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[redacted]

[11] 3,574,404

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[54] **DIGGING APPARATUS**
5 Claims, 4 Drawing Figs.

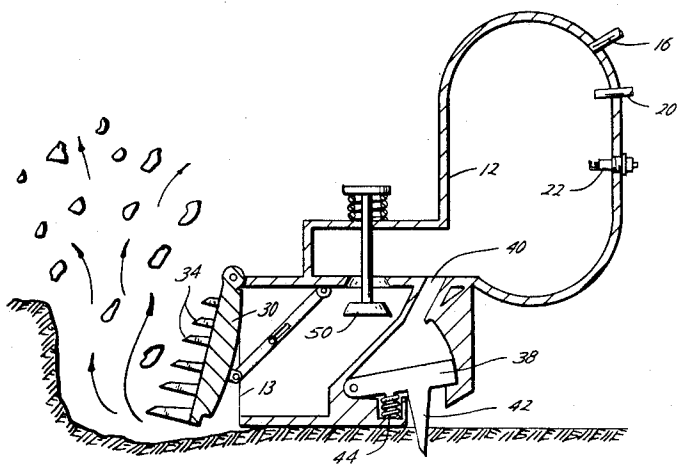
[52] **U.S. Cl.** **299/37,** 299/13
[51] **Int. Cl.** **E21c 29/00**
[50] **Field of Search** 299/13, 36, 37, 67, 69, 70, 81; 173/59, 73; 175/93, 14

[56] **References Cited**
UNITED STATES PATENTS

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ABSTRACT: An improvement in an apparatus for creating repetitive explosions from an outlet of a combustion chamber by actuating a digging assembly by the explosive pressures to loosen and break up hard materials. The use of piston-driven digging teeth for loosening and breaking up material formations both prior to and simultaneously with material displacement by repetitive explosive blasts. An apparatus positioning locking assembly including a piston-driven pin actuated by the repetitive explosive blasts into position for holding the apparatus in position and which is actuated either prior to or simultaneously with the material displacement blasts and digging assembly actuation.



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SHEET 1 OF 2

Fig. 1

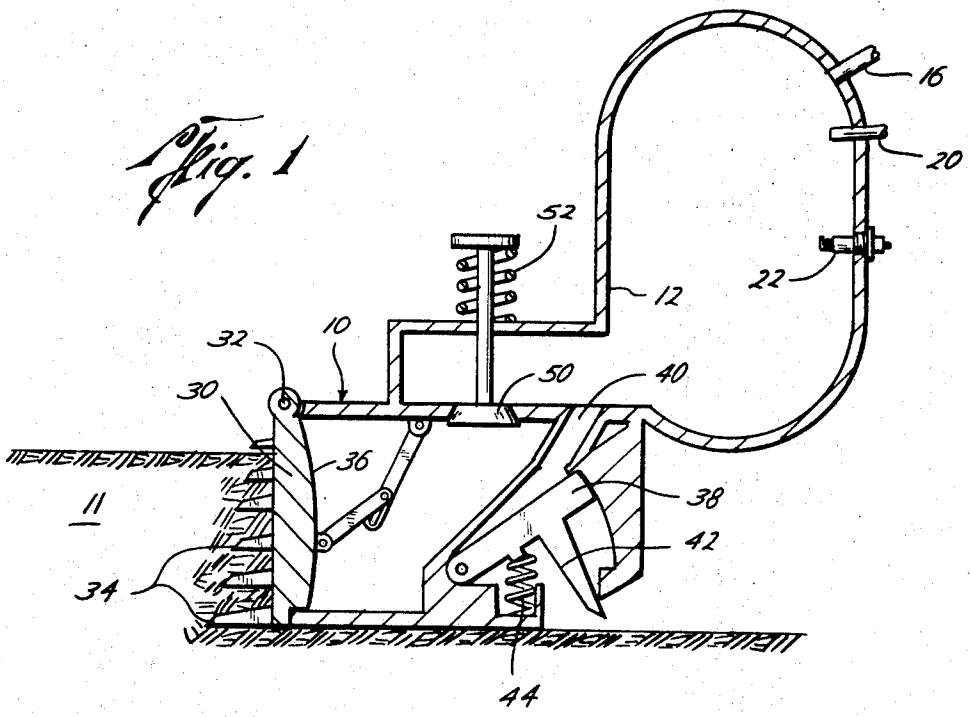
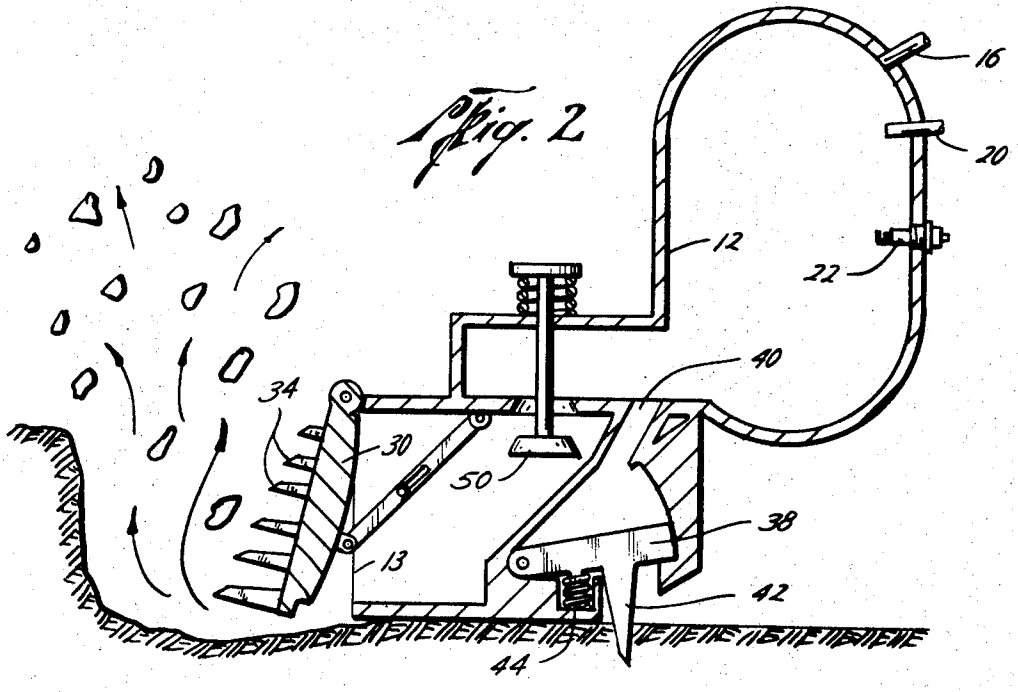


Fig. 2



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Fig. 3

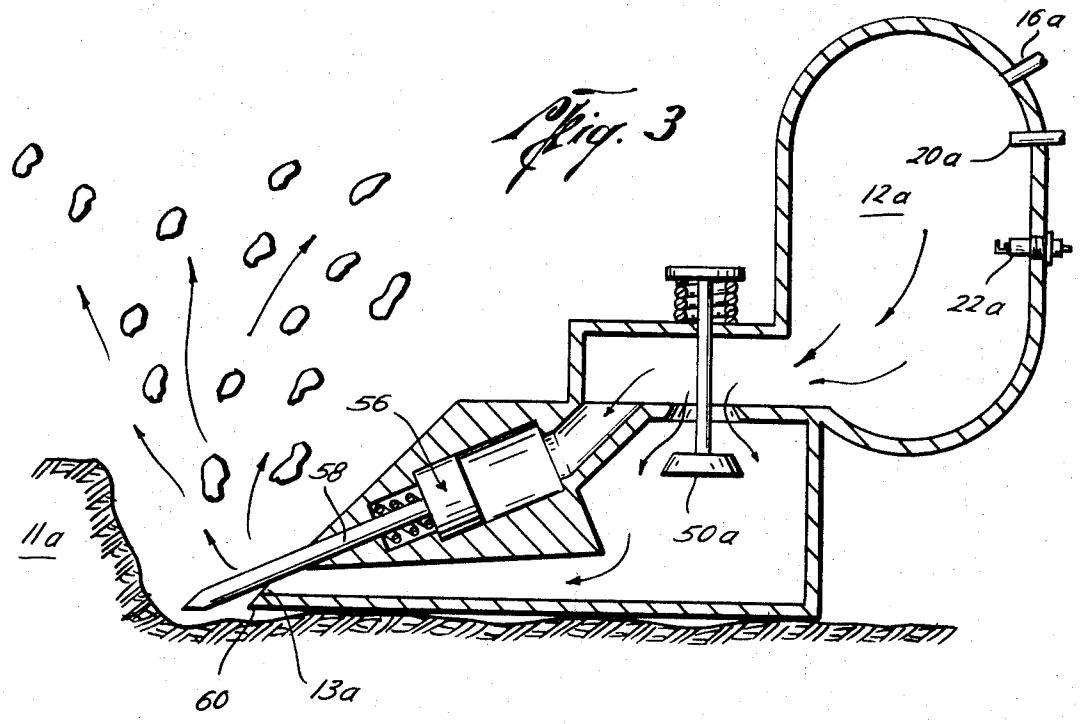
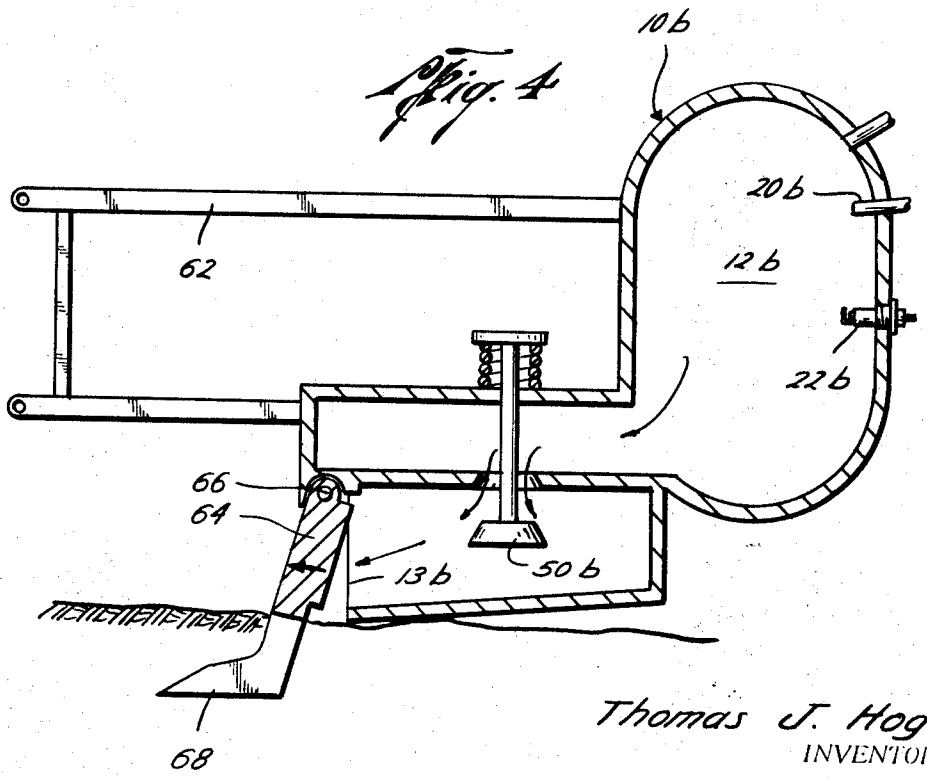


Fig. 4



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DIGGING APPARATUS

BACKGROUND OF THE INVENTION

U.S. Pat. No. 3,461,577 entitled "Method of and Apparatus for Displacing Materials," discloses the use of combustion heat and pressures from the repetitive firing of a hydrocarbon fuel/air mixture in a combustion chamber for displacing materials by the repetitive explosive blasts. However, rocky or hard soil conditions or materials offer a great deal of resistance to the optimum penetration and positioning of the exhaust outlet of the combustion chamber disclosed in the above mentioned patent application.

SUMMARY

The present invention is directed to providing accessories for use with and actuated by the repetitive explosions from the outlet of the combustion chamber by the ignition of fuels therein to loosen and break up the soil or materials desired to be moved, separately from, prior to, and simultaneously with the displacement of the material by the explosive blasts from the combustion chamber.

It is one object of the present invention to provide in combination with an apparatus for creating repetitive explosions from an outlet of a combustion chamber by the ignition of hydrocarbon fuel/air mixtures, a soil digging assembly having a piston in communication with and actuated from the combustion chamber with digging means connected to the piston and positioned to engage the material for breaking up and loosening the material.

A further object of the present invention is the provision of a door-type piston in the outlet of a combustion chamber hinged at its upper side and having a plurality of ripping teeth on the outside whereby on actuation the material is engaged and loosened by the ripping teeth as well as displaced as the explosive blast moves past the door and out of the explosion chamber outlet.

A still further object is the provision of a piston door in communication with a combustion chamber which is convexed in cross section to increase the leverage of the explosive force on the door for increased penetration of the digging assembly.

Yet a still further object of the present invention is the provision of a positioning locking assembly attachment which provides a second piston in communication with the combustion chamber with a holding pin connected to the piston and positioned to be extended downwardly into the material or soil as the second piston is actuated to hold the apparatus in position as the material is broken up or displaced, and also including means for providing for the actuation of the second piston at a time prior to actuation of the digging or displacement mechanism to hold the entire apparatus firmly in place.

Yet a still further object to the present invention is the provision of a soil ripping assembly or attachment to the outlet of a combustion chamber having a door connected at an upper side and positioned in the outlet of the combustion chamber to form a piston therein which is actuated by the repetitive ignition of a hydrocarbon fuel/air mixture in the chamber in which a plurality of ripper teeth are connected to the door and extend downwardly and are directed forwardly below the outlet and into the soil for loosening the soil.

BRIEF DESCRIPTION OF THE DRAWING

In the attached drawings, like character references refer to like parts throughout the several views in which:

FIG. 1 is a cross-sectional elevational view, partly schematic, illustrating one embodiment of the present invention prior to an explosion in the combustion chamber,

FIG. 2 is a view similar to FIG. 1, illustrating the apparatus of FIG. 1 in position after an explosion in the combustion chamber,

FIG. 3 is a cross-sectional elevational view, partly schematic, illustrating the use of a chisel for penetrating hard formations and to provide suitable penetration for positioning of the material displacement explosive outlet, and

FIG. 4 is a cross-sectional elevational view, partly schematic, illustrating another embodiment of the present invention used for ripping the material.

DESCRIPTION OF THE PREFERRED EMBODIMENT

By way of example only, the present invention will be described in use for displacing earth and soil, but it is to be understood that the present apparatus may conveniently be used for loosening, breaking up and displacing many and various other types of material.

Referring now to the drawings and particularly to FIGS. 1 and 2, the numeral 10 generally indicates the apparatus of the present invention in use in moving a material 11 such as soil and generally includes an explosion cell or combustion chamber 12 which may be periodically moved against the soil 11 to be displaced by a suitable vehicle (not shown) to provide an explosive force through the outlet 13 of the combustion chamber 12 against the soil 11 to displace and move the soil. The combustion chamber 12 is charged with a suitable combustion mixture for creating an explosion therein, preferably the chamber 12 is charged with an air/fuel mixture, the air being provided through an air inlet 16, the fuel, preferably a hydrocarbon fuel, being provided through an injection nozzle 20 to provide an air/fuel mixture at the desired pressure and air/fuel mixture ratio. Combustion is initiated by a suitable ignition source 22 for creating an explosive force from the combustion chamber outlet 13 which is directed against the soil 11. The foregoing is generally described in the above-mentioned patent application.

However, the displacement of the soil 11 by explosions may be more efficiently utilized by the optimum penetration and positioning of the outlet 13 against the soil 11 by providing a digging assembly, particularly in hard rocky soils and other relative adamantine materials. The present improvement relates to the use of a digging assembly such as ripping tools or penetration pins or chisels which are driven directly by the explosive pressures from the combustion chamber 12 to loosen and break up the material 11 by the repetitive explosive blasts. Thus, a plate or door 30 is provided which is pivotally connected at its upper side such as to a pin 32 and is positioned in the outlet 13 of the combustion chamber 12 to form a piston therein. A plurality of digging teeth such as ripper teeth 34 are provided on the outside of the door 30 for engagement with the soil 11. Thus, when an explosive blast is applied to the back of the door 30 the door will move out of the outlet 13 moving the teeth 34 against the soil 11 to break up and loosen the soil and the explosive blast explodes out of the outlet 13 and beneath the soil 11 which has been now loosened and broken up for displacement by the exhaust blast, as best seen in FIG. 2. Penetration into hard materials such as hard soils or rock-laden formations may be facilitated by one or more firings of the combustion chamber 12 at lower pressures below which would prove optimum for a mass displacement of the materials. The lower pressure firings would jar the door 30 and teeth 34 forward one or more times thereby allowing the apparatus 10 to move to a better position with the outlet 13 in full contact against the soil 11 to be displaced so as to be more effective for mass displacement of the material by the explosive exhaust. The explosive action acting on the back 36 of plate 30 provides an improved leverage around the pivot pin 32 for increasing the force applied against the material 11 and also for forcing proportionally greater amounts of the explosive exhaust out near the base or bottom of the plate 30 which also increases the leverage and increases the displacement action on the loosened material.

As explosive blasts are released from the outlet 13 of the combustion chamber 12, there is a tendency for the apparatus 10 to be thrust backwardly. Therefore, a position locking assembly may be provided if desired which may include a

second piston **38** in communication with the combustion chamber through a passageway **40** and to which is connected a holding pin **42** which is positioned to extend downwardly and into engagement with the soil or material **11** as the piston **38** is actuated. Pin **42**, as best seen in FIG. **2**, will thus penetrate hard surfaces and give the ripping door **30** a firm support from which to push. Spring **44** is provided to act as a retracting means for the piston **38** after an explosion in which the force behind the piston is vented back to the combustion chamber **12**.

Valve **50** normally is held in a seated position by the spring **52** and performs the function of sealing off the combustion chamber **12** from the outlet **13** until a predetermined buildup in the explosive force in the chamber occurs after which the valve **50** opens allowing the high pressure and the temperature gases to move out the outlet **13** and rupture the soil **11**. However, the valve **50** also performs an additional function in that it provides a timing means to allow the actuation of the position locking assembly piston **38** at a time prior to the actuation of the plate piston **30** thereby insuring that the apparatus **10** will be secured in place prior to the release of the explosive force through the outlet **13** so as to hold the apparatus **10** in place and insure that the full impact from outlet **13** will be exerted on the soil **11**.

Of course, various modifications may be utilized to provide various types of digging assemblies such as ripping tools or penetration pins or chisels driven directly by the explosive pressures from the chamber **12** to loosen and break up the formation either without, prior to, and simultaneously with the material displacement from the chamber **12**. FIGS. **3** and **4** illustrate modifications according to the present invention, letters *a* and *b* being applied to parts corresponding to those in FIGS. **1—2** inclusive, for convenience of reference. Thus, FIG. **3** illustrates in this embodiment a piston **56** which is exposed to the combustion chamber **12***a* drives a penetration rod or chisel **58** outwardly and forwardly of the front point **60** of the combustion chamber for breaking up the material formation adjacent the leading edge **60** to aid in the proper penetration and positioning of the outlet **13***a* of the combustion chamber to provide a more efficient penetration of the material **11***a* by the outlet **13***a*.

Referring now to FIG. **4** the material displacing apparatus **10***b* is preferably towed by means of supports **62**. The outlet **13***b* of the combustion chamber **12***b* is carried above the material **11***b* which is to be ripped or broken and excavation of the soil **11***b* will be performed by any suitable means at a later step in the operation. In providing only a ripping operation, a piston **64** is provided hinged at its upper side to a pin **66** and mounted in the outlet **13***b* and thus in communication with the repetitive explosions from the combustion chamber **12***b* and carries a plurality of ripping teeth **68** which are connected to the piston door **64** and extend downwardly and forwardly below the outlet **13***b* and into the soil or material **11***b* for ripping and breaking up the material. Preferably, the apparatus **10***b* is towed by suitable means (not shown) by the support **62** so that the prime mover is not required to travel over its own spoilage.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein. While presently preferred embodiments of the invention are given for the purpose of disclosure, numerous changes in the details of construction, and arrangement of parts will readily suggest themselves to those skilled in the art and which are encompassed within the spirit of the invention and the scope of the appended claims.

I claim:

1. In combination with an apparatus for displacing material having a combustion chamber for creating and applying a repetitive explosive force against the material, a digging assembly comprising:

a piston in communication with the combustion chamber, said piston including a door hinged at one side,

digging means connected to one side of the piston remote from the combustion chamber and positioned to engage the material, said digging means including a plurality of ripping teeth for penetration and loosening of hard materials, and

means limiting the travel of the piston and the digging means.

2. In combination with an apparatus for displacing material having a combustion chamber for creating and applying a repetitive explosive force against the material, a digging assembly comprising:

a piston in communication with the combustion chamber,

digging means connected to one side of the piston remote from the combustion chamber and positioned to engage the material,

means limiting the travel of the piston and the digging means,

a second piston in communication with the combustion chamber, and

a pin connected to one side of the piston remote from the combustion chamber and positioned to be extended downwardly as the piston is actuated thereby acting to hold the apparatus in position when the digging assembly is actuated.

3. The apparatus of claim **2** including valve means sealing off the combustion chamber from the first piston until the second piston has been actuated.

4. In combination with an apparatus displacing material by applying combustion pressure from the repetitive ignition of a hydrocarbon fuel/air mixture from the outlet of a combustion chamber against the material, a digging assembly comprising:

a door pivotally connected at its upper side and positioned in the outlet of the combustion chamber to form a piston therein,

a plurality of ripper teeth connected to the door on the side remote from combustion chamber for engaging the material to be broken up,

a piston locking assembly including:

a second piston in communication with the combustion chamber, and

a pin connected to the piston on the side remote from the combustion chamber and positioned to be extended downwardly as the second piston is actuated thereby acting to hold the apparatus in position when the fuel/air mixture is ignited, and

valve means sealing off the combustion chamber from the door until the second piston has been actuated.

5. In combination with an apparatus for creating repetitive explosions from an outlet of a combustion chamber by the ignition of a hydrocarbon fuel/air mixture, a soil ripping assembly comprising:

the outlet of the combustion chamber being positioned about the soil,

a door pivotally connected at its upper side and positioned in the outlet of the combustion chamber to form a piston therein,

a plurality of ripper teeth connected to said door and extending downwardly and directed forwardly below said outlet and into the soil for loosening the soil, and

means for towing said apparatus across the soil.