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FOAMED LIQUID EXPLOSIVE COMPOSITION

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to new compositions adapted for use in a novel method of actuating land mines buried beneath the surface of the ground. More particularly the invention concerns foam producing compositions capable of being formed into a blanket of explosive foam over designated areas of terrain, as for example enemy mine fields and the like, and which may be detonated by conventional means.

In general, the prior art methods of clearing mine fields may be placed in two broad classes, namely; physical removal of the mines, and actuation of the mines. The latter class may be further divided into two categories; actuation by mechanical means such as the flail, and actuation of the mines by an explosive blast. One example of the latter category is the use of the mine clearing snake disclosed in U.S. Patent No. 2,511,005.

It is known that blast resistant mine fuzes can be actuated by less than ¼ lb. of explosive per square foot of area if the mine is directly beneath the explosive charge. Therefore, if a mine field could be blanketed with a layer of explosive material amounting to about ¼ lb. per square foot, upon detonation, all the mines within the blanketed area would be effectively actuated.

The desirability of liquid explosives for mine field clearance has been recognized. However, serious difficulties have been encountered in their use by reason of their tendency to be rapidly absorbed into the ground, thus making detonation impossible. Furthermore, attempts to spread liquid explosives over irregular ground surfaces resulted in the formation of puddles and bare spots. Obviously this type of a discontinuous explosive surface layer cannot be reliably detonated by conventional methods of initiation.

To obviate the latter difficulties, it was suggested that a gelatinizing agent be employed to form a relatively non-absorbable ground blanket. Although the use of thixotropic gelatinized liquid explosives were more successful in preventing the absorption of the explosive into the soil, the method proved unsatisfactory in that it was difficult to lay the continuous, relatively uniform blanket necessary to achieve complete detonation and activation of all the mines planted within the blanketed area. Furthermore, cracking and fissuring of the ground blanket occurred to such an extent that the material could not be completely detonated, and reliable detonation and propagation could not be achieved unless the gelled explosive layer was much thicker than was needed to produce the explosive force required to actuate the mines.

Accordingly, a primary object of this invention is the development of an efficient, easily operated method of actuating land mines planted over a relatively large area of terrain.

A further object of this invention is the development of a fluid explosive composition suitable for distribution

over all types of terrain in the form of a blanket capable of being detonated by conventional means and which is sufficiently uniform to propagate the detonation throughout the blanket mass.

A still further object of the invention is the provision of a low density explosive capable of being projected over enemy minefields as a blanket and which on detonation will actuate and destroy mines buried in the ground beneath the explosive blanket.

Accordingly, pursuant to the above objects, I have now discovered that by the use of suitable foaming and stabilizing agents, liquid explosive compositions may be whipped into explosive foams of considerably increased volume. The resulting foams may readily be distributed over wide areas of terrain of all types, thus obviating all or most of the difficulties previously encountered in the use of liquid explosives in clearing mine fields. Such an explosive foam is particularly advantageous since the presence of finely divided, uniformly distributed explosive particles in the foam act to ensure complete initiation, detonation and propagation throughout the mass of foam. The physical consistency of the foam ensures continuous coverage over uneven ground, grass, small shrubs, wire etc. and will prevent excessive loss of explosive material through absorption into the ground. Furthermore, the low density of such foamed explosives permit coverage adequate to produce the required blast effect without using an excessive weight of explosive per square foot of area.

For the purpose of this invention it is desirable to use a liquid explosive which will be stable during transportation and which may be sensitized by means of a sensitizing agent such as ethylene diamine after arrival at the area of operations. The liquid explosive must further be suitable for whipping into a relatively stable foam by conventional means. In order to be ideally suited for the intended use the cohesive and flow properties of the foam must be such that it is projectable and will satisfactorily spread over the ground in a uniform blanket; there must be sufficient expansion in volume over the initial liquid to provide economy in the use of the explosive; the foam must be sufficiently stable under various prospective conditions of combat (normal weather, hot air, rain, sandy ground, turf, etc.) to make its use practicable, and finally the foam must be detonatable at a thickness which provides a sufficiently large coverage per tank of initial liquid and still provide force sufficient to actuate all mines lying beneath the blanket.

Briefly, the explosive foam composition of this invention comprises a mixture of a suitable liquid explosive material; a foaming agent in a finely divided state, a sensitizer and where applicable a foam stabilizing agent. Such compositions when mechanically whipped will form a foam of low density which will detonate when initiated by a conventional blasting cap when spread in the form of a blanket as thin as ¼ inch.

Any liquid explosive capable of being foamed may be employed for the purposes of this invention. However, explosives such as nitromethane or nitropropane are to be preferred since they may be safely transported to the field of operations where a sensitizer may be incorporated at the time of foaming.

Mechanical foams are generally produced by mixing a foaming agent with a liquid medium, in this case the liquid explosive, and then adding a stabilizing agent which acts to prolong the life of the foam. The foaming and stabilizing agents may, in some instances, be one and the same material so that only one material need be added. A satisfactory foam cannot be produced, however, with much less than 10% of solids present. The additives necessary to obtain foaming and stabilization

should, of course, not noticeably desensitize the liquid explosive material.

Among the sensitizing agents which may be employed are ethylene diamine and morpholine (diethylenimide oxide) or a solution of these amines in an alcohol such as methanol, propanol or butanol.

Surface active agents found to be suitable for use as foaming agents in forming stable foams, with or without the additional use of stabilizers include zinc stearate, lithium stearate, magnesium stearate, sodium stearate, Acrawax C (an octadecenamide), polyethylene glycol 42, Carbowax 1000 monostearate and Carbowax 4000 monostearate (the monostearates of polyethylene glycols having molecular weights of 1000 and 4000 respectively), and polyethylene glycol 400 mono stearate, either alone or in conjunction with stearic acid in a 1:1 weight ratio.

The invention can best be understood from the following specific examples, which, however, are not to be taken as limiting the scope of the invention but are cited as being among the preferred embodiments thereof.

TABLE NO. 1

Composition (parts by wt.)	Example No.					
	1	2	3	4	5	6
Nitromethane	92	----	90	----	90	----
Nitromethane-nitropropane [1]	----	92	----	90	----	90
Magnesium stearate	8	8	----	----	----	----
Lithium stearate	----	----	10	10	----	----
Zinc stearate	----	----	----	----	10	10
Sensitizer:						
Ethylene diamine	x	----	x	----	x	----
Ethylene diamine-alcohol [2]	----	x	----	x	----	x

[1] 85 parts nitromethane—15 parts nitropropane.
[2] 3 parts ethylene diamine—1 part ethyl, methyl or propyl alcohol.

The above explosive compositions are intended to be handled as two component mixtures. In practice from 5% to 15% of the sensitizing solution is mixed with the main composition just prior to use. By following this procedure the solutions can be handled as insensitive, inflammable but non-explosive materials.

The gas-retaining capacity of the liquid explosive composition is an important factor in increasing the foam volume of systems such as given in Table 1. As the result of a study of the effect of the addition of various solvents to the nitromethane composition, it was found that the gas retaining capacity of nitromethane may be noticeably increased by the addition of methanol, isopropanol or dibutyl tin diacetate. Of particular interest was the use of isopropyl alcohol in conjunction with the solid stabilizer lithium stearate.

The effect on foam volume and stability of variations in the amount and type of stabilizing, foaming and sensitizing agents is shown in the following table:

TABLE NO. 2

Example No.	Nitromethane, cc.	Isopropanol, cc.	Anhydrous Ethylene Diamine, cc.	Lithium Stearate, gm.	Foam Volume, cc.	Volume Drainage 2 Min., cc.	Percent Drainage
7	300	----	30	15	550	208	63
8	270	30	30	15	550	200	60.6
9	240	60	30	15	580	198	60
10	210	90	30	15	590	200	60.6
11	300	----	30	22.5	600	160	48.5
12	300	----	15	22.5	550	165	52.4
13	300	----	15	30	600	125	39.7
14	300	----	30	30	650	93	28.2
15	270	30	30	30	670	92	27.9
16	240	60	30	30	690	80	24.2
17	210	90	30	30	700	78	23.6
18	210	90 (Isobutanol)	30	30	700	80	24.2
19	210	90 (Ethanol)	30	30	670	90	27.3

In each of the compositions shown in Table No. 2, the liquid mixture was mixed with a perforated wooden paddle for four minutes, after which the volume increase was noted. The drainage was measured by pouring the foam onto a 325 mesh screen 5 inches in diameter and 1½ inches deep. The screen was placed over a large funnel which drained into a graduated cylinder. From the above table, it will be noted that at 10% concentration ethylene diamine contributes to the volume and stability of nitromethane foam systems containing lithium stearate; volume and stability of the foam also increases as the concentration of lithium stearate increases. Dilution of the nitromethane with isopropyl alcohol increases the foam volume but improved stability is obtained only at the higher lithium stearate levels.

Further preferred embodiments of this invention are illustrated by the following examples:

Example 20

Nitromethane	cc.	210
Isopropanol	cc.	90
Ethylene diamine	cc.	15
Lithium stearate	grams	30

When foamed, the above mixture had a volume of 640 cc. The drainage from the foamed mass was as follows:

	Cc.
½ min.	6
1 min.	10
2 min.	20
3 min.	30
4 min.	42
5 min.	52

Example 21

Nitromethane	cc.	210
Isopropanol	cc.	90
Lithium stearate	grams	30

This formulation contains approximately 9% solids and 36% of total inert material. When mechanically stirred at 1400 r.p.m. for two minutes the composition had a foamed volume of 620 cc. The volume of liquid drained from the foamed mass was as follows:

Time (seconds):	Volume (cc.)
30	3
60	6
120	12

Example 22

The composition of this example is the same as that given as Example 21 except that 21 cc. of commercial ethylene diamine (68% in water) was added before the lithium stearate was added. The initial volume was 320 cc. and the foamed volume was 650 cc. The liquid drainage from the foamed mass was as follows:

Time (seconds):	Volume (cc.)
30	3
60	7
90	12
120	17

Example 23

	Percent
Nitromethane	87.4
Magnesium stearate	7.6
Ethylene diamine	5.0

Example 24

Nitromethane	74.3
Nitropropane	13.1
Magnesium stearate	7.6
Ethylene diamine	3.75
Ethyl alcohol	1.25

Example 25

Nitromethane	78.2
Nitropropane	13.8
Magnesium stearate	7.9
Silicon dioxide	0.1

Each of the above examples of foamable explosive compositions were found suitable for use in accomplishing the objects of this invention. All of these compositions exhibited an increase of at least 100% in volume on being foamed. Each of the foamed compositions could be projected and formed into a continuous relatively uniform blanket effectively covering any designated area of terrain and which could be detonated regularly when the blanket was as thin as ¼ inch.

Detonation tests were performed on porous sand so that any liquid which drained away from the foam would be removed and could not aid in transmitting the detonation. In forming the explosive blanket the foam was projected through a nozzle which has two venturi tubes, one of which meters the solution containing the foaming and stabilizing agents while the other meters the amount of air which is introduced into the mixture.

Where desired suitable identification means may be incorporated in the foamed explosive for the purpose of defining the area of terrain cleared of mines, particularly where such area is in the form of a tortuous path. Also, the presence of identification means would act to alert troops arriving at the area of operations at a later hour, of the fact that said area had been cleared. For this purpose any dye, particularly of the fluorescent type, light reflecting particles of the type used on highway signs, or any other coloring, light emitting or light reflecting material which would not be destroyed by the detonation may be incorporated in the foamed explosive.

While the instant invention has been shown and described herein in what are conceived to be the most practical and preferred embodiments, it is to be recognized that departures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalents.

What is claimed and desired to be secured by United States Letters Patent is:

1. A foamable liquid explosive composition consisting esentially of a liquid nitroparaffin hydrocarbon, of from about 7.6 to 10 percent by weight of a metal stearate selected from the group consisting of magnesium, lithium, zinc and sodium stearates, and of from about 5 to 15 percent by weight of a sensitizing agent selected from the group consisting of ethylene diamine and morpholine.

2. The composition according to claim 1 wherein said composition contains a stabilizing agent selected from the group consisting of methanol, ethanol, isopropanol, isobutanol, dibutyl tin diacetate and silicon dioxide.

3. The composition according to claim 1 wherein the sensitizing agent is in solution in a lower aliphatic alcohol.

4. A foamable liquid explosive composition consisting essentially of a liquid nitroparaffin selected from the group consisting of nitromethane, nitropropane and mixture thereof, of from about 7.6 to 10 percent by weight of a metal stearate selected from the group consisting of magnesium, lithium, zinc and sodium stearates, and of from about 5 to 15 percent by weight of a sensitizing agent selected from the group consisting of ethylene diamine and morpholine.

5. A composition according to claim 4 which contains a stabilizing agent selected from the group consisting of lower aliphatic alcohols, dibutyl tin acetate and silicon dioxide.

6. The composition according to claim 4 wherein the metal stearate is lithium stearate.

7. The composition according to claim 5 wherein the stabilizing agent is isopropyl alcohol.

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