

TITLE

METHOD AND APPARATUS FOR CONTAINING
AND SUPPRESSING EXPLOSIVE DETONATIONS

I, John L. Donovan, have invented certain new and useful improvements in a METHOD AND APPARATUS FOR CONTAINING AND SUPPRESSING EXPLOSIVE DETONATIONS of which the following is a specification. This application is a continuation-in-part of my pending application Ser. No. 08/823,223 filed March 24, 1997. The latter application is a continuation-in-part of Ser. No. 08/578,200 filed December 29, 1995, which issued March 25, 1997 as U.S. Patent No. 5,613,453.

FIELD OF THE INVENTION

This invention relates to a method and apparatus for containing, controlling and suppressing the detonation of explosives, particularly for the explosion working of metals, and for the disposal of unwanted explosive munitions and toxic materials.

BACKGROUND OF THE INVENTION

Explosives have many useful industrial applications including surface hardening of austenitic manganese alloy steels, surface deposition coating, welding of metallic components, compression molding of components from powders and granular media, and disposal of unwanted explosive or toxic materials.

The prior art reflects many attempts to contain the explosion process for the suppression of noise, shock and

1 noxious polluting explosion products.

2 Hampel 5,419,862 discloses a large explosion chamber in
3 which an explosive work piece is introduced in through an
4 air lock into a vacuum chamber where it is detonated, and
5 after detonation the explosion products are allowed to
6 escape into the atmosphere. The chamber is mechanically
7 secured by anchor rods to a foundation.

8 Gambarov, et al. 4,100,783 discloses a cylindrical
9 containment vessel, split along its diameter for separation,
10 and openable for the insertion of large work pieces such as
11 railway frogs, stone crusher wear parts and the like. After
12 insertion of a work piece and explosive charge, the chamber
13 is closed and locked and the explosive detonated by a built-
14 in detonating device. The explosion combustion products are
15 allowed to exhaust to the atmosphere through an air valve.

16 Deribas 4,085,883 and Minin 4,081,982 disclose
17 spherical containment vessels with a bottom opening through
18 which a work piece incorporating an explosive is introduced
19 through an elevator means, and continuous feed wire
20 electrodes are used to make contact with an electrically
21 initiated detonator when the work piece is in place. The
22 latter patent also discloses means for introducing an
23 internal liquid spray after the explosion for the purpose of
24 neutralizing toxic by-products of the explosion.

25 Smirnov, et al. 4,079,612 discloses a roughly
26 hemispherical containment vessel mounted on a concrete
27 foundation with a shock-absorbing work table for supporting

1 the work piece and explosive material, which are detonated
2 through electric ignition wires leading through openings in
3 the containment vessel to the outside.

4 A different approach is disclosed by Paton, et al.
5 3,910,084 in which multiple closed-end pipes are disposed
6 radially around a central column in-which the explosion is
7 initiated, with the shock waves dampened by internal baffles
8 within the tubes. Access is gained to the chamber through a
9 removable top cover plate.

10 Klein, et al. 3,611,766 discloses a vertical explosion
11 chamber incorporating a cushioned work table for supporting
12 the work piece and explosive charge, and an internal shock-
13 mounted mechanical dampening means consisting of a steel
14 grate for absorbing the explosive pressure waves. Klein
15 3,464,249 discloses a similar containment vessel, in this
16 case spherical, with a bottom covering of loose granular
17 material such as sand which supports the work piece and
18 explosive charge. The explosion products are discharged
19 through a vertical pipe containing a noise silencer, and the
20 entire assembly is supported by shock absorbing means in a
21 reinforced brick or concrete pit for the further suppression
22 of shock and noise.

23 All of the above prior art devices represent
24 improvements over the methods first used for explosion
25 hardening of manganese steel rail components which involved
26 placing the explosive-covered work piece in an open field,
27 or at the bottom of an open pit such as an abandoned gravel

1 pit, and setting off the explosion in the open air with
2 resultant noise, dust, disturbance and contamination of the
3 environment. In addition, the uncontrolled use of
4 explosives required great amounts of space, posed
5 substantial danger to equipment and personnel, and had the
6 undesirable effect of demolishing the ignition leads, the
7 work piece support surface, and everything else within the
8 immediate vicinity of the explosion.

9 It is therefore the principal object of the present
10 invention to provide an improved method and apparatus for
11 containing, controlling and suppressing the effects of
12 explosive detonations used for industrial purposes. The
13 purpose of the invention is to provide a containment device
14 which can contain and suppress each explosion so that it
15 poses no hazard to surrounding plant and equipment, or to
16 the environment.

17 A further object is to provide such a method and
18 apparatus which permits rapid and convenient charging and
19 removal of work pieces, thereby achieving much higher rates
20 of production than have been possible using prior art
21 devices and techniques. A related object is to provide an
22 explosive containment vessel which can be constructed
23 inexpensively of common materials using conventional welding
24 techniques but which is sturdy enough to withstand months
25 and years of continuous use without deterioration. A
26 related object is to provide such a device in which
27 inexpensive consumable materials, such as silica sand and

1 pea gravel, are used as damping and shock absorbing agents,
2 rather than complex and expensive internal springs, metal
3 grates, and the like.

4 Another object is to provide an explosion containment
5 chamber which is readily opened from one end to allow
6 charging and removal of work pieces by conventional means
7 such as a forklift truck, and to allow easy entrance and
8 exit by maintenance personnel. A further object is to
9 provide quick and efficient removal of gaseous explosion by-
10 products after detonation so that maintenance personnel can
11 immediately enter the chamber to remove the treated work
12 piece and put another in place for the next operation.

13 Still another object is to provide an internal ignition
14 system in which the electrical leads for the detonation
15 initiation system are protected from blast effect and are
16 reusable for a great number of explosion cycles, rather than
17 being destroyed and having to be replaced after each cycle.

18 Another principal object of the invention is to provide
19 a means of quickly removing and treating the gaseous
20 explosion by-products by passing them through a scrubber
21 system, so that operating personnel can re-enter the chamber
22 immediately while the scrubber continues to process the
23 products of the previous explosion as a new work piece and
24 explosive charge are being readied. Also, it is an object
25 of the scrubber system to further dampen and suppress shock
26 and noise from each detonation by virtue of the extended
27 travel path of the explosion products as they pass through

1 the scrubber.

2 A particularly important object of the invention is to
3 provide a simple and inexpensive means for absorbing the
4 unused energy of the explosion, for instantaneously reducing
5 temperatures and pressures within the chamber, while at the
6 same time suppressing dust and particulate matter in the
7 explosion by-products.

8 Still another principal object of the invention is to
9 provide a method and apparatus for controllably destroying
10 munitions containing multiple explosive units (cluster bomb
11 weapons) by detonation.

12 Yet another principal object of the invention is to
13 make the explosion-containing apparatus portable so that it
14 can be moved from one location to another by conventional
15 motorized transport means.

16 SUMMARY OF THE INVENTION

17 The improved explosion chamber of the invention
18 comprises a double-walled steel explosion chamber anchored
19 to a concrete foundation, and having a double-walled access
20 door for charging new work pieces, and a double-walled vent
21 door for discharging the products of the explosion. The
22 double walls of the chamber, access door and vent door are
23 filled with granular shock damping material such as silica
24 sand, and the floor of the chamber is covered with granular
25 shock-damping bed such as pea gravel.

26 Along the outside of the chamber are steel manifolds
27 from which a linear array of vent pipes penetrates the

1 double walls of the chamber, with each pipe terminating in a
2 hardened steel orifice through which the explosion
3 combustion products pass.

4 Within the chamber, pre-measured containers of an
5 energy-absorbing medium, preferably comprising plastic
6 polymer film bags containing water are suspended from steel
7 wires over the explosive material, and at each end of the
8 chamber. Electrical igniter lead wires enter the chamber
9 through a steel hood having a downward-facing access opening
10 positioned in a protected location below the surface of the
11 granular bed, but accessible by an operator for quickly
12 attaching an electrical blasting cap.

13 The access and vent door are interlocked with the
14 electrical igniter to block ignition unless both doors are
15 positively shut. When the doors are opened after a
16 detonation, a vent fan is positioned to exhaust explosion
17 combustion products from the chamber and to draw fresh air
18 in through the access door. The manifolds and vent door
19 discharge into a scrubber for further cooling and
20 environmental treatment of the gaseous combustion products.

21 The method of operation of the invention comprises the
22 steps of placing an explosive work piece through the access
23 door and onto the granular bed, suspending plastic bags
24 containing an amount of water approximating the weight of
25 explosive, attaching an electrical blasting cap to the
26 igniter lead wires, closing the access and vent door,
27 electrically detonating the explosive, immediately opening

both access and vent door, and using fan means for exhausting the combustion products of the detonation from the chamber in preparation for inserting the next explosive work piece.

The gaseous combustion products exiting the manifolds and vent discharge are then cooled and environmentally treated in a scrubber before being released to the atmosphere.

When used to dispose of munitions, a fragmentation containment unit ("FCU") is used. The FCU is a heavy-walled bucket-shaped casting, preferably of manganese steel, having at its bottom a bed of silica sand onto which the munition is placed, supported by one or more layers of gypsum board. Over the FCU, suspended from the roof of the chamber, is a conventional steel cable or chain blast mat. The munition is detonated by a starter charge, and the FCU and blast mat absorb the impact of any fragments or shrapnel, and the chamber then serves to absorb the remaining energy of the blast and to dissipate the explosion combustion products in the manner described above.

In another embodiment of the invention, the explosion chamber is sized to be transportable on rails or on public roads, and is provided with attachment points at each end whereby it may be picked up and attached to wheeled carriage means. In use, the chamber is transported in an empty condition to the work site, where after it has been lowered into position, its hollow walls are filled with flowable

1 silica sand. Before use, its interior bed is filled with
2 granular shock-absorbing material. If fragmentation
3 munitions are to be destroyed, a shrapnel-resistant
4 fragmentation containment unit ("FCU") is positioned on the
5 granular bed within the chamber. After use, the chamber is
6 lightened by removing the granular material from the bed of
7 the chamber, and by allowing the silica sand to flow out of
8 the hollow walls. In its lightened condition, the chamber
9 may then be picked up and re-mounted on its carriage means
10 for transport to another location.

11 A BRIEF DESCRIPTION OF THE DRAWINGS

12 In the drawings,

13 Figure 1 is a cut-away perspective view of a first
14 preferred embodiment of the improved explosion containment
15 chamber of the present invention;

16 Figure 2 is a cut-away partial perspective view of the
17 opposite end of the chamber of Figure 1, including a
18 scrubber for cleaning the gaseous explosion products before
19 venting them to the atmosphere;

20 Figure 3 is a partial sectional plan view of the
21 explosion chamber of the preceding figures;

22 Figure 4 is a partial sectional side elevation of the
23 explosion chamber of the preceding figures;

24 Figure 5 is a reduced-scale sectional plan view of the
25 full length of the explosion chamber of the preceding
26 figures showing a railroad track work piece in place for
27 explosion hardening treatment;

1 Figure 6 is a sectional end elevation showing the
2 access door 6 end of the explosion chamber of the preceding
3 figures;

4 Figure 7 is a sectional end elevation showing the vent
5 door 7 end of the explosion chamber of the preceding
6 figures, with a piece of rail trackwork in place for
7 treatment;

8 Figure 8 is an enlarged partial sectional end elevation
9 of the ignition wire entry point into the explosion chamber
10 of the preceding figures;

11 Figure 9 is a sectional side elevation of a typical
12 multiple-weapon or "cluster bomb" artillery munition, such
13 as the United States Army 155 mm. M483 projectile containing
14 88 individual shaped-charge anti-personnel grenades, which
15 is typical of the munitions which may be safely disposed of
16 by the present invention.

17 Figure 10 is a sectional end view of the munition of
18 Figure 9, showing the individual grenades disposed in eight
19 columns of ten units.

20 Figure 11 is a perspective illustration of how the
21 grenades within the munition of Figure 9 are, according to
22 the invention, expelled as a group into a plastic carrier
23 tube, prior to being loaded into the FCU.

24 Figure 12 is a side elevation of a fragmentation
25 containment unit or FCU adapted for use with the explosion
26 chamber of the preceding figures, containing the explosive
27 contents of a cluster munition encased within the carrier

1 tube of the preceding figure.

2 Figure 13 is a partial sectional side elevation of a
3 second preferred embodiment of the explosion chamber adapted
4 for munitions disposal, showing the FCU containment unit of
5 Figure 12 positioned within the chamber and ready for the
6 destruction of the contents of a munition positioned within
7 the FCU.

8 Figure 14 is a side elevation of a transportable
9 chamber embodying the present invention, showing an
10 automotive tractor with fore and aft wheeled carriers for
11 picking up, supporting, and carrying the chamber from one
12 location to the next.

13 Figure 15 is an enlarged partial cross-section side
14 elevation of the transportable chamber of Fig. 14, showing
15 an FCU containing a munition ready for detonation.

16 Figure 16 is a plan view of the transportable chamber
17 of Figure 15.

18 Figure 17 is an end elevation of the transportable
19 chamber of Figure 15.

20 Figure 18 is a perspective view in partial cross-
21 section, showing the internal structure of the transportable
22 chamber in association with one or more exhaust manifolds
23 discharging into an expansion tank.

24 DETAILED DESCRIPTION OF THE INVENTION

25 Turning to the drawings, Figure 1 is a sectional
26 perspective of the improved explosion chamber of the present
27 invention. The chamber comprises an inner casing 1 having a

1 ceiling, floor, side walls and ends, being fabricated of
2 sheet steel using conventional welding techniques.

3 Surrounding the inner casing 1 are a plurality of spaced
4 circumstantial flanges or ribs 2 over which a welded sheet
5 steel outer casing 3 is constructed so that the ribs 2 cause
6 the outer casing 3 to be spaced from the inner casing 1 and
7 leaving a gap which is then filled with a granular shock-
8 damping material. In the first preferred embodiment as
9 shown in Figs. 1 - 8, which embodiment is particularly
10 adapted for the explosion surface hardening treatment of
11 railroad trackwork, the inner and outer metal casings are
12 constructed of three-quarter inch thick sheet steel
13 separated by circumferential steel I-beam ribs 2 spaced
14 every two feet. All seams are continuous-welded. According
15 to the invention, the space between the inner and outer
16 casing 3 is filled with a firm, granular shock-absorbing
17 material, preferably silica sand.

18 The explosion chamber is anchored by bolts or other
19 suitable means (not shown) to a reinforced concrete
20 foundation 5. In the preferred embodiment shown, the inside
21 dimensions of the explosion chamber are: eight feet high,
22 six feet wide, and fifty feet long. The reinforced concrete
23 foundation 5 is preferably at least four feet thick.

24 As one of the major advantages of the invention, the
25 internal dimensions of the chamber allow an operator to
26 enter, stand up and work easily, and its length, in the
27 first preferred embodiment, permits long pre-welded sections

1 of railroad trackwork to be inserted and explosion-hardened,
2 which was not possible in prior art explosion chambers.

3 The chamber is provided with two doors, an access door
4 6, and a vent door 7. Both doors are constructed of double-
5 walled welded steel similar to the chamber walls, and each
6 is hinged to open in an inward direction. The door jams
7 are constructed so that each door fits in a sealing
8 relationship so that increased pressure within the chamber
9 causes the door to seal tighter against its frame. The
10 volume within the double-walled doors is also filled with
11 shock-damping material, preferably silica sand.

12 The floor of the chamber is preferably covered with a
13 bed 8 of granular shock-damping material, preferably pea
14 gravel, to a uniform depth of about one foot, thereby
15 forming a support surface for the work piece and explosive
16 to be detonated.

17 To initiate ignition of the explosive, electrical wire
18 firing leads 9 penetrate the chamber through a pressure-
19 sealed opening 10 and emerge through a welded sheet steel
20 shield box or hood 11 having a downward-facing opening
21 positioned below the surface of the granular shock-damping
22 material. To prepare the work piece and charge for
23 detonation, a suitable electric detonator cap 12 is inserted
24 into the explosive charge and the ends of its wire leads 13
25 are routed over to the firing wire hood 11. The pea gravel
26 is scooped away to expose the ends of the firing wire leads
27 9, the leads are twisted together to complete the firing

1 circuit, and then the pea gravel is swept back over the
2 detonator cap leads 13 to again surround and enclose the
3 open end of the hood 11. While the detonator cap leads 13
4 are substantially disintegrated by the explosion, the firing
5 wire leads 9 remain protected under the hood 11 and may be
6 re-used repeatedly.

7 As a principal feature of the invention, shock
8 suppression means are provided for the chamber in the form
9 of a plurality of vent pipes disposed along the centerline
10 of one or more of the interior side walls of the chamber,
11 with each vent pipe communicating through the chamber double
12 wall into an elongated steel manifold 15 means extending
13 alongside the chamber on each side and terminating in a
14 discharge outlet 16. In the first preferred embodiment each
15 manifold 15 is ten inches square and is fabricated by
16 continuous-seam welding from one-half inch steel plate. The
17 ribs 2 consist of eighteen-inch I-beam sections spaced at
18 two foot intervals. The vent pipes 14 are of two inch
19 diameter steel tubing, and like the ribs 2 are spaced at two
20 foot intervals. Where it connects to the inner wall of the
21 chamber, each vent pipe is fitted with a hardened steel
22 orifice 17 three-quarters of an inch in diameter. In the
23 first preferred embodiment, the fifty-foot chamber has
24 twenty-four vent pipes 14 and orifice 17 per side, for a
25 total of forty-eight vent pipes 14 and orifice 17 in all.

26 Within the chamber, square corners are avoided because
27 of the tendency of explosives to exert unusually high

1 pressures at such critical points. Therefore, a fillet
2 piece 18 is welded into each corner to break the 90° square
3 corner into two 45° angles, which has the effect of rounding
4 the corner and eliminating stress-raising corners or pockets
5 which would otherwise impose undesirable destructive forces
6 on the corner welds.

7 In the first preferred embodiment of the invention,
8 additional sound suppression is obtained by coating the
9 exterior surfaces of the outer chamber and manifold 15 with
10 a polyurethane rigid foam coating 20 of known composition to
11 a depth of at least four inches. The entire foam-covered
12 structure is further enclosed in an enclosure such as a
13 sturdy wooden shed (not shown) having screened ventilating
14 slots to permit free circulation of air.

15 To open and close the access and vent door 7, double-
16 acting hydraulic cylinders 19 are provided. As a further
17 feature of the invention, important safety objectives are
18 realized by providing each door with sensor means 21 as part
19 of an electrical interlock (not shown) between the access
20 door 6, vent door 7 and ignition means, whereby the access
21 door 6 must both be in a closed and sealed position before
22 the ignition means can be energized. In this way it is
23 impossible to inadvertently detonate an explosive charge
24 prematurely before the doors are fully closed the result of
25 which would be substantial destruction and damage to
26 equipment such as the vent fan 22, not to mention the risk
27 of bodily injury to operating personnel in the vicinity of

1 the access door 6.

2 In the first preferred embodiment the chamber ceiling
3 is fitted with a welded I-beam for use as a trolley to
4 insert and remove particularly long lengths of steel
5 trackwork or other work pieces of a similar shape.

6 Another principal feature of the invention is the
7 provision for each explosion of liquid-filled energy
8 absorption modules disposed roughly along the interior
9 centerline of the chamber. These devices serve to cool the
10 gaseous explosion products, and to suppress dust and debris
11 in the chamber after each explosion.

12 In both of the preferred embodiments, the energy
13 absorption devices are simple self-sealing polyethylene bags
14 filled with water and hung on hanger wires 25 approximately
15 along the center line of the chamber above and around the
16 work piece and explosive charge. It has been discovered
17 that commercially available "ZipLock" brand sandwich bags,
18 six by eight inches in dimension and .002 inches (two mils)
19 thick are satisfactory for this purpose. While water is
20 preferable, any suitable energy-absorbing vaporizable
21 material can also be used.

22 According to the invention, the volume of water placed
23 in the chamber for each explosion is selected to be
24 approximately equal in weight to the amount of explosive to
25 be detonated. This volume of water is distributed among
26 several bags which are then hung in a staggered array
27 approximately along the center line of the chamber in the

1 vicinity of the explosive. Preferably, the water bags 24
2 are hung on the hooked ends of nine-gauge steel rods welded
3 to the ceiling of the chamber.

4 By using the water-filled energy absorption means, it
5 has been found that the instantaneous theoretical pressure
6 of the explosion is reduced by more than half, and the
7 introduction of moisture into the chamber at the moment of
8 detonation and thereafter has a beneficial effect of
9 suppressing dust and cooling the explosion products
10 instantly. In contrast to explosions without the use of the
11 water-filled bags, the perceived impact and noise of the
12 explosion is substantially reduced, and operating personnel
13 are enabled to enter the chamber immediately after each
14 detonation to remove one work piece and replace it with the
15 next.

16 It has also been found in practice that the beneficial
17 effects of the water bags 24 are enhanced if an additional
18 water bag 26 is placed at each end of the chamber, away from
19 the work piece, approximately four feet from the access door
20 6, and twelve feet from the vent door 7, although other
21 spacings are satisfactory also.

22 In practice, using the water bags 24 in the manner of
23 the invention results in the complete vaporization of both
24 the water and the polyethylene bags, serving to absorb and
25 suppress the undesired shock of the explosion, while leaving
26 behind virtually no debris or residue. After each
27 explosion, the access door 6 can be opened immediately, and

1 all that can be seen are wisps of water vapor which are
2 swept out the vent door 7 in the manner described further
3 herein.

4 According to another important feature of the
5 invention, all gaseous explosion by-products are quickly
6 exhausted from the chamber in a controlled manner. After
7 each explosion, the vent door 7 and access door 6 are
8 simultaneously opened, the vent fan 22 is energized, and the
9 gaseous explosion products from the chamber are drawn
10 through the vent door 7 opening while the atmosphere in the
11 chamber is replaced with fresh air drawn through the open
12 access door 6. In practice, using the method and apparatus
13 described, it has been found that the access and vent door 7
14 may be immediately opened after each explosion, thereby
15 permitting operating personnel to enter the chamber
16 immediately after each explosion to remove the treated work
17 piece and replace it with the next.

18 Another major feature of the present invention is that
19 all gaseous explosion products are controllably discharged
20 and directed into a suitable environmental treatment means
21 such as a scrubber 27. In the illustrated embodiment, a
22 water-spray scrubber 27 of conventional construction is used
23 to receive the discharge from both side-mounted manifold 15,
24 and from the vent fan 22 as well, so that no gaseous
25 explosion products escape to the atmosphere untreated. In
26 addition, the tortuous path offered by the scrubber 27
27 creates a further level of advantageous shock and noise

1 suppression.

2 To permit the refilling of gaps in the chamber walls
3 caused by settling of the shock damping silica sand, a bin
4 or hopper 28 is provided above the chamber with spaced
5 openings 29 through which sand may move to replace lost
6 volume as the sand in the walls settles or compacts with
7 each detonation. It has been found that despite such
8 compaction, the use of silica sand (as opposed to masonry
9 sand) does not result in any diminishing of the shock-
10 damping effect.

11 Despite the immense destructive forces of each
12 explosive detonation, the chamber of the present invention,
13 with its vent pipes 14 and energy absorbing liquid modules,
14 has been found in practice to diminish the surplus
15 destructive energy of each explosion to a point where the
16 trolley beam 23 is virtually unaffected. Similarly, the
17 depending wires for hanging the energy absorption water bags
18 24 are virtually unaffected after each blast. This allows
19 the chamber to be used continuously, with a productive
20 output of as many as 10 or 12 explosions per hour, which is
21 an order of magnitude greater than permitted by any of the
22 explosion chambers of the prior art, or by conventional
23 open-pit explosive techniques.

24 In practice, with the preferred embodiment described,
25 the method and apparatus of the present invention has been
26 successfully utilized to safely detonate explosive charges
27 in a wide range of sizes, ranging from two to fifteen pounds

1 of C-2 plastic explosive (also known as PETN), with minimal
2 amounts of shock, noise and adverse effect on the
3 environment. Surprisingly, it has been found that business
4 office operations in an adjoining office building only two
5 hundred feet away from the explosion chamber can be
6 conducted in a completely normal manner, with the explosions
7 being indistinguishable from the ordinary background noise
8 of the office environment.

9 A second embodiment of the invention, shown in Figures
10 11, 12 and 13, is particularly adapted for the destruction
11 of surplus or defective munitions, particularly
12 fragmentation munitions. Figures 9 and 10 illustrate one
13 such munition 30, the United States Army M483 155 mm.
14 "cluster bomb" artillery shell, each of which contains a
15 close-packed array of 88 individual miniature shaped-charge
16 grenades or bomblets 31 arranged in ten layers of eight
17 grenades each, all contained in a cylindrical shell adapted
18 to be fired from a 155 mm. howitzer. The munition comprises
19 a cylindrical metal body 32 closed at its forward end by a
20 threaded cone or ogive 33 and at its base by a base plug 34.
21 At the tip of the ogive 33 is a fuse and expulsion charge
22 35. When the munition is fired and approaches its target,
23 the fuse ignites the expulsion charge 33, driving the array
24 of grenades backward, causing the base 34 to separate from
25 the body 32 and the individual grenades to disperse in the
26 air. Once dispersed, each of the individual grenades is
27 armed by a spinning ribbon fuse (not shown) and detonates on

1 contact with any hard surface. The grenades each have a
2 frangible metal shell which breaks apart into shrapnel
3 fragments on detonation, and also a shaped-charge component
4 designed to pierce armor.

5 To deactivate and dispose of such munitions,
6 conventional techniques of hand disassembly and removal of
7 explosive components are dangerously impractical because of
8 the large number of small individual grenades contained in
9 each cluster-bomb munition. Should the munition be
10 suspected of being defective or unstable, the problems are
11 multiplied even further.

12 In accordance with the second embodiment of the
13 invention, a munition 30 intended for disposal is first
14 stripped of its ogive 33 and base plug 34, thereby exposing
15 and allowing access to the stacked array of individual
16 grenades 31 from both ends of the shell. Then, a
17 cylindrical carrier tube 36 of any suitable light organic
18 plastic material such as polyvinyl chloride (PVC) is
19 positioned in line with the open base end of the shell body
20 32. The entire array of grenades is then simply pushed as a
21 single unit out of the shell body 32 and into the carrier
22 tube 36 so that none of the grenades need be individually
23 handled by the operator. This manipulation, because it is
24 relatively simple, is also adapted to being performed by
25 remote control through robotic manipulation means (not
26 shown).

27 When the array of grenades 31 has been transferred from

1 the shell body 32 into the carrier tube 36, the carrier tube
2 is placed into the open-topped cylindrical container 37
3 referred to herein as the Fragmentation Containment Unit, or
4 "FCU". The FCU 37 acts as a primary containment chamber for
5 the detonation of the munition, serving to partially
6 suppress and contain the explosion and to absorb the initial
7 high-velocity impact of fragmentation shards and debris from
8 the explosion. The gaseous explosion products and
9 fragmentation debris not contained by the FCU are deflected
10 and escape upwards into the containment chamber, which is
11 constructed in the manner shown in Figures 1 through 8 and
12 described in the preceding specification.

13 Preferably, the main explosion chamber intended for use
14 with an FCU for the destruction of munitions has interior
15 dimensions in which the side and end walls are of equal
16 length, so that in plan view it is substantially square. It
17 is also preferably constructed with greater interior height
18 as well, all for the purpose of providing the greatest
19 interior volume consistent with practical and reasonable
20 construction techniques. In this embodiment of the
21 invention intended primarily for munitions disposal, the
22 chamber preferably is constructed with internal dimensions
23 of sixteen feet on each side and a height of fourteen
24 feet.

25 In the preferred embodiment shown in Figures 12 and 13,
26 the interior diameter of the FCU at its mouth (upper end) is
27 42 inches, with a wall thickness of 3.5 inches, and a height

1 of 48 inches. At its base, the FCU interior diameter tapers
2 of 36 inches. The FCU 37 is preferably cast of manganese
3 alloy steel, to give it impact-hardening characteristics and
4 to make it more resistant to the impact of shrapnel
5 fragments. On each side of the FCU are integral cast handle
6 lugs 38 with openings adapted to receive the prongs of a
7 fork-lift device (not shown), so that the FCU may be charged
8 with a munition outside of the chamber, and then carried by
9 fork-lift into the chamber and placed in position for
10 detonation.

11 At the bottom of the FCU there is preferably placed a
12 granular layer 39 of about 12 inches of energy-absorbing
13 material such as silica sand. According to another aspect
14 of the invention, on top of the sand layer 39 is placed a
15 support platform 40 to keep the carrier tube 32 upright and
16 centrally positioned within the FCU. The support platform
17 is preferably made of one or more layers of gypsum board
18 (hydrated calcium sulfate sheets with a paper covering).
19 This inexpensive, readily available material is
20 disintegrated entirely by the ensuing detonation with no
21 detectable residue and provides a strong and stable flat
22 surface on which to position the carrier tube 32 containing
23 the array of bomblets 31 after removal from the munition.

24 Alternatively, a granular material may be used which
25 can be mounded by hand into base for supporting an
26 irregular-shaped munition (not shown). A hydrated granular
27 mineral material such as commercially available cat litter

1 has been found quite suitable for this purpose, and, like
2 gypsum board, it leaves no residue after detonation.

3 Within the chamber, an interlocked steel blast mat 43
4 of woven steel cable or linked chain is suspended from the
5 ceiling of the chamber directly overhead the FCU 37. The
6 blast mat 43 serves to absorb the impact of any shrapnel
7 fragments or debris not contained within the FCU.

8 As with the first preferred embodiment of the
9 invention, liquid energy absorption modules are dispersed
10 within the larger chamber in close proximity to the FCU to
11 absorb and disperse the energy of the detonation of the
12 munition. As before, these are preferably vaporizable
13 containers comprising plastic film bags (not shown) filled
14 with water, substantially evenly distributed in the space
15 around and above the FCU by wire hangers in the manner
16 previously described.

17 The mass of water to be used in the energy absorption
18 modules has been found to be dependent upon the type of
19 explosive to be detonated and its mass. Because the energy
20 liberated per unit of explosive varies according to the type
21 of explosive involved, for optimum blast suppression the
22 mass ratio of water to explosive must also be varied. The
23 following ratios have been determined to be substantially
24 optimal for use with the types of explosives indicated:

Explosive	Btu/lb	Water/Explosive Ratio
HMX	3,402	2.50
RDX	2,970	2.20

1	PETN	2,700	2.00
2	C-2	1,700	1.25

3 Once the FCU 37 has been charged with the munition to
4 be disposed of, either as an array of grenades contained
5 within the carrier tube 32 or as a separate munition, the
6 FCU is picked up by a fork-lift (not shown) by means of its
7 handle lugs 38 and placed within the explosion chamber as
8 shown in Figure 12. A small starter charge 41 is attached
9 to the munition and wired for external initiation in the
10 manner previously described.

11 With the FCU in place within the chamber, and the
12 starter charge wired for ignition, the doors of the chamber
13 are closed, and the closure is verified. The starter charge
14 41 is then detonated, thereby detonating the munition. The
15 initial blast and fragmentation are substantially, but not
16 completely, contained by the FCU, and the remaining force of
17 the blast is thereby deflected and diverted upwards into the
18 chamber itself. The explosion chamber, having a much
19 greater containment volume than the FCU, serves to suppress
20 and evacuate the gaseous explosion products in the manner
21 previously described, while the fragmentation shards left
22 behind are picked up and disposed of separately. The
23 carrier tube 32, being of light PVC plastic, is essentially
24 vaporized, as is the gypsum board support platform 40, so
25 that there is virtually no other debris to be removed before
26 the next munition is loaded for detonation.

27 A transportable apparatus for controllably destroying

munitions by detonation is shown in Figs. 14 - 18. In Fig. 14, a mobile explosion containment chamber 50 is shown supported by detachable goose-neck arms 51, each of which is supported on one of two multiple-wheeled trailer units 52 by a pivoted hydraulic lift mechanism 53.

The internal structure of the mobile chamber 50 is similar to that of the previous embodiments, with certain modifications to make it more compact, and to allow its hollow walls to be easily filled with a pourable shock-damping means such as silica sand before use, and emptied again to prepare it for transport.

As best shown in Figs. 15 - 17, the chamber is of double-walled welded steel construction, with the top, bottom and side walls each comprising steel plates spaced apart by steel I-beams to form a fillable wall cavity comprising hollow segments communicating horizontally across the chamber on the top and bottom, and vertically on the sides.

At the top of the chamber, suitable means for the introduction of silica sand is provided, such as a dump pit 54 and horizontal auger 59 for spreading the sand across the top of the chamber, where it is deposited into openings (not shown) which direct the sand into the hollow segments of the chamber top, and from which the sand will flow of its own weight down the side segments into the bottom segments, until all the segments are substantially filled with sand. The interconnection between the top and side wall segments

1 is best shown in Fig. 18.

2 At the bottom of each wall segment of the chamber 50 is
3 a suitable emptying means 55, such as a pivoted dump valve
4 such as might be employed with a grain bin. When it is
5 desired to lighten the chamber 50 for transport, the dump
6 valves 55 are opened, and the sand, being flowable,
7 discharges from each wall segment by its own weight. Any
8 sand left can be easily removed by a vacuum ejector (not
9 shown), such as is used for handling grain.

10 Atop the chamber 50 are steel manifolds 56
11 communicating with the interior of the chamber by an array
12 of vent pipes 57 penetrating through the double walls, with
13 each pipe terminating in a hardened steel orifice through
14 which the explosion combustion products must pass. The
15 manifolds 56 communicate in turn with an expansion tank 58
16 at the end of the chamber.

17 The chamber 50 has two openable blast-resistant doors
18 consisting of a relatively larger front door 60 for workers
19 to enter the chamber through, and a smaller rear door 61 for
20 evacuating explosion products after each explosion. The
21 rear door 61 is connected through an exhaust vent 62 to
22 carry the explosion products into the expansion tank 58.
23 The expansion tank 58 may be provided with scrubber means or
24 other environmental control systems (not shown) to treat the
25 explosion products before they are discharged through vent
26 openings 63 into the atmosphere.

27 As shown in Fig. 15, the portable chamber 50 is

1 prepared for use by providing a layer of pea gravel or other
2 granular energy-absorbing material 65 as a floor. For the
3 disposal of fragmenting munitions, the munition 66 is placed
4 inside a bell-shaped cast steel shrapnel-containing
5 fragmentation containment unit (FCU) 67 supported on the bed
6 of pea gravel. To initiate detonation, an initiating charge
7 68 is placed atop the munition and detonated.

8 As with the previous embodiments of the invention, a
9 principal feature is the provision of vaporizable bags or
10 other containers filled with water 70, or other suitable
11 energy absorbing units, in proximity to the munition 66 and
12 initiating charge 68. The instantaneous vaporization of the
13 water bags 70 serves to absorb and dissipate a substantial
14 amount of the explosive energy. Also, the resulting water
15 vapor, on condensation, assists in removing particulate
16 combustion products from the exhaust gasses.

17 After the detonation, the rear door 61 is opened first,
18 followed by the front door, and the exhaust products are
19 drawn by fan means (not shown) into the expansion tank for
20 further treatment, or for discharge through vents 63 to the
21 atmosphere.

22 Dimensionally, the chamber 50 of this embodiment is
23 sized to pass without substantial difficulty on public
24 roads, being about 12 feet wide, 33 feet long, and 13 high.
25 The two parallel manifolds atop the chamber are about 8
26 inches square, each being welded from 1/4 inch rolled steel
27 and having nine exhaust ports of 2 inch Schedule 160 steel

1 pipe communicating to the interior of the chamber. The
2 expansion chamber is 8 feet in diameter. All material is
3 desirably of annealed rolled (AR) structural steel. The
4 entrance (front) door is about 6 feet square, and the
5 exhaust (rear) door is about 2 feet square. The fillable
6 wall cavities are 19 inches thick, which is the height of
7 the steel I-beams which separate interior and exterior
8 walls. The empty weight of the chamber, with manifolds and
9 expansion tank but without sand or pea gravel, is about
10 160,000 lb., of which 80,000 is supported by each wheeled
11 trailer. When ready for use, the additional weight of the
12 added sand and pea gravel is about 30,000 lb.

13 When it is desired to move the mobile chamber 50 to a
14 new location, it is easily lightened by allowing the
15 flowable silica sand to drain from the wall cavities by
16 gravity, or by removing it using a vacuum ejector. The pea
17 gravel bed may also be removed in a similar fashion. The
18 goose-necks 51 are then reattached, the trailer units 52
19 moved into position, and the chamber is then raised up for
20 travel clearance using the hydraulic lifts 53.

1 I claim:

2 1. A mobile device for containing and suppressing
3 explosions comprising:

4 a pressure-resistant chamber having an inner casing and
5 an outer casing surrounding and spaced from the inner casing,
6 spacer means for connecting the inner and outer casings to
7 define a fillable wall cavity therebetween, at least one
8 access door penetrating said casings, and characterized by:
9 wheeled carriage means for transporting said chamber to
10 a point of use,

11 filling means for filling the wall cavity with pourable
12 granular shock-damping material prior to use, and

13 emptying means for evacuating said shock-damping
14 material after use.

15 2. The device of claim 1 including means for
16 detaching said chamber from the wheeled carriage means and
17 lowering it onto a support surface for use, and means for
18 raising and attaching said chamber onto said wheeled carriage
19 means for transport after such use.

20 3. The device of claim 1 in which the chamber has a
21 floor covered with granular shock-damping material forming a
22 support surface for an explosive object.

23 4. The device of claim 1 in which a plurality of
24 liquid-filled energy absorption modules is positioned in a
25 spaced array within the chamber with respect to an explosive
26 object.

27 5. The device of claim 4 in which the energy



1 absorption modules comprise vaporizable containers filled
2 with water.

3 6. The device of claim 5 in which the containers are
4 individual self-sealing polyethylene bags.

5 7. The device of claim 5, in which the mass of water
6 is selected to match the energetic mass of the explosive
7 object selected from the following table according to the
8 principal explosive component of the object:

9 Explosive	Btu/lb	Water/Explosive Mass Ratio
10 HMX	3,402	2.50
11 RDX	2,970	2.20
12 PETN	2,700	2.00
13 C-2	1,700	1.25

14 8. The device of claim 1 in which the chamber further
15 includes a manifold means for receiving and directing
16 explosion products to a discharge point, and a plurality of
17 spaced vent pipes communicating between the inside of the
18 chamber and said manifold means.

19 9. The device of claim 8 in which the chamber further
20 includes a vent door and exhaust fan means for evacuating
21 gaseous explosion products through the vent door and for
22 drawing fresh air in through the access door.

23 10. The device of claim 9 in which the chamber further
24 includes scrubber means for stripping said explosion products
25 of particulate matter and noxious vapors, and conduit means
26 for conveying said explosion products from the discharge
27 point and vent door to the scrubber means.



* C L M S *

11. The device of claim 1 further including a separate shrapnel-resistant containment vessel for receiving and containing a fragmentable explosive object within the chamber, and detonation means including an initiating explosive charge and ignition means for initiating the explosion of said object.

12. The device of claim 1 further including means for sensing the position of the access door, detonation means including ignition means and an initiating explosive charge, and means for electrically locking out the ignition means when said door is not in a closed and sealed condition.

13. A method for destroying an explosive object using a mobile explosion containing and suppressing chamber comprising the steps of:

providing a pressure-resistant chamber supported by wheeled carriage means, and characterized by an inner casing and an outer casing surrounding and spaced from the inner casing, spacer means for connecting the inner and outer casings to define a fillable wall cavity therebetween, at least one access door penetrating said casings, filling means for filling the wall cavity with pourable granular shock-damping material prior to use, and emptying means for evacuating said shock-damping material after use,

transporting said chamber on the wheeled carriage means to a selected location for use,

filling said fillable wall cavity with the pourable shock-damping material,



1 destroying the object by attaching ignition means and
2 an explosive initiating charge to said object, opening the
3 access door, introducing the object into the chamber, closing
4 and sealing the access door, and detonating the initiating
5 charge,

6 upon completion of object destruction, lightening the
7 chamber for transport by evacuating the pourable shock-
8 damping material from the chamber wall cavity, and

9 employing the wheeled carriage means to transport the
10 chamber to another location.

11 14. The method of claim 13 including the steps of
12 detaching said chamber from the wheeled carriage means and
13 lowering it onto a support surface for use, and raising and
14 attaching said chamber onto said wheeled carriage means for
15 transport after such use.

16 15. The method of claim 13 including the step of
17 placing a plurality of liquid-filled energy absorption
18 modules within the chamber with respect to the object to be
19 destroyed.

20 16. The method of claim 15 in which the energy
21 absorption modules comprise vaporizable containers filled
22 with water, and including the step of selecting the mass of
23 water to match the energetic mass of the explosive object
24 from the following table according to the principal explosive
25 component of the object:



	Explosive	Btu/lb	Water/Explosive Mass Ratio
1			
2	HMX	3,402	2.50
3	RDX	2,970	2.20
4	PETN	2,700	2.00
5	C-2	1,700	1.25

6 17. The method of claim 13 in which the chamber has a
7 floor, and including the step of covering the floor with
8 granular shock-damping material forming a support surface for
9 the explosive object.

10 18. The method of claim 13 in which the chamber has a
11 manifold means for receiving and directing explosion products
12 to a discharge point, and a plurality of spaced vent pipes
13 communicating between the inside of the chamber and said
14 manifold means, and including the step of directing the
15 explosion products from the vent pipes through the manifold
16 means to the discharge point prior to opening the access door
17 for charging the next object.

18 19. The method of claim 18 including the step of
19 directing the explosion products from the discharge point
20 into a scrubber means for stripping said explosion products
21 of particulate matter and noxious vapors.

22 20. The method of claim 13 for use in destroying
23 fragmentable explosive objects including the steps of placing
24 the object in a separate shrapnel-resistant containment
25 vessel positioned within the chamber prior to detonating the
26 initiating charge.

27 21. The method of claim 13 including the step of



1 sensing the position of the access door, and electrically
2 locking out the ignition means when said door is not in a
3 closed and sealed condition.

