Aug. 5, 1952 W. E. LAWSON 2,605,703

LINER FOR HOLLOW CHARGES

Filed July 6, 1944

Fig. 1.

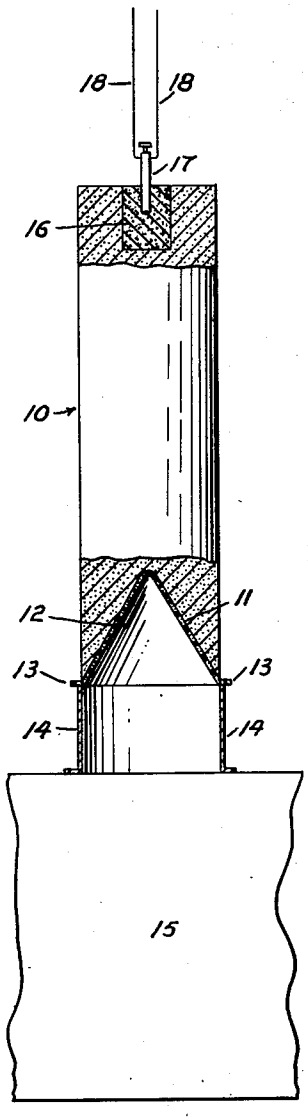


Fig. 4.

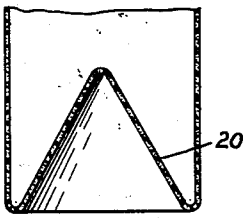


Fig. 5.

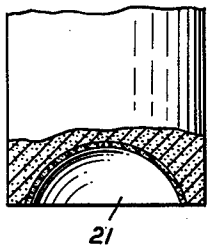


Fig. 2.

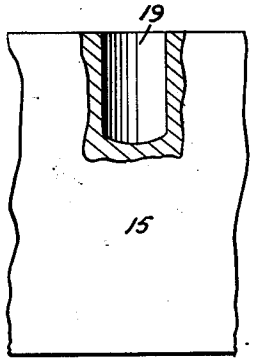


Fig. 3.

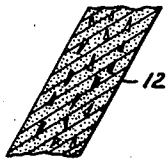


Fig. 6.

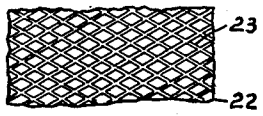
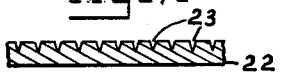


Fig. 7.



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UNITED STATES PATENT OFFICE

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LINER FOR HOLLOW CHARGES

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10 Claims. (Cl. 102—24)

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This invention relates to a novel explosive assembly wherewith increased explosive execution may be obtained and to a method of utilizing this explosive assembly or device.

Explosives are used frequently for demolition purposes and with the object of causing the greatest possible destructive work locally. In such work it was an earlier practice to bring the explosive into as close contact as possible with the object or material to be blasted. While early practice of hollowing non-detonating charges was practiced, it was commonly considered desirable to compress or tamp the high explosive very tightly against the surface of the material to be demolished. The last named practices have been followed in uses of disruptive explosives, generally until recently in placing demolition charges.

The Munroe effect has been described in the literature over a period of years, this term being applied to the heightened effect obtained when a detonating high explosive charge was hollowed out on the side toward the material to be blasted. By reason of this cavity (recently accompanied by a definite space relation between explosive and opposed material), explosive waves appeared to be focussed or localized in such manner as to cause increased destructiveness against the adjacent surface and body. This effect has been a matter of considerable interest and has received some practical application in disruptive operations. The present application is directed to an extension of the Munroe principle whereby unusual execution results.

An object of the present invention is a novel and improved explosive device and assembly whereby enhanced destructive effects are obtained in the use of high velocity explosives. A further object is such an assembly with which a controlled and directed blasting effect of increased effectiveness results. This includes producing a focussed jet of comminuted particles moved in the fore front of the wave of detonation projected against the work or target, to improve cleavage or fragmentation of the material worked on. A still further object is such an arrangement allowing the deep penetration of said blasting effect into any abutting material. A further object is a method of operating such an explosive unit or assembly and securing the results described. Additional objects will be disclosed as the invention is described more at length in the following.

In the drawings

Fig. 1 is an elevational view partly in section, illustrating my invention in use in one form;

Fig. 2 is a view of the work or target material

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partly in section showing the execution effected by detonation of the charge applied as in Fig. 1;

Fig. 3 is a fragmentary enlarged section of the liner involved in Fig. 1;

Fig. 4 is a sectional view of an extension of the liner;

Fig. 5 is a fragmentary section of a main charge with a modified form of recess;

Fig. 6 is a fragmentary representation of the face of a modified liner material;

Fig. 7 is a sectional view of such material.

I have found that the foregoing objects are accomplished when I prepare a charge of a detonating explosive of relatively high density, form a hollow or depression in said charge on one side, and introduce or form a rigid frangible lining structure in said depression intimately contacting, or united with the explosive. This lining may be formed of a frangible body of rigid metal, or metallic compound, or other hard material which has been made up of particles of metal, metallic compound or other hard material strongly bonded together. Under the influence of the explosion of the charge, this liner becomes disintegrated instantaneously into small granular particles, which may be its component particles. There have also been demonstrated lining elements comprising particles of glass, Carborundum, and other non-metallic materials including quartz sand, held together with a binder.

The use of the foregoing hollowed charge with rigid frangible liner brings about an enhanced and directed or focussing effect of the explosive that causes greatly increased blasting execution. As stated, I employ a liner of frangible metal—that is, bonded particles of a metal or a compound thereof, or of other hard material rather than a single shaped piece of ordinary metal, because the use of the latter would under ordinary practice cause the formation of a solid metal slug rather than disintegration of the liner into particles, It is contemplated, however, that a more frangible, brittle metal than heretofore employed may become available, as well as other brittle material which may be produced as an integral body.

In carrying out the invention, I may make use of various types and forms of frangible metal, the requirement being that the liner be a rigid structure (in one form, of bonded particles), such that, under the force of the explosion, said structure will disintegrate into small particles. Metal particles may, for example, be bonded together by heat or by pressure or by the combination of the two, or again by a suitable binding thermo plastic or other agent. Suitable materials for use will be iron filings or other form of comminuted me-

tallic iron or steel, nickel particles, zinc, tin, and other metals, metal oxides such as zinc and tin oxides, such materials as tungsten carbide, and the like. Various binding agents may be used with the comminuted metals or metallic compounds, for example linseed oil, starch, dextrin, gums, sodium silicate, etc. Plastics and cements, plaster of Paris etc. have been used as matrices to carry particles of harder material, for instance, glass, carborundum, quartz sand, and other material. While a cone or other hollowed structure of frangible material alone is particularly contemplated, I may use such frangible structure as a liner in conjunction with a one-piece solid liner of metal or other material, alone, or, for example, as an inner layer on such solid liner either along the whole structure or at the apex of the cone. A moulded glass liner is effective, as disclosed in a copending application of Clyde Oliver Davis, Serial No. 477,379, filed February 27, 1943, now abandoned, and owned by the same assignee as the present application.

As has been stated, the invention comprises the maintenance of a hollowed or depressed portion on one side of the explosive charge and the lining of said hollowed portion with a frangible structure conforming substantially to the shape of this hollowed portion. I may, for example, use a frangible liner of curved or hemispherical shape and adapted to fit a concavity in the explosive charge. Preferably, however, I employ a liner in the form of a cone, since this gives highly effective results, lends itself well to controlled adjustment and is readily fabricated. Any shape of liner adapted to fit into or to integrally or otherwise form a hard brittle face of a hollowed portion of the explosive charge may be used, where the shape of the hollowed portion is determined to be effective for the purposes hereinafter indicated.

The following will serve as specific examples of assemblies prepared and tested in accordance with the invention:

Example 1

A high density charge of a 50–50 blend of pentaerythritol tetranitrate and trinitrotoluene in the form of a cylinder 5 inches long and 2 inches in diameter was prepared with a conical cavity at one end, into which was fitted a similarly shaped conical liner of 1½ inches diameter, having an internal angle of 45°. This charge weighed approximately one pound. This cone was fabricated from iron filings bonded together by a sufficient amount of linseed oil. This explosive unit, comprising a hollowed cylinder of explosive with a frangible metal cone fitted into the cavity, was placed closely adjacent to a piece of homogeneous steel armor plate of 5 inches thickness, the conical cavity in the explosive facing the armor plate, and the recessed end of the explosive being separated from the armor by a slight distance. The explosive was then fired by means of an electric blasting cap inserted within a booster charge of explosive fitted within the main charge at its outer end. The blast caused the formation of a small diameter hole of considerable depth in the armor plate, indicating an enhanced explosive effect. The weight of the explosive in the cylinder above referred to was approximately one pound.

Example 2

A similar test was carried out using the same type of explosive in the form of a cylinder 5 inches in length and 2 inches in diameter. A conical cavity was formed at one end of the explosive charge, into which was fitted a cone 2 inches in diameter, prepared by coating the interior of a solid steel cone of 45° angle (the wall of the steel cone being approximately .03 inch thick) with a layer of iron filings bonded together with linseed oil, constituting a coating of approximately .035 inch thickness on the metal cone. This explosive unit was likewise placed close to a test piece of the same type of armor plate as used in Example 1, the conical cavity in the explosive facing the armor plate and being spaced 1½ inches therefrom. When the explosive was fired, a hole was formed in the armor plate 1 inch deep and having a volume of 5.8 cc.

Example 3

An explosive charge was formed of the same type of explosive in the form of a cylinder of 6 inches length and 1.6 inches diameter. Into a conical cavity at one end of the charge was inserted a cone having a 45° angle, formed by bonding particles of zinc oxide with linseed oil. Again the charge was placed close to a piece of steel armor plate with the conical cavity toward the plate and spaced 1½ inches away. When the explosive was fired, a hole was formed in the armor plate 1¼ inches deep and having a volume of 5.5 cc.

The invention may be seen more clearly by reference to the accompanying drawing, in which Figure 1 is an elevation of the explosive charge on a steel plate **15** which is to receive the explosive impact, while Figure 2 is an elevation cutaway, showing the perforation in the plate as a result of the explosion.

In Figure 1, **10** represents a cast block consisting of one pound of a **50—50** blend of pentaerythritol tetranitrate and trinitrotoluene. This block is substantially in the form of a cylinder 6 inches in height and 2 inches in diameter, but at one end has a conical indentation **11**, into which fits a hollow cone **12**, fabricated of particles of metallic iron bonded together by a suitable binder. The cone may have a wall of about ⅛ inch thickness, and at its base is formed with outturned support flanges **13** in suitable number. The explosive block and inserted cone with arms **13** are spaced one and one half inches to two inches away from the test piece or target 15 of 5-inch armor plate by a support **14** of suitable material, a cardboard hollow cylinder having been used, resting on the plate **15**. A 10-gram charge **16** of compressed tetryl is inserted into the top of the cast block. An electric blasting cap **17** with leading wires **18** is introduced into the booster charge of tetryl. When the explosive is fired by means of the blasting cap, a deep perforation in the steel plate or target **15** results. Larger charges similarly proportioned or proportioned in accord with prior practice will produce correspondingly increased destructive effect.

Figure 2 shows the penetrating and perforating effect of the explosive unit described, when fired according to the arrangement of Fig. 1. The hole **19** of several inches depth and about 1 inch diameter is cut cleanly, with smooth straight sides.

With the explosive units and assemblies described in the foregoing, very striking and effective blasting effects result. Clean cut holes of perhaps 1 inch diameter and several inches deep in steel plates may be obtained, whereas the same amount of explosive by itself would

scarcely have perforated the plate but would only have marred the surface. Other tests have shown that with the same amount of explosive and with the conical cavity therein, but without the liner of my invention, the effectiveness of the blast would have been greatly inferior. Conventional solid metal liners used in the recess have resulted in only slight denting of the surface of the work or target. It will be understood that the novel assembly has paplication in the destruction and demolition of all types of structures, whether of metal, cement or other material.

In carrying out the invention in accordance with the examples cited, the main explosive charge used comprised a high density blend of pentaerythritol tetranitrate with trinitrotoluene. Various other explosives may be used, a requirement being that they be high velocity detonating explosives, at high density, and capable of attaining maximum detonating velocity very rapidly. Cast explosives and compressed explosives of the military type are well adapted to such purposes. Such explosives as trinitrotoluene, pentaerythritol tetranitrate, cyclotrimethylenetrinitramine, picric acid, tetryl, and ammonium picrate are suitable for use. Trinitrotoluene and its blends with pentaerythritol tetranitrate, cyclotrimethylenetetramine, tetryl and ethylenedinitramine are favored particularly, as they are well adapted to casting, because of the low melting point of trinitrotoluene. Preferably I use (for the main charge at least) such explosives at densities above 1.50, which will be assured wth cast explosives. The rate of propagation of the detonation approximates or exceeds 20,000 feet per second, in the mixtures named, it is understood. Commercial high velocity and high density explosives may also be used, however, for example high strength straight dynamites, high velocity ammonium nitrate explosives containing a sensitizer, and high velocity gelatin dynamites. In applying the explosive assemblies in accordance with the invention, the initiator will be inserted into the explosive at the end away from the one having the cavity, and desirably near the center at such end.

Tests and results from the practice of this invention indicated that with charges of the size set forth in reference to the tests described, the process during detonation consists of a pulverulent, if not molecular fragmentation of the target material for a distance thereinto from the face of impact, with no indication of fusing or plasticization of the metal removed. In this respect it may function as an armor piercing device corresponding to and possibly preferable to or supplementary to points heretofore used on armor piercing shells. The material removed in the use of the invention recited was not recoverable and no verification of the assumption stated has been possible otherwise than as stated. It is believed that abrasive action may be a material factor in effecting at least initiation of the fragmentation of the material at the surface of the target.

While heavy weight in the particles formed by the destruction of the lining is thought desirable and may be a contributing factor in the net destructive effect it is not an arbitrary requirement, and it has not been possible to determine this.

It has been contemplated to use a molded glass liner which will readily fracture and disperse over a somewhat reduced area of the face of the target within the area of impact of the wave produced by the explosive, and if desired such glass liner body may be treated as well known, to place it under permanent internal stresses which cause it to granulate readily.

It should be understood that the invention is not intended for use only for placed, stationary or immobile explosives, but use of the invention is contemplated in demolition, armor-piercing and other projectiles, including shells, bombs, rockets, and grenades. While small sizes of charges are referred to in the specific tests, knowledge indicates that function of larger charges applied in the utilization of the Munroe effect may be correspondingly improved.

It has also been contemplated to form a lining of particles of iron, abrasives or other material held in form by a binder or bond of a plastic, which may include explosives, for instance, a double base powder, or which may consist of trinitrotoluene. The method of combining the particles and the explosive safely may be adapted to the requirements. Thus, the double base powder may be applied as a thin liquid coating into which the particles may be afterward sifted or thrown.

After another procedure a coating of a hardener may be applied to the cone face of the cast body of explosive **10**, so that an integral shell or liner face of harder material is formed of the explosive body **10** itself, the thickness of which liner face may be determined by the quantity or viscosity of the applied binder coating material.

In the formation of the liner, wide latitude in the thickness of the facing has been found permissible. Thicknesses of as little as .036 inch have been found effective and thicknesses of one-eighth inch have also operated satisfactorily in charges of the sizes before indicated. It is believed that greater thicknesses should be used in the larger charges than in the smaller ones.

The angle of the cone faces may also be varied, angles of 30 to 45 degrees having been used and heretofore greater angles (up to 90 degrees) have been found useful especially in large charges used with my invention.

The cast blocks referred to were produced and used without encasement other than the liner element in the cavity and it is interesting to note that, as to depth of penetration, no material benefit has been obtained by fitting a case to the outer sides and outer end of the block, although the aggregate execution is much increased, resulting in a cavity of much greater area being formed in the material subjected to attack or causing other greater destructive effect, according to the amount of the principal charge.

While the specific instances of practice of the invention herein relate to the formation of apertures or holes in armor plate, this is merely taken as a convenient means of indicating comparative results following the incorporation of my invention with the material used, and the contribution of my invention to improvement of the destructive effects is proportionately manifest in conjunction with charges larger or smaller encased laterally and at the outer end and employed against masonry or other structure. Such encasement when used may conform to prior conventional practice, or any which may be devised.

It should be borne in mind that metal liners of pressed, stamped or rolled metal as heretofore known are outside the scope of this invention, as well as liners of continuous or uninterrupted metal of extremely soft or ductile metal, or of metals of such low melting point and thinness as to disintegrate by fusion, melting, or fluxing.

But while I have disclosed the invention in the best specific form known to me at this time, it will nevertheless be understood that this is purely exemplary and that modifications of structure, form, arrangement, and combination of elements including substitution of materials and equivalents, structural or otherwise, in making use of my disclosure, may be made without departing from the spirit of the invention.

Thus in Fig. 4 I have indicated the possibility of forming a moulded or otherwise produced rigid cup **20** which may consist of a mixture of a suitable matrix material and a desired proportion of an aggregate of particles of material of desired quality, as to hardness, specific gravity, abrasiveness, and the like, alternatively or in the aggregate as to these qualities, or as to other qualities, properties or characteristics. The liquified explosive may be cast and allowed to remain in this cup for use, suitable supports, booster and detonator being provided for in accordance with the earlier disclosure herein.

Fig. 5 illustrates the use of a liner **21** which may be nearly or quite hemispherical or parabolic in form, produced from materials such as indicated herein as desirable.

Figs. 6 and 7 illustrate a method of utilizing integral sheet metal of qualities heretofore employed, by a special treatment, to render it frangible, to such extent that, while remaining safely integral in production, shipment and handling prior to explosive use, it will fragmentate and be directed as will the earlier described forms herein.

This material **22** may consist of rolled and/or pressed or stamped metal, such as steel, which may or may not have special metallurgical qualities rendering it more liable to fragmentate rather than merely become distorted and remain substantially integral under detonative impact. It is, however, worked or treated, to produce a multitude of weakened lines **23** crisscrossing the material on one or both sides, so that when an explosive with such a liner is detonated, the material will separate along all the weakened lines, or along most of them, and the material of the lines will separate into a multitude of small particles corresponding to those between the lines. These lines may consist of scorings or cuttings extending part way through the thickness of the material **22** and in two or more parallel or otherwise arranged series, the lines of one series intersecting those of another series so as to form diamond-shaped, rectangular or other shapes of material between the lines.

It is intended that the term "metal derivative" as used in the claims shall include particles of metal, or particles of metallic compounds.

I claim:

1. A shaped explosive charge having an outwardly-opening cavity in one wall thereof, and a liner of solid material fitting said cavity and comprising particles of hard material and a binder disintegrable at the temperatures engendered by explosion of said charge.

2. In an explosive unit, a shaped explosive charge having a regularly shaped cavity therein and opening through one wall thereof, and a liner fitting said cavity, said liner comprising a solid homogeneous material of hard metallic particles and a binder of material disintegrating in response to detonation of said charge.

3. In an explosive device of the character described, a body of explosive having a cavity in one side and a liner in said cavity, said liner comprising an aggregate of hard particles and a binding material of low tensile strength less than that of said particles.

4. In an explosive device of the character described, a body of explosive having a cavity, and a liner for said cavity, said liner comprising a matrix of material of low tensile strength capable of maintaining rigidity at climatic temperature, and particles of harder material of greater tensile strength than said matrix material.

5. In an explosive device of the character described, a body of explosive having a cavity therein opening through one wall thereof, and a liner for said cavity, said liner consisting of a matrix of material rigid at climatic temperatures and having low tensile strength, and particles of abrasive material therein.

6. An explosive unit comprising a solid shaped explosive charge having an outwardly diverging cavity opening through one surface thereof, and a liner fitting said cavity and comprising a matrix rigid at climatic temperatures and of relatively low tensile strength, and particles of abrasive embedded in said matrix.

7. In an explosive device of the character described, a body of explosive having a cavity in one side and a liner fitting said cavity and comprising a matrix and an aggregate of abrasive particles.

8. In an explosive device of the character described, a body of explosive having a cavity in one surface, and a liner fitting said cavity, said liner comprising a matrix and an aggregate of particles of hard dense material of greater specific gravity than said matrix.

9. An explosive device comprising a high density charge of a detonating explosive with a depressed portion on one side of said charge, and a rigid structure lining said depressed portion and conforming generally to the shape thereof, said lining structure comprising particles of hard material and a bond of lower tensile strength than said particles.

10. An explosive device comprising a high density charge of a detonating explosive with a depressed portion on one side of said charge, and a rigid structure lining said depressed portion and conforming generally to the shape thereof, said lining structure comprising particles of abrasive material and a bond of lower tensile strength than said particles.

WALTER E. LAWSON.

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