Nov. 9, 1965 H. E. THOMAS ETAL 3,216,320

APPARATUS FOR EXCAVATING BY MEANS OF EXPLOSIVES

Original Filed Sept. 2, 1958 4 Sheets-Sheet 1

FIG. 1.

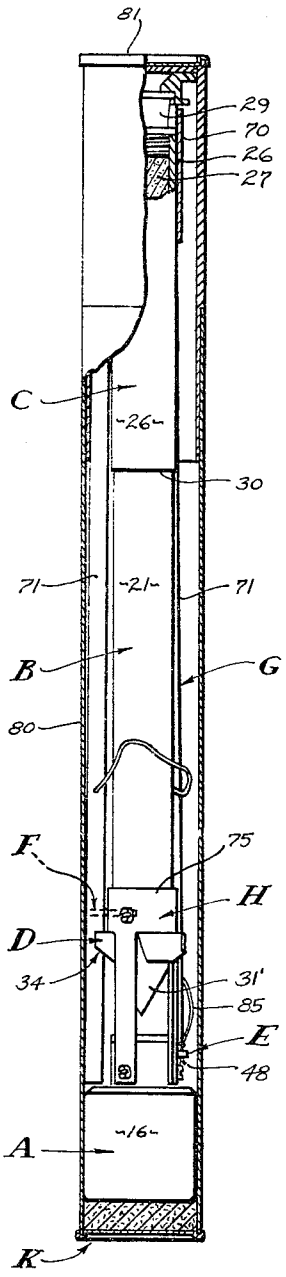

FIG. 2.

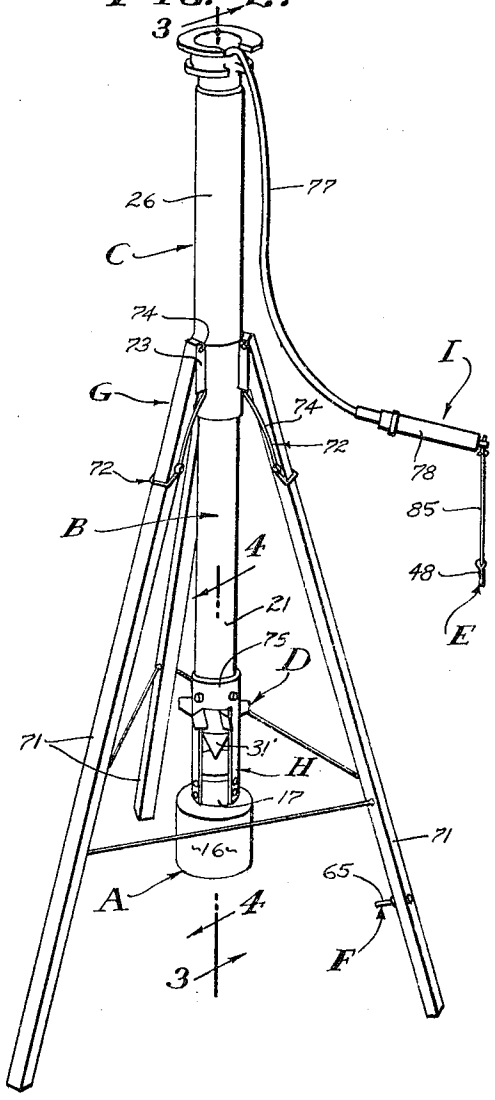

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FIG. 3.

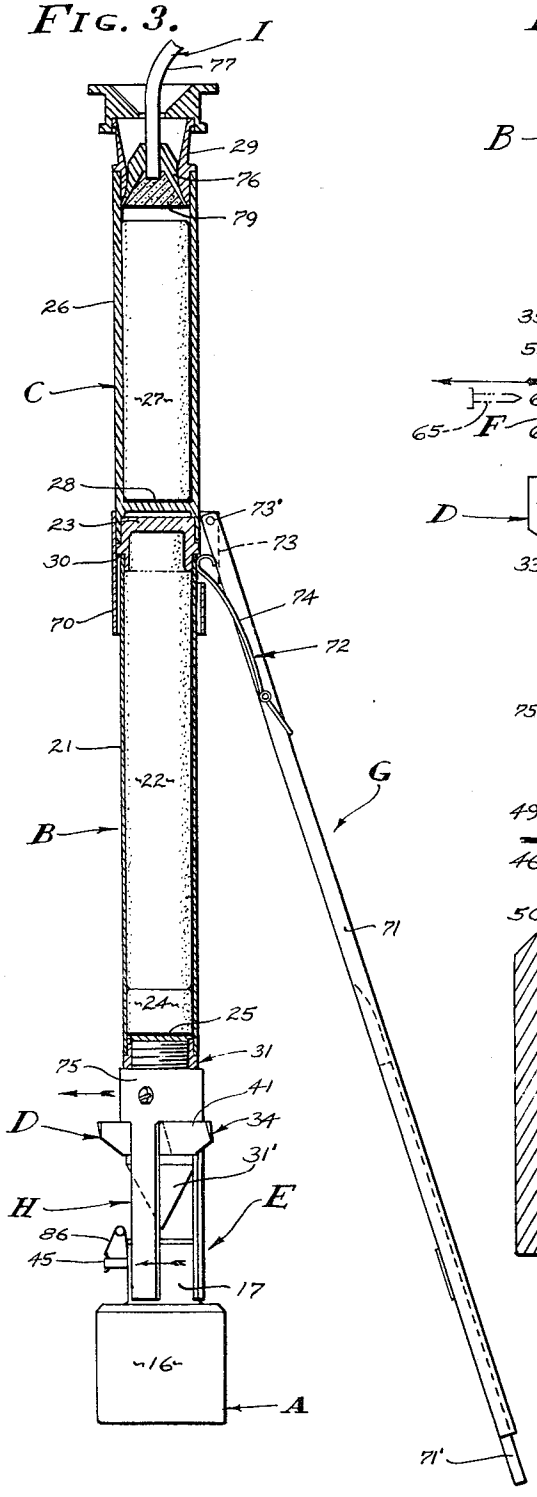

FIG. 4.

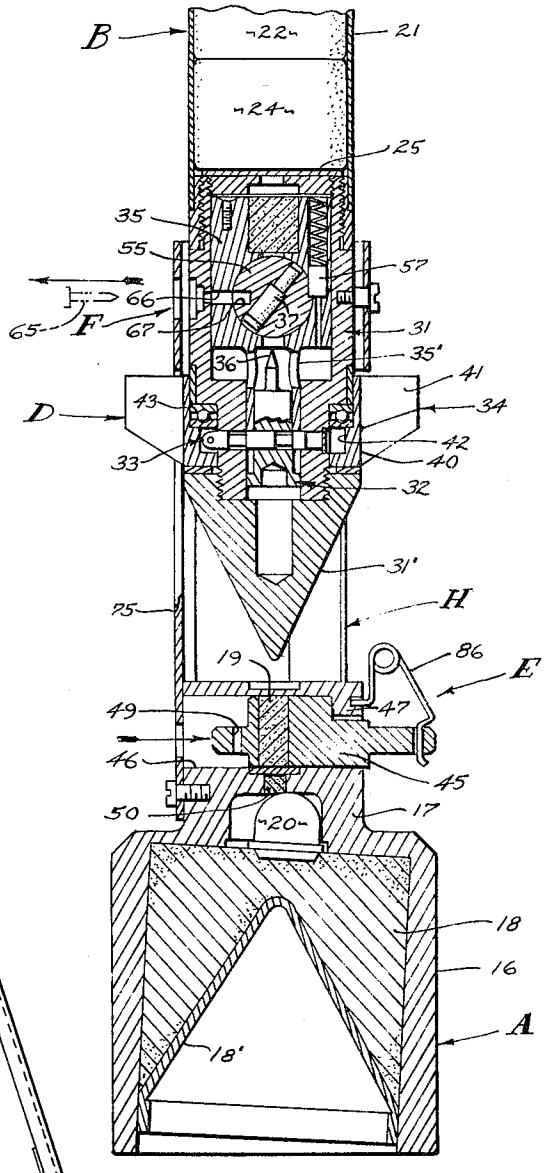

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FIG. 5.

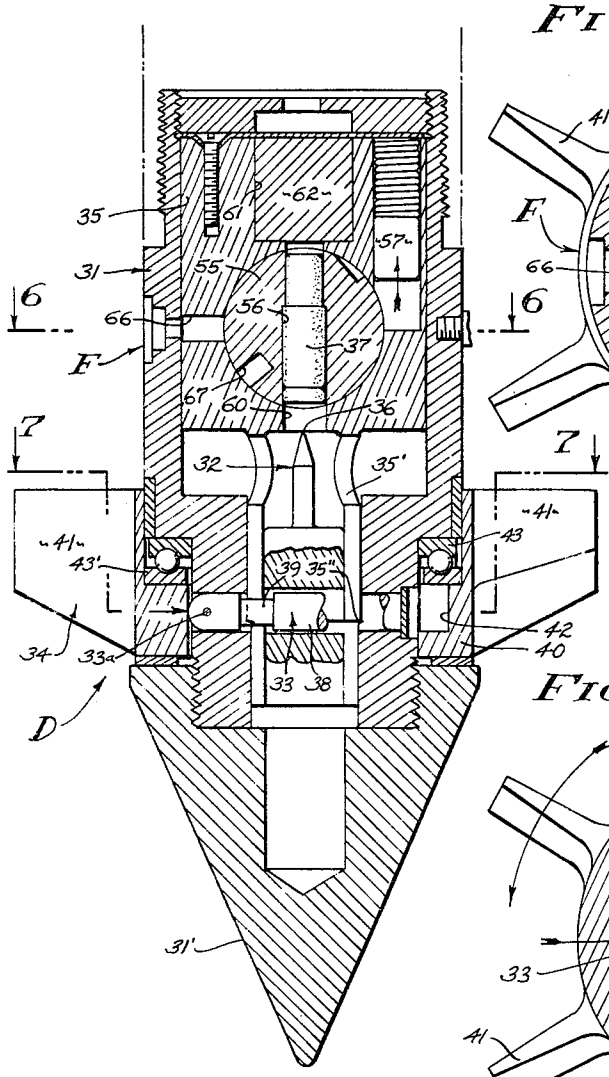

FIG. 6.

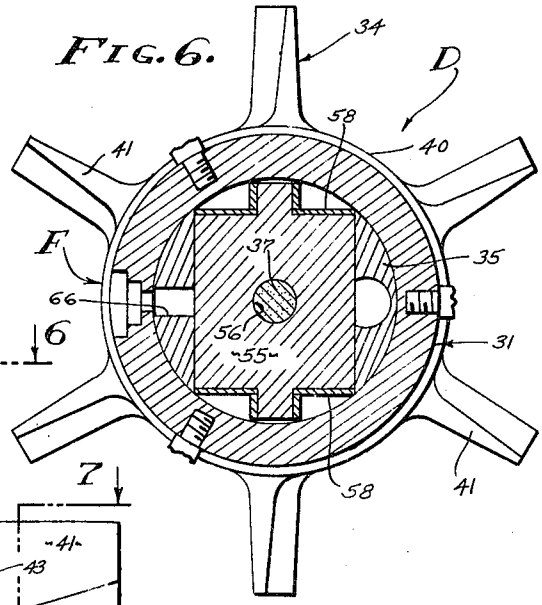

FIG. 7.

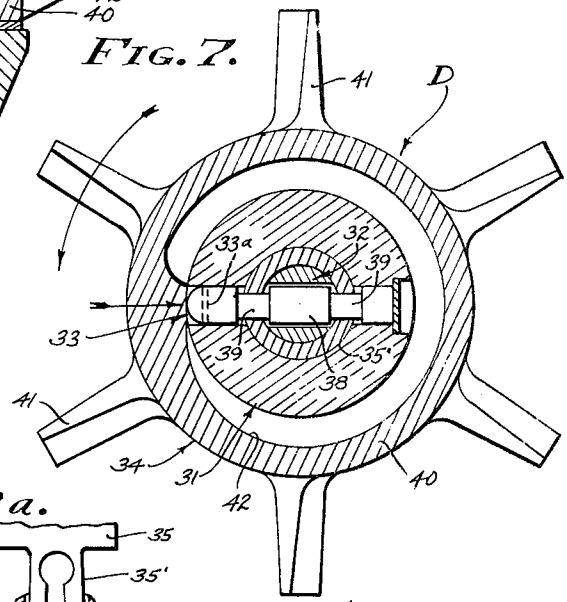

FIG. 8.

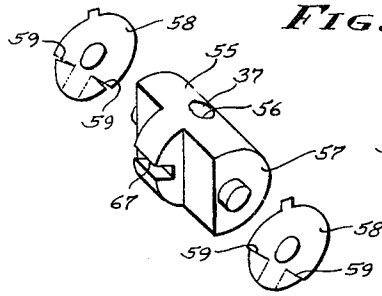

FIG. 8a.

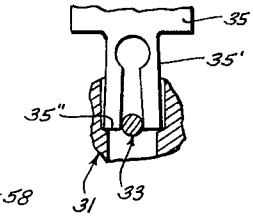

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FIG. 9.

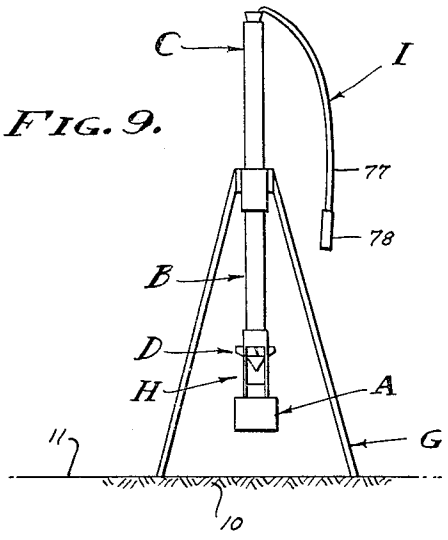


FIG. 10.

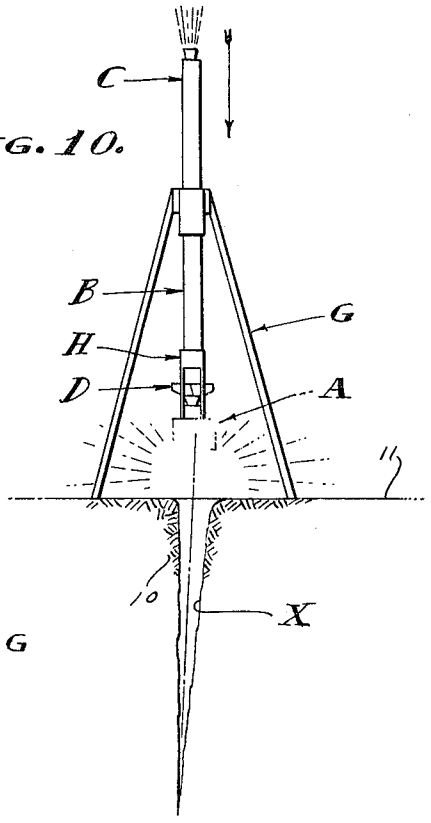


FIG. 11.

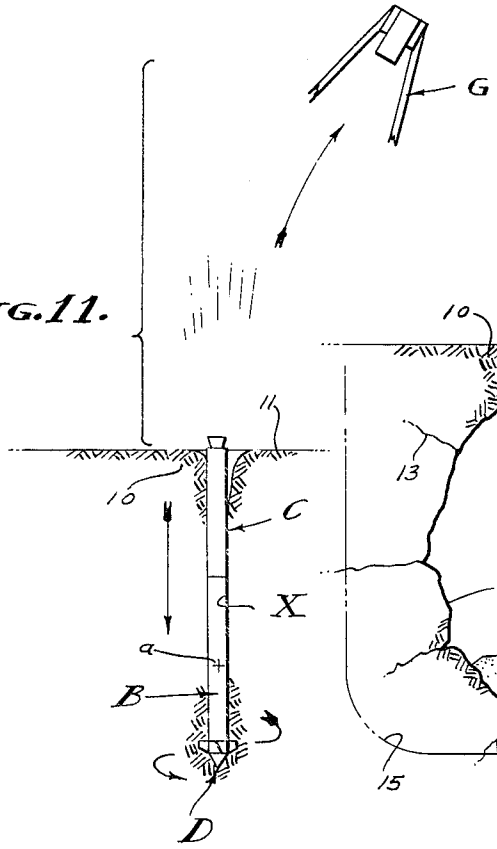
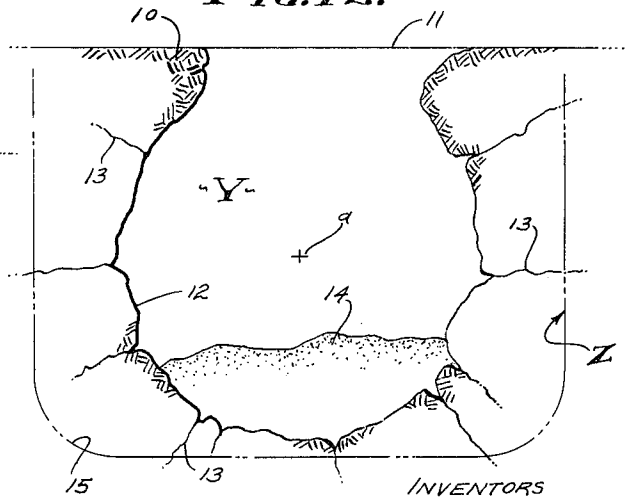


FIG. 12.



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3,216,320

APPARATUS FOR EXCAVATING BY MEANS OF EXPLOSIVES

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Continuation of application Ser. No. 758,263, Sept. 2, 1958. This application July 9, 1962, Ser. No. 208,531
6 Claims. (Cl. 89—1)

This application is filed as a continuation of application Serial No. 758,263 filed September 2, 1958, now abandoned.

This invention relates to a method and apparatus for excavating by means of explosives and is particularly concerned with the loosening and/or removal, partially or completely, of ground or earth formation. It is to be understood, however, that the method and apparatus herein disclosed is not to be limited to the loosening and/or removal of any particular substance or material since the method and apparatus has general utility and is useful in any case where it is desired to excavate or dig a hole, or the like.

In the drawings and throughout the specification the present invention is shown applied to the digging of a fox-hole for military purposes, which is ordinarily a time consuming and exhausting operation, as it is commonly carried out by military personnel. That is military personnel have been subjected to the strenuous work of manually digging protective trenches and fox-holes, which not only consumes valuable time, but which also results in fatigue at critical times or moments. In any case, whether for military or for commercial purposes, it is highly desirable to facilitate excavating that would otherwise necessitate manual removal of material in order to form a trench, or hole, or any like opening.

A general object of this invention is to provide a method, and apparatus to carry out said method, whereby explosives are employed with facility to form excavations.

An object of this invention is to provide a method and apparatus for excavating with explosives that eliminates the usual preparation procedures. With the present invention it is merely necessary to initiate operation of the apparatus used in carrying out the method, all without preliminary boring into or insertion of elements into the material being excavated.

Another object of this invention is to provide a method and apparatus whereby the formation of a bore is created by means of explosives for the insertion of an explosive charge therein that creates an excavation.

It is another object of this invention to provide a method and apparatus whereby an explosive charge is driven into a previously formed bore where it is then detonated to create an excavation by loosening and/or removing, partially or completely, the material being excavated.

It is still another object of this invention to provide a method and apparatus whereby an explosive charge is thrust into a previously formed bore by an explosive means, preferably a rocket-type motor, where said explosive charge is detonated to create an excavation.

Further, it is an object of this invention to provide an apparatus whereby the ignition of one explosive means operates to sequentially discharge other explosive means, whereby a bore is formed and after which an explosive charge is thrust into said bore and is then detonated to create an excavation.

Further, another object of this invention is to provide an apparatus of the character thus far referred to that is safe to handle and operate. The apparatus remains unarmed until deliberately set for use, and the explosive charges involved are each individually safetied.

An object of the invention is to provide an apparatus of the character above referred to that is automatically armed when set in operating position. The explosive means are technically pre-armed by release of safeties when the apparatus is erected for operation and firing.

An object of the invention is to provide an apparatus of the character above referred to that automatically arms the explosive charge only when the said charge is accelerated and thrust into proper detonating position.

It is an object of the invention to provide an apparatus of the character above referred to that fuzes the explosive charge so that said charge is detonated only after predetermined penetration into the material to be excavated.

Generally, it is an object of this invention to provide a reasonably inexpensive and yet practical method and apparatus for the purpose referred to, the apparatus of which is not only small and compact and light in weight, but which is also safe and easily handled with a minimum of effort, and which excavates in a minimum length of time and with predetermined accuracy.

The various objects and features of our invention will be fully understood from the following detailed description of a typical preferred form and application of our invention, throughout which description reference is made to the accompanying drawings, in which:

FIG. 1 is a side view with portions broken away to show in section and illustrating the apparatus of the invention in a collapsed condition for ease of handling and for storage. FIG. 2 is a perspective view of the apparatus as it is erected for operation and ready to be fired. FIG. 3 is an enlarged sectional view taken as indicated by line 3—3 on FIG. 2. FIG. 4 is an enlarged detailed sectional view taken as indicated by line 4—4 on FIG. 2. FIG. 5 is an enlarged detailed sectional view of a portion of the structure shown in FIG. 4 and showing elements thereof in different operative positions. FIGS. 6 and 7 are transverse sectional views taken as indicated by lines 6—6 and 7—7 on FIG. 5. FIG. 8 is a perspective view of one of the parts as it appears removed from the structure. FIG. 8*a* is a view showing operation of certain parts and removed from the surrounding structure. FIGS. 9 to 12 are diagrammatic views illustrating the method and employing of the particular apparatus provided, FIG. 9 showing the apparatus as erected in FIG. 1, FIG. 10 showing the apparatus fired and the explosive means detonated to create a bore. FIG. 11 showing the explosive charge being thrust into the material to be excavated, and FIG. 12 showing the excavation that is formed and created by operation of the method and apparatus.

Explosives have been used in various ways to dislodge materials in order to form openings of various kinds. For example, it is common practive to drill or bore into solid material, such as rock, and to insert an explosive charge therein which fractures and loosens the material when detonated, and in this way a relatively small charge is sufficient. On the contrary, an explosive charge merely applied to the surface of such material has little effect in comparison and requires a relatively large charge in order to accomplish the same result. Therefore, the method and apparatus of the present invention employs a bore into which an explosive charge is inserted to the end that said charge is of minimum size and weight and so that maximum effect is gained therefrom. However, with the method and apparatus as disclosed herein it is not necessary to manually prepare a bore in the material nor to manually insert an explosive charge into such a bore prior to detonation of said charge. With the method and apparatus provided, the steps of boring, in-

sertion and detonation are all automatically carried out in the proper sequence and in a positive predetermined manner.

The method provided by the present invention involves, generally, a first step of establishing a bore, a second step of projecting an explosive charge into said bore, and a third step of detonating said charge when it is properly positioned in the bore. Although a preferred form of apparatus is later described for the specific purpose of carrying out the three general steps of this method, it is to be understood that various forms of apparatus may be employed without deviating from the scope of the method involved. That is, each step may be carried out separately, for example, and not necessarily with a particular unitized apparatus wherein the elements combine to operate in combination and jointly, all as later described.

In accordance with the method, the first step of establishing a bore, for instance a bore X (see FIG. 10) in earth formation **10** or the like, is accomplished by means of an explosive "shaped-charge," later described. Said "shaped-charge" is positioned at and faces toward the surface **11** of the earth formation **10** and is preferably spaced a short distance away from said surface **11**. When the "shaped-charge" is detonated, the blast thereof is focused to penetrate through the earth formation **10** a substantial distance creating the bore X which is, in actual practice, a slender elongate opening in the earth formation **10**, and in the nature of a pilot hole.

The second and intermediate step of projecting an explosive charge into the bore X (see FIG. 11) may be accomplished by various means and preferably by means of thrust resulting from the ignition of an explosive charge, or rocket type motor. In other words, the explosive charge (later described) is driven into the bore X through ignition of a propellant charge that advances the explosive charge into the bore X for insertion within the earth formation **10** well beneath the surface **11** thereof.

The third and final step of detonating said explosive charge is carried out after said charge has reached a proper detonating position within the earth formation **10** (see FIG. 11). The proper detonating position is indicated at *a* in FIGS. 11 and 12, in which position the explosive charge is set off to fracture, loosen and remove material from the earth formation **10**. As shown, the explosive charge is buried a substantial distance into the earth formation **10** following the direction of the bore X, and as a result, material is blown out of position leaving a spherically shaped cavity Y preferably opening at the surface **11**. The cavity Y is defined by a wall **12** and is characterized by radiating interstices **13** caused by fracturing of the earth formation **10** when the explosive charge is detonated.

It will be apparent how explosion of the explosive charge expels material from the earth formation **10** to establish the cavity Y therein. Further, a substantial amount of material will fall back into the cavity Y as indicated at **14**. It will be apparent that the effect of the explosion at point *a* will vary widely depending upon the properties of the particular earth formation involved and upon the condition thereof, but in any case the general result is the same, That is, a cavity Y will be formed, and a certain amount of material **14** will fall back into the cavity or remain therein. In addition to the above mentioned steps, the cavity Y is cleaned out to the depth of the radiating interstices **13**, as indicated by the line **15**, by manual or any other suitable means, to establish a finished opening, for instance a fox-hole Z for military purposes.

In accordance with the invention there is provided apparatus adapted to be collapsed for handling and transporting and adapted to be erected for operation and use. As best illustrated in FIGS. 1 and 2 of the drawings, the apparatus involves, generally, a boring means A, an explosive charge B, driving means C to project the charge B into the bore X created by the means A, and detonating means D to set off the charge B at a predetermined position in the bore X. In addition, the apparatus includes safety means E for the boring means A, safety means F for the explosive charge B, a standard G, a support H for the boring means A, and igniting means I to initiate operation of the apparatus. Also, there is a housing K to contain the entire structure in a collapsed condition.

The boring means A is provided to carry out the first step of the method and involves a "shaped-charge" of explosive. The structure of the present invention is constructed along a longitudinal axis that will be referred to as a central vertical axis since the particular apparatus under consideration will ordinarily be employed upon a substantially horizontal surface. The means A is placed to occur on the central axis of the structure and is spaced above the surface **11** when in working position. The means A involves a shell **16** of cylindrical shape closed at its top **17** and open at its bottom. A jet cartridge **18** is carried in the shell **16**, said cartridge having a cylindrical outer wall, a flat top wall, and an inverted cone-shaped bottom wall. A linear and retainer **18'** is pressed into the shell **16** and has a conical wall conforming to the shape of the bottom wall of the cartridge **18**. A jet cartridge booster **20** is carried in the shell **16** adjacent the top of the cartridge **18** to detonate it, as later described. The cartridge **18** is set off by a detonator **19** that is carried and positioned by the safety means E. Further, the axis of the cartridge **18** is angularly related to the central axis of the structure to insure operation of the detonating means D, as later described. For example, it is canted at an angle of about 3½°.

The explosive charge B is provided to be projected into the bore X in accordance with the second step of the method and involves a high explosive charge. The explosive charge B is placed to occur above the boring means A on the central axis of the structure and is spaced somewhat from the means A. The explosive charge B involves a case **21** of cylindrical shape that carries an explosive load **22**. In practice the case **21** is a slender elongate element closed at its upper end **23** and open at its bottom. The load **22** occupies the interior of the case and is confined therein by an exposive booster **24** that is carried in the case at the lower end portion thereof to close the case and to detonate the load **22**, as later described. In practice, a thin frangible disc **25** is placed beneath the booster **24** to secure it in the proper position.

The driving means C is provided to project the explosive charge B into the bore X, in accordance with the second step of the method, and preferably involves a rocket type thrust motor. However, it is to be understood that other equivalent thrust producing means may be employed in order to project the explosive charge B downwardly, for example a cylinder and piston mechanism, or the like. The driving means C, as illustrated in the drawings, involves a body **26** of cylindrical shape that carries a propellant charge **27**. In practice, the body **26** is a continuation of the case **21** of the explosive charge B and is a slender elongate element closed at its bottom **28** and open at its top. A venturi-shaped nozzle **29** is carried at the top of the body **26** to handle the exhaust blast of the propellant charge **27**, when it is ignited, and is a tubular element formed concentric with the central axis of the structure. As best illustrated in FIGS. 1 and 3, the body **26** is slightly larger in diameter than the case **21**, there being a downwardly faced shoulder **30** where the two elements are joined.

The detonating means D is provided to set off the explosive charge B in accordance with the third step of the method and operates to set off the charge B only after said charge has reached a predetermined position in the bore X. It is to be understood that the means D may be varied as circumstances require and may be

any suitable mechanism responsive to movement or positioning of the explosive charge B. The particular detonating means illustated in the drawings is in the nature of a fuze and is best illustrated in FIGS. 5, 6 and 7. As shown, the fuze type detonating means D involves a head **31**, a firing pin **32**, a sear **33** and an actuator **34**. The head **31** houses and carries the elements of the detonating means D and also carries the elements of the safety means F for the explosive charge B, later described.

The head **31** is a continuation of the lower end of the case **21** and depends therefrom to carry a pointed tip **31'** adapted to have piercing action for purposes later described. The firing pin **32** is seated in the head **31** to face upwardly along the central axis and has a pointed upper end **36** adapted to strike a detonator **37** that is carried and positioned by a shiftable part of the safety means F. A fuze body **35** is shiftably carried within the head **31** to move longitudinally of the head from a normally unactuated position, as shown throughout the drawings, to a position where the detonator **37** strikes the firing pin **32**. As clearly shown in FIG. 5, the fuze body **35** is a cylindrical part that incorporates the means F later described for positioning the detonator **37** and it has a depending stem **35'** that is passed through a bore in the lower end portion of the head **31**. The stem **35'** is tubular in form and accommodates the firing pin **32** so that the pin is slidable within the stem **35'**. As shown in FIG. 8*a* the stem **35'** is split or bifurcated so that it can be spread laterally by the sear **33**, and in accordance with the invention, the bore in the head **31** that passes the stem **35'** is provided with an upwardly faced shoulder **35''** to have supporting engagement with the stem. As shown, the stem **35'** has a flat end face that spreads diametrically outwardly to seat upon the shoulder **35''**.

The sear **33** is a shiftable element that operates transversely of the head **31** and firing pin **32**, and is is a spool-shaped element with an enlarged central portion **38** and with spaced reduced portions **39** adjacent each end of the portion **38**. The sear **33** is round in cross section and extends through an opening that passes transversely through the pin **32** to hold the pin in operating position. When the central portion **38** of the sear is offset as shown in FIG. 4 the enlarged portions of the firing pin **32** engage in the bifurcations of the stem **35'** to spread the stem for supporting engagement on the shoulder **35''**. When the portion **38** is shifted to occur centrally of the structure as shown in FIGS. 5 and 7 the stem **35'** is allowed to constrict for release from the shoulder **35''** to move longitudinally of the head and downwardly relatively to strike the cap **37** against the firing pin **32**.

A feature of the present invention is the actuator **34** provided to release the sear **33** only after said explosive charge B has reached a predetermined position in the bore X. The head **31** is carried at the lower end of the assembly formed by the explosive charge B and driving means C, and the actuator **34** involves a ring-shaped element characterized by a sleeve **40**, vanes **41** and by a cam **42**. The element forming the actuator **34** is rotatably carried by the head **31**, the sleeve **40** being an annular part occupying a correspondingly shaped recess in the head. In practice, the head **31** has a reduced portion forming the recess, and the tip **31'** is secured to the said reduced portion, preferably by a threaded connection, to retain the sleeve **40** in working position. Since substantial axial thrust is applied to the sleeve **40** under operating conditions, there is provided a bearing **43**, preferably an anti-friction ball bearing unit that rotatably supports the sleeve **40** and which is designed to receive upwardly directed axial forces. As shown, the bearing **43** has an upper race seated in the head **31**, a lower race **43'** carrying the sleeve **40** and ball bearings intermediate the races.

One or more vanes **41**, preferably a plurality of vanes, for example six vanes, project radially from the periphery of the sleeve **40** in order to engage in the earth formation **10**. That is the vanes **41** are adapted to engage with the wall of the bore X as the assembly of parts enters into said bore. As clearly illustrated, the vanes **41** are flat longitudinally disposed fin-shaped parts suitably pitched or inclined in helical planes so as to have a screw action within the earth formation **10**. In practice, the vanes are pitched to rotate the sleeve **40** counter clockwise when the actuator **34** is advanced downwardly toward the proper firing position (see FIG. 7).

The cam **42** is of the actuator **34** is a circular cam formed in the inner wall of the sleeve **40** and involves an involutely curved wall (see FIG. 7) that extends circumferentially and which engages one end of the sear **33** to shift the sear to the above-mentioned central position when the sleeve **40** is rotated. A light shear pin **33***a* assures that the rear **33** remains in a safe position until operation of the actuator **34**. The relationship of elements in such that the sear **33** is centrally positioned upon turning of the sleeve **40** caused by the forward and downward movement of the means D and consequent turning of the actuator **34** a predetermined amount, as indicated.

The safety means E is provided to unarm the boring means A, above described, and involves a shiftable carrier **45** to position the detonator **19** that is struck to set off the cartridge **18**. In the preferred forms of the invention the carrier **45** is a slide that operates transversely of the top **17** of the shell **16**, said carrier being shiftably supported in an opening **46** that overlies the jet cartridge **18**. A leg of the standard G, as later described, normally holds the slide in a safe position, and there is a stop **47** that positions the slide, as shown in FIG. 4, so that the detonator **19** is aligned with the cartridge **18**. There is a cotter **48**, as shown in FIG. 1, that is engaged in an opening **49** in the slide to normally hold the slide in an unarmed position with the detonator **19** substantially offset from the cartridge **18** and a spring **86** normally yieldingly urges the carrier **45** into engagement with the stop **47**. In practice, a central explosive lead filled passage **50** extends between the detonator **19** and jet cartridge **18** when the slide carrier **45** is in the armed position. Further, the top **17** of the shell **16** is provided with a relatively thin wall that normally protects the detonator **19** but which is frangible when struck to set off the said detonator.

The safety means F is provided to unarm the explosive charge B, above described, and involves a shiftable carrier **55** to position the detonator **37** that is struck by the firing pin **32** to set off the booster **24**. In the preferred form of the invention the carrier **55** is a rotary element that is unbalanced to operate by means of inertial forces to move the cap **37** into alignment with the firing pin **32** and booster **24** only when the structure is accelerated by the driving means C. As shown, in FIGS. 5 and 8 of the drawings, the carrier **55** is a cylindrical part with an opening **56** extending diametrically therethrough to carry the cap **37**. A spring biased weight **57** normally presses against a ratchet tooth at the periphery of the carrier to hold it in the unarmed position, wherein the opening **56** is out of alignment with the central axis of the structure (see FIG. 4). However, the carrier is weighted at **57'** (see FIG. 8) so that when the structure is accelerated downwardly and forwardly the carrier is rotated to the position shown in FIGS. 5 and 6 wherein the opening **56** is in alignment with the central axis of the structure. Further, during acceleration the weight **57** is retracted to allow the carrier **55** to turn. In FIG. 8 there is shown suitable spring elements in the form of plates **58** that provide the necessary frictional resistance for ordinary handling shocks, and that provide stops **59** to limit rotation of the carrier and to lock it in the aligned position. When the carrier **55** is in the armed

position, the opening communicates with the firing pin **32** through an opening **60** and with the booster **24** through an opening **61**. In practice, an intermediate lead charge **62** is carried in the opening **61**.

In carrying out the invention, means is provided to assure that the carrier **55** remains in the unarmed position while the apparatus is collapsed and in storage. This means is in the form of a lock pin **65** that is projected through an opening **66** in the head **31** to engage in a notch **67** in the carrier **55**, said pin **65** being shown in the process of removal in FIG. 4 of the drawings. When the pin **65** is engaged in the notch **67** the carrier **55** is locked unarmed.

The standard G is provided to support the above described mechanisms in an erected working position such as shown in FIG. 2. The standard G is collapsible and is such as to be easily and quickly manipulated to carry the operative elements of the apparatus. As shown, the standard G involves a collar **70** slidably carried over the body **26** of the driving means C, legs **71** pivoted to the collar **70**, and positioning means **72**. The collar **70** is a simple tubular element with outwardly projecting ears **73** to carry the legs **71**. The legs **71** are secured to the ears **73** by pins **73'**, there being three legs in the preferred form of the invention. In carrying out the invention, one of the legs has an extension **71'** that is used for leveling the apparatus, as circumstances require. The positioning means **72** is best illustrated in FIG. 3 and involves a spring element at each leg and which has an arm **74** anchored to the leg and biased inwardly to engage the body **26** and/or the case **21**. The arm **74** normally yieldingly urges the leg **71** outwardly and a rounded terminal end on the arm engages the shoulder **30** to retain the collar **70** in the supporting position. It will be apparent that the collar **70** is operable from the upper end of the body **26** to the upper end of the case **21** (see FIGS. 1 and 2).

The support H is provided to carry the boring means A in operative position relative to the explosive charge B and driving means C and is in the nature of a coupling element that joins the boring means A to the explosive charge B. In practice, the head **31** depends from the case **21** of the charge B and the support H is in the form of a sleeve **75** that surrounds the head **31** and extends forwardly and downwardly over the head to have supporting engagement with the shell **16** of the means A. Suitably spaced screw fasteners, or the like, secure the sleeve **75** to the head **31**, preferably spaced therefrom leaving an annular gap between the head and sleeve. The said screw fasteners are shear elements designed to fail at a predetermined load or pressure. Similarly, ordinary screw fasteners secure the top **17** of the shell **16** to the sleeve leaving some distance between the vertex of the tip **35** and the frangible wall that protects the cap **19**.

The igniting means I is provided to set off the apparatus of the present invention and forms a closure that protects the propellant charge **27** of the driving means C. Any suitable device may be employed for ignition of the proconventional igniting means involving a closure **76**, a safety fuse **77**, and an operator **78**. The closure **76** normally occupies the nozzle **29** and contains an igniting charge **79** adapted to ignite the charge **27** whereby pressure acts to discharge the closure **76** from the nozzle **29**. The operator **78** is manually actuated by withdrawing a cotter pin therefrom (see FIG. 2) to activate the safety fuse and the charge **79**. In any case, a time interval is established by the operator **78** between the moment of manual actuation and the moment of detonation, during which time interval a person can remove himself to a safe distance.

The housing K is provided to contain and store the collapsed apparatus in an unarmed and safe condition. The housing K is a closed tube **80** having a cover **81**, and of a diameter to slidably receive the legs **71** that are spaced to centrally position the means A, charge B and means C. With the legs **71** collapsed, the lock pin **65** remains engaged with the carrier **55** to unarm the explosive charge B, and the cotter **48** remains engaged in the opening **49** to secure the slide carrier **45** to unarm the "shaped-charge" of the means A. In accordance with the safety features of the present invention, a lanyard **85** extends from the operator **78** to the cotter **48** so that by ordinary manipulation of the operator the cotter **48** is removed from the carrier **45**. As above mentioned, the lock pin **65** is normally engaged with the carrier **55** and it is retracted to pre-arm the charge B only when the leg **71** carrying the pin **65** is moved to an erecting position. Thus, the apparatus is automatically pre-armed as it is erected as shown in FIG. 2.

With the apparatus erected as thus far described, operation is initiated by manual actuation of the igniting means I that times the ignition of the propellant charge **27** of the driving means C. Upon ignition of the charge **79** the propellant charge **27** acts to discharge gases through the nozzle **29** to create thrust for moving the elements of the apparatus downwardly and forwardly. In practice, the initial thrust is substantial and sudden with the result that the charge B and detonating means D, and associated elements, are accelerated rapidly. In accordance with the invention, the shear screws at the sleeve **75** of the support H are structurally weak and fail in order to allow the tip **31'** to be guided by the sleeve **75** to advance into engagement with the detonator **19** to set off and detonate the "shaped-charge" of means A, the inertia of the elements of means A being sufficient to hold said means in position, momentarily.

With the detonation of the boring means A the bore X is formed in the earth formation **10** and on an axis canted relative to the central axis of the apparatus. The elements of the means A and H are fabricated of frangible materials that disintegrate from the forces of the blast of means A and whereby there is no obstruction in the downward path of the explosive charge B. With the combustion of the propellant charge **27** well under way the driving means C and charge B are moved with accelerated force into the bore X established ahead thereof whereupon the vanes **41** operate in the earth formation, which action is assured by canting the bore X, to rotate the sleeve **40** to release the fuse body **35**, all as above described. As the charge B and safety means F are accelerated the carrier **55** is rotated by inertial forces as above described so that the charge B is armed for detonation when the proper firing position is reached beyond the surface **11** and well within the earth formation **10**. Upon reaching the lower end portion of the bore X, the moving structure is decelerated rapidly by means of frictional engagement with the earth formation **10**. Thus the fuze body **35** carries the detonator **37** forcefully into engagement with the firing pin **32**, all to the end that the explosive charge B is set off at the point *a*, as set forth above.

Having described only a typical preferred form and application of our invention, we do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to ourselves any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims:

Having described our invention, we claim:

1. An apparatus for excavating material and including:

(a) a standard disposed on an axis normal to and for supporting engagement upon the surface of the material to be excavated,

(b) a shaped-charge of explosive supported by the standard on said axis to form a bore in said material and having a detonator to be set off by percussion,

(c) a safety means comprising a carrier shiftably supporting the detonator to move it from an unarmed offset position to an armed position aligned with said axis,

(d) a second explosive charge releasably carried by the standard on said axis and having a head movable

into engagement with the detonator of the shaped-charge to detonate it,

(e) a rocket propellant charge to thrust said explosive charge into the detonator of the shaped-charge and into the bore,

(f) and means to detonate said second explosive charge and comprising a fuse carrying body, a sear normally engaging said fuse carrying body and a rotatable actuator adapted to release the sear from the fuse carrying body, said actuator having at least one radially projecting element engageable with the side walls of the bore to rotate the actuator and detonate the fuse, whereby said second charge is set off at a predetermined depth within said bore and said material is loosened forming a cavity.

2. An apparatus for excavating material and including:

(a) a standard disposed on an axis normal to and for supporting engagement upon the surface of the material to be excavated,

(b) a shaped explosive charge carried by said standard to form a bore in said material,

(c) a second explosive charge carried by the standard on said axis,

(d) a rocket to thrust said second explosive charge into the bore,

(e) and means to detonate said second explosive charge and comprising a fuse carrying body shiftable longitudinally, a sear normally engaging said fuse carrying body and a rotatable actuator with a cam face to release the sear from the fuse carrying body, said actuator having radial vanes engageable with the side walls of the bore and pitched to rotate the actuator and detonate the fuse, whereby said second explosive charge is set off at a predetermined depth within said bore and said material is loosened and expelled forming a cavity.

3. Apparatus according to claim 2 wherein said shaped charge is slightly tilted with respect to said axis to ensure engagement of said radial vanes with the side walls of the bore.

4. An apparatus for excavating material including:

(a) a support disposed on a longitudinal axis normal to the material to be excavated and carrying a shaped-charge of explosive to form an elongated bore in said material and along said axis;

(b) a container having a second explosive charge positioned therein, said container and said second explosive charge being substantially aligned with said longitudinally disposed axis and with said shaped-charge;

(c) driving means coupled to said second explosive charge for projecting said second explosive charge along said longitudinal axis and into said bore; and

(d) detonating means mounted on the exterior surface of the side wall of said container and engageable with the side walls of said bore to detonate said second explosive charge at a predetermined depth within said bore, whereby said material is loosened and expelled, forming a cavity.

5. Apparatus according to claim 4 wherein said detonating means mounted on the exterior of the container includes an actuator rotatable on said longitudinally disposed axis and having vanes engageable with the side walls of said bore.

6. Apparatus according to claim 4 wherein said first mentioned shaped-charge of explosive is slightly tilted with respect to said longitudinally disposed axis.

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