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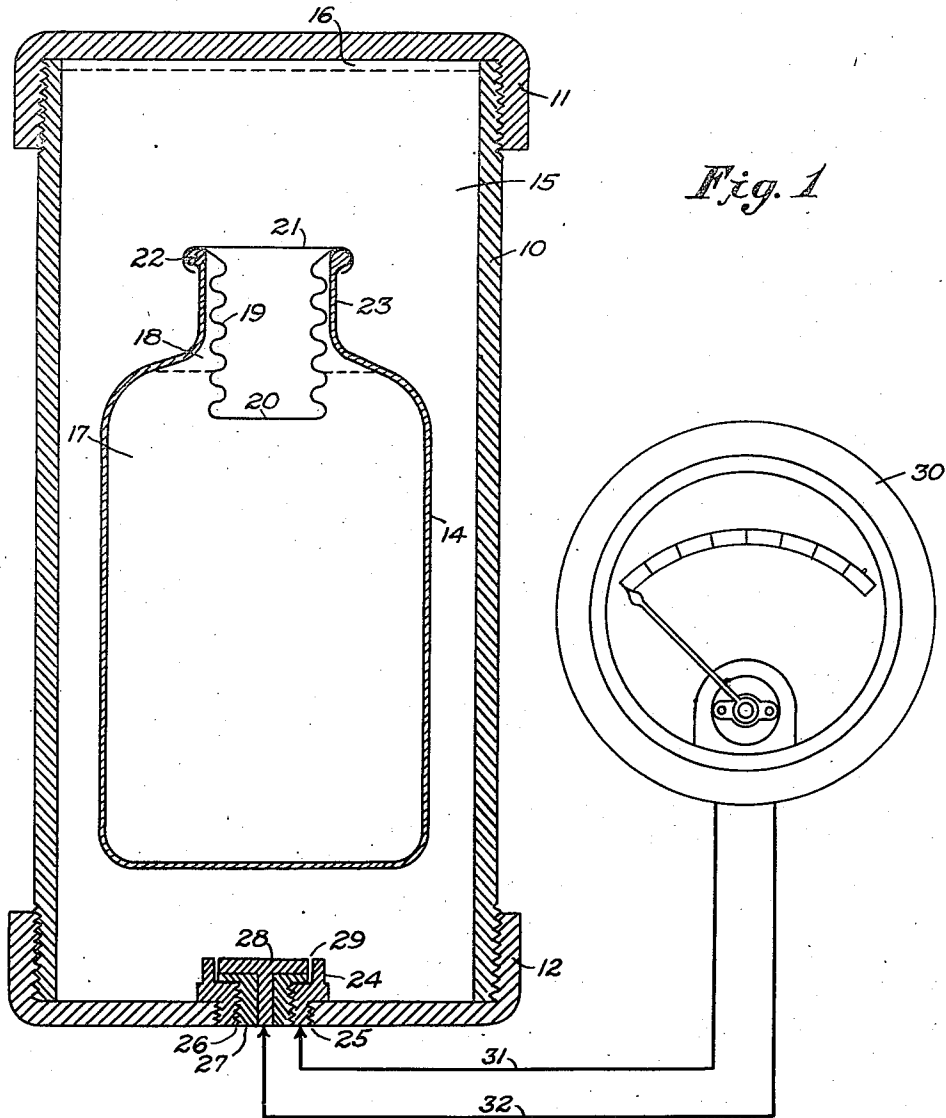
N. M. HOPKINS

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NONLEAK LIQUID EXPLOSIVE FILLER SYSTEM FOR AMMUNITION

Filed July 31, 1942

2 Sheets-Sheet 1



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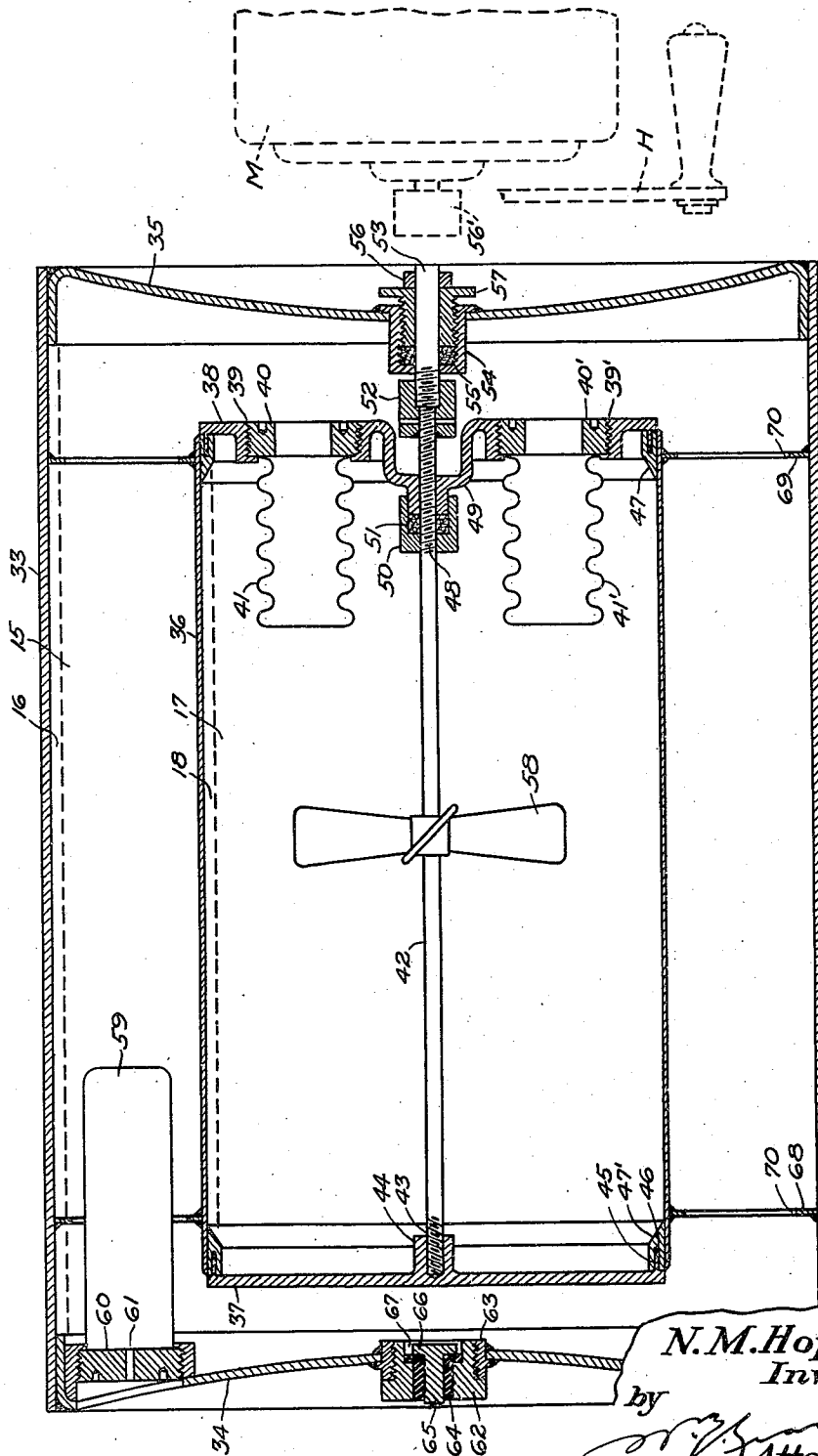
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UNITED STATES PATENT OFFICE

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NONLEAK LIQUID EXPLOSIVE FILLER
SYSTEM FOR AMMUNITION

Nevil Monroe Hopkins, New York, N. Y., Raymonde B. Hopkins, executrix of said Nevil Monroe Hopkins, deceased, assignor, by mesne assignments, to Raymonde Briggs Hopkins, Samuel Lloyd, and Murray T. Quigg, as trustees

Application July 31, 1942, Serial No. 453,084

5 Claims. (Cl. 102—57)

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This invention pertains to improvements in methods and ways of, as well as means for safely and securely using liquid component parts of a liquid explosive and/or combustible in mines, missiles, and certain other devices.

It is a particular object of this invention not only to meet the ever present objections of ordnance service men against the possible dangers incident to internal leakage of structures for missiles fashioned to keep separated, until the time of use, the liquid component parts of a liquid high combustible mixture, but to produce a far safer missile than one containing tri-nitrotoluene, or other solid explosive.

It is also a particular object of this invention to produce, through the new teachings herein set forth, not only a far safer missile with a liquid explosive filler than is possible with the present solid explosives, but to produce a more powerful explosive for the missile.

It is also a particular object of this invention therefore to provide new methods and ways of, as well as means for, safely and surely using liquid nitrogen tetra-oxide and one or more liquid hydrocarbons in mines, missiles and certain other devices, in a bi-compartment structure, and to prevent their admixture through internal leakage of a part or member of said bi-compartment structure on heating said mines, missiles and other devices.

It is also a particular object of this invention to provide methods and ways of, as well as means for safely and surely using liquid nitrogen tetra-oxide and one or more liquid hydrocarbons in mines, missiles and certain other devices in a bi-compartment structure, and to prevent their admixture through internal leakage of any part of said bi-compartment structure as the result of rough handling, mechanically speaking.

It is also a particular object of this invention to provide methods and ways of, as well as means for safely keeping the liquid component parts of a liquid combustible separated under conditions of extremely hot weather, and extreme rough handling, but to surely bring them together and mix them thoroughly at the desired time for use.

It is also an important object of this invention to not only provide for the safe and sure usage of liquid nitrogen tetra-oxide and a liquid combustible substance in mines, missiles and certain other devices in a bi-compartment structure and to prevent their admixture through internal leakage of any part of said bi-compartment structure on heating, or/and rough mechanical

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treatment, but to provide methods and ways of, as well as means for, quickly demonstrating at any time, without opening the outer casing of the mine or missile or other device, that the bi-compartment structure, or any part of it, has not leaked internally.

It is also an object of this invention to not only produce a far safer missile, one that will withstand the detonation of an enemy shell in contact therewith without exploding it, but a missile which is lighter in weight than a tri-nitrotoluene missile of equal size for example, an important factor in the use of aerial bombs where bomb loads are carefully reckoned with; this because the mixed liquid explosive of this invention only weighs about 75 pounds per cubic foot, as against the weight of 102 pounds per cubic foot for cast trinitrotoluene.

With the foregoing objects in view, as well as certain other objects which will become apparent as the description proceeds and the drawings are studied, this invention resides in the novel and useful applications of scientific principles and parts with reference to the use of liquid component parts of a liquid high combustible and/or explosive, all as hereinafter set forth, and particularly covered by the claims.

This invention relates to an improvement over my earlier development work in the arts of military and naval mines, missiles and certain other devices with explosives and/or ignitable fillers therefor, as set forth and exemplified in my previously filed and copending applications for Letters Patent of the United States as follows: Missiles, Serial No. 217,900, filed July 7, 1938; High explosive device, Serial No. 217,901, filed July 7, 1938; Penetration liquid explosive missiles, Serial No. 268,487, filed April 18, 1939; Liquid explosives, Serial No. 272,434, filed May 8, 1939, now Patent 2,298,255; Torpedoes, Serial No. 427,406, filed Jan. 20, 1942; Explosive devices for war, naval and industrial purposes, Serial No. 433,816, filed March 7, 1942; Explosive device, Serial No. 433,989, filed March 9, 1942; Container for liquid mixtures and method of filling the same, Serial No. 433,983, filed March 9, 1942; Aerial bombs, Serial No. 437,702, filed April 4, 1942; Dual purpose aerial bomb, Serial No. 477,570, filed June 18, 1942.

Referring to the accompanying illustrations forming a part of this specification, in which like numerals designate like parts in all the views,

Fig. 1 is a diagrammatic showing, partly in section, illustrative of the scientific principles

and parts common to all of applicant's new filler systems for all of his mines, missiles and other devices; and

Fig. 2 is a view, principally in longitudinal section of one of applicant's new missiles, a naval depth charge for example.

With particular reference to Fig. 1, the numeral 10 indicates a short section of heavy iron pipe threaded at both ends and hermetically closed by heavy threaded cap members 11 and 12. Metal gaskets may be used, as well as a sealing compound in the threads. This stout hermetically closed structure represents, for example, the stout outer casing of an aeroplane drop-bomb, the casing of an artillery shell, torpedo war-head, mine, or naval depth-charge, and is designed for the reception of one of applicant's inner chambers and high combustible and/or explosive filler systems. This particular structure has been chosen for Fig. 1 not only because it represents the principles applied and common to all of the various mines and missiles which applicant has designed, but because actual experimental demonstration work has been completed with it.

The inner chamber 14 shown is a tin can or glass bottle, both having been used successfully in the experimental test work presently described. This inner chamber, which let us say is of glass, represents the inner chamber of an artillery shell, the inner chamber of a torpedo war-head, aerial drop bomb, or naval depth-charge for example, and said chamber is preferably positioned within the outer casing to provide a space between the cylindrical walls of said chamber and said casing. Within this space, and therefore substantially surrounding said chamber, is placed one of the liquid component parts 15 of a liquid high explosive, benzol, mono-nitro-benzol, kerosene or fuel oil for example, or certain mixtures of such substances, with a small space 16 left unfilled for gas or vapor between the level of the liquid component part and the under side of the heavy cap member 11. The cubic contents of this gas or vapor space 16, is of scientific importance for at least two reasons, as will be pointed out later.

The inner chamber is substantially filled with another of the liquid component parts 17 of the liquid high explosive, liquid nitrogen tetra-oxide for example, there being left unfilled a small space 18 for gas or vapor. The inner chamber is preferably bottle-shaped or reduced in diameter at its upper extremity and closed by a metal cup-shaped bellows 19 extending downwardly into the chamber and having a bottom wall 20 but an outwardly extending flanged upper edge portion 21 which is spun or forced over the beading 22 of the glass bottle neck 23, "crown-cap" fashion as shown, thereby hermetically sealing the bottle. Thus it will be understood that the one liquid component part 15 enters and fills the cavity of the bellows 19, and that the other liquid component part 17 and its vapor completely surround the outer or convex surface of the bellows; in other words the bellows constitutes a separating wall between the two liquids.

The cubic volume of the gas or vapor space 18 is also of scientific importance for at least two reasons, as will be pointed out later, in connection with the gas or vapor space 16 of the outer casing. The glass bottle and its contained liquid nitrogen tetra-oxide, was held positioned substantially as shown submerged in the liquid 15, by cork rings and cork wedges (not shown).

It is pointed out here that whereas the specific gravity or density of the liquid nitrogen tetra-

oxide component 17 is greater than the specific gravity or density of the liquid hydrocarbon (or liquid hydrocarbon mixture) component 15, the latter has a higher hydrostatic head, which is not only true here but in all of the practical missiles fitted with this filler system.

Preferably disposed in the center of the lower cap member 12, is the annular iron ferrule 24 secured in place as by the threaded engagement shown at 25, said ferrule internally supporting as by the threads 26 an insulating bushing 27 (of Bakelite for example), and said bushing carrying a plug member 28 of copper or zinc, for example. This metal plug may be forced, or screwed into (threads not shown), the insulating bushing, leaving an annular space 29, between the head of the zinc plug 28 and the iron ferrule 24. The joints between the members 12, 24, 27 and 28 are of course made liquid-tight. A suitable electrical indicator 30 of electrical potential or current, such as a milli-voltmeter or a milli-ampere-meter, is shown with its quickly attachable wire connectors 31 and 32 engaged with iron ferrule 24 and the zinc plug 28, respectively. The purpose of this construction will be described hereinafter.

Liquid nitrogen tetra-oxide does not attack iron, steel or aluminum, even with the addition of a small quantity of water thereto, but it has a vapor pressure of about 15 pounds to the square inch at a temperature of 70° F., and an ascending vapor pressure with ascending temperature according to the following table which has been taken from international critical tables.

Temperature, degrees F.	Pressure (in atmospheres)	Vapor pressure, lbs. per sq. inch
70.....	1.00	15
86.....	1.48	22.20
104.....	2.28	35.00
122.....	3.42	52.00
140.....	5.03	75.45
158.....	7.26	108.90
176.....	10.30	154.50
194.....	14.46	216.00
212.....	26.80	402.00

The liquid hydrocarbon (or liquid hydrocarbon mixtures) proposed to be used as a component part of the liquid explosive, would have very much lower vapor pressure at all of the listed temperatures, and especially at the higher ones, the boiling point of water, for example.

For any temperature between 70 and 140 degrees F. applicant may add, according to his earlier teachings in this art, some normal or iso-butane to the liquid hydrocarbon (or mixture of hydrocarbons) 15 in his outer casing and, because normal or iso-butane have comparatively much lower boiling points and consequently much higher vapor pressures than the proposed liquid combustibles 15, thereby balance the vapor pressures, and consequently the hydrostatic pressures, of both of the liquid component parts of his liquid explosive. The hydrostatic balance may be adjusted with the requisite amount of butane, to be perfect at any one of these lower temperatures, and thereby establish a virtually leakproof system for the bi-compartment missile.

It is the fear of internal leakage that has delayed the favorable consideration of the proposed new missiles by the Army and the Navy, and in this connection applicant was recently informed that a temperature test of 212° F. would be applied to all of his missiles containing the proposed component parts of the liquid explosive. With a perfect hydrostatic balance between the

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component liquid parts of the explosive, through the agency of normal or iso-butane at 70° F. it would not be possible to secure the desired balance at 212° because the vapor pressures of the two component parts of the liquid explosive would not follow the same pressure curves.

By substituting the metal bellows 19, however, for the normal or iso-butane according to applicant's earlier teaching in this art, it is not only possible to balance the hydrostatic pressures perfectly at any one of the lower temperatures enumerated, but at all of them on up to the higher ones, including the boiling point of water. By adjusting the cubic contents of the gas or vapor space 16 to be equal to the gas or vapor space 18, there would not even be movement of the bottom wall 20 of the metal bellows, in the maintaining of perfect hydrostatic balance. Of course with slight difference between the cubic contents of the two respective gas or vapor spaces, there would be slight compensating movement of the bottom wall 20 of the metal bellows, this being in accordance with Boyle's law as applied to gases and vapors. Such a system as illustrated and described, therefore, could meet any Army or Navy tests up to and including 212° F.

At higher temperatures, the limit would only be reached when the vapor pressure, and consequently the hydrostatic pressure of the liquid nitrogen tetra-oxide exceeded the tensile strength of the heavy outer steel casing or shell of the bomb, artillery shell, or depth-charge, or its burst-pressure per square inch. Such casings test up to and over 1000 pounds to the square inch, wherefore it becomes evident that a heating test may be applied to the new munitions at a temperature well above 212° F. at which temperatures the liquid nitrogen tetra-oxide develops a vapor pressure, and consequently a hydrostatic pressure, of 400 pounds to the square inch, giving us a factor of safety of over 600 pounds to the square inch. Now, by adjusting the gas or vapor volume 16 to be equal to the gas or vapor volume 18, there will be no movement of the metal bellows with change of temperature. Whereas properly designed and constructed metal bellows will withstand practically unlimited movement within the elastic limits of the corrugated metal from which it is made, applicant wishes to make the point in his new ammunition that, in prolonged storage with alternations of temperature, the metal bellows will have practically unlimited life. Applicant has repeatedly immersed such a system in boiling water without causing leakage of the bellows closure, or the breaking of the glass bottle.

Furthermore, applicant has repeatedly dropped such a system through a distance of 20 feet upon a flag-stone anvil, three feet square by four inches thick, without causing leakage of the bellows closure, or breaking of the glass bottle, the latter safety being due in part to the fact that the hydrostatic head of the fluid 15 is higher than the hydrostatic head of the fluid 17, which is the case in all of applicant's filler systems for artillery shells, bombs, depth-charges and the like. Applicant may now not only meet the specifications of the services, but also meet a test to which they would not dare submit a bomb, artillery shell or depth-charge containing tri-nitrotoluene, amatol or the like.

Applicant will now describe the action of the galvanic plug 28 which, as stated, may be of zinc or copper, for example, and whereas copper is further removed from iron on the negative and

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positive electrolytic scale, zinc answers very well for the galvanic metal of the plug.

In the remote case of leakage of the liquid nitrogen tetra-oxide from the inner chamber 14 to the space encompassed by the walls of the outer casing 10, due to leakage of the iron caps 11 and/or 12 which is the only failure which could induce leakage, some liquid nitrogen tetra-oxide 17 would diffuse throughout the fluid hydrocarbon (or hydrocarbons) 15, and if there was some moisture present therein, either inherent with the product or added to the product in the assembly control, the liquid nitrogen tetra-oxide would quickly combine with the water to form nitric acid. Any nitric acid formed by the combination of liquid nitrogen tetra-oxide and a limited quantity of water, is necessarily very concentrated nitric acid, which does not attack iron, steel or aluminum but does attack copper and zinc.

Upon the diffusion of the nitric acid formed throughout the fluid 15, the zinc plug 28 is energetically attacked by it and myriads of minute gas bubbles are generated in the annular space 29, as well as an electrical potential established between the zinc plug and the iron ferrule 24, and the resultant electrical current puts the pointer of a milli-ampere meter, with a scale reading 0 to 1 milli-ampere, completely off the scale. Thus applicant is not only able to produce ammunition which can stand high temperature and rough handling tests, far beyond the capabilities of the present ammunition, but provides new methods and ways of, and means for, inspection without opening the outer casing. It is contended that this component part liquid ammunition is now the safest of all, to make, store, transport and use in battle. In fact dynamite cartridges may be detonated in contact with any of applicant's missiles without inducing explosive response in his missiles.

In Fig. 2 there is illustrated one design of one of applicant's new naval depth-charges, where 33 is the outer steel casing with the welded-in fixed closure members 34 and 35, and 36 is the inner chamber of smaller diameter and having the movable end closure members 37 and 38. The space between the inner chamber and said casing is substantially filled with one of the component parts 15 of a liquid high explosive, benzol, mono-nitrobenzene, gasoline, kerosene or fuel oil, or a certain mixture of such fluids, but a small space 16 is left unfilled for vapor or gas, this small space being carefully allowed for, quantitatively, as previously set forth. In this illustration 17 represents another of the liquid component parts of a liquid explosive, liquid nitrogen tetra-oxide for example, which nearly fills the inner chamber 36 leaving a small space 18 for vapor or gas also carefully and quantitatively allowed for as previously set forth.

In certain designs of my new depth-charges, I may elect to reverse the order of the component parts of the liquid explosive, placing the fluid hydrocarbon, or fluid hydrocarbon mixtures, within the inner chamber 36, and the liquid nitrogen tetra-oxide in the space surrounding said chamber. The reversal is for reasons of handling the respective volumes of the respective component parts of the liquid explosive more advantageously, especially when it is desired to keep them completely apart, and in the ratio of substantially two parts by volume of the liquid nitrogen tetra-oxide to one part by volume of the combustible fluid.

The movable end closure member 33 is flanged as shown to make a liquid and gas tight closure with the annular groove in the ring member 47 welded to the inside of the chamber 36, and graphited asbestos cord may serve there as a gasket. The closure member 33 is furthermore equipped with shouldered openings 39, 39' threaded to receive the threaded closure rings 40, 40' the shoulders and rings being fashioned to securely clamp therebetween flanges on the metal bellows 41, 41', with a gas and liquid-tight union, and thereby effect yieldable closures for the inner chamber 36. As in Fig. 1, these metal bellows are open at one end to receive fluid from the outer chamber, but closed at the opposite end which is immersed in the fluid 17 in the inner chamber. After the end closure members 37 and 38 are drawn into their closed positions as shown, it is through one of these shouldered openings 39, 39' that the refrigerated liquid nitrogen tetra-oxide is poured into the previously chilled inner chamber 36, and of course before the insertion of the flanged metal bellows and the application of the threaded clamping rings 40 and 40'.

The centrally disposed steel shaft 42 is threaded at 43 with a left hand thread, which enters the similarly threaded boss 44 on the movable closure member 37 which, as shown, is equipped with a flange 45 fashioned to enter the annular groove 46 in the ring member 47' which has been welded to the inside of the casing 36. Graphited asbestos cord packing is used to excellent advantage in the annular groove to insure the desired gas and liquid-tight fit.

The shaft 42 is threaded at 48 with a right hand thread which engages a similar thread in the boss 49 and in the stuffing box member 50, which stuffing box member provides space for the packing 51 which may be graphited asbestos cord. The right hand thread 48 continues and enters the heavy similarly threaded collar 52 and is pinned and/or welded thereto as shown. This heavy collar may be square or hexagon shaped externally for engagement with a similarly shaped recess in the shank of a wrench by means of which the shaft 42 may be turned in order to draw the end closure members 37 and 38 toward each other into the grooves of their respective seating rings 47' and 47, thus tightly closing the inner chamber 36. The heavy collar member 52 is additionally threaded with a right hand thread for the reception of a similarly threaded and comparatively short steel shaft 53 (of larger diameter than the shaft 42) which passes through the stuffing box 54, with its graphited asbestos packing 55, and the stuffing box screw plug 57. On the end of the shaft 53 is welded a member 56, which may be square or hexagon for the reception of the square or hexagon recess of the member 56' which may be the extension shaft of an electric motor M for example shown in dotted lines, or the extension shaft of a compressed air motor or the end of a hand crank H also shown in dotted lines. The welded on member 56 may be the carrier of the hub of a heavy fly wheel driven through one or more reduction gears (not shown) for the storage of applied power.

At the approximate center of the shaft 42 is the keyed-on impeller 58, fashioned to circulate and mix the liquid nitrogen tetra-oxide 17 with the combustible fluid 15 after the movable end members 37 and 38 have been screwed in directions away from each other and out of their closure positions. The application of a heavy fly-wheel, mounted upon the member 56 and con-

tained largely within the "dish" of the welded-in end member 35, may or may not be used to continue the revolving of the shaft 42 and impeller 58 after the release or projection of the depth-charge. The geared fly wheel may have gear teeth cut on its periphery for the easy engagement and disengagement of a driving gear upon the projecting engine or catapulting device. Depth-charges are either rolled off a platform at the stern of a fast vessel, or are thrown from the stern, or from the sides of such a vessel by a catapulting engine or device. Either in the process of rolling the depth-charge off of a specially designed platform, and during the time required therefor, or in projecting the depth-charge from a specially designed, or modified engine or catapult, the shaft of my new depth-charge may be rapidly revolved. This may be accomplished through the agency of a rotating shaft with clutch mechanism, constructed to have in addition to rotation, a lateral movement. The time required for opening the inner casing, by pushing off the end closure member 37, and drawing off the end closure member 38, by the left hand and right hand threads respectively, and the suitably prolonged rotation of the impeller 58 for proper mixing, is of the order of 15 seconds.

At 59 is indicated the casing of a standard depth-charge firing device, held in hermetical position with regard to the welded in end member 34 by the screw member 60 in suitable fitting, with an opening 61 leading to a diaphragm or metal bellows (not shown) and such other mechanism as approved. 62 is the iron ferrule of one of my electrolytic indicators, screwed into the welded in receptacle 63, and 64 is electrical insulation, 65 the galvanic plug having an enlarged head 66, and 67 is the important annular spacing between the iron ferrule 62 and the zinc plug 65. 68 and 69 are suitable spacing rings for supporting the inner chamber 36 in the casing 33, each ring being provided with apertures such as 70 to permit the circulation and admixture of the explosive ingredients after opening of the inner chamber.

Such a depth charge as described, when containing a mixture of substantially two parts of liquid nitrogen tetra-oxide to one part of benzol by volume, will excell the power of a depth-charge of the same dimensions filled with trinitrotoluene, by at least forty percent. It will, in addition, be safe to carry in battle, whereas the depth-charge filled with tri-nitrotoluene is dangerous to carry in battle. Recent disasters to destroyers have been the result of direct hits upon tri-nitrotoluene-loaded depth-charges, and more are likely to take place. With the new ammunition of this invention, such accidents are not possible, and moreover many enemy submarines which now resist hydraulic blows of tri-nitrotoluene depth-charges would be destroyed when subjected under like distances and depths to this new missile.

From the foregoing it will be understood that this invention in its broadest aspect covers the provision of two liquid ingredients which, when united, form a combustible or explosive mixture, the two ingredients being normally in separate compartments and having different vapor pressures, there being provided a yieldable wall section separating the compartments so as to equalize the vapor pressures of the ingredients, together with means for opening at least one of the compartments and bringing about the admix-

ture of the ingredients, and means for causing combustion or explosion of the mixture. The matter of the specific liquid ingredients, the details of the yieldable wall section, the means for and method of bringing about the admixture, chemical and/or physical union, of the ingredients, and the means for and method of bringing about the combustion, explosion, detonation, ignition, firing, etc. of the admixed ingredients, are each and all of secondary or minor importance; the foregoing description being by way of exemplification only of the invention, and not as limitations thereof.

It is obvious that those skilled in the various arts involved as herein set forth may vary the details of construction and arrangements of parts, as well as the methods, ways and means of the applicant which enable him to produce this superior device, without departing from the spirit of this invention, and therefore it is not desired to be limited to the exact foregoing disclosures except as may be required by the claims.

What is claimed is:

1. An explosive filler system for a unit of ammunition, comprising a bi-compartment receptacle, a liquid combustible fluid in one of the compartments, a vapor space between the said liquid combustible fluid and a wall of its compartment, liquid nitrogen tetra-oxide in the other compartment, a vapor space between the said liquid nitrogen tetra-oxide and a wall of its compartment, the one vapor space being equal to the other vapor space, said receptacle comprising a yieldable wall section disposed between the two compartments to transmit the hydrostatic pressure of the liquid nitrogen tetra-oxide to the liquid combustible fluid, means to open one of the compartments and to bring about the admixture of the liquid combustible fluid and the liquid nitrogen tetra-oxide, and means to detonate the mixture.

2. An explosive filler system for a unit of ammunition, comprising a casing, a container within

said casing, a liquid combustible fluid within said casing and substantially surrounding said container, liquid nitrogen tetra-oxide in said container, an expansible diaphragm separating the liquid nitrogen tetra-oxide from the liquid combustible fluid, means to open said container and to bring about the admixture of the two liquids, and means to detonate the admixture.

3. An explosive filler system for a unit of ammunition, comprising a casing, a container within said casing, a liquid explosive ingredient having a certain vapor pressure within said casing and substantially surrounding said container, a second liquid explosive ingredient having a different vapor pressure in said container, an expansible diaphragm separating the two liquid ingredients to equalize their vapor pressures, means to open said container and to bring about the admixture of the two ingredients, and means to detonate the mixture.

4. An explosive filler system for a unit of ammunition, comprising a casing, a container within said casing, a liquid explosive ingredient having a certain vapor pressure within said casing and substantially surrounding said container, a second liquid explosive ingredient having a different vapor pressure in said container, an expansible diaphragm comprising a metallic bellows separating the two liquid ingredients to equalize their vapor pressures, means to open said container and to bring about the admixture of the two ingredients, and means to detonate the admixture.

5. A filler system for a unit of ammunition, comprising a casing, a container within said casing, a liquid ingredient within said casing and substantially surrounding said container, a second liquid ingredient in said container, an expansible diaphragm separating the two liquid ingredients, means to open said container and to bring about the admixture of the two liquids, and means to fire the admixture.

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