May 12, 1970 R. G. GUENTER 3,511,538

APPARATUS AND PROCESS FOR EXCAVATING WITH EXPLOSIVES

Filed July 8, 1968 2 Sheets-Sheet 1

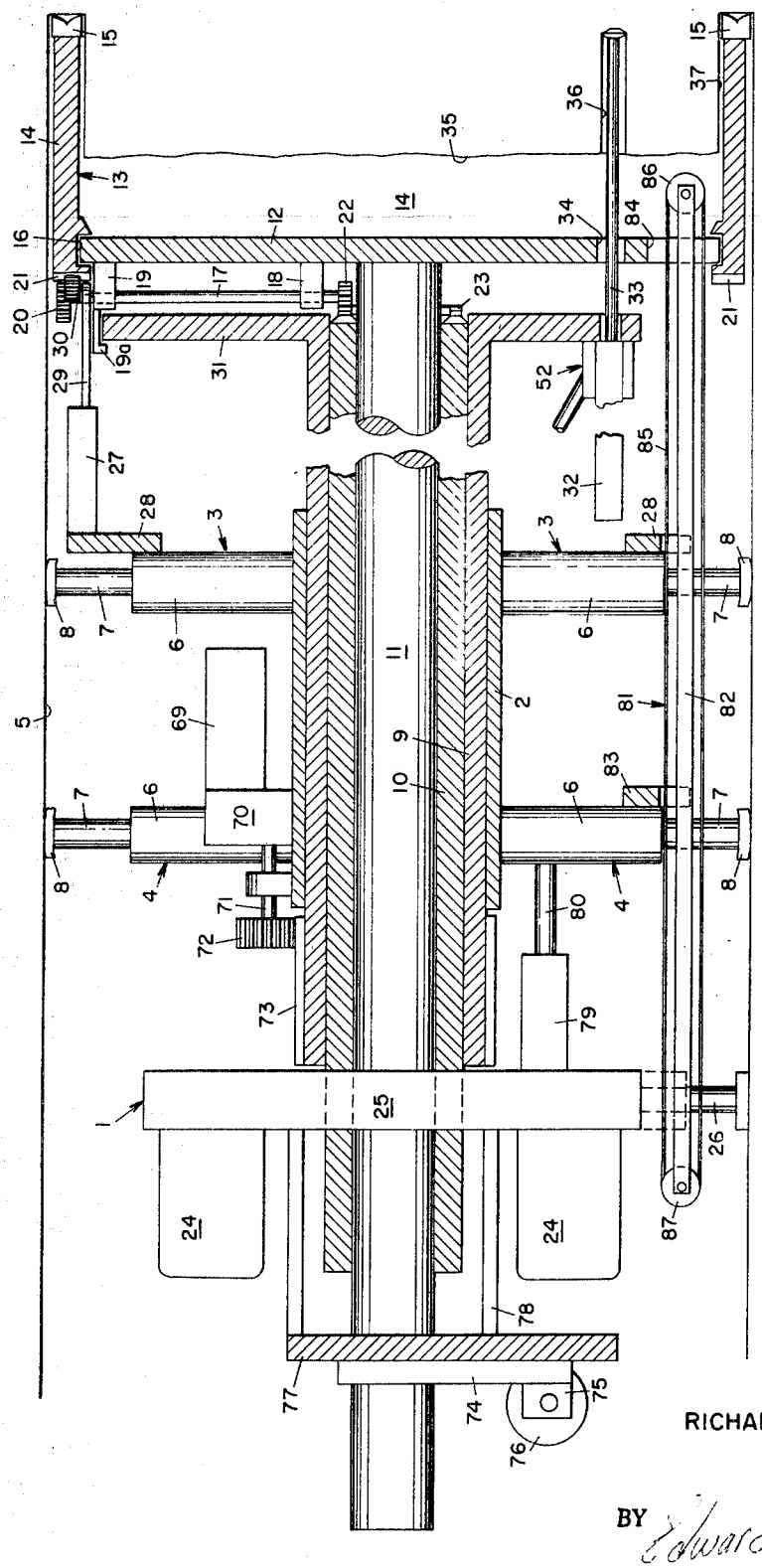


FIG. 1

RICHARD G. GUENTER
INVENTOR.

BY Edward L. Bell

ATTORNEY

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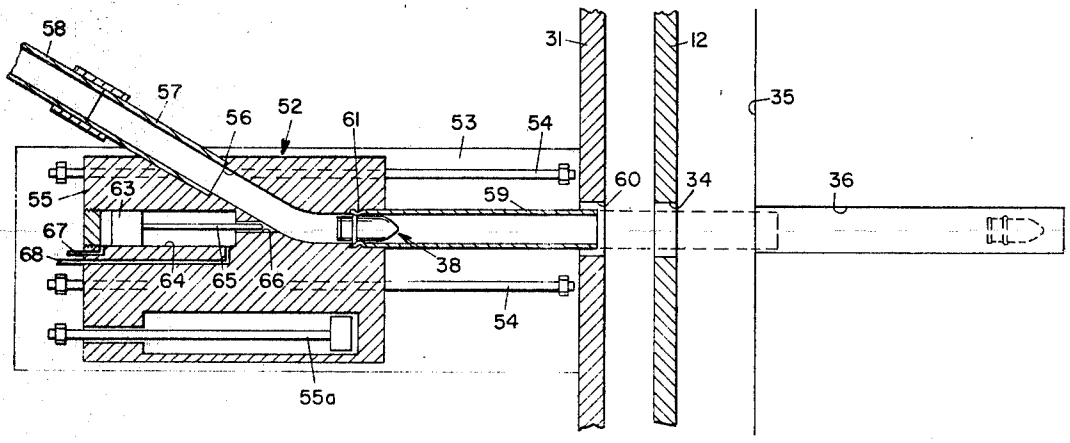



FIG. 2

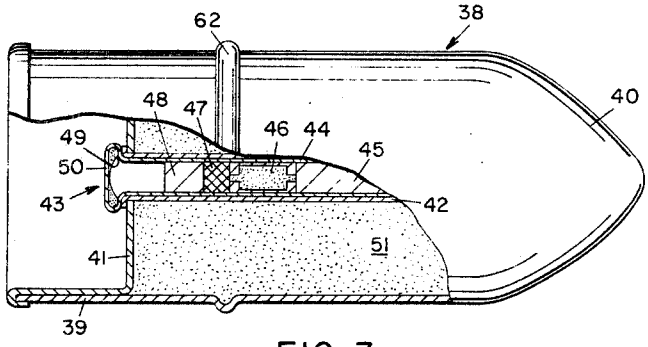



FIG. 3

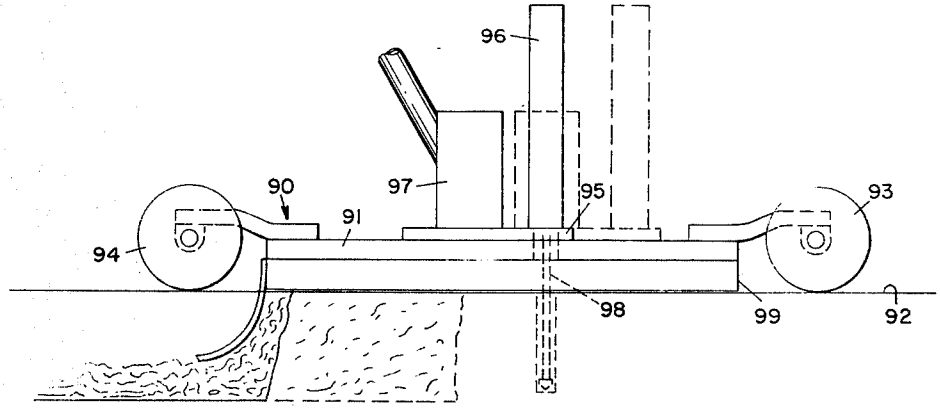



FIG. 4

RICHARD G. GUENTER
*INVENTOR.*

BY Edward A. Bell

ATTORNEY

United States Patent Office

3,511,538
Patented May 12, 1970



3,511,538

# APPARATUS AND PROCESS FOR EXCAVATING WITH EXPLOSIVES

Richard G. Guenter, Brandywood, Wilmington, Del., assignor to Hercules Incorporated, Wilmington, Del., a corporation of Delaware

Filed July 8, 1968, Ser. No. 743,130
Int. Cl. E01g 3/00
U.S. Cl. 299—3 12 Claims

## ABSTRACT OF THE DISCLOSURE

The present invention relates to a machine for forming excavations and particularly tunnels, ditches and the like in rock through the use of explosives, the invention comprising a shield through which a boring tool is operated to form a blast hole and through which a pre-ignited explosive charge with a delayed detonation is moved into the blast hole and stemmed. With the use of relatively small charges that are detonated individually, the blast effects are confined by the shield so that it is not necessary to clear the area during blasting. Method is provided including the steps of forming a plurality of blast holes in the rock phase, introducing individually into each bore hole a charge above described, and preigniting the charges as introduced for successive detonations.

The present invention relates to excavating apparatus and particularly to an apparatus for excavating hard rock formations and the like with explosives.

In the method generally employed in forming excavations such as tunnels or ditches with explosives, a blast hole or a series of blast holes are bored, an explosive charge is introduced into each blast hole and stemmed, after which, the area is cleared of operators and equipment and the charges are shot. Such a method has been rather universally adopted. However, because of the shock, vibration, noise and rock-fly, this method has limited utility in populated areas since it can be used only with elaborate and expensive precautions, and even then gives rise to complaints because there is still extensive noise and vibration associated with it. Coupled with the inherent expense of the method, the added expense of the necessary precautions often renders this approach to excavating uneconomical in comparison with available alternatives.

The objects of this invention are to provide an apparatus for excavating with explosives wherein the costs, as well as the shock, vibration, noise and rock-fly are substantially reduced in comparison with practices that are now generally used.

The above objects have been achieved primarily by the provision of apparatus designed for continuous and automatic operation with a minimum of labor and which acts to bore blast holes and to deliver into each blast hole a pre-ignited explosive charge with a delayed detonation. The explosive charges are relatively small and are detonated individually, so that there is a minimum of shock, vibration, noise, and rock-fly generated. At the same time, because of the small yield of the explosion, it can be readily



shielded and muffled, which not only further reduces the noise and rock-fly but also permits a continuous and time-saving operation because, with adequate shielding, there is no need to clear the area of the operators and equipment at the time of the explosion.

With the above and other objects in view, the present invention is hereinafter described with reference to the accompanying drawings, in which:

FIG. 1 is a vertical sectional view longitudinally of a machine embodying the present invention.

FIG. 2 is a fragmentary sectional view of the cartridge feed mechanism of the machine of FIG. 1.

FIG. 3 is a view, partly in elevation and partly in section, of an explosive cartridge adapted to be used in the machine of FIG. 1.

FIG. 4 is a schematic illustration of a modified machine that also embodies the present invention.

With reference to the drawings, there is illustrated somewhat diagrammatically in FIG. 1 an excavating machine and specifically a tunneling machine **1** that includes a supporting member in the form of a sleeve-like body **2** having two sets of legs including a front set of a plurality, e.g., four, individual legs **3** equally spaced angularly about the body **2** and a comparable rear set of legs **4**. Each of the legs **3** and **4** is extensible into engagement with the wall **5** of the tunnel in which the machine is operating to lock the machine in position, and for this purpose includes a hydraulic cylinder **6** arranged radially relative to the axis of the body **2** and fixed at its inner end to the periphery of the body **2**. A piston rod **7** telescopes into the outer or free end of each of the cylinders **6** and has a foot **8** at its outermost end.

Journaled concentrically within the body **2** are a pair of sleeve-like intermediate shafts **9** and **10** and a central shaft **11**. A shield **12** is fixed to and thereby supported by the forward end of the shaft **11**. The shield **12** is cylindrical in outline and is formed of a material capable of withstanding the shock, pressures, and flying rock associated with explosions on the working side of the shield, that is, at the right in FIG. 1. By way of example, the shield **12** may be a heavy steel or armor plate.

At the leading end of the machine **1** there is a rotary cutter **13** comprising a ring **14** coaxial of the shaft **11** and provided at its leading edge with a plurality of cutting heads **15**. Adjacent to its rear end, the ring **14** is provided with a bearing surface **16** that cooperates with the periphery of the shield **12** for supporting the ring **14** for rotation on an axis concentric with the axis of the body **2**. The ring **14** is rotatably driven by the shaft **10** by drive means including a drive shaft **17** arranged radially of the axis of the body **2** and journaled in a pair of brackets **18** and **19** on the rear face of the shield **12**. The shaft **17** is coupled to the ring **14** by a gear **20** fixed on the outer end thereof and meshing with a ring gear **21** on the rear edge of the ring **14**. At its inner end, the shaft **17** is coupled to the shaft **10** by a gear **22** on the inner end of the shaft **17** that meshes with a gear **23** on the forward end of the shaft **10**. For clarity, there is illustrated only a single drive means, i.e., shaft **17**, etc., although it is contemplated that a plurality of such drive means will be provided so that the ring **14** is driven at a plurality of angularly spaced points.

Rotation is imparted to the shaft **10** by a pair of main drive motors **24** that are supported by and connected to the shaft **10** through a reduction unit **25** having a keyed connection to the shaft **10** permitting endwise sliding of the shaft **10** relative to the unit **25**. The unit **25** is held against rotation through reaction to the driving force by a plurality of feet **26**, only one of which is illustrated, and which are extensible to engage the wall **5** of the tunnel.

Forward thrust is imparted to the cutter **13** by a hydraulic cylinder **27** carried by a bridge piece **28** that is in turn supported by the cylinders **6** of the front legs **3** of the machine. The cylinder **27** is disposed on an axis parallel to the axis of the body **2** and has a piston rod **29** upon which a pressure roller **30** is journaled at the free end thereof. The roller **30**, which may be in the form of a gear, bears against the ring gear **21** at the rear edge of the ring **14**. While, for clarity, only a single cylinder **27** is shown in FIG. 1, a plurality of such cylinders are spaced about the ring **14** and are arranged to engage the ring gear between the drive gears **20** so that the cutter **13** is biased uniformly without binding in the direction axially of the machine.

The sleeve **9** is provided at its forward end with a plate **31** that is disposed normal to the axis of the sleeve and parallel to the shield **12**, and is coupled to the shield **12** for movement in the direction axially of the machine and for rotation relative to the shield **12**. The illustrated means for coupling the plate **31** to the shield **12** comprises a strap **19***a* on the outer bearing **19** for the drive shaft **17**, that overhangs the periphery of the plate **31**. With a plurality of the bearings **19** spaced angularly about the shield **12**, there is provided a non-binding connection.

The plate **31** carries a rotary drill **32**, which may be of any suitable conventional design. The drill **32** is arranged on an axis parallel to the axis of the machine with the bit **33** thereof extending forwardly through the plate **31**. The plate **31** is adapted to be indexed angularly to align the drill axially with a hole **34** in the shield **12** so that when the drill is operated, the bit **33** advances through the hole **34** into the rock face **35** at the end of the tunnel that is being formed, to form a blast hole **36** therein. Also for purposes of clarity, there is shown in FIG. 1 only one of the drills **32** although it will be understood that a plurality of such drills is to be used. The drills **32** are preferably arranged on concentric circles about the axis of the machine and provided in such number so that the entire face **35** within the cut **37** made by the rotary cutter **13**, is provided with blast holes **36** on about one foot centers for example. The shield **12** is provided with a hole **34** for each of the drills **32** which are adapted to operate concurrently.

After the blast holes **36** are drilled to the desired depth, for example, eighteen inches, the bits **33** are withdrawn and an explosive cartridge **38**, FIG. 3, is introduced. The cartridge **38** forms the subject matter of the co-pending U.S. patent application of Fitch et al., Ser. No. 724,942, filed Apr. 29, 1968, to which reference is made for a more complete description thereof. Briefly, the cartridge **38** comprises a shell or container **39** that may be cylindrical in cross-section and formed with a tapered leading end **40**. The container **39** is closed by a crimped and recessed cover member **41** that carries a well **42** for a primer device **43** which consists essentially of a shell **44** containing, in order from the bottom thereof, a high explosive primer charge **45**, a two-part detonator that consists of a heat sensitive detonating charge **46** and a flame sensitive burning charge **47**, a delay charge **48** and an ignition charge **49**. In the illustrated form, the ignition charge **49** comprises a conventional .22 caliber rim-fire rifle cartridge case **50** without the usual propellant and bullet. The container **39** is filled with a base charge **51** that is adapted to be detonated by the primer charge



**45** of the primer device **43**. The primer charge **45** is detonated by striking the case **50** by a firing pin in the same manner in which it is struck in a rifle, thereby igniting the ignition charge **49**. The flame of the ignition charge **49** ignites the delay charge **48** which burns for a pre-determined time before igniting the burning charge **47**. The charge **47** generates sufficient heat to detonate the detonating charge **46** which detonates the primer charge **45** and which in turn detonates the base charge **51**.

The various charges in the cartridge **38** may be of any suitable material, and, by way of example, may comprise a base charge **51** of nitrocarbonitrate, a primer charge **45** of PETN, a detonator of diazodinitrophenol with the burning charge **47** being compacted to a density sufficiently high so that it will burn when ignited while the detonating charge **46** is sufficiently loose so that it will be detonated by heat generated by the burning charge **47**. The delay charge **48** may for example be a mixture of barium peroxide and selenium.

The cartridge **38** is adapted to be ignited, loaded into a blast hole **36**, and coupled and stemmed therein by a cartridge feed mechanism **52** which may be generally of the type forming the subject matter of the co-pending application Ser. No. 724,942 above referred to. This mechanism includes a mounting plate **53** secured to the rear face of the plate **31** and having mounted thereon a pair of guide rods **54** on which the body portion **55** of the feed mechanism is mounted for sliding movement and along which it is adapted to be driven, for example by a hydraulic actuator **55***a*. The body portion **55** has a conduit in the form of a bore **56** through which the cartridges **38** are adapted to pass freely. The bore **56** is connected at its input end by a fitting **57** to a flexible conduit **58** that leads to a magazine (not shown) for feeding the cartridges into the same and to a source (not shown) of fluid such as compressed air as well as a stemming medium which may be drilling mud. The compressed air is adapted to move the cartridge and a charge of drilling mud along the conduit **58** and fitting **57** into the bore **56**. At its output end, the bore **56** is connected to an elongated nozzle **59** which, when the body **55** is advanced, is adapted to project through a bore **60** in the plate **31**, the bore **34** in the shield **12**, and into the blast hole **36**.

The end of the nozzle **59** that is mounted in the body portion **55** is provided with an inwardly extending detent or rib **61** that may be in the form of a groove extending about the periphery of the nozzle in a plane normal to the axis thereof. This detent cooperates with a rib **62** on the periphery of the cartridge **38** to prevent free passage of the cartridge **38** past the detent. The detent **61** is dimensioned relative to the rib **62** so that the cartridge **38** will be stopped as it is advanced by the fluid pressure means but can be forced past the same. The means for forcing the cartridge **38** past the detent **61** comprises a piston **63** mounted in a bore **64** formed in the body portion **55** on an axis aligned with the axis of the nozzle **59**. The piston **63** carries an axially arranged pin **65** that extends forwardly through a bore **66** into the bore **56**. The piston is adapted to be advanced and retracted by fluid pressure introduced through conduits **67** and **68** respectively. When the piston **63** is advanced, the pin **65** extends through the bore **66** into the bore **56** to strike the cartridge **38** at the case **50**. Not only does the pin **65** thus force the cartridge **38** past the detent **61** but also ignites the charge **49** so that the cartridge **38** will automatically detonate after the time interval determined by the delay charge **48**.

After passing the detent **61**, the cartridge **38** is again advanced by the fluid pressure imposed behind it in the bore **56**. At the time the piston **63** is advanced, the body portion **55** of the feed mechanism **52** is in its forward position so that the nozzle **59** is extended through the hole **34** in the shield **12** and into the mouth of the blast

hole 36 as illustrated in dotted lines in FIG. 2. Thus, when the cartridge 38 is forced past the detent 61, it advances through the nozzle 59 and into the base of the blast hole 36. As mentioned above, the fluid pressure for advancing the cartridge 38 comprises a viscous liquid such as drilling mud that is advanced in turn by compressed air. The charge of drilling mud is designed to fill the blast hole 36 so that when the cartridge 38 is seated at the base of the blast hole 36, the shot is automatically coupled and stemmed by the drilling mud.

After the piston 63 is actuated to dislodge the cartridge 38 relative to the detent 61 and to ignite the delay fuse, and after a short delay to provide for seating the cartridge 38 in the blast hole, the body portion 55 of the feed mechanism 52 is retracted to withdraw the nozzle 59 to its inoperative position as illustrated in full lines in FIG. 2, and the shield 12 is indexed angularly, as hereinafter described, a distance substantially equal to one-half the distance between two angularly adjacent holes 34. Thus the hole 34 is moved out of registry with the mouth of the blast hole 36 at the time the cartridge 38 detonates and there is presented instead a blank face of the shield 12.

The means for angularly indexing the plate 31 for aligning the feed mechanism 52 with the blast hole 36 previously formed by the drill 32 comprises a motor 69 mounted on the body 2 of the machine between a pair of the rear legs 4 and connected through a reduction unit 70 to a drive shaft 71 having a gear 72 that meshes with a gear 73 formed on the rear of the shaft 9. The unit 70 is designed to impart to the shaft 9 upon each cycle a specific angular movement that is equal to the angular spacing of the drill 32 and feed mechanism 52 on the plate 31 to align the feed mechanism 52 with the hole previously drilled by the drill 32. By way of example, with a machine having six drills 32 and a feed mechanism 52 for each drill, all of which are arranged in a single circle concentric with the plate 31, the drills 32 are angularly spaced at intervals of sixty degrees and the feed mechanisms 52 are disposed at the angular midpoint between each drill. With such an arrangement, the shaft 9 is indexed thirty degrees upon each actuation so that upon one actuation, each feed mechanism 52 is advanced into registry with the blast hole 36 formed by the immediately preceding drill 32, and upon the next actuation, the drills 32 are advanced into registry with the holes 34 and the feed mechanisms are moved to inoperative positions between the holes 34.

As a safety precaution, a cut-out switch may be provided to prevent actuation of the piston 63 and thus detonation of the cartridge 38 in the event that the end of the nozzle 59 fails to enter the mouth of the blast hole 36 as in the event that the plate 31 is not properly registered with the blast hole.

Numerous alternative arrangements in the number and placement of the drills 32 and the feed mechanisms 52 will be obvious. For example, where they are provided in two or more circular rows rather than in a single row, the innermost row or rows may consist of drills 32 that are used alternately so that the designed spacing between the blast holes (e.g., on one foot centers) will be maintained despite the difference in the radial location of the drills. It is also contemplated that a single feed mechanism 52 will be provided for a plurality of drills 32 so that, upon completion of a drilling cycle in which all of the drills were operated, the plate 31 will be indexed to register the feed mechanism 52 successively with each blast hole 36 before the beginning of the next drilling cycle. Since the cartridges 38 are preferably detonated individually even when a plurality of feed mechanisms 52 are provided, the use of a single feed mechanism for a plurality of drills does not materially delay the operation, particularly since drilling constitutes by far the major portion of the cycle.

As mentioned above, the shield 12 is angularly shifted back and forth between a drilling and loading position in which the hole 34 is aligned with the drill 32 or with the feed mechanism 52 and the blast hole 36, and the shielding position in which the hole 34 is disposed out of alignment with the blast hole 36 and a blank face is presented, thereby shielding the machine at the time a cartridge 38 is detonated. The means for shifting the shield 12 angularly comprises a crank 74 keyed to the rear end of the shaft 11 for unitary angular movement with the shaft 11, and connected at its free end by a link 75 to a hydraulic cylinder 76 that is mounted on a plate 77 that is in turn mounted by supports 78 on the unit 25. When the cylinder 76 is actuated in opposite directions, the shaft 11 and thus the shield 12 are correspondingly moved. The alignment of the shield 12 in its drilling and shielding positions may be by stops (not shown) on the plate 77 and cooperating with the crank 74.

The machine is adapted to be advanced stepwise along the tunnel by means comprising for example a hydraulic cylinder 79 fixed to the frame of the unit 25 and having the piston 80 thereof acting on the rear legs 4. While only a single cylinder 79 is shown, it will be understood that a plurality of such cylinders will be used. In order to advance the machine at the end of the drilling cycle, the cylinders 27 are actuated to withdraw the cutter 13 to its retracted position and the legs 3 and 4 are shortened to release the body 2 relative to the walls 5 of the tunnel. While the unit 25 is still secured to the wall 5 of the tunnel by its legs 26, the cylinders 79 are actuated to slide the machine 1 forwardly. After the machine 1 has been advanced the desired distance, the legs 3 and 4 are extended to secure the same in its new position. The legs 26 of the unit 25 are then released, the piston rod 80 of the cylinder 79 is retracted to advance the unit 25 along the shaft 11, and the legs 26 are again extended to lock the unit in its new position. The machine is then ready for a new cycle which begins with the cylinder 27 biasing the cutter 13 into the face 35 at the end of the tunnel.

In the illustrated embodiment of the invention, the material blasted loose by the detonation of the cartridges 38 is removed from the space between the shield 12 and the rock face 35 by means of a conveyor mechanism 81 including supporting rails 82 carried by the bridge piece 28 on the front legs 3 of the machine and a brace 83 on the rear legs 4 of the machine. The rails 82 extend forwardly through an opening 84 or, more particularly, an enlarged notch, in the bottom of the shield 12, and into the space between the shield 12 and the face 35 of the tunnel. A continuous belt 85 is entrained about rollers 86 and 87 that are journaled respectively at the forward and rear ends of the rails 82. It will be understood that a plurality of belt-supporting rollers (not shown) are also journaled on the rails 82 intermediate the rollers 86 and 87. The belt 85 is preferably driven by a drive means (not shown) associated with the rear roller 87. In order to direct the loose material onto the leading end of the belt there may also be provided a deflector (not shown) carried by the shield 12 against which the material is thrown as it is tumbled by the rotary cutter 13.

In FIG. 4 there is schematically illustrated a different embodiment of the invention and particularly a machine 90 that is designed for excavating ditches in hard or rock-like formations. The illustrated machine comprises a shield 91 which may itself constitute the supporting member or body of the machine or may be carried by a separate supporting member or frame. The shield 91 is supported for movement along the surface 92 of the ground in which the ditch is to be formed by front wheels 93 and rear wheels 94 of which the front wheels 93 may be steerable and the rear wheels 94 may be driven in the usual fashion. A plate 95 is mounted on the shield 91 for sliding between

the drilling position illustrated in full lines in FIG. 4 and a loading position illustrated in dotted lines. A drill **96** and a feed mechanism **97** that are the same as the drill **32** and feed mechanism **52** are mounted on the plate **95** on a vertical axis and are adapted to be aligned with and to operate through a hole **98** in the shield **91** when the drill or the feed mechanism are in operative position. A protective skirt **99** which may be a heavy wire mesh for example depends from the periphery of the shield **91** to close the gap between it and the ground. While only a single drill **96** and feed mechanism **97** is shown, a plurality of them may be used with the drills arranged for example along a line transversely of the machine whereby all of the blast holes laterally of the ditch are drilled simultaneously. While a feed mechanism **97** may be provided for each drill **96**, a single such mechanism may be used by mounting the same on the plate **95** for movement laterally of the machine into cooperation with the blast hole formed by each of the drills **96**.

The operation of the machine **90** is analogous to that of the machine **1**. The machine is positioned with the drills **96** at the desired drilling points. After the blast holes have been drilled to the desired depth, the drills are withdrawn and the plate **95** is shifted to its dotted line position in FIG. 4 to align the feed mechanism **97** with the blast hole. A cartridge **38** is then pre-ignited and loaded into the blast hole, and coupled and stemmed by the fluid used to advance the same. When the cartridge is loaded into the blast hole, the feed mechanism is preferably withdrawn and the plate **95** moved to an intermediate position to close the hole **98** at the time the cartridge detonates. After shootting all of the blast holes drilled in one drilling cycle, the machine **90** is advanced for example, a distance of one foot, and the cycle is repeated.

The base charge **51** of the explosive cartridge **38** is relatively small, e.g., one-half pound, and each charge is preferably detonated individually. At the same time, the blast holes **36** are relatively shallow and closely spaced so that the formation in which the excavation is being made will be adequately broken by the small charge. By using small, individually detonated charges and a shield such as the shield **12** or **91**, there is no necessity for clearing the area at the time of blasting. On the contrary, blasting can be effected immediately upon completion of a blast hole simply by aligning and actuating the cartridge feed mechanism. The shield confines the blast effects without damaging the equipment or presenting a hazard to the operators. Among the advantages of the present invention is the fact that the speed of the operation is significantly increased since it is not necessary to remove the equipment from the blast site, nor is it necessary to wait during the placement and shooting of the explosives, ventilating the area and clearing the loose material. Another advantage of the invention is that the operation is less expensive since it is not necessary to maintain separate drilling, blasting and mucking crews that operate only one at a time. An additional advantage is that the present apparatus has reduced shock, vibration and noise, which would adapt it more readily for use in populated areas.

While the means for forming the blast holes **36** and cut **37** are herein shown as being mechanical, it will be apparent that other means could be used such as spalling by a jet of flame or a thermal drill.

What I claim and desire to protect by Letters Patent is:

**1.** An apparatus for forming an excavation in rock formations and the like, comprising:

a supporting member,

blast hole forming means carried by said supporting member and having an advance and retract stroke relative thereto for forming a blast hole in the formation upon the advance stroke thereof,

feed means on said supporting member for feeding into each blast hole an explosive cartridge having a base charge and a primer device for detonating the base charge after a pre-determined time delay after ignition of the primer device, said feed means comprising conduit means through which the cartridge is adapted to be moved into the blast hole, fluid means for moving said cartridge through the conduit means and into the blast hole, means for delay of travel of said cartridge in said conduit, and means for igniting the primer device of said cartridge in said conduit during said delay of travel, and for then moving said cartridge past said delay means whereby the base charge will be detonated after the predetermined time interval during which the cartridge is discharged from the conduit and deposited in the blast hole, and

means for aligning said conduit at its outlet end with the mouth of a blast hole formed by said boring means.

**2.** An apparatus in accordance with claim **1** having a shield, said boring means operating through a hole in said shield to drill a blast hole, and said feed means being movable relative to said shield for passing a cartridge through said hole and into the blast hole formed by said boring means.

**3.** An apparatus in accordance with claim **2** wherein said feed means has a nozzle communicating with said conduit, and means for moving said feed means for extending said nozzle through the hole in said shield and into the mouth of a blast hole formed by said boring means.

**4.** An apparatus in accordance with claim **1** in which said fluid means for moving the explosive cartridge through the conduit means and into a blast hole comprises means for impelling along said conduit and into a bore hole a fluid stemming medium for filling a blast hole after an explosive cartridge has been deposited therein.

**5.** An apparatus in accordance with claim **1** in which the primer device includes a percussion detonated ignition charge and said means for igniting said primer device comprises means for impacting said ignition charge.

**6.** An apparatus in accordance with claim **1** having means for advancing said supporting member along an excavation line.

**7.** An apparatus in accordance with claim **6** in which said boring means comprises drill means disposed on an axis substantially parallel to the excavation line whereby said drill means operates in advance of the supporting member and thereby adapts the apparatus for forming a tunnel.

**8.** An apparatus in accordance with claim **7** in which said drill means is mounted on said supporting member for movement relative to the excavation line between spaced drilling sites and said feed means is adapted to direct a pre-ignited explosive cartridge into the blast hole after said drill means is retracted therefrom and moved to a position intermediate said spaced drill sites.

**9.** An apparatus in accordance with claim **8** in which there is provided a cutter for undercutting the formation in advance of said supporting member and conveyor means for receiving the material dislodged by the explosive charges and for transporting the same to the rear of the supporting member.

**10.** An apparatus in accordance with claim **6** in which said boring means comprises drill means disposed on an axis substantially normal to the excavation line whereby said drill means operates beneath the supporting member and thereby adapts the apparatus for forming a ditch.

**11.** A method for forming an excavation in rock formations and the like, comprising:

forming a plurality of blast holes in the rock face, and introducing individually into each of said blast holes an explosive charge comprising a base charge and a primer device for detonating the base charge after a predetermined time delay, and preigniting said charges, as they are introduced, for successive detonations.

12. An apparatus for forming an excavation in rock formations and the like, comprising:

a supporting member,

blast hole forming means carried by said supporting member and having an advance and retract stroke relative thereto for forming a blast hole in the formation upon the advance stroke thereof,

feed means on said supporting member for feeding into each blast hole an explosive cartridge having a base charge and a primer device for detonating the base charge after a pre-determined time delay after ignition of the primer device, said feed means comprising conduit means through which the explosive cartridge is adapted to be moved into the blast hole, fluid means for moving an explosive cartridge through the conduit means and into the blast hole, and means for igniting the primer device of an explosive cartridge in said conduit whereby the base charge will be detonated after the pre-determined time interval during which the cartridge is discharged from the conduit and deposited in the blast hole, and means for aligning said conduit at its outlet end with the mouth of a blast hole formed by said boring means.




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ERNEST R. PURSER, Primary Examiner

U.S. Cl. X.R.

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