June 25, 1946. N. M. HOPKINS 2,402,552

EXPLOSIVE DEVICE

Filed March 7, 1942 3 Sheets-Sheet 1

Fig. 1

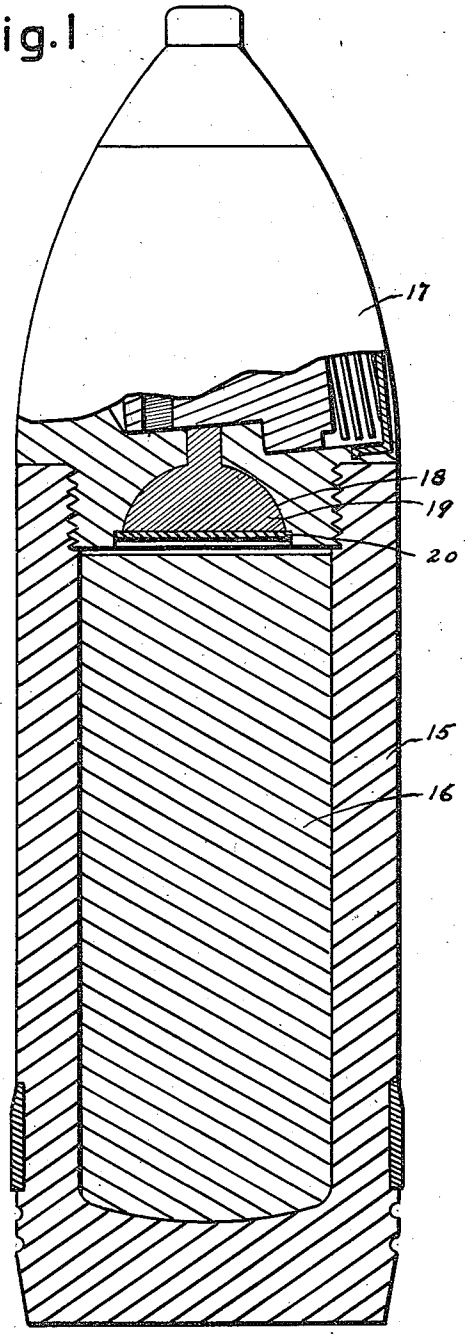
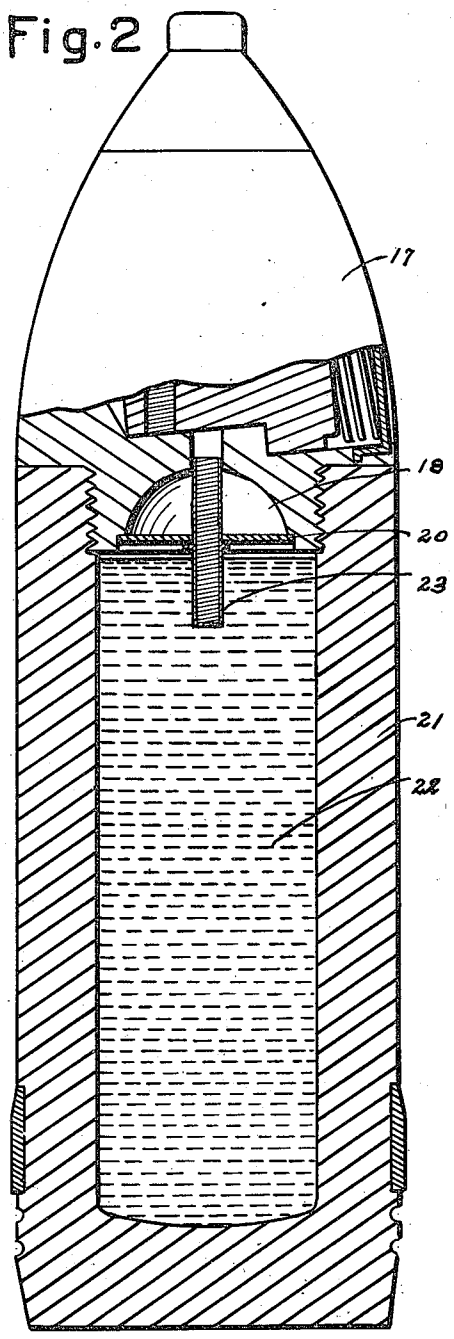


Fig. 2



INVENTOR

Newell Monroe Hopkins

June 25, 1946. N. M. HOPKINS 2,402,552

EXPLOSIVE DEVICE

Filed March 7, 1942 3 Sheets-Sheet 2

Fig.3

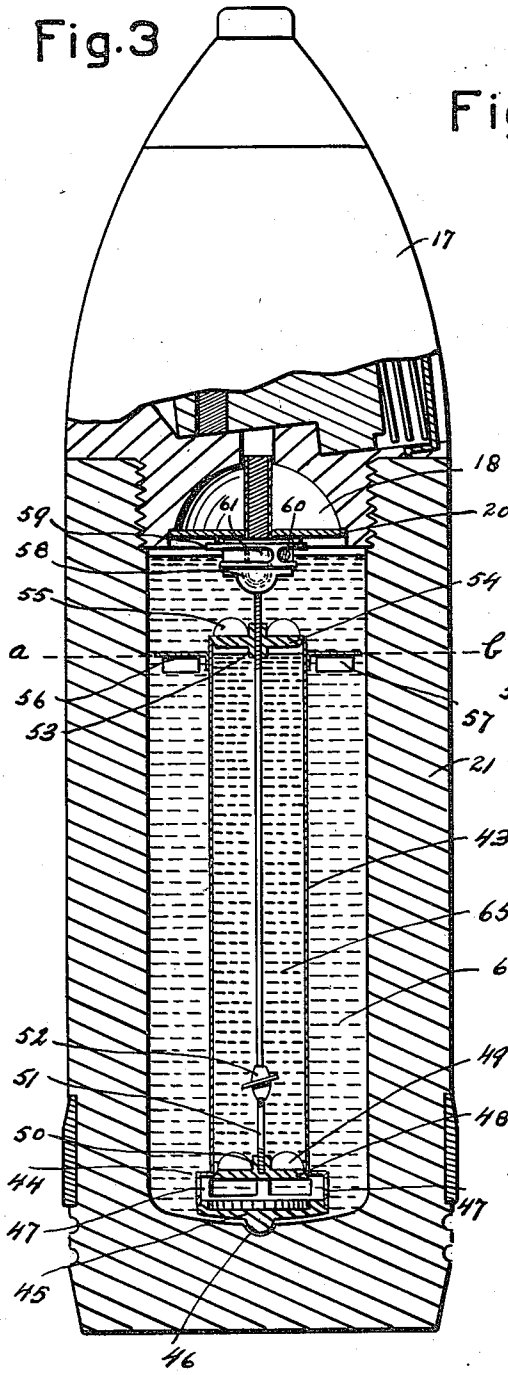
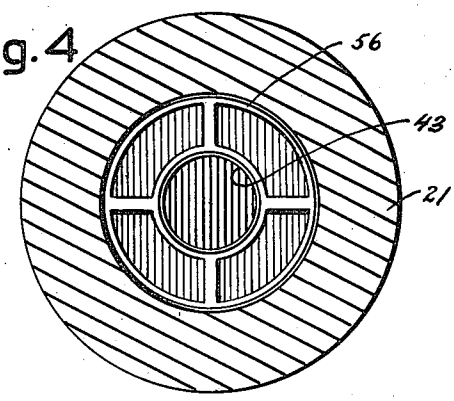


Fig.4



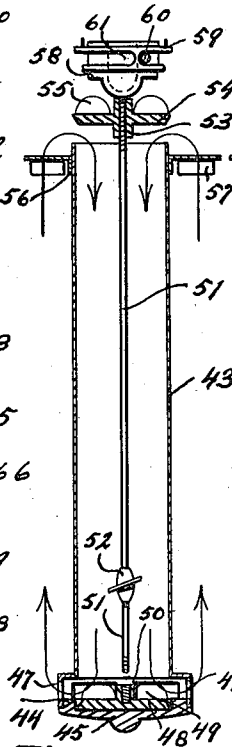


Fig.5

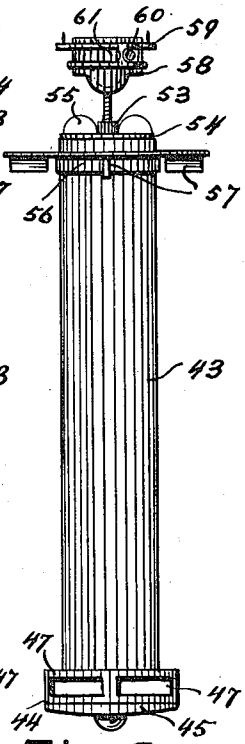


Fig.6

INVENTOR



June 25, 1946. N. M. HOPKINS 2,402,552

EXPLOSIVE DEVICE

Filed March 7, 1942 3 Sheets-Sheet 3

Fig. 7

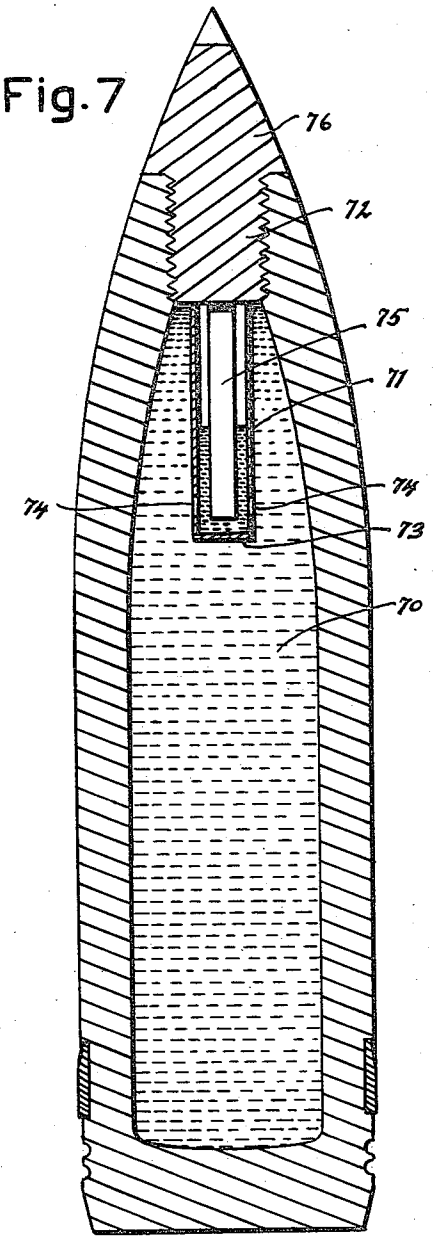
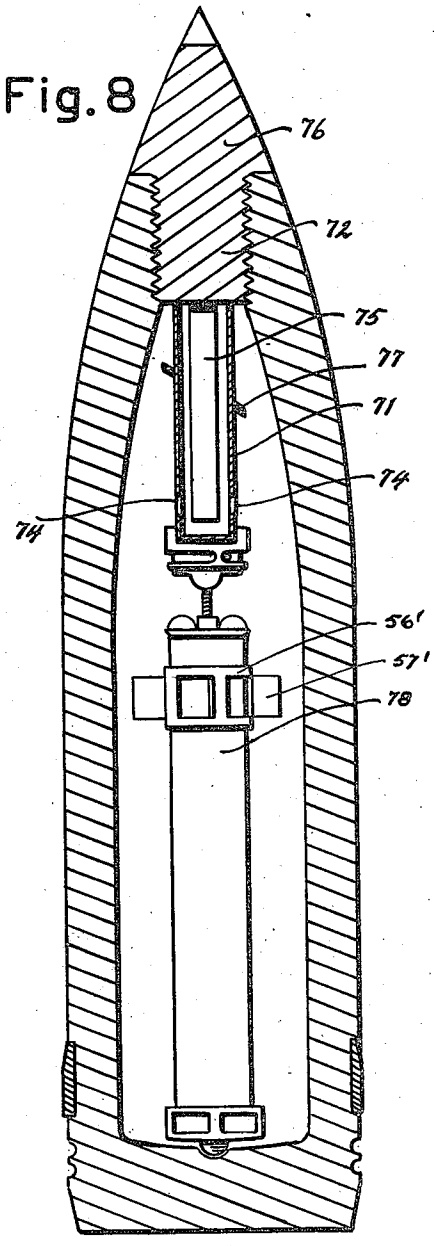


Fig. 8



INVENTOR

Neil Monroe Hopkins

Patented June 25, 1946

2,402,552

UNITED STATES PATENT OFFICE

2,402,552

EXPLOSIVE DEVICE

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

Application March 7, 1942, Serial No. 433,816

8 Claims. (Cl. 102—57)

1

This invention pertains to explosive devices such as artillery shells and the like for military and naval purposes and in improvements in explosive fillers therefor.

It is an object of this invention to produce new military and naval weapons, using safer, more quickly produced, cheaper, and yet more powerful explosive fillers than TNT.

It is a particular object of this invention to produce a liquid high explosive, just prior to or at the instant of use, through the correct admixture with proper time factor of suitable liquid component parts of said liquid high explosive.

It is a particular object also of this invention to produce safely, and to safely use, in both summer and winter temperatures, a high explosive in liquid form, which is more powerful than the solid explosives now in use.

With the foregoing enumerated objects in view as well as certain other objects which will become apparent as the description proceeds and the illustrations are studied, the invention consists in the novel parts, combinations of parts and admixtures, solutions and mutual solutions of substances in association therewith, scientific principles and methods, all as hereinafter set forth and particularly covered by the claims.

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

Fig. 1 represents a view in partial section through a conventional design of high explosive shell containing a solid high explosive filler;

Fig. 2 represents a view in partial section through one design of applicant's high explosive shell comprising relatively thicker walls than those disclosed in Fig. 1, and containing a liquid high explosive filler;

Fig. 3 is a view similar to Fig. 2 but illustrating another design of applicant's high explosive shell with liquid high explosive filler therein;

Fig. 4 is a transverse sectional view taken as on the line *a*—*b* of Fig. 3;

Fig. 5 is a longitudinal sectional view of one design of the inner chamber shown in Fig. 3, with the opposite ends of said chamber in opened position;

Fig. 6 is an elevational view of the chamber shown in Fig. 5 but with the opposite ends in closed position;

Fig. 7 represents in section another design of one of applicant's high explosive shells with liquid filler;

Fig. 8 is a view similar to Fig. 7 but illustrating a modification thereof.

2

It is understood of course that the foregoing enumerated illustrations are not by any means precisely proportioned, and therefore they are not working drawings. They do, however, illustrate the principles involved, leaving the practical designs open to modification and/or elaboration in certain of the dimensions, particularly with regard to the relative proportions or volumes of the inner chambers containing the liquid ingredients of the high explosive ultimate admixture, the such ingredients being for example nitrogen peroxide in one chamber and a liquid hydrocarbon in the other chamber. The precise relative volume of the liquid nitrogen peroxide to the liquid hydrocarbon is to be determined by sensitivity requirements which may vary considerably. These sensitivity requirements may be met by impact or percussion tests.

Referring to Fig. 1 there is shown at 15 the cylindrical wall of an artillery shell fashioned to give proper density and stability in flight when the shell is filled with a solid or "cast-in" explosive indicated at 16 and such as tri-nitrotoluene (TNT), 17 being the head of the shell and containing a conventional contact or time fuse and safety arming device 18 representing a cavity containing a booster charge 19 held in position by the partition 20.

In Fig. 2 there is illustrated a shell similar to that shown in Fig. 1, but 21 is the cylindrical wall of this device which may be for example an artillery shell adapted for use with muzzle velocities below 2500 feet per second, and fashioned to give proper density and stability in flight when filled with a liquid poured-in explosive designated by the numeral 22 and such as an admixture of liquid nitrogen peroxide and benzene in suitable proportions to withstand the force of set back at a muzzle velocity of 2500 feet per second. It is specifically pointed out in this connection, that the wall 21 of this shell has been increased in thickness over the wall 15 of the shell shown in Fig. 1, and has been carefully calculated to compensate not only for the lighter weight of the liquid filler over solid TNT but also for the lack of gyroscopic force of a liquid filler, as compared with a solid or "cast-in" explosive such as TNT. This new shell, therefore, may be adjusted to have at least the same density and stability in flight as a shell containing a solid filler, notwithstanding a difference in the specific gravities of the solid explosive filler and the liquid explosive filler, respectively. Technicians versed in the aerodynamics of a spinning shell in flight will fully appreciate that one of applicant's shells

may be so adjusted mechanically, i. e. designed and/or fabricated, with its liquid explosive as to be interchangeably used and/or fired, from the same gun and under the established range table for that gun, with respect to a similar shell of the usual construction and having a solid or cast-in explosive filler. The cavity **18** is retained but left unfilled so as to serve as an expansion chamber, and the partition **20** is perforated to receive, with a gas and liquid tight fit, the detonator tube **23**.

In Fig. 3 there is illustrated an artillery shell such as used with anti-aircraft guns, fashioned to be fired with a higher muzzle velocity than given to the shell shown in Fig. 2, a muzzle velocity for example of from 2500 to 3500 feet per second or over, where a completely mixed liquid explosive, using liquid nitrogen peroxide and benzene in the most sensitive and powerful proportions, would not stand the force of set back at firing without danger of detonation in the gun. In the present case for not only using admixtures or mutual solutions of liquid nitrogen peroxide and benzene, but for certain other liquids conducive to producing high explosives when brought together, I elect to introduce an inner chamber **43** of metal such as aluminum or steel for example, the lower portion **44** of such chamber being enlarged in diameter and having lateral openings **47**, the extreme lower end of the chamber being provided with a semi-ball-bearing member or knob **45** fashioned to center and to support the inner chamber by resting with a minimum of friction in the semi-spherical bearing **46** provided in the bottom wall of the shell.

Centrally positioned within the enlarged lower portion of this tubular chamber **43**, is the bevelled disk or closure member **48** carrying the upwardly projecting ears **49** and a boss **50**, said boss drilled and threaded (as with a right hand thread) to receive a like threaded end of the metal rod or shaft **51** which carries a rigidly attached impeller device **52**.

The other end of this metal rod or shaft **51** is oppositely threaded (as with a left hand thread) to engage a like threaded opening through the boss **53** of another and somewhat similar bevelled disk or closure member **54** carrying similar upwardly projecting ears **55**, the ears **49** and **55** of these two closure members being relatively thin and radially positioned on said closures, thereby cooperating with the liquid explosive ingredients to thwart rotary or turning movement of the closures except when said liquid ingredients have circular motion imparted thereto. Rigidly attached to the outside of the inner chamber **43** is the spacing collar **56** carrying downwardly projecting and radially positioned ears **57** also cooperating in a similar manner with the liquid ingredient in the outer chamber. After passing through the threaded boss **53**, the shaft **51** is screwed into and soldered or otherwise rigidly fixed to the member **58** and thereby prevented from turning independently thereof. Surrounding the member **58** is a slotted collar **59** free to revolve through a limited number of angular degrees, as controlled by the pin **60** securely screwed into and soldered to the member **58**, the ends of the slotway **61** in said collar colliding with said pin as an arrest of circular movement. The collar **59** is firmly attached by pins, as indicated, to the partition **20**, and said partition is so close fitting as to be substantially fixed to the shell head **17**. A recess shown by dotted lines in the member **58** receives an end of the detonator casing with a loose fit, thereby acting as a centering pivot for said member.

Within the inner chamber **43** is a component or ingredient **65** of a liquid explosive, and within the shell casing and substantially surrounding the inner chamber is another component or ingredient **66** of a liquid explosive, at least one of these components being relatively insensitive to explosion but the admixture of these two liquid components forming a highly sensitive explosive mixture.

When this design and construction of shell, with the component liquids as illustrated, is fired from a rifled gun barrel, the rotation of the shell suddenly communicates rotation to the shaft **51** by virtue of its rigid attachment to the slotted collar **59** and this rotation of the shaft by virtue of the left and right hand threaded shaft ends causes the bevelled disks or closure members **48** and **54** to open the opposite ends of the inner chamber **43**, the upwardly extending ears of these closure disks acting hydraulically with the respective liquid component parts of the potential liquid explosive mixture and tending to prevent the turning of the disks, and in similar manner the downwardly projecting ears **57** of the spacer collar **56** rigidly attached to the outside of said member, tend to prevent rotation of said chamber.

Because of the hydrostatic action of the column of liquid **66**, under the force of acceleration of the shell, and acting under Pascal's law, there is a useful lifting force upon the underside of the part **45** of the inner chamber, thereby relieving the semi-ball-bearing of much of the otherwise crushing force.

As the chamber **43** is opened, the impeller **52** starts a forced circulation of the liquid **65**, which is communicated to the other liquid component **66**, thereby insuring perfect admixture of the two components during the time of flight of the shell.

Coming now to Fig. 7, there is illustrated a somewhat different design of artillery shell with expansion chamber and detonator, the thickness of the cylindrical wall being adjusted for a liquid explosive filler **70**, said filler being sufficiently insensitive as to explosion to safely withstand the forces of acceleration without detonation at the muzzle velocities contemplated. In this modification of construction, **71** is a metal chamber closed at one end by the plug **72** of the shell head **76**, and closed at its opposite end by the bottom wall **73** of said chamber, the side walls being provided with lateral openings such as **74**. The detonator generally identified by the numeral **75** is surrounded completely as shown, and is connected in any suitable manner to a conventional fuse mechanism in the shell head **76** not illustrated since these elements of a shell are well understood. By providing the lateral openings **74**, the outer chamber or shell proper may be completely filled or substantially completely filled with the liquid explosive filler **70**, and then the shell head with its attached inner chamber **71** screwed in place, the liquid filler or a portion thereof displaced by said inner chamber, entering said inner chamber through said openings and creating in the upper portion of said inner chamber an air or expansion chamber, thereby resulting in a completely liquid-filled outer chamber as shown.

The modification, shown in Fig. 8, of the shell just described, comprises generally a similar construction, but the shell of Fig. 8 is adapted for higher muzzle velocities where the set back shock upon firing the projectile from a gun, is greater,

and is particularly adapted where the admixture of liquid component parts of a liquid explosive is desirable after the departure of the shell from the gun and prior to impact of the shell upon the target, thereby combining somewhat the features of the construction shown in Fig. 3. In other words an impeller device 77 is carried by and externally of the chamber 71, and fashioned to force a circulation of the liquid contents of the shell by the rapid revolution of the spinning shell about its major axis in flight. Another inner chamber 78 is fashioned and centrally supported in very much the same manner as that shown in Fig. 3, with a collar 56' cut so as to provide bendable radially extending vanes 57' as clearly shown, the purpose of this construction of collar and vanes being so that the vanes can be bent outwardly into radial positions from the tubular body portion of the collar, after the insertion of the chamber 78 in the shell. Otherwise the inner chamber 78 and its associated parts, is a substantial duplicate of the inner chamber 43 of Fig. 3.

The present inventor has devoted many years to the study of liquid nitrogen peroxide in connection with one or more combustible bodies and has fashioned innumerable containers therefor in the form of missiles and other naval and military devices such as submarine mines and earth mines, as well as in the form of industrial containers, and has tested in the laboratory and on a large scale in the field the correctness of the principles involved.

Many of these devices depend upon the applicant's teaching of converting a relatively insensitive and relatively low power liquid explosive or explosive ingredient into a relatively sensitive and relatively high power liquid explosive on the one hand, and several of them on the other hand lend themselves to making a mixture of liquid nitrogen peroxide with a liquid combustible body, such as benzol, just prior to or at the time of use.

The fundamental principle as illustrated and described herein resides in the novel plan and teaching of completely surrounding a chamber containing liquid nitrogen peroxide with either a liquid combustible body or a mixture of one or more liquid combustible bodies with nitrogen peroxide. This arrangement is of vital importance in many instances since it allows of fashioning a scientifically designed leak-proof system. This leak-proof system according to such structure embodies a liquid hydrocarbon completely surrounding the chamber containing the liquid nitrogen peroxide, said liquid hydrocarbon possessing a higher vapor pressure than the said liquid nitrogen peroxide. With this vapor, and consequently this hydrostatic system, it is impossible for the liquid nitrogen peroxide to leak outwardly into the liquid hydrocarbon. If the vapor pressure of the liquid hydrocarbon is so adjusted as to be only silghtly greater than that of the liquid nitrogen peroxide, then only a negligible quantity of the liquid hydrocarbon could enter into the inner chamber because a hydrostatic balance would quickly be attained therein.

The teachings in this application furthermore cover the practical use in a satisfactory manner of a liquid explosive filler in an artillery shell, said shell fashioned to be fired spinning from a rifled gun and having the thickness of its cylindrical wall increased with respect to the thickness of the wall of a comparable shell provided with a solid or "cast-in" filler. It is desired emphasized that this invention provides a missile or

explosive device which is considerably safer to handle and store yet more powerful in detonation, than those heretofore devised. That is to say, this invention covers the use of a liquid mixture which is highly sensitive to explosion and exceedingly powerful, more powerful than T. N. T., said mixture comprising a proper proportion of nitrogen peroxide and a hydrocarbon such as benzene. However, up to the time of actual use, this proper proportion is non-existent. In other words, the proper and ultimate mixture of these ingredients is brought about at the time of use, by supplying and mixing a certain quantity of the one relatively insensitive ingredient to an "incomplete" (and therefore relatively insensitive) mixture of the two ingredients, the such admixture adding the necessary quantity of the one ingredient to make the ultimate mixture highly sensitive to explosion.

Emphasis is directed to the fact that the foregoing illustrations are not actual working drawings wherefore it is possible to vary the dimensions, proportions, distributions of masses and materials as dictated by actual sensitivity requirements and tests. The foundations, however, have been laid for the fabrication of highly practical missiles. Whereas, the invention has been illustrated by diagram and description and there has been described novel methods as well as novel ways and means of fashioning the various devices, it is possible that those skilled in the arts and in the sciences involved, may further vary the methods, ways and means as well as develop new devices without departing from the spirit of this invention, and it is therefore desired not to be limited to the foregoing disclosure and teachings except as may be called for by the claims.

What is claimed is:

1. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell having two chambers therein, one chamber movable with respect to the other chamber, a liquid explosive ingredient in each chamber, one ingredient having a relatively low sensitivity to explosion but the admixture of the two ingredients having a relatively high sensitivity to explosion, means carried by one of said chambers and immobile with respect thereto for opening the other relatively movable chamber and causing the two ingredients to admix, means for exploding the admixture, the outer wall of said shell having a thickness different from the thickness of the corresponding wall of such missile and in compensating proportion to the difference in weight between the mass of explosive admixture and the mass of solid explosive.

2. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell comprising a casing and a liquid therein, a closed chamber containing a second liquid and disposed within the liquid in said casing, the two liquids when admixed forming a highly sensitive explosive mixture, chamber-opening means actuated during the flight of said shell, said means provided with an impeller establishing an admixing circuit through said chamber and said casing of the two liquids upon opening of said chamber, said shell having the thickness of its wall increased over that of the corresponding wall of such missile thereby to provide addi-

tional weight of metal to compensate for the difference in weight between the mass of liquid explosive and the mass of solid explosive.

3. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell comprising a casing and a liquid therein, a closed chamber containing a second liquid and disposed within the liquid in said casing, the two liquids when admixed forming a highly sensitive explosive mixture, chamber-opening means actuated solely by the rotary motion of the shell in flight, said means provided with an impeller establishing an admixing circuit through said chamber and said casing of the two liquids upon opening of said chamber, said shell having the thickness of its wall increased over that of the corresponding wall of such missile thereby to provide additional weight of metal to compensate for the difference in weight between the mass of liquid explosive and the mass of solid explosive.

4. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell comprising an outer metallic casing and a closed inner chamber, the walls of said chamber being in spaced relation to the walls of said casing, one liquid in said casing and a different liquid in said chamber, the two liquids when admixed forming a highly sensitive explosive mixture, means actuated during the flight of said shell for opening said chamber, said means provided with an impeller establishing an admixing circuit of the two liquids through the space between the walls of said casing and said chamber upon opening of said chamber, said shell having the thickness of its wall increased over that of the corresponding wall of such missile thereby to provide additional weight of metal to compensate for the difference in weight between the mass of liquid explosive and the mass of solid explosive.

5. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell comprising a casing and a liquid therein, a closed chamber containing a second liquid and disposed within the liquid in said casing, the two liquids when admixed forming a highly sensitive explosive mixture, chamber-opening means actuated during the flight of said shell, said means extending through said chamber and provided with an impeller establishing, together with the walls of said chamber, an admixing circuit through said chamber and said casing of the two liquids upon opening of said chamber, said shell having the thickness of its wall increased over that of the corresponding wall of such missile thereby to provide additional weight of metal to compensate for the difference in weight between the mass of liquid explosive and the mass of solid explosive.

6. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell comprising a casing and a liquid therein, a container within said casing and provided at opposite ends with movable closures normally in closed position, a different liquid within the closed container, the two liquids when admixed forming a highly sensitive explosive, and means carried by said casing causing movement of said closures into container-opening positions, said means extending into said container and provided with a member producing circulation and admixture of the two liquids through said container and said casing upon opening of said container, said shell having the thickness of its wall increased over that of the corresponding wall of such missile thereby to provide additional weight of metal to compensate for the difference in weight between the mass of liquid explosive and the mass of solid explosive.

7. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell comprising a casing and a liquid explosive ingredient therein, a container within said casing and provided at opposite ends with movable closures normally in closed position, a different liquid explosive ingredient within the closed container, and means carried by said casing and immobile with respect thereto causing movement of said closures into container-opening positions, said means extending into said container and provided with a member producing circulation of the two liquids through said container and said casing upon opening of said container thereby to produce an explosive admixture, said shell having the thickness of its wall increased over that of the corresponding wall of such missile thereby to provide additional weight of metal to compensate for the difference in weight between the mass of liquid explosive and the mass of solid explosive.

8. A shell adapted to be rotated about its longitudinal axis in flight, and comparable substantially equally as to dimensions and trajectory to the present-day similar missile containing a solid explosive, said shell comprising a casing and a liquid therein, a closed chamber containing a second liquid and disposed within the liquid in said casing, the two liquids when admixed forming a highly sensitive explosive mixture, chamber opening means actuated by a rotary motion imparted to said casing, said shell having the thickness of its wall increased over that of the corresponding wall of such missile thereby to provide additional weight of metal to compensate for the difference in weight between the mass of liquid explosive and the mass of solid explosive.

NEVIL MONROE HOPKINS.