United States Patent [11] 3,580,171

[72] Inventor Michael E. Maes
Bellevue, Wash.
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[73] Assignee Explosives Corporation of America
Issaquah, Wash.
Continuation-in-part of application Ser. No. 703,994, Feb. 8, 1968, now abandoned, which is a continuation-in-part of application Ser. No. 631,123, Apr. 17, 1967, now Patent No. 3,419,443.

[54] FIELD SENSITIZED EXPLOSIVE DEVICES AND SENSITIZING METHOD

23 Claims, 18 Drawing Figs.

[52] U.S. Cl. 102/28
[51] Int. Cl. F42b 3/10, F42b 3/18
[50] Field of Search 86/1, 20, 20.3; 102/22—24, 28

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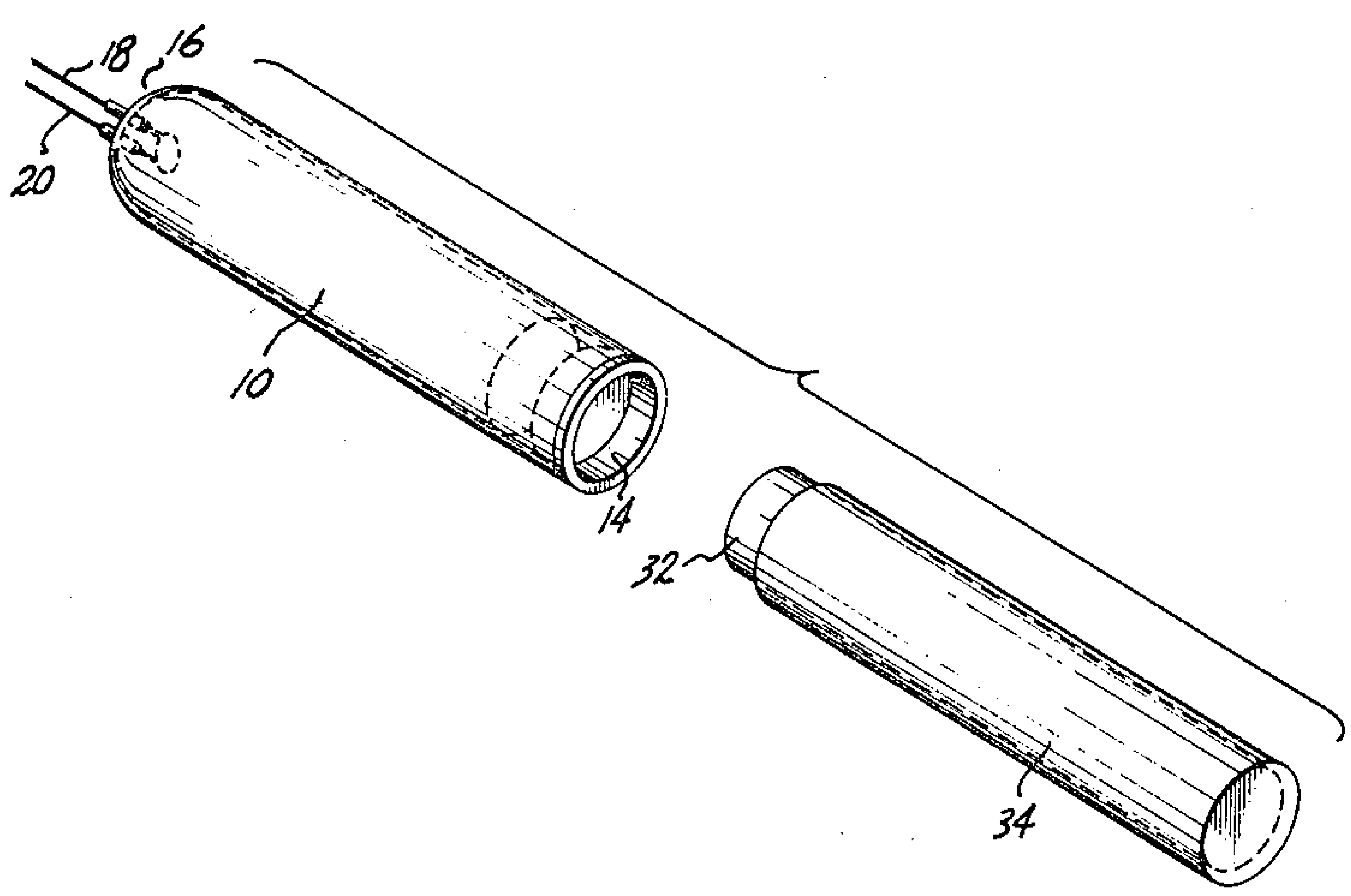
Primary Examiner—Verlin R. Pendegrass
Attorney—Graybeal, Cole and Barnard

ABSTRACT: Rigid and flexible container type portable devices incorporating an intrinsically nonexplosive solid constituent of an explosive composition. Sensitizing of the device at the site of use by adding thereto a complementary intrinsically nonexplosive liquid constituent of the explosive composition, for admixing with the solid constituent. Such devices including built-in electrical initiators or fuse wells. Such devices constructed for coupling with a similar container containing the liquid constituent in a frangible capsule, including means for cutting or fracturing the capsule when the containers are moved together, and means for preventing fluid leakage from the assembly or the device. Such two container devices which are joinable in a first prearm, nonmixing position, and are movable into a second mixing position, in which the frangible capsule is fractured.



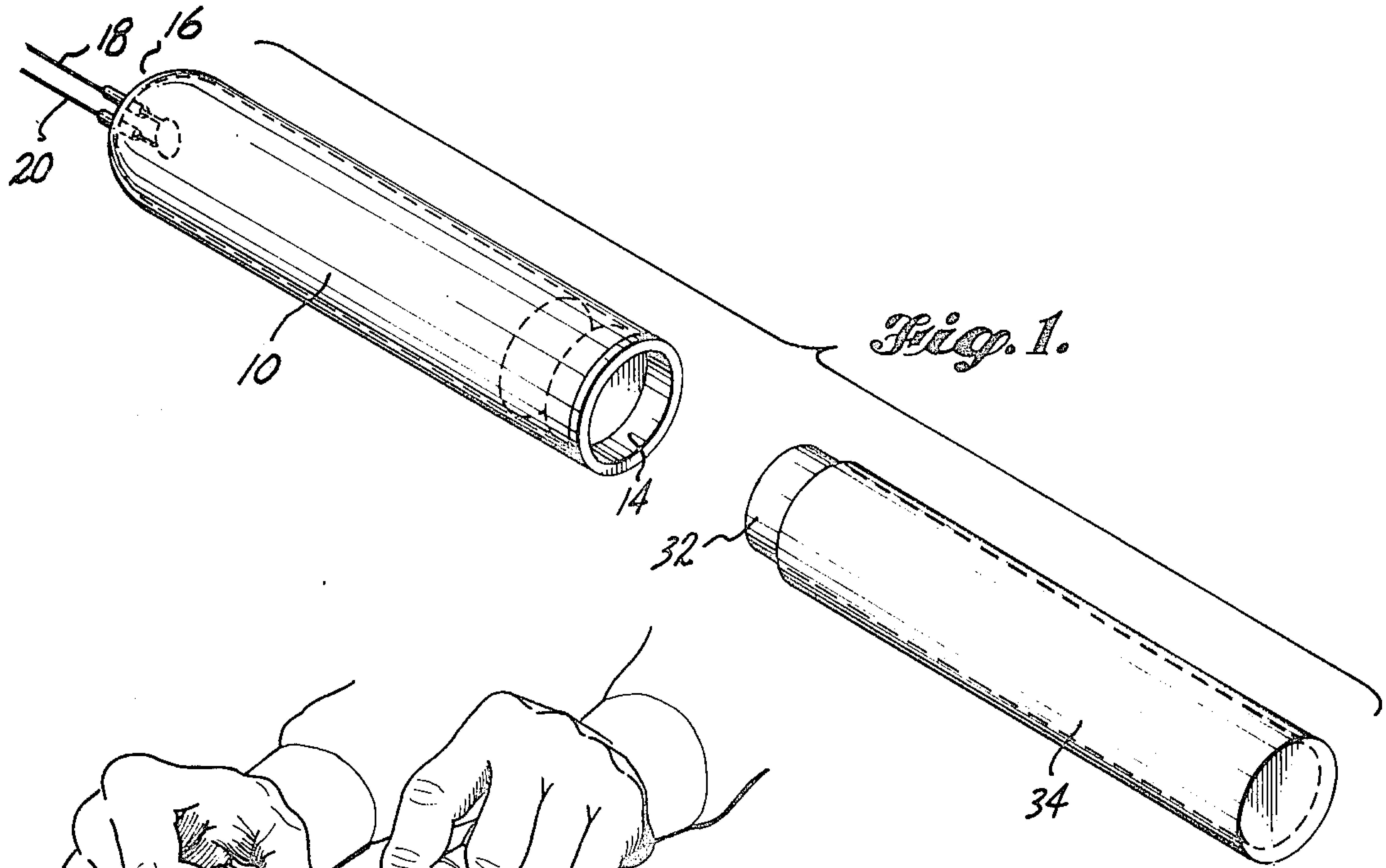


Fig. 1.

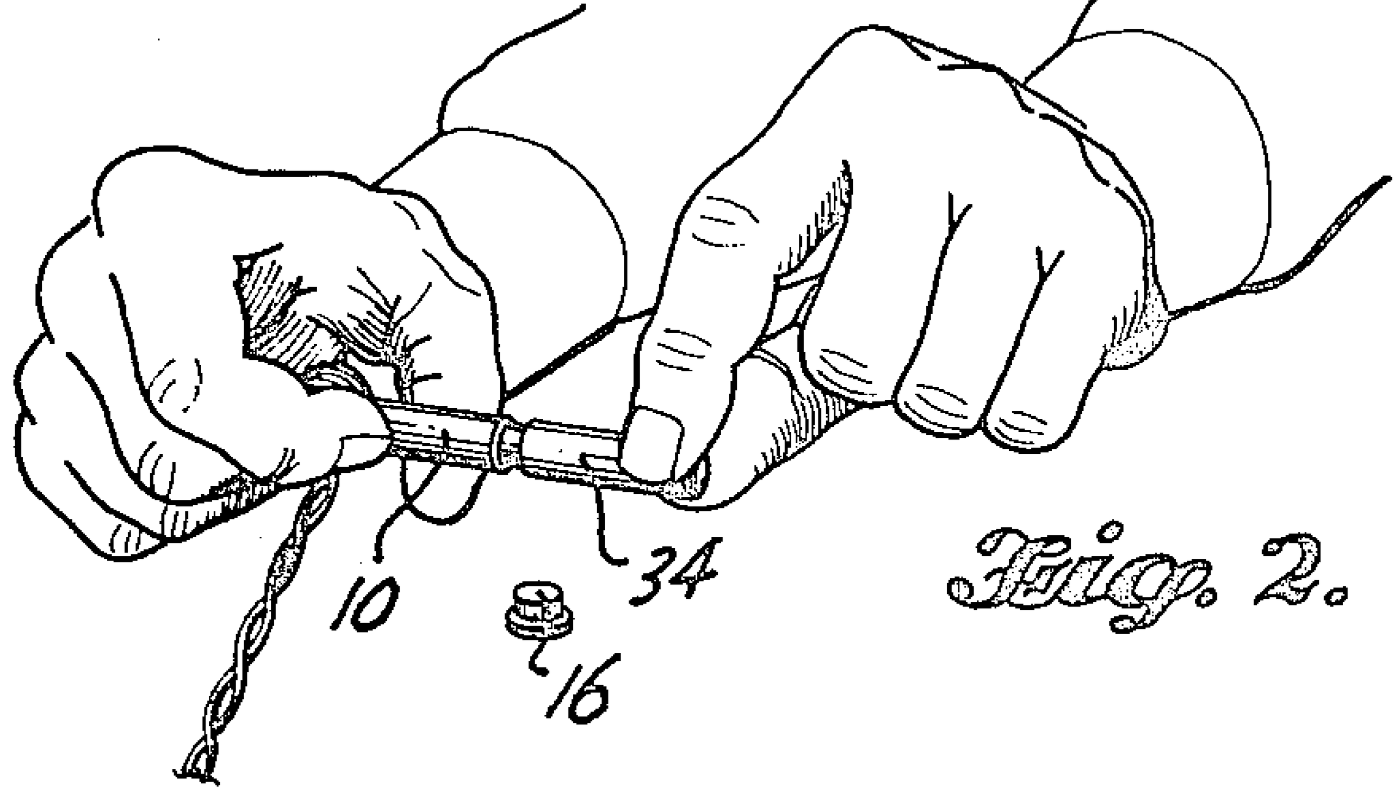


Fig. 2.

Fig. 3A

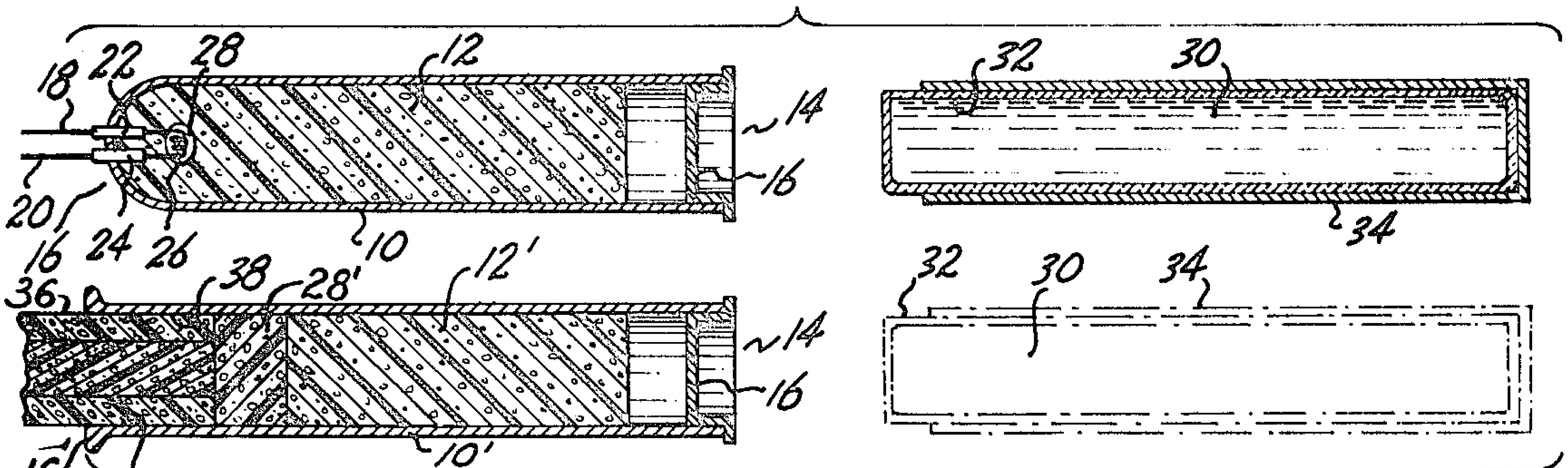


Fig. 3B.

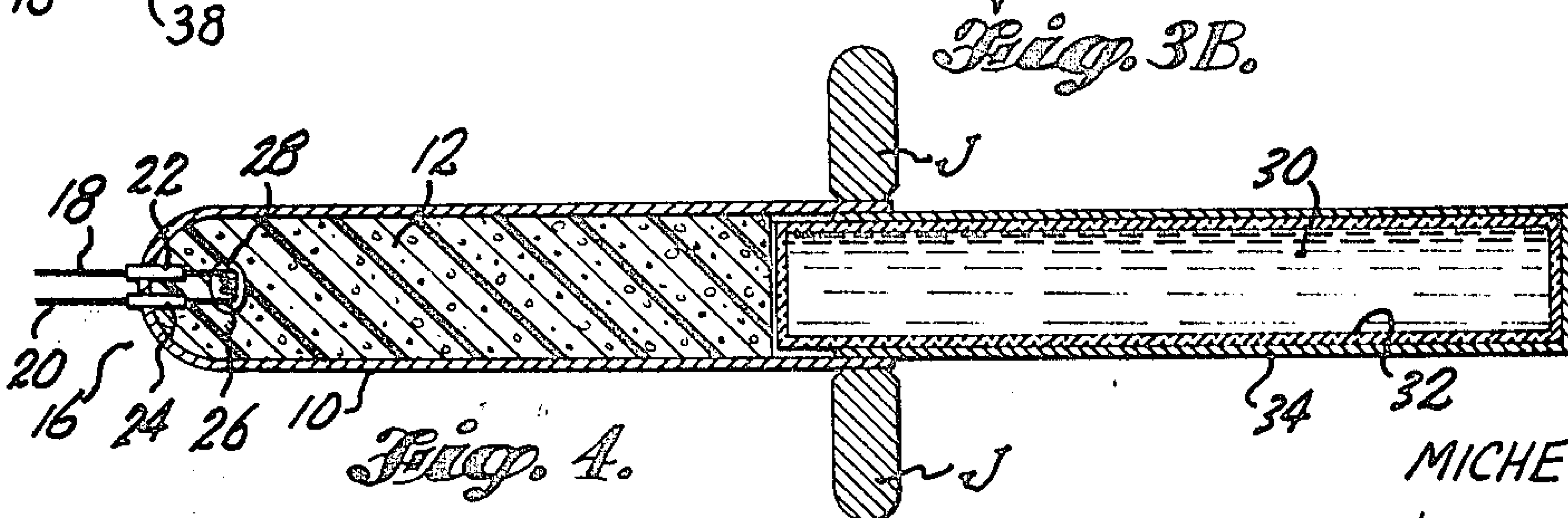


Fig. 4.

INVENTOR.
MICHEL E. MAES
BY Graybeal, Cole & Barnard
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Fig. 5.

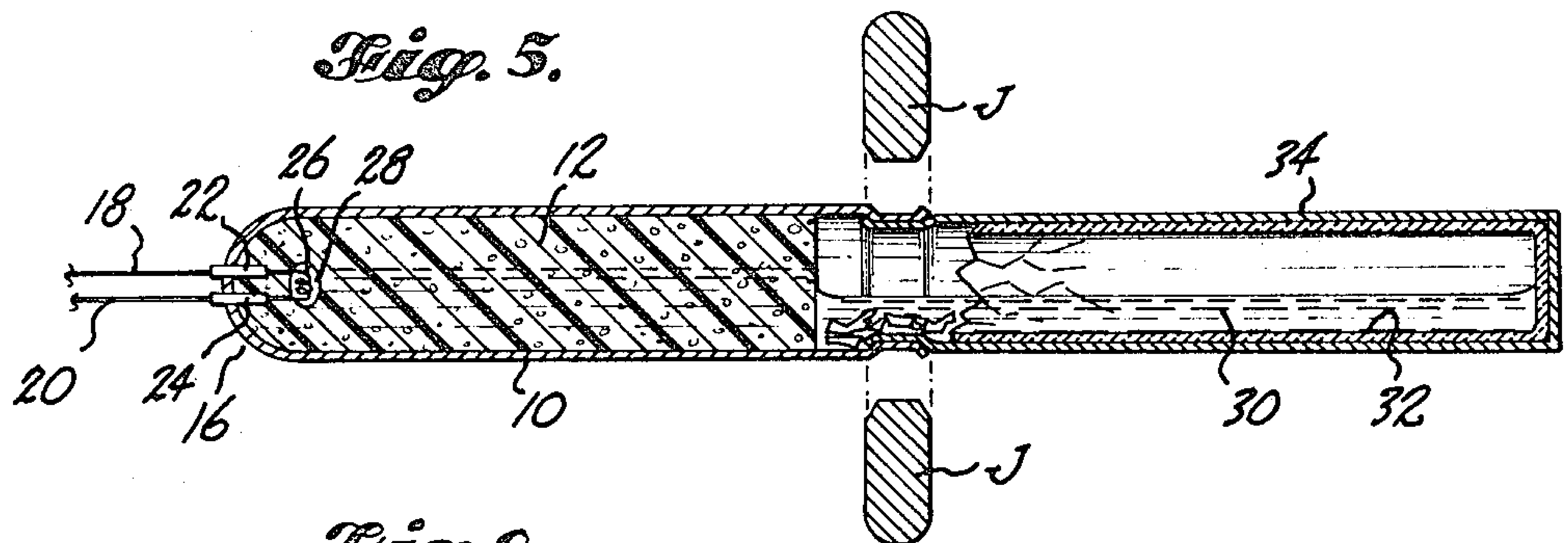
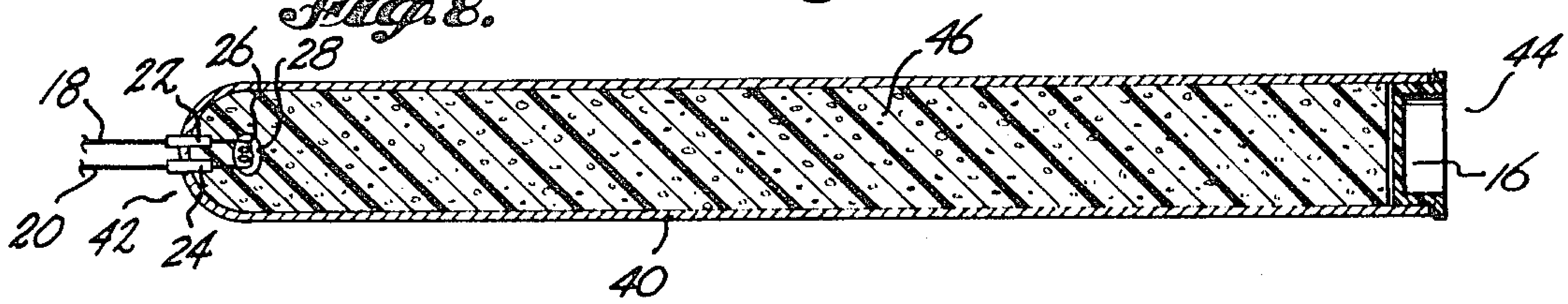


Fig. 8.



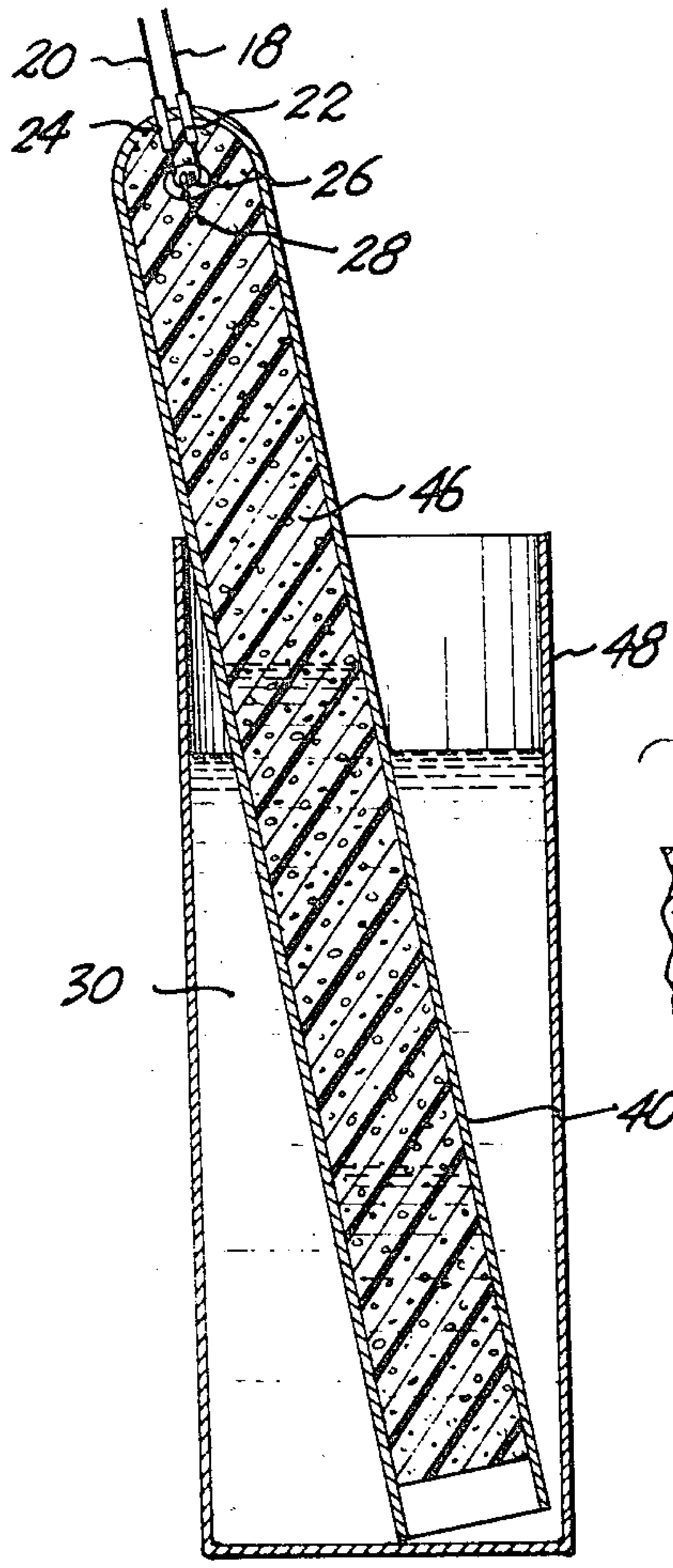


Fig. 9.

Fig. 6.

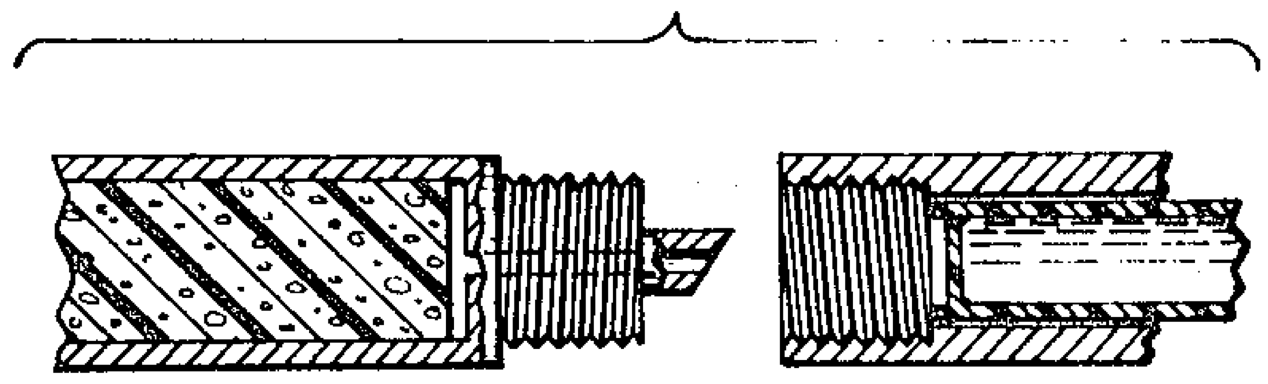
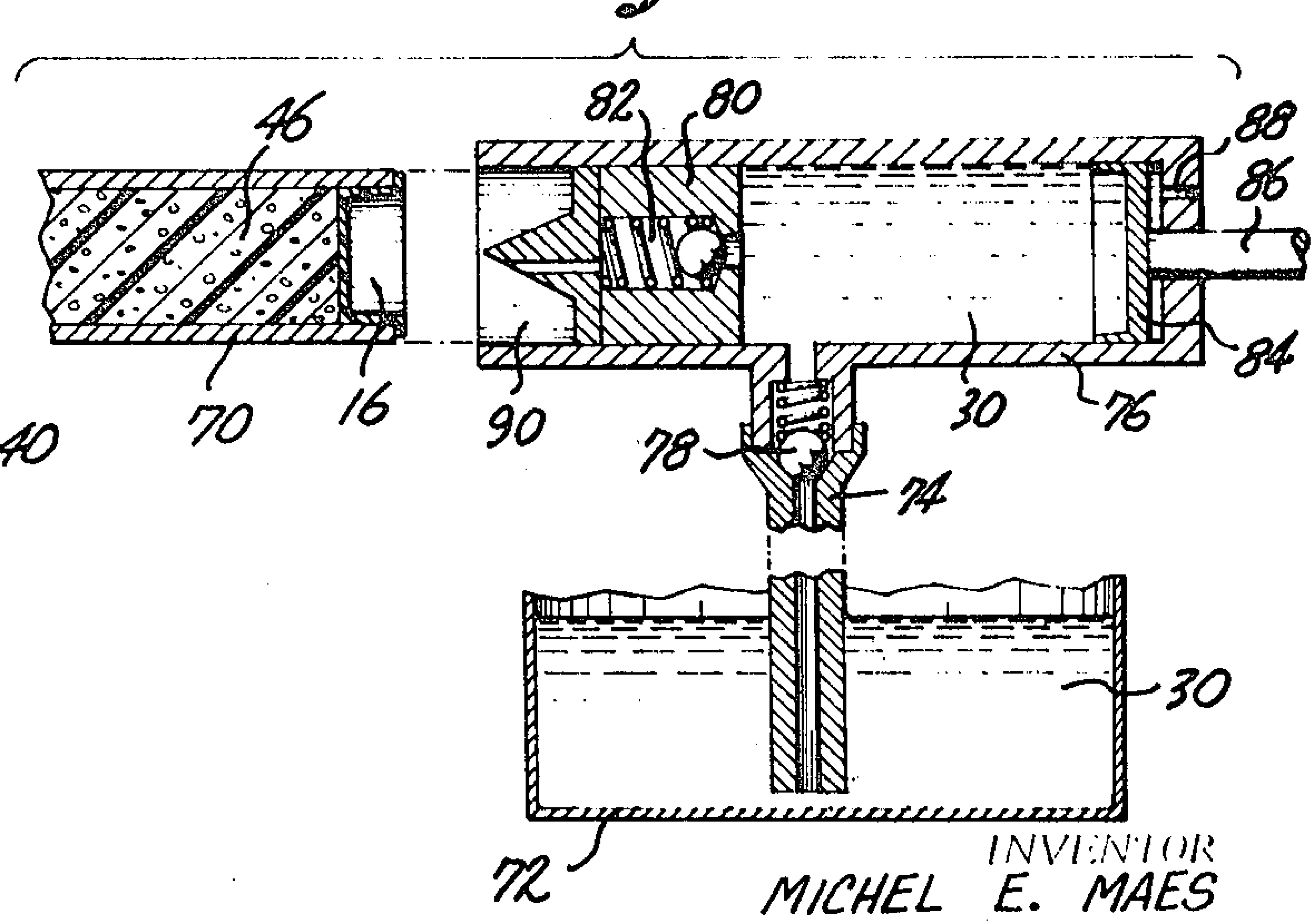


Fig. 7.



INVENTOR
MICHEL E. MAES

BY Graybeal, Cole, & Barnard

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Fig. 10.

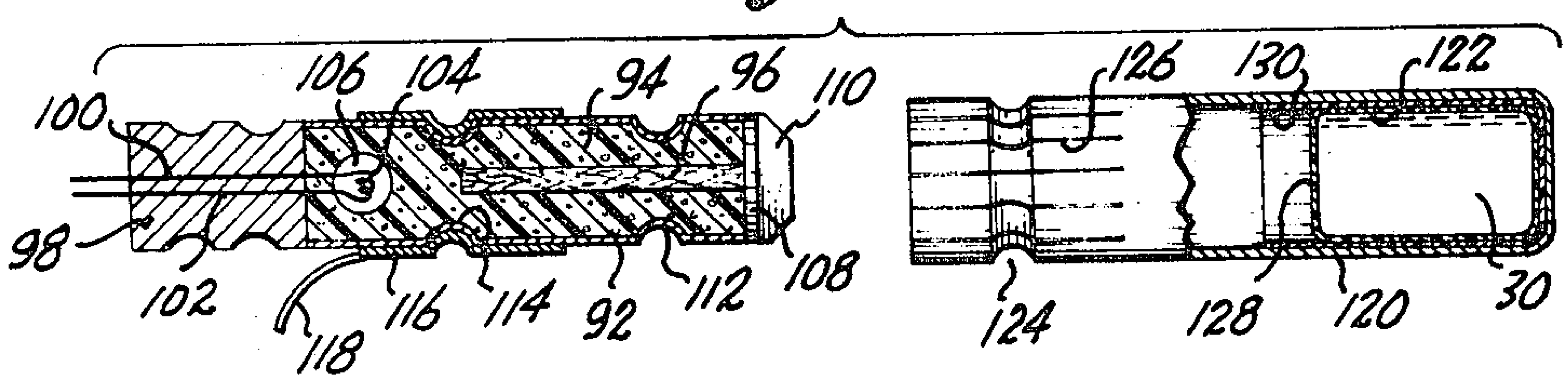


Fig. 11.

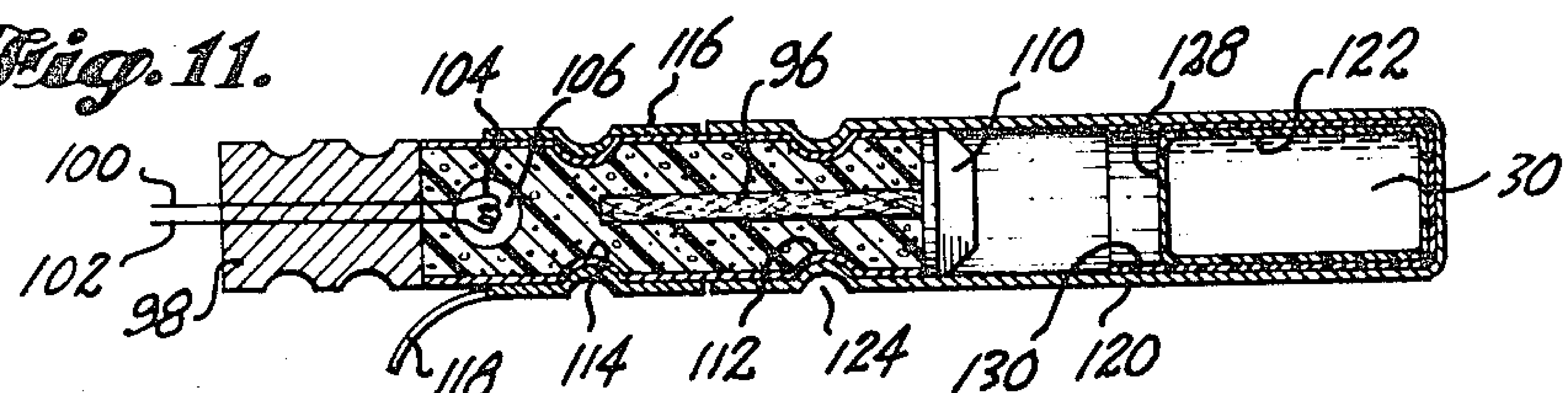


Fig. 12.

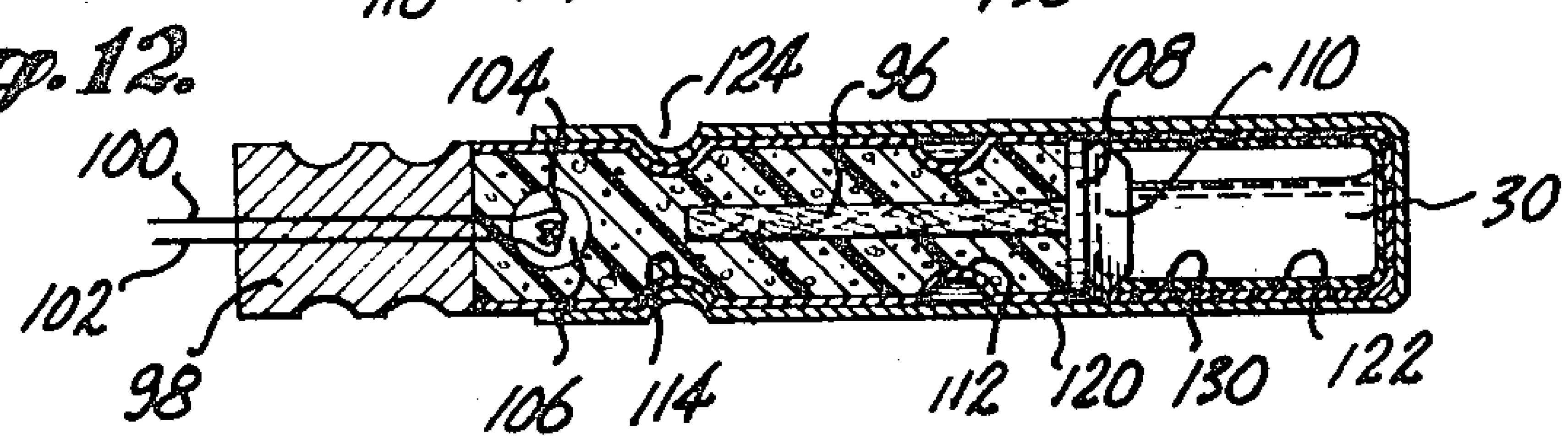
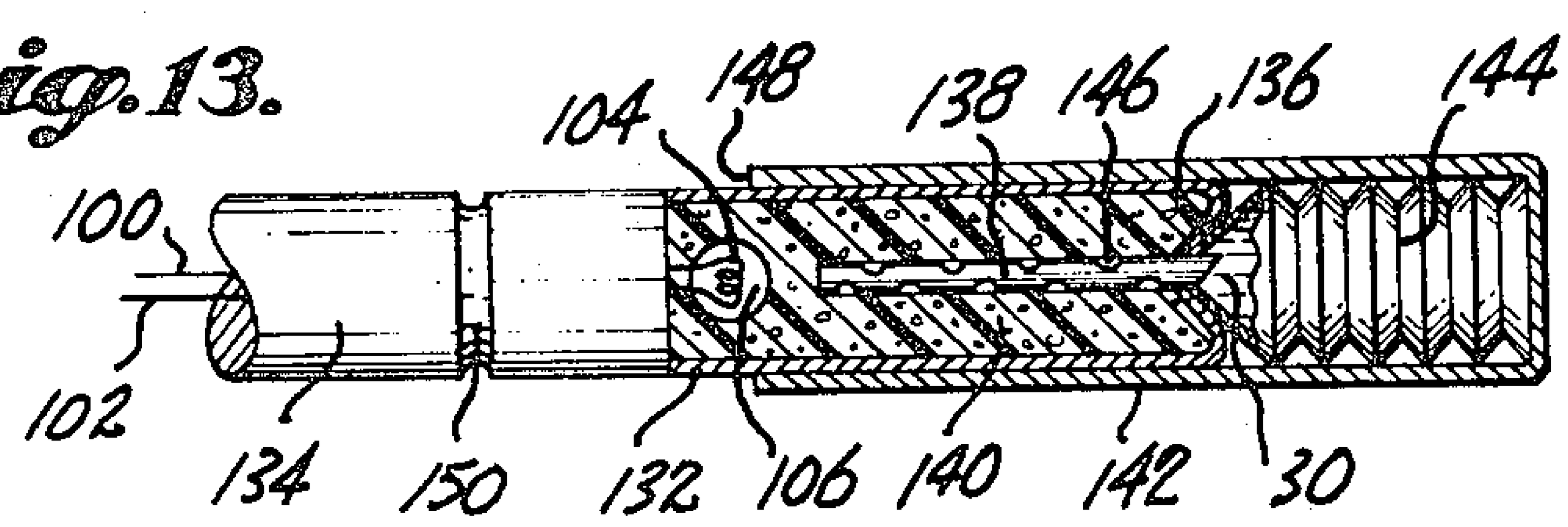


Fig. 13.



INVENTOR.
MICHEL E. MAES
BY Graybeal, Cole & Barnard
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Fig. 14

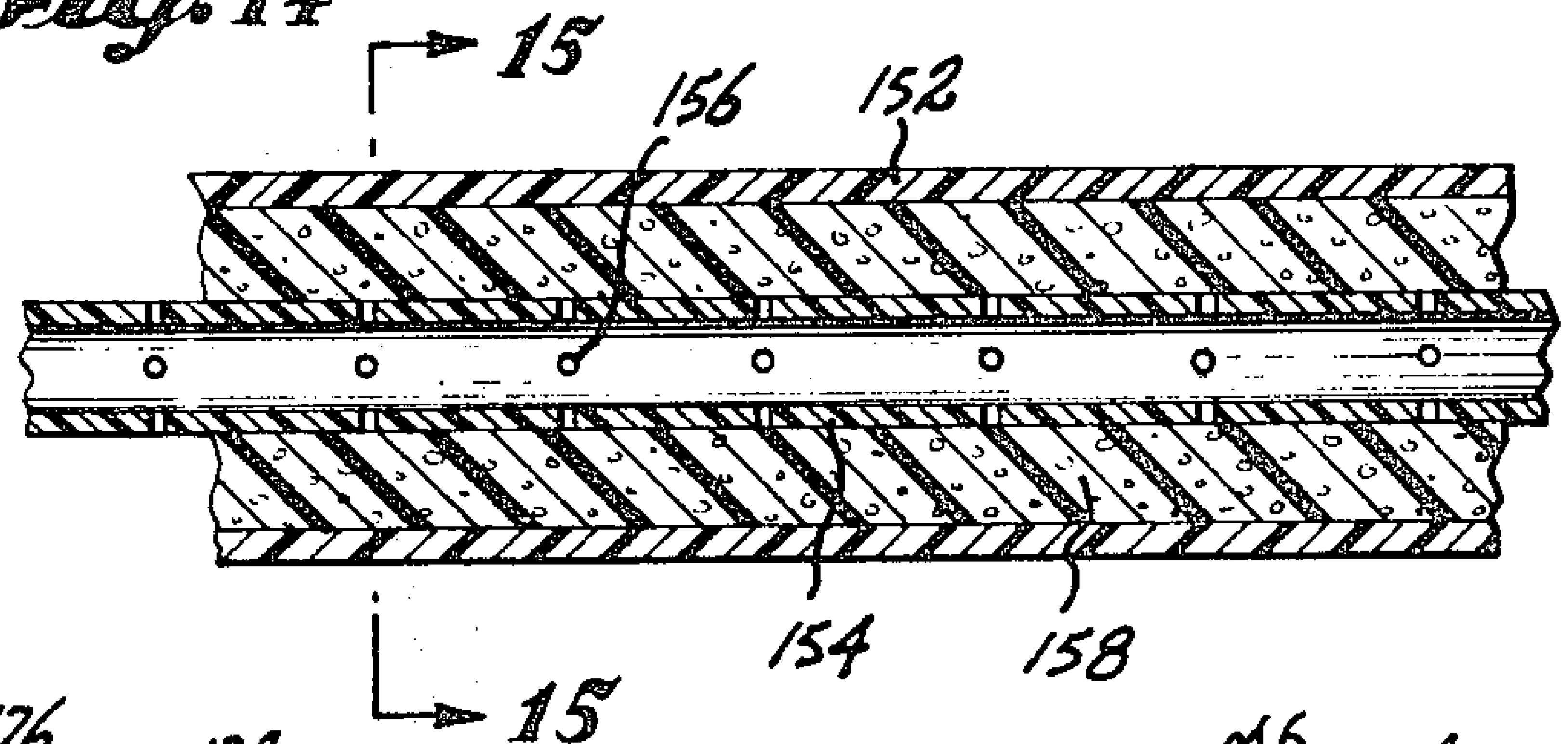


Fig. 15.

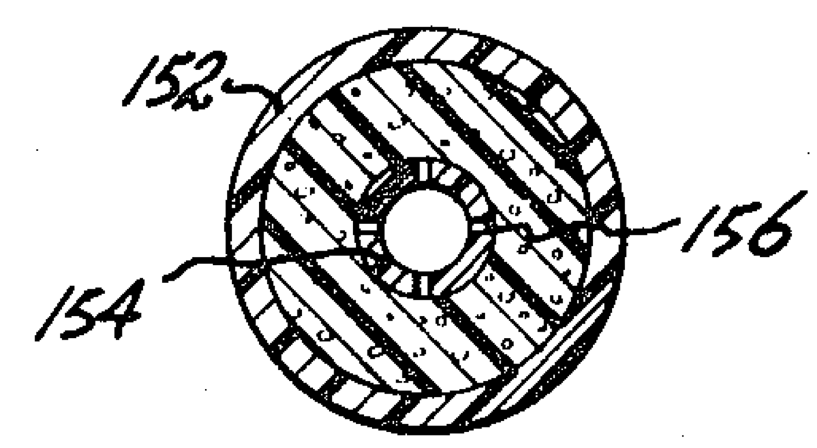
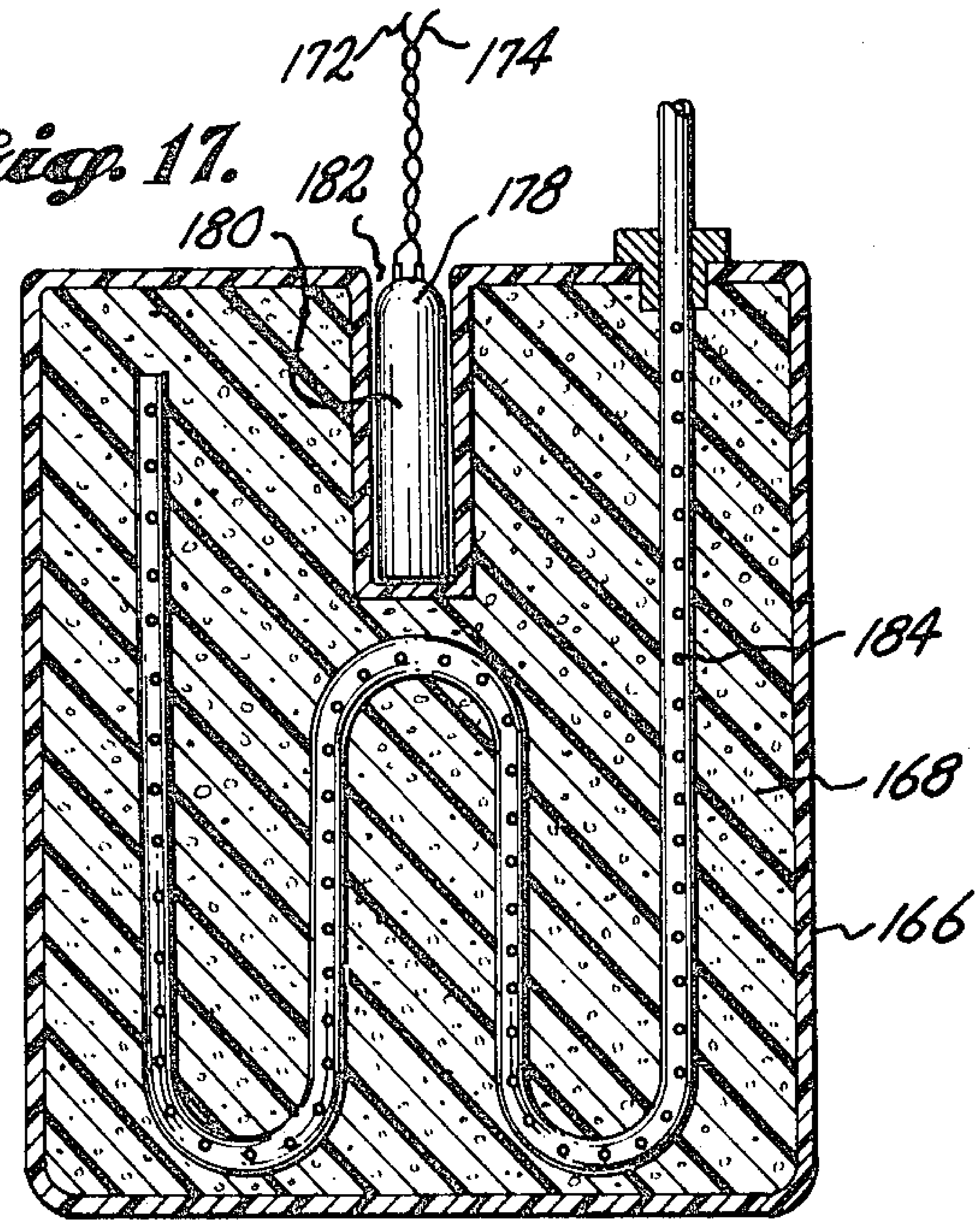


Fig. 17.



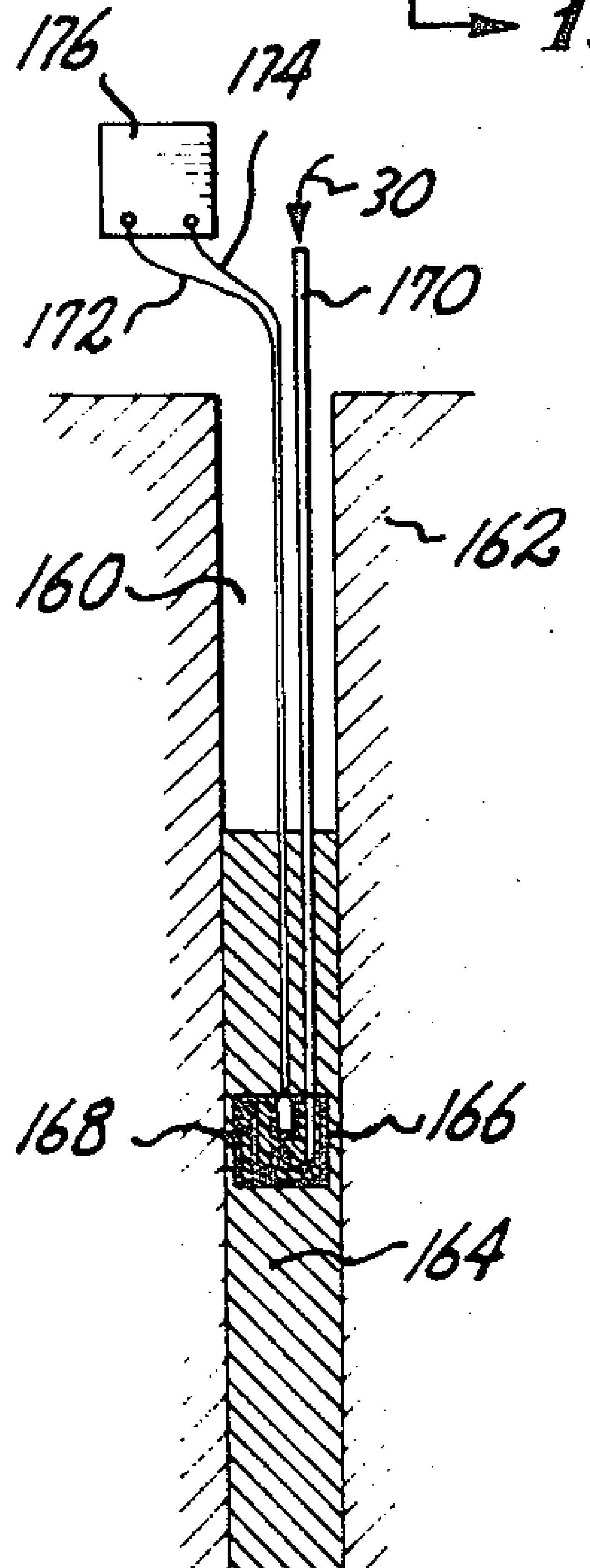


Fig. 16.

INVENTOR.
MICHEL E. MAES
BY Graybeal, Cole & Barnard
ATTORNEYS

FIELD SENSITIZED EXPLOSIVE DEVICES AND SENSITIZING METHOD

CROSS-REFERENCES TO RELATED APPLICATIONS

This is a continuation-in-part of my now pending U.S. application Ser. No. 703,994, entitled Field Sensitized Explosive Devices and Sensitizing Method, and filed Feb. 8, 1968, and now abandoned as a continuation-in-part of my prior application Ser. No. 631,123, filed Apr. 17, 1967, entitled Hydrazine Containing Explosive Compositions, and issued as U.S. Pat. No. 3,419,443 on Dec. 31, 1968.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to portable types of explosive devices, and particularly to the field of explosive devices which includes caps, detonators, fuse cords and boosters. 2. Description of the Prior Art

Conventional preformed portable explosive devices contain chemical substances which are explosive in nature, and most are susceptible to easy detonation by static electricity, impact and crush damage, fire strong radial signals, and small arms fire. Detonators and caps particularly, because of their necessary sensitivity, are considered most hazardous items to carry, and standard safety practices require that they be carried in special containers and/or be handled with extreme care.

In certain military missions, such as infiltration, for example, small groups of men must all carry all supplies and cross difficult terrain. In such missions it is usual for each man to carry a supply of detonators. Carrying of detonators is in a trade off between minimum exposure of the detonator to outside shock and minimal danger to the man in the event of accidental detonation. Generally, detonators are carried on ankles or inside boots. They are reasonably well protected in this way but are nevertheless dangerous, particularly in the case of an air drop.

Even in more routine missions involving demolition or construction, the handling of detonators presents logistic problems. They should be transported separately from explosives and stored in separate magazines. They should be treated more carefully than is often time possible or convenient in the field, and are susceptible to total loss by accident or when under fire. There is, therefore, a need for a completely safe, highly reliable detonator which is inert until activated just prior to use. The detonator must be equivalent in strength to conventional detonators, and it should be usable with existing fusing mechanisms and ordinance devices.

Typical examples of conventional blasting caps or detonators are shown by Stuart U.S. Pat. No. 2,389,086; Higashishima et al. U.S. Pat. 3,132,585; **and Rucker U.S. Pat. No.** 3,264,988.

Detonators and other explosive devices of the present invention make use of explosives which are made by mixing together two intrinsically nonexplosive substances, i.e. each part, by itself, cannot be detonated. Each component is, therefore, handled not as an explosive but merely as an ordinary chemical, and can be stored and transported without any of the special handling normally accorded detonable materials. Upon mixing, however, a detonable compound is formed.

Ransom U.S. Pat. No. 3,005,373; Lambert et al. U.S. Pat. No. 3,068,791 and Clay et al. U.S. Pat. No. 3,303,738 disclose techniques of on site mixing of two normally nonexplosive bulk ingredients to form detonable slurries in a blasthole. However, none of these patents relate to detonators or other preformed explosive devices, nor to the problem of introducing one constituent of an explosive composition into a preformed device incorporating a second complementary constituent of the explosive.

Davidson U.S. Pat. No. 2,982,377 teaches packaging discrete ammonium nitrate in a waterproof container having a soft elastic wall at one end thereof. The ammonium nitrate is not an explosive in and of itself, but is rendered explosive by the addition thereto of a liquid nonexplosive fuel. A hypodermic syringe is used to inject the fuel through the elastic wall and into the ammonium nitrate.

Lewis U.S. Pat. No. 2,929,325 teaches packaging particulate ammonium nitrate in a first container, a particulate fuel in a second container, telescopically joining the two containers, and shaking the assembly for the purpose of mixing the two substances together.

SUMMARY OF THE INVENTION

Broadly stated, field sensitized detonators of the present invention comprise (a) a container containing an intrinsically nonexplosive solid constituent of an explosive composition, and an ignition means incapable of detonating the solid constituent alone, but capable of detonating the explosive composition; (b) a source of an intrinsically nonexplosive liquid second constituent of the explosive composition; (c) means for maintaining said constituents separate from each other during transportation thereof to the site of intended use; and (d) means for introducing the liquid constituent into said device for mixing with said solid constituent to form said explosive composition within the device, thereby rendering it an explosive device.

Additional aspects of the invention which will hereinafter be described in detail, in conjunction with the several figures of the application drawing, include attachments containing the liquid constituent which are either permanently or temporarily joinable to a container type device; to apparatus for causing flow of the liquid constituent from its storage space into the device and into admixture with the solid constituent therein; to such joinable components or parts which are telescopically couplable together in a prearm, nonmixing position, and are then movable further together, to cause fluid release and mixing, either prior to or after placement of the detonator in or adjacent to the main explosive; and to some specific techniques of safely handling and/or using explosive devices of the two part type.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing like element designations refer to like parts, and;

FIG. 1 is an exploded perspective view of a two part electrically initiated detonator incorporating features of the present invention;

FIG. 2 is a smaller scale perspective view of the two parts of such detonator, shown in the process of being joined by the hands of a user;

FIG. 3A is a longitudinal sectional view of the two detonator parts in which they are axially spaced apart;

FIG. 3B is a view like 3A, but showing the initiator equipped part adapted for detonation by a fuse-type initiator, and merely presenting a phantom line showing of the second part since it is identical to its counterpart in FIG. 3A;

FIG. 4 is a view similar to FIG. 3A, but with the two parts telescopically joined and showing jaw portions of a crimping tool surroundingly engaging the lapping and and lapped parts of the assembly;

FIG. 5 is a view similar to FIG. 4, but of the assembly following use of the crimping tool to crimp together the lapping and lapped parts, to break the frangible container for the liquid constituent;

FIG. 6 is a view similar to FIG. 3A, but fragmented and relating to a modified embodiment, involving a screw-type connection between the two parts, with the liquid constituent being encapsuled by an inner shell having a frangible end portion, and with second part carrying means for bursting the frangible closure as the two parts are screwed together;

FIG. 7 is a view similar to FIG. 6 but of a further embodiment of the invention, shown to comprise a positive displacement pump type of injector for the liquid constituent, such injector having an outlet portion adapted to engage the inlet portion of the shell containing the solid constituent;

FIG. 8 is a longitudinal sectional view of still another modified embodiment of the invention, shown to comprise a full length shell containing a body of a solid constituent possessing good wick characteristics;

FIG. 9 is a longitudinal sectional view of the embodiment of FIG. 8, with the protective cap therefor removed and the detonator partially immersed, inlet end down, into a body of the liquid explosive constituent;

FIG. 10 is a view like FIG. 3A but of yet another form of the invention, such form being characterized by interfitting detent and recess means arranged to permit a prearming of the two parts involving a condition in which the two parts are telescopically together but are locked into a position with a piecing means carried by the solid constituent carrying part being axially spaced away from contact with a frangible closure for the liquid constituent within the other part;

FIG. 11 is a view showing the parts of FIG. 10 telescopically locked together in the prearmed position;

FIG. 12 is a view of the same parts telescopically moved together an amount sufficient to cause the piercing means to cut or pierce the frangible closure for the liquid constituent;

FIG. 13 is a view similar to FIG. 12, but showing a different form of piercing means and a different type of frangible closure for the liquid constituent;

FIG. 14 is a fragmentary longitudinal sectional view of a primacord or fuse type device incorporating features of the invention;

FIG. 15 is a cross-sectional view taken across the device of FIG. 14, substantially along line 15–15 thereof;

FIG. 16 is a view of a booster device incorporated within an explosive mass contained within a ground hole or the like, such view showing the booster in section, with electrical ignition wires leading from an electrical current source located outside of the hole, and a liquid constituent delivery tube leading from outside of the hole down into the booster; and

FIG. 17 is an enlarged scale view of the booster of FIG. 16.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Each embodiment of the present invention comprises a portable device incorporating an intrinsically nonexplosive solid constituent of an explosive composition and a source of an intrinsically nonexplosive liquid second constituent of the explosive composition. The two constituents are maintained separate from each other during their transportation to the site of intended use. The liquid constituent is introduced into the device, in admixture with said solid constituent. In this manner an explosive composition is formed within the device, rendering it an explosive device, capable of being detonated by a suitable initiator.

In the embodiment of the invention shown by FIGS. 1, 2, 3A, 4 and 5, each of which is a detonator, the portable device comprises wall means forming a chamber 10 containing a body 12 of the solid constituent (or a mixture of it and an additive or some inert filler) which occupies a major portion of the space in the chamber 10. The chamber 10 includes an inlet 14 at one end thereof through which the liquid constituent is introduced into the interior of the chamber 10, for admixing with the solid constituent 12 therein. The chamber 10 is of an elongated tubular form and is substantially closed at the end 16 thereof opposite the inlet 14. Preferably, a removable closure means, shown in the form of a plastic plug 16, is provided for initially closing the inlet end 14 of the device.

The initiator for the first embodiment is shown to be an electrical type, and to comprise a pair of leg wires 18, 20 which extend through insulators 22, 24 at the closed end of the casing 10. The inner ends of the leg wires 18, 20 are shown to be connected together by means of a bridge wire 26. A bead or match head type substance 28 may be employed in addition to the bridge wire 26. The ignition bead or match head material 28 may be any material capable of initiating the explosive once it is formed in the casing 10. The strength of this material should be sufficiently low so as not to compromise the basic safety feature of the detonator in the event of any accidental ignition. Ignition of the bead 28 prior to admixture of the liquid constituent to the solid constituent should do no more than expel the solid constituent from the casing 10, with no physical injury to an individual who might be holding the casing 10 at that time.

In the first embodiment the liquid constituent 30 may be contained in a frangible capsule (e.g. a glass vial) 32 which in turn is contained in a second elongated tubular shell 34. Casing 34 has an outside diameter that is substantially equal to the inside diameter of casing 10, so that when the closure plug 14 is removed the open end of casing 34 can be telescopically inserted into the open end of casing 10.

Each separately encased part of the detonator, by itself, cannot be detonated. Each constituent is, therefore, handled not as an explosive but merely as an ordinary chemical, and can be stored and transported without any of the special handling normally accorded detonable materials. Upon mixing, however, a detonable compound is formed, and because of the manner in which mixing is accomplished it is formed within the confines of the casings 10, 34.

Following removal of the closure plug 16, and insertion of the open end portion of casing 34 into the open end portion of casing 10, the two casings are secured together and the mixing is started by crimping together the engaged end portions of the casings 10, 34. Crimping, which may be done by the jaws J of a plyerslike tool (FIGS. 4 and 5) both seals the assembly and breaks the frangible capsule or vial. This releases the liquid constituent 30, allowing it to penetrate into and mix with the solid constituent 12 to form the explosive. The mixing procedure involves no hazards and is completed within a matter of seconds after crimping. Crimping presents no hazards since the explosive is not formed until after the crushing action takes place.

The casings 10, 34 are sized so that when they are crimped together to form a unitary casing assembly such assembly has the proper dimensions of the blasting cap or detonator cavity formed in the particular explosive with which it is to be used.

FIG. 3B relates to a nonelectric version of the field sensitized detonator of the present invention. The mechanical features of the nonelectric version may be identical to the electric detonator with the exception of the manner in which initiation is caused. Its casing 10′ is provided with an opening in its closed end for the reception of an end portion of a suitable time fuse 36. The fuse 36 engergizes a heat sensitive "slug" or reactive element 28′ (e.g. lead azide or chloride white phosphorus) which in this form of detonator is equivalent in function to the bead 28 in the electrical form.

The end portion 16′ of the casing 10′ may be provided with an extension (not shown) for crimping around the fuse, as in the case of many standard nonelectric detonators. In like manner to the electric version, the nonelectric detonator will be sized to be interchangeable with existing detonators to permit its use in standard detonator wells. In FIG. 3B the second part of the detonator, comprising the casing 34, the capsule 32 and the liquid constituent 30, is shown by phantom lines since it is identical to the corresponding part in FIG. 3A, shown directly above it.

FIG. 2 shows how easily the two parts of the detonator may be slipped together, following removal of the closure plug 16. Upon completion of the assembly the concentrically related engaged portions of the two parts are crimped together, as described above.

Preferably, the solid constituent is an absorbent material which as the body 12, 12′ is in pressed granular form. The absorbent nature of the material gives it the characteristic of a wick, and this assists in ready distribution of the liquid component throughout the body 12, 12′. The wick characteristic of the body 12, 12′ may be enhanced by constructing such body to include a fabric wick core, or by mixing a more absorbent inert material with the solid constituent.

FIGS. 8 and 9 relate to an embodiment which is constructed to make good advantage of the wick characteristics of the body consisting of or including the solid constituent. The device is shown to comprise an elongated tubular casing **40** of the same dimensions as the conventional cap or detonator which it is intended to replace. The casing **40** is closed at its end **42** and provided with an inlet opening at its end **44**, normally closed by a cap or closure plug **16**. This embodiment may be either electrically or fuse initiated. By way of typical and therefore nonlimitive example, it is shown as including the same electrical initiator components as the embodiment of FIGS. **1, 2, 3A, 4** and **5**. Inside the casing **40** there is an absorbent body **48** which may be composited from granules of the solid constituent and a loose absorbent material, or may consist of a highly absorbent solid constituent material alone. According to this aspect of the invention, the liquid constituent is brought to the site where the detonator is sensitized to some sort of vessel or container. At such site it is poured into a container which may be of the type illustrated by FIG. **9**, and designated **48** therein. The cap **16** is removed from the casing **40** and the casing **40** is inserted open end first into the body of liquid **30** in vessel **48**. The liquid **30** then flows upwardly into the casing **40**, is absorbed into the body **46**, and becomes mixed with the solid constituent, all owing to the wick characteristics of the body **46**. Graduations may be provided on the wall of the vessel **48** so that one can observe the quantity of liquid being absorbed and then remove the device from the vessel **48** when a proper amount of the liquid constituent **30** has been absorbed. The closure plug **16** may then be reinstalled to seal the casing **40** against leakage.

The embodiment as shown by FIG. **6** is like the first embodiment with the exception of the manner in which the two casings are joined and the capsule containing the liquid constituent is fractured. In this embodiment the first part comprises a casing **50** containing an absorbent solid body **52** comprising the solid constituent. The open end of the casing **50** may include an externally threaded portion **54** and a smaller diameter punch **56**, the end of which may be cut as a slant so as to provide it with a cutting edge **58**. A passageway **60** extends from the interior of casing **50** axially through both the threaded end portion **54** and the punch **56**. The second part is shown as comprising a casing **62** containing a capsule or vial **64** which in turn houses the liquid constituent **30**. The open end portion of casing **62** is internally threaded at **66**, and is adapted to receive the threaded end portion **54** of the casing **50**. The end wall **68** of capsule **64**, which is positioned closely adjacent the base of the threads **56**, is made of a material that can be fractured by the punch **56** when the two parts are threaded together. Upon such fracturing the mated threads provide a sealed joint where the two parts are joined and the liquid constituent **30** flows through the passageway **60** and into the casing **50**, wherein it is absorbed by the body **52** and becomes mixed with the solid constituent to form the explosive.

FIG. **7** relates to an embodiment of the invention which may involve a single casing **70** of similar dimensions as casing **40** in the embodiment of FIGS. **8** and **9**. In this embodiment the liquid constituent is pumped into the solid body **46**. The pump may comprise a reservoir **72** which may be fixed relative to the other parts of the pump. A delivery tube **74** is shown extending upwardly from the reservoir **72** to a cylinder or pump chamber **76**, and a check valve **78** is arranged in the delivery tube **74** to permit fluid flow out from but not into the reservoir **72**. One end of the cylinder **76** is substantially closed by a fixed wall **80** which includes an axial passageway fitted with a check valve **82** adapted to permit fluid flow out from but not into the interior of the cylinder **76**. The opposite end of the cylinder **76** is defined by a movable wall or piston **84** adapted to be moved by an operator **86**. The operator side of the piston **84** is appropriately vented, such as by a vent opening **88**.

The outlet end of the pump may be sized to telescopically receive therein the inlet end portion of the casing **70**, following removal of the closure plug **16**. The volume of the space defined between the fixed wall **80** and the piston **84** when it is fully retracted is equal to the volume of the liquid which must be added to the solid constituent. Prior to each use of the pump the piston **84** is moved from a fully extended position to a fully retracted position for the purpose of drawing a full chamber of liquid constituent up from the reservoir **72**. The cap **16** of the device **70** is removed and the opened end portion of the device **70** is inserted into the socket **90** formed at the outlet end of the pump. The piston **84** is then advanced the full distance through the chamber **76** to pump the liquid constituent through the outlet passageway and into the body **46** through which it becomes distributed, partially by the force of the pump and partially by the wick action of the absorbent material making up body **46**. Following injection the closure cap **16** may be reinstalled, readying the detonator for use. The same pump may then be used for arming additional detonators of the same general type.

The embodiment of FIGS. **1, 2, 3A, 4** and **5** is mechanically simple and inexpensive. The crimp-together feature utilizes a conventional crimping tool and provides a liquid seal for the assembly. However, in some installations it is desirable to have an assembly which does not require the use of crimping tools to lock the components together and to release the liquid constituent. The embodiment of FIG. **6** is one example of such an assembly. However, the incorporation of a prearm safety position would be a desirable additional feature, permitting preassembly of the detonator at some time prior to reaching the site of use, with simple arming of the device by removal of a safety lock and a simple mechanical action just prior to its use in the field. Such a feature would minimize handling time at the use site.

FIGS. **10—12** are sequence views relating to detonator apparatus incorporating the prearm feature. Referring to these figures, the first component is shown to comprise a casing **92**, which may be made from aluminum, for example. Contained in the casing is a solid body **94** comprising the solid constituent, and a central liquid constituent distribution wick **96**. One end of the casing **92** is closed by a member **98**. Insulated leg wires **100, 102** extend through the member **98** and partially into the body **94**. The inner ends of the leg wires **100, 102** are interconnected by a bridge wire **104** surrounded by a bead or match head **106**. The opposite end of the casing **92** is spanned by an absorbent retaining cover **108**, occupying a radial plane and a built-in punch blade **110** occupying an axial plane. The casing **92** is formed to include axially spaced prearm and mixing lock grooves **112, 114**, respectively, each extending about the girth of the casing **92**. This component is initially fitted with a plastic safety guard **116** including a pull tab **118**.

The second part or component of the detonator assembly comprises a casing **120** which also may be made of aluminum. The liquid constituent **30** is housed in the closed end portion of the casing **120**, within a hermetically sealed, thin wall capsule, e.g. a capsule fabricated from polyethylene. The casing **120** includes a lock ring **124**, and is slotted to give the locking ring **124** radial resiliency. As best shown by FIG. **10**, the slots **126** extend axially from the open end of the casing **120**, through the region of the locking ring **124**, and terminate at a location spaced inwardly of the inner edge of the locking ring **124** a distance equal to about 2—2½ times the width of the locking ring **124**. The slots **126** are substantially equally spaced circumferentially about the casing **120**.

The two parts are stored and handled separately as nonexplosive items. A plastic cap (not shown) may be inserted over the open end of the first part to protect the internal substances during storage and handling, and a plastic plug (not shown) may be inserted in the open end portion of the second part for the same purpose.

At some period prior to use, and at a place away from the use site, the two parts are unpackaged and the protective plastic cap and plug are removed. The inlet end portion of casing **92** is then inserted into the open outlet end portion of casing **120**, and is telescopically moved into casing **120** until the split lock ring **124** engages the prearm lock groove **112** and snaps in place. The plastic safety guard **116**, which at this time is indented into the mixing lock groove **114**, and therefore cannot move itself, prevents further inward movement of casing **92** into casing **120**. This condition is depicted by FIG. **11**. When the parts are in such prearm position the knife **110** is spaced well away from the forward wall **128** of the liquid constituent storage capsule **122**. Thus, although the two parts of the assembly are coupled together, the two constituents of the explosive are maintained separate from one another and the assembly remains nonexplosive in character. The assembly can be safely carried into the field as a nondetonable article and without danger of accidental mixing of the constituents to make it a detonable article.

Shortly prior to use, the tab **118** on the plastic safety guard **116** is pulled, and in this manner the guard **116** is pulled off. This frees the two parts so that they can be telescopically moved together an additional amount for the purpose of seating the split lock ring **124** in the mixing lock groove **114**. Before such seating occurs, the puncher blade **110** will cut into the end wall **128** of the liquid constituent's storage capsule **122**. This releases the liquid constituent allowing it to flow into admixing contact with the solid constituent within casing **92**. As the puncher blade **110** cuts the capsule wall **128**, the outer peripheral surface of the casing **92** immediately bordering the absorbent cover **108** is wedged into sealing contact with the leading inner peripheral surface of a ring **130** of sealing material. This forms a liquid tight seal between the two parts and prevents escape of either the liquid component prior to mixing, or the mixed explosive.

The absorbent cover **108** at the open end of casing **92** serves to prevent loss of the solid constituent which is preferably in pressed granular form. It is made of an absorbent material in order to assist in distribution of the liquid constituent after puncture. The small diameter wick **96** is also provided to draw the liquid constituent into the central region of the body **94**, so as to permit rapid and uniform distribution of the liquid throughout the solid for maximum mixing efficiency and performance.

The two-step locking groove offers another advantage in addition to allowing preassembly of the detonator. The detonator can be placed inside an explosive or ordinance device in an unarmed position, and then be armed at the last minute after wiring by pushing the outer component further into the inner component, until the lock ring **124** becomes seated within the mixing lock groove **114**. This capability results in a high degree of safety in the arming operation since the individual performing this last mechanical step can leave the area within the time period required for sufficient mixing of the constituents to form a substance which is detonable, estimated to be about a 5 second period.

FIG. **13** relates to still another embodiment of a detonator incorporating features of the present invention. It is shown to comprise a first part including an elongated tubular casing **132** having an igniter end portion **134**. Although an electrical igniter is shown, it is to be understood that the igniter end portion **132** could be formed to include a fuse well, for receiving a suitable ignition fuse to be used in lieu of the electrical igniter. The opposite end portion **136** of the casing **132** is shown to be rolled back against the end portion of a perforated, centrally located distribution tube **138**. A body of the solid constituent, or a mixture of such constituent and other materials, occupies the space in the casing **132** about the tube **138**. The second part comprises a casing **142** sized to snuggly receive the casing **132**. It is shown as including a collapsible bellows capsule **144** in which the liquid constituent **30** is housed. This detonator is activated by pushing the casing **142** down over the casing **132** until the pointed end of the perforated injection and distribution tube **138** punctures the bellows capsule **144**. Continued pressure then forces the liquid constituent into the body **140** of packed granular material. The several perforations **146** distributed both about and lengthwise of the tube **138** insure that the liquid constituent is well distributed throughout the body **140**. A positive verification that all of the liquid constituent has been injected into the solid body **140** is obtained by feel, since the end **148** of the casing **142** will reach the indentations **150**, or a similar gauge marking once the bellows **144** has been completely collapsed.

It takes approximately five seconds to complete injection of the liquid constituent into the body **140**. Mixing is virtually instantaneous, so the detonator is ready for use within about 10 seconds. The casing **142** is removed from the casing **132** following complete injection, and is then discarded. This results in the detonator having no wasted volume after mixing. Furthermore, the diameter of the casing **132** can be increased to the size of the detonator well. This in turn makes it possible to increase the size and capacity of the chamber formed within casing **132**, enabling it to contain a greater amount of the solid granules. The form of the invention shown by FIG. **3** can be designed with the same prearm position as used in the embodiment of FIGS. **10—12**. This would merely involve grooving the casing **132** and providing casing **142** with a split lock ring. However, such a detonator would not have all the capabilities of the detonator shown by FIGS. **10—12**. It would be necessary for the person doing the arming to stay at the use site during the entire mixing process, so he would be available to remove the disposable part including casing **132**, into the cavity for it in the explosive device. Leakage of the explosive by way of the tube **138** may be prevented by adding a swelling or gelling agent to the body **140** which is activated by the liquid constituent, i.e. it assumes a jell or gummy form and plugs or seals off the apertures **146**.

Although the various embodiments which have to this point been described in conjunction with FIGS. **1—13** of the drawing have been referred to as fuses or detonators, it is to be understood that the various aperture and assemblies involved are actually explosive devices and/or explosive forming devices, and they may be used for other purposes than triggering larger explosive bodies. Also, various ones of the techniques and features of the present invention can be employed with or embodied in explosive devices having entirely different forms than are illustrated in FIGS. **1—13**.

FIGS. **14—17** relate to some additional typical forms of field sensitized explosive devices constructed according to the present invention, and they will now be specifically described.

FIGS. **14** and **15** relate to a field armed detonating cord shown to comprise an imperforate outer tube **152** of plastic or a similar flexible material, and a perforated or pervious inner tube **154** of a smaller diameter, also constructed of plastic or a similar flexible material. The perforations or openings **156** are distributed both lengthwise and girthwise of the inner tube **154**. A spongy material comprising a suitable intrinsically nonexplosive solid constituent (e.g. powdered ammonium nitrate, ammonium perchlorate, sodium nitrate, sodium chlorate, sodium perchlorate, potassium nitrate, potassium chlorate, potassium perchlorate, or mixtures of any of these compounds, and a quick gelling agent).

As in the earlier form, the cord would not be detonable until armed. Arming is done by simply pouring a suitable liquid constituent, (e.g. hydrazine, hydrazine and water, hydrazine and alcohol, or hydrazine and water and alcohol, for the solid constituents mentioned above) in through the central tube **154**. The liquid material would seep out through the perforations or openings **156**, into the spongy mass **158**, wherein it would mix with the solid constituent to form the explosive. The gelling agent would eventually plug and in that manner seal the zones around the perforations, to function as gauge means to limit the amount of liquid constituent entering each aperture **156**, and to prevent the mixed explosive from running out.

FIGS. **16** and **17** relate to a booster for use in detonating relatively nonsensitive explosives, e.g. an explosive formed by mixing fuel oil with ammonium nitrate. FIG. **16** shows a blasthole **160** formed in an earth formation **162**, and charged with a slurry **164** of a low sensitivity type of explosive. A plastic bag, bottle or other container holding an intrinsically nonexplosive solid constituent is shown submerged in the slurry. A liquid constituent delivery tube **170** is shown extending from a surface location downwardly through the blasthole and into the container **166**. Lead-in wires **172**, **174** from a source **176** of electrical energy are shown leading downwardly through the blasthole to an electric initiator **178** at the upper end of a cap **180** set into a cap well **182** that is built into the container **166**. Of course, a time fuse type of igniter could just as well be used in place of the electrical igniter **178**.

The portion of the tube **170** which is housed within the container **166** is perforated and may be wound around through the mass **168** so as to provide a relatively even distribution of the liquid constituent. The booster is armed by introducing the liquid constituent into the plastic tubing **170**. As in the fuse cord form of the invention shown by FIGS. **14** and **15**, the mass **168** may include a gelling agent which is converted from a dry solid to a gell form by the liquid constituent, and functions to gauge the amount of liquid constituent which enters the mass **168** from each aperture **184** in the tube **170**. The high velocity of the resulting explosive will provide excellent boosting and the two component approach relates in a safe, noncap sensitive charge in the blasthole until it is ready to fire and the liquid constituent as introduced into the booster **166**.

As heretofore mentioned, an ammonium oxidizer salt (e.g. ammonium nitrate or a mixture of ammonium nitrate and ammonium perchlorate, for example) constitutes a suitable intrinsically nonexplosive solid constituent, and hydrazine constitutes a suitable complementary intrinsically nonexplosive liquid constituent. Further examples of suitable constituents are set forth in my aforementioned U.S. Pat. No. 3,419,443, the contents of which are hereby expressly incorporated in this application by reference.

I claim:

1. A two part explosive package comprising:
a first housing having an open end, a closed end and sidewall means, said first housing containing an absorbent body of an intrinsically nonexplosive solid first constituent of an explosive composition, and ignition means including a reactive substance prepackaged in said first housing contiguous said solid first constituent, said reactive substance being capable of detonating the explosive composition but not the solid first constituent by itself, or the two constituents when close together but uncombined; and
a second housing having an open end joinable to the open end of said first housing, a closed end and sidewall means, said second housing containing an intrinsically nonexplosive liquid second constituent of said explosive position, said second housing also including means for initially retaining the liquid constituent in said second housing, said means being readily openable when the two housings are joined to permit the liquid constituent to flow from the second housing through the open end thereof, through the open end of the first housing, and into the first housing, to be absorbed into the solid constituent.

2. Explosive forming means comprising:
a. a casing containing a body of an intrinsically nonexplosive solid constituent of an explosive composition, said casing including an inlet;
b. a source of an intrinsically nonexplosive liquid second constituent of the explosive composition;
c. means for maintaining said constituents separate from each other during transportation thereof to the site of intended use;
d. means for introducing the liquid constituent through said inlet for admixture with said solid constituent to form said explosive composition within the housing; and
e. electrical ignition means including an electrically initiated igniter element preembedded in said solid constituent, and conductor wire means extending through said casing and connecting with said igniter element, said igniter element being capable of detonating the explosive composition but not the solid constituent by itself, and not the solid and liquid constituents when close together but uncombined.

3. Explosive forming means according to claim **2**, wherein said body possesses wick properties enabling it to readily absorb the liquid constituent.

4. Explosive forming means according to claim **2**, wherein said body comprises an absorbent matrix and the solid constituent is in the form of crystalline solids impregnated in said matrix.

5. A two part detonator usable to detonate an explosive, said detonator comprising a shell part of elongated tubular form housing an intrinsically nonexplosive substantially solid first constituent of an explosive composition, and including means defining an inlet at one end thereof; ignition means extending through a wall portion of the shell part and into a position contiguous said substantially solid constituent; and a container housing an intrinsically nonexplosive liquid second constituent of the explosive composition, and including means defining an outlet joinable with the inlet of said shell part, so that the second constituent can be directly transferred from the container into said shell part for admixture therein with the first constituent to form the explosive composition, with said ignition means being capable of detonating the explosive composition but not the substantially solid constituent by itself, and not the solid and liquid constituents when close together but uncombined.

6. A two part detonator according to claim **5**, wherein said container is also of elongated tubular form and is sized to be telescopically joinable with said shell part.

7. A two part detonator according to claim **6**, wherein said shell part is provided with a removable closure means for closing its inlet until it is desirable to join the shell part and the container, and said container includes a frangible closure at its outlet end for maintaining the liquid second constituent in said container during separate handling thereof.

8. A two part detonator according to claim **5**, wherein said solid first constituent incorporates means through which the liquid constituent will readily flow so that the liquid second constituent can be relatively quickly absorbed into the solid constituent.

9. A two part detonator according to claim **5**, wherein said liquid constituent is contained within a frangible capsule and the capsule is housed in said container, the shell part and the container are telescopically joinable, and the shell part carries opening means at its inlet end for breaking or cutting the frangible capsule when constituent shell part and the container are telescopically moved together a predetermined amount.

10. A two part detonator comprising a shell part of elongated tubular form housing an intrinsically nonexplosive first constituent of an explosive composition, and including means defining an inlet at one end thereof; ignition means extending through a wall portion of the shell part into said first constituent; and a container housing an intrinsically nonexplosive liquid second constituent of the explosive composition, and including means defining an outlet joinable with the inlet of said shell part, so that the second constituent can be directly transferred from the container into said shell part for admixture therein with the first constituent to form the explosive composition, said shell part and said container being telescopically joinable, said container including closure means for maintaining the liquid constituent in the container, said shell part including opener means for opening said closure when the shell part and container are telescopically moved together a predetermined amount, and said shell part and container including releasable locking means for releasably locking them together while telescopically engaged an amount less than said predetermined amount, so that said opener means and said closure are axially spaced apart.

11. A two part detonator according to claim **10**, wherein the releasable locking means comprises radial recess means formed in a sidewall portion of one of said shell part and container and radial detent means formed in a sidewall portion of the other.

12. A detonator component comprising an elongated tubular shell housing an intrinsically nonexplosive solid constituent of an explosive composition, and including means defining an inlet at one end thereof for reception of a liquid which when combined with said constituent forms the explosive composition, closure means at the opposite end of said shell part, and ignition means including a reactive substance positioned contiguous the solid constituent, said reactive substance when energized being capable of detonating the explosive composition but not capable of detonating the said solid constituent by itself.

13. A detonator component according to claim 12, wherein said solid constituent incorporates means providing it with wick characteristics.

14. A detonator component according to claim 12, wherein said solid constituent incorporates a previous tube in communication at one end thereof with said inlet, to facilitating inflow of the liquid into the solid constituent.

15. Explosive forming means comprising:

a. a housing containing a length of pervious tubing;
b. a body of an intrinsically nonexplosive solid constituent of an explosive composition in said housing surrounding said pervious tubing;
c. a source of an intrinsically nonexplosive liquid second constituent of the explosive composition;
d. means for maintaining said constituents separate from each other during transportation thereof to the site of intended use;
e. means for introducing the liquid constituent endwise into and through said previous tubing, for delivery thereby to said solid constituent, for admixture therewith to form said explosive composition within the housing; and
f. initiator means of detonating said explosive composition by an operator sometime following its formation.

16. Explosive forming means according to claim 15, wherein said housing is a length of impervious flexible tubing, the pervious tubing is also flexible, a generally annular chamber is formed between the outer wall of the pervious tubing and the inner wall of the impervious tubing, and said body of the solid constituent occupies the generally annular chamber.

17. Explosive cord forming means comprising a length of impervious flexible tubing, a length of pervious flexible tubing inside said impervious tubing, with a generally annular chamber being formed by and radially between said impervious and pervious lengths of tubing, and a body of an intrinsically nonexplosive substantially solid constituent of a detonable composition, which composition is formed in said chamber when a liquid second constituent of the composition is admixed to said solid constituent, by being introduced endwise through said pervious tubing and then flowing radially outwardly from said pervious tubing into said solid constituent.

18. Explosive cord forming means according to claim 17, wherein said solid constituent comprises an oxidizer reactant selected from the group consisting of powdered ammonium nitrate, ammonium perchlorate, sodium nitrate, sodium chlorate, sodium perchlorate, potassium nitrate, potassium chlorate, potassium perchlorate, and mixtures thereof.

19. Explosive cord forming means according to claim 17, wherein said solid constituent contains a gelling agent which when wetted by an added liquid constituent gels and plugs, and in that manner seals, around the pervious tubing, so as to limit the amount of liquid constituent entering into any particular portion of the solid constituent.

20. A technique of safely handling and using an explosive detonator, comprising:

a. placing in a detonator shell the solid constituent of an explosive composition of a type comprising two separately producible, intrinsically nonexplosive, constituents, one being a solid and the other a liquid, which are explosive only when combined;
b. transporting said shell and the liquid constituent to the site of the use, with the two constituents apart from one another;
c. combining the two constituents within such shell at the site of use to form the explosive composition and render said detonator sensitive to detonation;
d. placing said detonator in an explosive causing position with an explosive at said site of use; and
e. detonating said detonator so as to in turn detonate said explosive.

21. A technique according to claim 20, further comprising prepackaging the liquid constituent in a second detonator shell that is telescopically joinable with the first shell; transporting the two shells to the site of use with the shells apart at least to the extent that the two explosive constituents are apart; and telescopically bringing the two shells together at the site of use, to form a single housing, and to place the two constituents into contact with each other within the shell of the solid constituent, so as to cause their mixing to form the explosive composition.

22. A technique according to claim 20, further comprising the step of housing the liquid constituent in a frangible vial contained in said second shell, and crimping the two shells together where telescopically joined, to secure them together and also to break the vial.

23. A technique of safely handling an explosive detonator, comprising:

a. placing in a detonator shell the solid constituent of an explosive composition comprising two separately producible, intrinsically nonexplosive, constituents, one being a solid and the other a liquid, which are explosive only when combined;
b. prepackaging the liquid constituent in a second detonator shell that is telescopically joinable with the first shell;
c. transporting the two shells to the site of use with the shells apart at least to the extent that the two explosive constituents are apart;
d. partially joining the two shells, but not enough to cause mixing, then temporarily locking the two shells together as so joined; and
e. telescopically bringing the two shells further together at the site of use, to place the two constituents into contact with each other, so as to cause their mixing to form the explosive composition.