during the forward driving movement of the device is substantially identically to that disclosed hereinabove with regard to the device shown in FIG. 1 and a repeat of that discussion is not felt necessary. However, it should be noted that the device of FIGS. 5 and 6 is a refined embodiment of the device of FIG. 1 and its additional features generally provide for a better performance in the field.

When the herein disclosed device of FIGS. 5 and 6 encounters an insurmountable obstacle or when it is desired for other reasons to reverse the motion of the device whereby the device can be retreated under the action of the compressed air back to the surface, the compressed air supply hose 110 is temporarily disconnected from the compressed air source (not shown) and is rotated to transmit the torque to the compressed air supply sleeve 94 with which the hose 110 is connected non-rotatively. In this manner the sleeve 94 is rotated in the unscrewing direction, that is, it is unscrewed from the nut assembly 100 into the rearmost position of the sleeve 94, in which the abutment 106 thereof engages the front face of the nut 100.

With the compressed air supply sleeve 94 being set in the last mentioned position, the impact member during its forward stroke is stopped by the pressure of the compressed air in the front chamber 90 before it reaches the internal end wall of the housing 80, and thus delivers no impact upon the housing 80 in the forward direction. Moreover, the now increased initial volume of the front chamber 90 and the rearmost posi-

tion of the head of the sleeve 94 are responsible for the impact member 84 reaching the front face of the nut 100 during the return stroke thereof and thus delivering a rearwardly directed blow upon the nut. These repeated impacts of the impact member 84 upon the nut 100 drive the entire mechanism for the retreating motion.

The present invention provides an improved impact device for driving holes into the earth having reversing means which permit the device to be retreated from the hole. The device includes novel air distribution means which adjust the supply of compressed air to the working chambers according to the direction of the device desired.

Having fully described our invention, it is to be understood that we do not wish to be limited to the details herein set forth, but our invention is of the full scope of the appended claims.

We claim:

1. A pneumatically operated impact-action self-propelled device for driving holes in the earth, comprising:

a housing having a driving end portion and a rear end portion;

an impact member mounted for reciprocation within said housing and defining therewith working chambers of variable volume, said impact member adapted to reciprocate and deliver impacts to one of the ends of said housing during a distribution of compressed air to said working chambers;

air supply means rotatably mounted and threadably connected to said housing for longitudinal movement therein, said longitudinal movement adapted to effect a modification in the distribution of compressed air to said working chambers and thereby change the delivery of impacts to the other end of said housing; and air delivering passages connecting said air supply means to said working chambers of variable volume.

2. In a pneumatically operated impact-action self-propelled device for driving holes in the earth having a housing with a driving end portion and a rear end portion, an impact member adapted for reciprocation within the interior of said housing for delivering impacts at one end thereof during operation of the device and defining there with working chambers of variable volume, air delivering passages connecting said working chambers of variable volume to air conduit means; wherein the improvement comprises:

air distribution means adapted to modify the distribution pattern of compressed air to said working chambers and thereby change the delivery of impacts at one end of said housing to said other end, said air distribution means including an air supply sleeve fixedly secured to said air conduit means to prevent relative rotational movement therebetween, said air supply sleeve cooperating with said impact member to supply reciprocation of said impact member, the distribution pattern of compressed air depending on the relative positions of said impact member and said air supply sleeve, said air supply sleeve being rotatably and threadably mounted to said housing for axial displacement therein whereby the position of said air supply sleeve with respect to said impact member can be changed by rotating said air conduit means at a remote position from said housing.

3. A pneumatically operated impact-action self-propelled reversible device for driving holes in the earth, comprising:

- a housing having a generally pointed driving end portion, and a rear end portion; 5
- an impact member adapted for reciprocation inter-iorly of said housing and defining therewith working chambers of variable volume, said impact member delivering upon said housing repeating impacts, as said impact member is reciprocated there-inside in 10 operation of said device;
- air conduit means;
- a sleeve connected with said air conduit means in a manner to prevent a relative rotational movement therebetween, said sleeve cooperating with said im- 15 pact member and being adapted to supply com-

pressed air into said chambers for effecting recip-
rocation of said impact member;
passage means in said impact member for communi-
cation of air to certain of said chambers, the open-
ing and closing of said passage means determining
a forward or rearward direction of movement of
the device and depending on the relative positions
of said impact member and said sleeve;
said compressed air supply sleeve being threadably
secured to said housing proximate said rear end
portion for axial displacement within said housing
when said air conduit means is rotated whereby the
position of said sleeve with respect to said impact
member can be changed to effect a reversal in the
direction of the mechanism.

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