W. S. ISHAM.

PROJECTILE AND FUSE OR FIRING MECHANISM THEREFOR.

APPLICATION FILED MAR. 11, 1916.

1,237,909.

Patented Aug. 21, 1917.

3 SHEETS—SHEET 1.

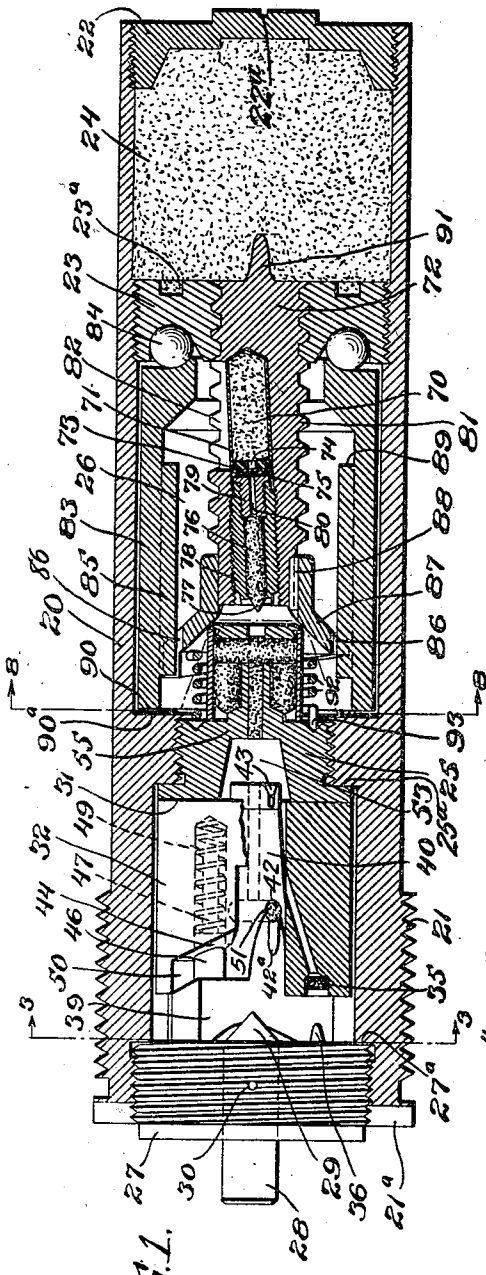


FIG. 1.

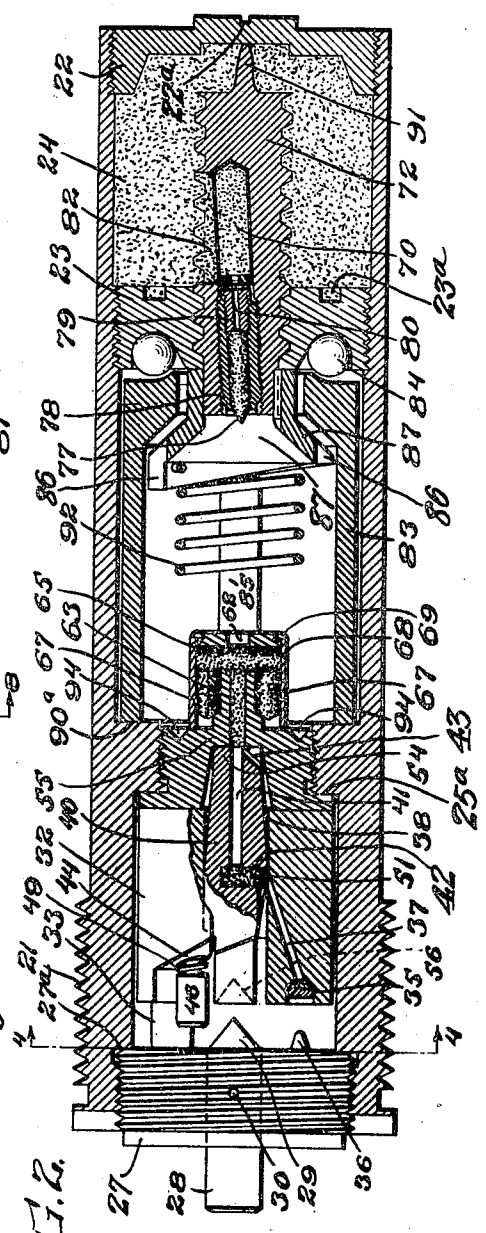


FIG. 2.

Witness

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3 SHEETS—SHEET 2.

FIG. 3.

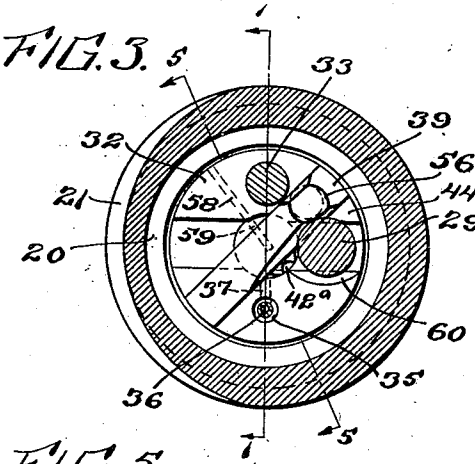


FIG. 4.

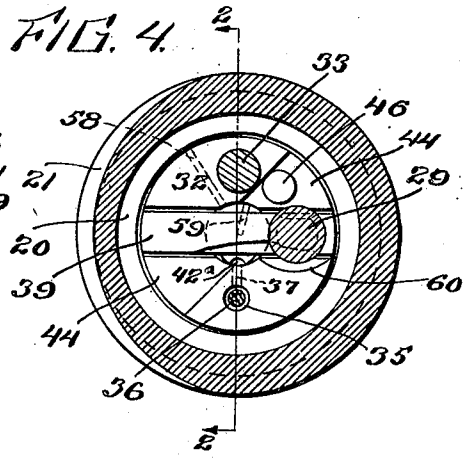


FIG. 5.

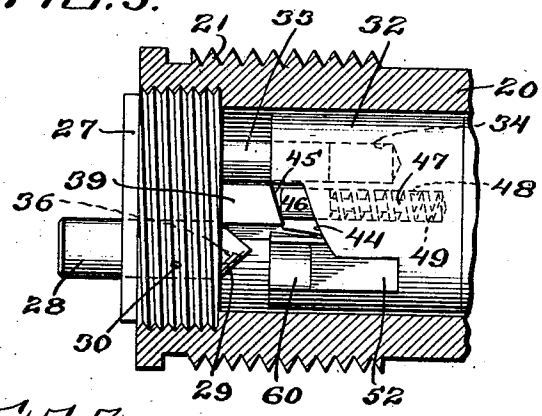


FIG. 6.

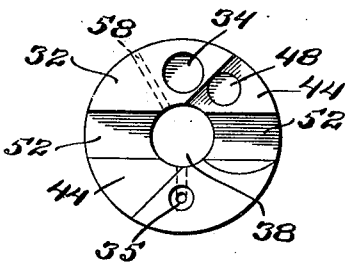


FIG. 7.

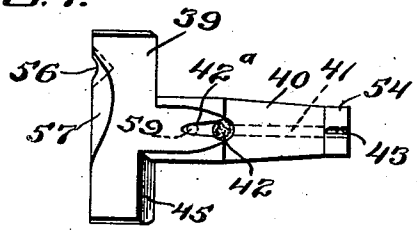


FIG. 8.

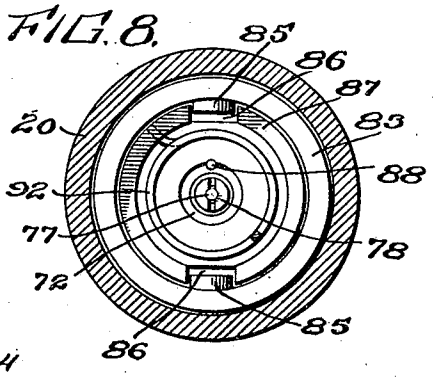
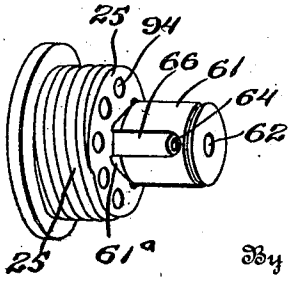


FIG. 9.



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3 SHEETS—SHEET 3.

FIG. 11.

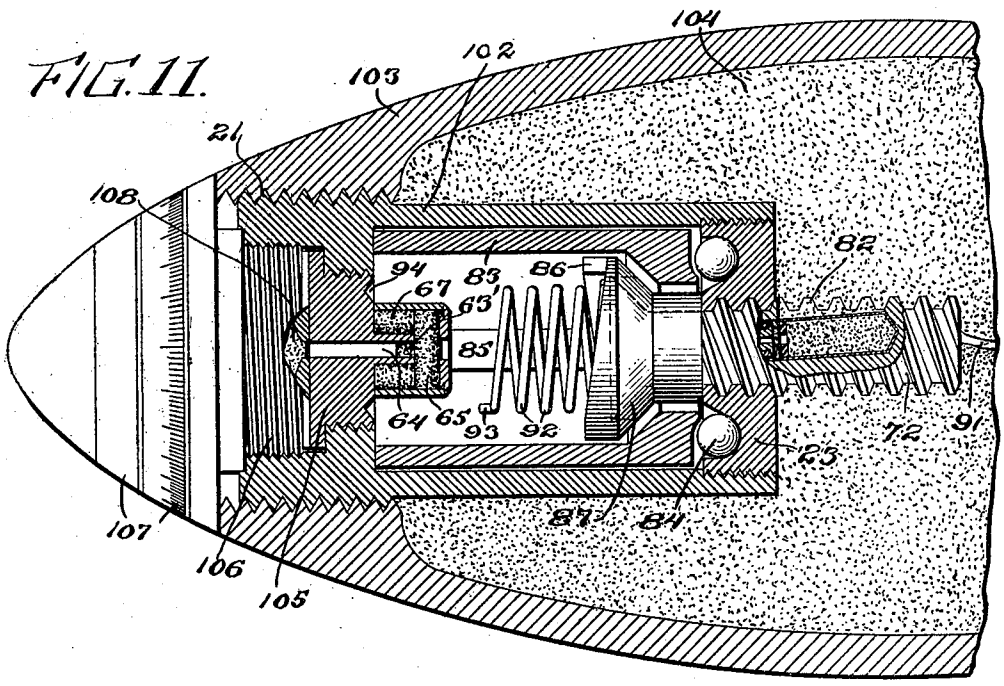


FIG. 12.

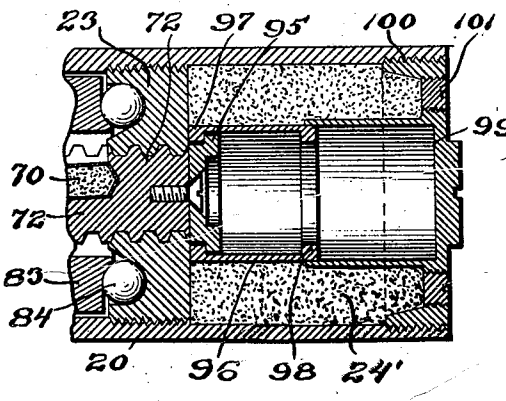


FIG. 13.

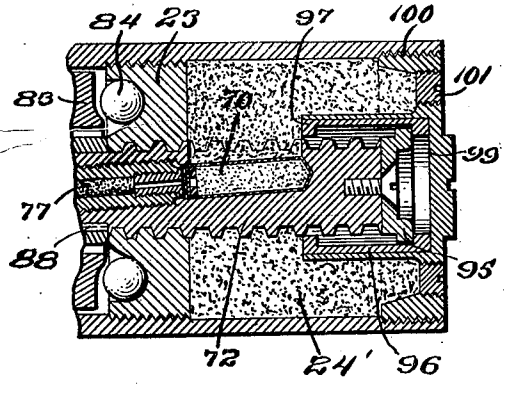
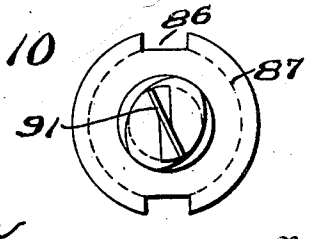


FIG. 10



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UNITED STATES PATENT OFFICE.

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PROJECTILE AND FUSE OR FIRING MECHANISM THEREFOR.

1,237,909. Specification of Letters Patent. Patented Aug. 21, 1917.

Application filed March 11, 1916. Serial No. 83,578.

To all whom it may concern:

Be it known that I, WILLARD S. ISHAM, a citizen of the United States, residing at Washington, District of Columbia, have invented certain new and useful Improvements in Projectiles and Fuses or Firing Mechanism Therefor; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to projectiles and fuses or firing mechanism therefor; and it is concerned more particularly with fuses for what are known in the art as torpedo shells.

In a copending application, Serial No. 838,119 filed May 12, 1914, (Patent No. 1,179,105, granted April 11, 1916), I have disclosed and claimed a fuse operable to effect practically instantaneous explosion of a torpedo shell when the shell strikes heavy armor plate or other solid target offering resistance of similar character and intensity, and also operable to effect delayed explosion when the shell strikes water, whereby the shell may function as a mine. These results are attained by the conjoint use of what I have for brevity designated in said co-pending application as a "semi-insensitive charge," and percussion mechanism combined with a delay action or time train. The so-called semi-insensitive charge is a detonator charge consisting of an explosive of such character or so arranged as to explode by shock of impact of the containing projectile with heavy armor plate or the like, but not to explode upon impact with water or with thin armor such as is used on torpedo boats, for example. The delay action train is arranged to be set in action by any appreciable impact or retardation. Impact with water or a material offering a degree of resistance equal to or even much less than that offered by water will readily set the train in action. Provision is made for automatically cutting out the delay train, wholly or in part, upon impact of the projectile with a solid target, impact with even thin armor, skeleton masts, or the like, being sufficient to operate the delay cut-out. When the delay train is thus cut out by impact, the percussion mechanism causes substantially instantaneous explosion of the projectile even where shock of impact with the solid target in question is insufficiently intense to detonate the semi-insensitive charge. The fuse mechanism includes safety means operative to prevent accidental and premature explosion in handling and firing the shell from a gun, said safety means being automatically rendered inoperative, however, by motion of the projectile in flight.

It is evident therefore that the invention of my prior application provides for effecting explosion of a shell in at least three different ways according to the character of the target hit by the shell, the particular mode of explosion appropriate to impact of any given character being automatically effected independently of conditions of flight prior to impact.

An object of the present invention is to utilize the above broad principles of operation in a fuse construction differing in some respects from the construction of my prior application aforesaid and superior thereto for certain conditions and requirements of actual service.

Another object of my invention is to insure still greater efficiency and certainty of fuse operation by utilizing certain broad principles never utilized in fuse construction heretofore so far as I am aware.

Another object of my invention is to throw additional safeguards around the handling and firing of high explosive shells whereby the possibility of premature explosion is practically eliminated.

Further objects of the invention will appear as the description proceeds.

An important feature of the present invention in an especially desirable embodiment thereof is the character and disposition of the so-called semi-insensitive charge, which in the present instance is embodied in a movable detonator charge. In a specific example, this detonator charge may be of mercury fulminate or other material of similar characteristics. The design and arrangement of said detonator charge may be such as to bring the same within the above definition of a semi-insensitive charge, in spite of the well known sensitiveness of fulminates to shock. In order that the use of such a charge may be further safeguarded, I provide for maintaining it normally, that is, prior to firing the shell from a gun, either in, or in communication with, an ex-

pansion or safety chamber which is suitably isolated from the burster or main charge of the shell, or from the booster charge, if this latter be employed. As will appear, the detonator charge may itself constitute part or the whole of a booster charge; or a booster charge distinct from the said detonator charge may be employed. Said expansion or safety chamber is most desirably of sufficient capacity and solidity of construction to accommodate an explosion of the detonator charge without being ruptured. Less advantageously, the safety chamber may be of a construction insufficiently strong to entirely escape rupture upon accidental explosion of the detonator charge, but capable nevertheless of taking up the explosion shock to such an extent that the explosion is without detonating effect on the shell charge. I do not recommend this alternative construction, however, in practice. In the construction to be more fully hereinafter disclosed, such an explosion would not rupture the safety chamber, would be wholly without detonating effect on the shell charge, and would therefore be harmless.

While I have above referred to a semi-insensitive charge as constituting a desirable feature of my invention, and while I employ such a charge in certain desirable practical embodiments of my invention hereinafter to be described, it is not to be inferred that such a charge is necessarily an indispensable element of said invention in all its possible forms. The benefits of the invention can be realized, at least in part, without regard to the special character of the detonator charge.

Provision must be made, however, to insure that upon firing the shell, the outlet for the detonator charge is transferred automatically from the safety chamber or position of inoperativeness into operative relation to the burster or main shell charge. Or, stating it more broadly, the inoperative relation normally existing between the detonator charge and the burster is changed to an operative relation. According to the present form of my invention this is accomplished by providing a carrier member for the movable detonator charge, said carrier member being arranged to be suitably moved to effect the desired transfer by a force or by forces developed in connection with the operation of firing the shell from the gun. In the best form of the invention at present known to me, the set-back pressure at the instant of firing is directly utilized to effect the transfer of the carrier and its contained detonator charge from inoperative to operative position. Incidentally the rotary force developed by the spin of the shell may be utilized to control or supplement to a greater or less extent the effect of set-back pressure in moving the charge carrier. Employment of set-back pressure as a motive agency offers the great practical advantage that even though the projectile be fired from a gun whose rifling has been destroyed to a greater or less extent by erosion, nevertheless the detonator charge is moved into operative position with certainty. In connection with the carrier for the movable detonator charge, I usually employ means for governing the rapidity at which said carrier can operate to effect the transfer in question. In a practical embodiment such means may take the form of an inertia governor which functions in a manner analogous to a fly-wheel; acting initially as a brake to prevent too rapid movement of the detonator charge out of the safety chamber, whereby said charge does not leave inoperative position until the shell is safely out of the gun, and then giving out stored power to the carrier whereby the latter is certain to complete its movement into operative position.

In order to more fully explain the nature and operation of my invention, but without intending thereby to be limited to any specific mechanical construction, I have illustrated in the accompanying drawings certain practical embodiments of the broad principles involved, said embodiments being merely typical of constructions within the scope of the appended claims. In these drawings:—

Figure 1 is a longitudinal section partly broken away, of a fuse embodying the invention, the section being taken on the line 1—1 of Fig. 3 and the parts being shown in the position occupied prior to firing the projectile;

Fig. 2 is a similar view in section on the line 2—2 of Fig. 4, showing the position of the fuse parts after the projectile has left the gun and prior to impact;

Fig. 3 is a transverse section on the line 3—3 of Fig. 1;

Fig. 4 is a transverse section on the line 4—4 of Fig. 2;

Fig. 5 is a longitudinal section of the forward portion of the fuse taken about on the line 5—5 of Fig. 3, the combined hammer and bearing block, and associated parts, being shown in elevation and in their respective positions prior to firing;

Fig. 6 is an end elevation of the combined hammer and bearing block;

Fig. 7 is a side elevation of a combined train member and delay-train-cutter;

Fig. 8 is a transverse section on the line 8—8 of Fig. 1;

Fig. 9 is a view of the fuse plug in perspective;

Fig. 10 is an end view of the movable charge carrier from the rear;

Fig. 11 is a longitudinal section of the forward portion of a shell equipped with

firing mechanism embodying certain principles of the invention, parts being in elevation;

Fig. 12 is a longitudinal section of the rear portion of a fuse mechanism broadly similar to the fuse mechanism of Figs. 1 and 2 but embodying additional features of advantage, the parts being shown in position prior to firing; and

Fig. 13 is another longitudinal section of the mechanism of Fig. 12, showing the respective positions of said parts after firing.

The fuse or firing mechanism illustrated in Figs. 1 to 10, inclusive, is a nose or point fuse adapted more particularly for use with shells to be fired at ships. The hollow cylindrical casing or fuse stock 20, which is best constructed of steel, is provided externally near its forward end with screw threads 21, whereby it may be secured in a threaded opening in the nose of a torpedo shell (not shown). Notches or recesses 21ª are provided to accommodate a spanner wrench or other tool for screwing the fuse into place. When assembled with the shell, the fuse device therefore extends rearwardly from the point or nose of the shell into the shell chamber and is substantially surrounded by and embedded in a high explosive such as trinitrotoluol for example, which constitutes the burster charge and which it is the function of the fuse device to detonate at the proper moment. This burster is a relatively insensitive charge; that is, it is not explosible by shock alone, but requires what is technically known as a detonator or exploder charge to send it off.

The casing or stock 20 is closed at the rear by a screw threaded brass end plug 22. Somewhat forward of this plug is a heavy screw-threaded bronze or brass partition plug 23. Both these plugs screw into place from the rear of the fuse stock and have left hand threads in order that the clockwise spin of the shell and fuse stock induced by the gun rifling may tend to screw them the more tightly into place. The chamber 24 lying between these plugs contains in this instance a booster charge, trinitrotoluol for example. The walls of the booster chamber are so designed with reference to the booster as to be readily shattered upon explosion of the latter, whereby the burster charge is detonated.

At a suitable distance in front of partition 23 is a screw threaded bronze or brass flanged fuse plug 25 which screws into position against annular shoulder 25ª from the front of the casing and which therefore has right hand threads. The chamber 26 comprised between the fuse plug and partition 23 constitutes an expansion or safety chamber wherein the detonator charge, to be hereinafter fully described, is maintained entirely isolated from the booster and burster charges at all times prior to firing the shell from a gun. The cubic capacity and strength of this safety chamber are so designed as to render it amply able to withstand the bursting pressure which would be developed by an accidental explosion of the detonator charge.

For convenience is assembling, plugs 22 and 23 may be provided with suitable tool engaging means, such as kerf 22ª and recesses 23ª, respectively.

In front, the casing is closed by a head plug 27 of bronze or brass, which screws into place on a right hand thread against shoulder 27ª. An eccentrically located steel impact pin 28 projects in front of plug 27 and extends through a bore in said plug with a tight fit, terminating at the rear in a conical point 29. A shear pin 30 of brass or the like extends laterally into the head-plug and into a recess provided in the impact pin, the parts being so designed that the pin 30 will be sheared and the impact pin 28 driven rearwardly through the head plug upon impact of the shell with solid material, but not upon impact with water.

To the rear of the head plug and normally in contact with the forward flanged end 31 of the fuse plug is a cylindrical hammer block 32, of bronze or brass, which fits loosely in the fuse stock. A guide pin 33 secured to the head plug is shown partly entering with an easy sliding fit a deep recess 34 in the forward face of the hammer block. By this means proper alinement of parts carried by the head-plug and hammer block is insured, the hammer block being held against rotation relatively to the head plug, while being permitted limited movement longitudinally with respect thereto. The hammer block carries a percussion cap 35 which, upon sufficient relative forward movement of the hammer block, strikes against firing pin 36 carried by the head plug. The percussion cap is arranged to flash through channel 37 which leads to a bore 38 extending axially through the hammer block.

Means for controlling and transmitting the flash from channel 37 to the fuse plug will now be described. In the embodiment here illustrated said means comprises a T-shaped member of steel having a transverse head 39 and a stem or punch portion 40 provided with an axial vent passage 41, which passage opens laterally at 42 (Fig. 7) and is widened to the stem edges at the rear end as at 43 to provide an escape vent for air trapped in the rear portion of vent passage 41. This member not only functions as a movable train member, but as will later be explained, it may also operate as a punch to cut out the delay action train to be hereinafter described.

The normal or safety position of the

member 39—40 is illustrated in Figs. 1 and 5 where it is shown abutting the head plug, the arms of the T being in alinement, respectively, with helically sloped bearing surfaces 44 formed on the hammer block; while the stem portion lies in the axial bore 38. The rear faces 45 of the T-arms are sloped to mate with the sloped bearing surfaces 44. A detent stud 46 with guide stem 47 fits in a longitudinal bore 48 in the hammer block, and is normally pressed against the rear face of one of the T-arms, by a strong coiled spring 49, whereby the T member is held firmly against the head plug. Rotational movement of the T in one direction is prevented by the inner end 29 of the impact pin, and in the other direction by portion 50 of the hammer block. When the T member is thus locked in safety position, the vent opening 42 and pellet 51 of quick-burning powder at the forward end of passage 41 are out of registry with the rear end of passage 37 and are isolated therefrom. Moreover the spring 49 is so designed that if it be momentarily compressed as by a pressure developed by the inertia of the T member upon rough handling of the projectile or by its falling from a considerable height upon its base, the spring will react instantly before the T member can turn on its axis, and will return the T member to normal position. Furthermore the thickness of the T-arms from front to rear is such that if the shell fell on its nose from a considerable height and the hammer member were to compress spring 49 and move forward, the hammer would be positively stopped by the T-arms, thus preventing cap 35 from reaching firing pin 36.

When the shell is fired from the gun, however, the parts just described automatically assume an operative or non-safety position, illustrated in Fig. 2. Owing to its inertia, the T member tends to stand still while the hammer block and fuse stock travel forward with the shell. The T member executes an apparent relative movement toward the rear until its arms bear against surfaces 44, where they are held by the set-back pressure against the resistance of spring 49. Since these surfaces are best sloped at an angle greater than the angle of friction, the T-arms are caused by the set-back to ride rearwardly down said surfaces, and in so doing the arms turn so that they enter transverse channel or recess 52 in the forward face of the hammer block. This brings vent 42 into registry with passage 37; while the rear portion of stem 40 of the T member has entered axial recess 53 in fuse plug 25, the hardened punch end 54 resting against a relatively thin neck or section 55 of the metal, brass for instance, of which the fuse plug is made. At the same time, the eccentrically located conical recess 56 on the forward face of the T-head 39 is brought into alinement with the conical inner end 29 of the impact pin. The described rearward turning movement of the T member is possible because after it moves back into engagement with bearing surfaces 44, it is no longer blocked by the end 29 of the impact pin. In order to insure free clearance in thus turning, the T-head may be beveled or cut away as at 57 (Fig. 7). As soon as the shell has left the gun and has lost its forward acceleration, the spring 49 again moves the detent 46 forward, effectually preventing return of the T member to safety position.

For convenience in assembling the described parts in the safety position of Fig. 1, the hammer block may have a small bore 58 (Figs. 4 and 6) extending inwardly from one side into the axial bore 38 and into registry with a shallow bore 59 provided in the T-stem or punch 40, said bores being designed to accommodate an assembling pin (not shown) of small brass wire or the like which will be readily sheared by the set-back pressure of firing.

The hammer block may be cut away somewhat as at 60, if necessary, in order to insure clearance between the block and the impact pin for unobstructed relative longitudinal movement of these parts.

The fuse plug has a reduced portion 61 (Fig. 9) extending back into the expansion chamber 26, said portion being necked or notched at 61[a] so that it may be readily broken off by a lateral shock of the requisite intensity. The purpose of this construction will appear later. Through this reduced portion extends an axial bore 62 in alinement with passage 41 of the T punch and containing a time or delay action train 63. A cross bore 64 accommodates a quick-burning pellet 65 and oppositely disposed recesses 66 contain reinforcing quick-burning pellets 67. A sleeve 68 holds the pellets in place and is itself secured in position by the crimped-over edges 69 of the fuse plug end. Obviously other arrangements than that described could be employed for securing a powerful flash at the end of the time train; but the construction described gives good results. The function of the reinforcing quick-burning pellets just described is to throw a strong pencil of flame toward the detonator charge hereinbefore mentioned and now to be described.

Said detonator charge is of such character that explosion thereof in detonating relation to a booster charge or to a burster charge will detonate said booster or burster. Said detonator charge is here shown as automatically movable by set-back from non-detonating into detonating position. It comprises in the present example a column 70 of fulminate of mercury of such length

and arrangement that it cannot experience a shock of sufficient intensity to explode it except by impact of the projectile in flight against solid material. This fulminate charge may be inclosed in an extremely thin brass casing 71 of negligible strength, the capsule thus formed being located in a suitable chamber provided in the interior of a movable carrier member 72 which is most desirably made of bronze. The forward end of casing 71 is provided with a thin closure 73, of rubber, for example, the closure being provided with a central vent opening 74. A thin covering 75 such as silk gauze is also provided and loose powder may be placed on this gauze covering. The amount of fulminate, fulminate mixture, or other detonating material employed and the dimensions of the detonating column naturally vary in practice, these details being dependent upon several factors such as the size of the shell, and its design. For a 12-inch shell weighing approximately 750 pounds, I have found that the requirements are satisfactorily met by a capsule of the form here illustrated having a length of about one inch and a diameter sufficient to carry 30 grains of fulminate of mercury. These dimensions are to be understood as merely typical and not as restrictive.

Suitable provision must be made for insuring that, under the proper conditions, flame will be transmitted with certainty to the fulminate detonator capsule from the reinforcing pellets 65 and 67, while at the same time the fulminate detonator charge is properly confined so that its explosion force is suitably directed and is not wasted by venting into the safety chamber. In other words, barrier means must be provided which will effectively confine the detonator charge and prevent undesirable dissipation of its explosion force forwardly from the detonator capsule, but which will nevertheless afford a passage for ignition of the detonator from pellets 67. Provision should also be made for insuring that the flash from said pellets is positively transmitted to said passage. An arrangement fulfilling these requirements will now be described.

In front of the fulminate charge, and also located within the movable carrier, is an elongated quick-burning pellet 76 whose pointed end 77 is exposed to the flash from pellets 65 and 67. A wisp of gun cotton might be substituted for pellet 76. In the present instance pellet 76 is shown as contained within a sleeve 78 tapered internally at its forward end to receive its pointed end 77. At the rear of pellet 76 is a strong barrier plug 79 which is secured by screw threads in the rear end of sleeve 78 and which has a restricted central passage 80. This passage affords a free path for transmission of flame from pellet 76 to the fulminate detonator; or, if desired, it may contain quick-burning explosive for flame transmission. But the passage is of such small bore as to preclude any substantial venting of the detonator charge explosion therethrough, and consequently the full force of such explosion is exerted in detonating the burster charge, either directly or through a booster. Said plug 79 also serves as a pressure abutment for the fulminate capsule, as will be explained hereinafter.

The movable carrier 72 is provided with external right hand threads 81 engaging corresponding threads in a passage extending coaxially through the partition plug 23. In the present example threads 81 are double and their pitch is greater than the angle of friction. The chamber provided within the movable carrier member is here shown as extending longitudinally thereof at a slight angle to its axis; and at its rear portion adjacent the fulminate charge there is an elongated lateral vent opening 82. By thus inclining the chamber to the axis of the carrier, the fulminate charge is brought very close to the outside of the carrier at the location of the vent opening. In practice, the proximity of the detonator to the charge to be exploded is a matter of importance, especially where said charge is not readily detonated, as is the case with trinitrotoluol.

In the position shown in Fig. 1, the movable detonator charge is seen to be in detonating communication only with the interior of the safety or expansion chamber 26. In this position no harm will be done if said charge should for any reason happen to explode. As previously stated, said expansion chamber is so designed with reference to its cubic capacity and wall strength as to withstand such an explosion without rupture. Moreover the high pressure of the explosion would immediately seal the mating threads of carrier 72 and partition plug 23 by forcing the malleable metal of the two members into close contact. This has been proved to be the fact by repeated practical tests.

In order that the movable detonator charge may function to detonate the burster charge of the shell either directly, or indirectly through booster charge 24 as in the embodiment of Figs. 1 and 2, it is necessary that the carrier member 72 be screwed through the partition plug 23 so as to bring vent opening 82 partly or wholly to the rear of the partition plug. The pitch of the screw threads of the carrier member is advantageously so steep that this rearward screwing movement can be effected solely by the set-back pressure developed in firing the projectile from a gun; but the effect of the set-back pressure may be supplemented or controlled by utilizing also the clockwise spin of the shell. It is not my intention, therefore, to be limited to a construction in

which the pitch of the threads 81 is greater than the angle of friction, although a pitch steeper than the angle of friction is ordinarily most advantageous.

In order to guard against the possibility of premature explosion occurring after firing but before the shell has left the gun, provision should be made for timing the rearward movement of the movable carrier and its detonating charge in such manner as to insure that such rearward movement shall not have been completed or shall not have progressed to such an extent that the detonator charge has been brought into operative relation to the booster charge or the burster charge until after the projectile is out of and safely away from the gun. Owing to the enormous force developed at the instant of firing, it is difficult to design the threads on the movable carrier so that it will meet the foregoing conditions, and at the same time to insure uniform and certain movement through the safety partition 23. To secure this result, I have found that a governing device is desirable to regulate its movement. In the present instance I provide the necessary regulation by means of a rotatable member so connected to the carrier as not to interfere with its longitudinal movement, while at the same time the screwing movement of the carrier is made to impart rotation to said rotatable member, which latter by reason of its inertia acts as a brake when the carrier member starts to screw rearwardly. This delays the movement of the carrier member to such an extent that the detonator charge carried thereby does not come into operative relation to the burster charge until the projectile is out of the gun. At the same time, the rotatable braking device, having once been speeded up then acts as a fly wheel, giving up energy to the movable carrier and making it doubly certain that the carrier is eventually screwed back to the limit of its rearward movement.

In the present mechanical embodiment of the mechanism just described in broad terms, the heavy steel sleeve 83 engaging at its rear end the antifriction thrust bearings 84 constitutes the rotatable governing device. Said sleeve is shown as provided with ribs or keys 85 fitting into slots or key ways 86 provided in a cross head member 87 which is keyed or otherwise effectively secured to the forward end of the rotatable carrier as at 88. It will be seen that as the carrier member screws toward the rear, the cross head will slide longitudinally along the ribs 85 while at the same time compelling the governing sleeve or fly wheel 83 to rotate. The ribs 85 are shown as terminating at 89. The forward edges of the circular cross head are beveled or sloped between the key ways 86, step fashion. Consequently when the movable carrier 72 has nearly reached the limit of its rearward movement, the key connection between the fly wheel 83 and the screw carrier is broken and the carrier having then screwed rearwardly as far as it can and having stopped, the fly wheel continues to turn and in so doing the ribs or keys 85 ride up over the sloped edges of the cross head, wedging the fly wheel forward to take up the small clearance shown at 90 (Fig. 1) between said fly wheel and shoulder 90^a of the fuse stock, and thereby stopping the fly wheel after it has traveled less than 180° farther than the carrier. As a result, the carrier is now wedged and locked firmly in operative position (Fig. 2), and it cannot return to inoperative position by any chance.

The quantity of explosive constituting the booster charge in chamber 24 is such that when the carrier member 72 is in its rearmost position, said booster charge will be packed to the requisite density around said carrier. In order to facilitate passage of the carrier through the charge, a twisted boring blade 91 may be provided at its rear end. This boring blade acts as a distributer, supplementing the effect of centrifugal force, developed by the shell spin in distributing the booster charge against the walls of the booster chamber and around the carrier.

Where it is not considered necessary that the projectile shall have traveled forward a certain distance before the fuse mechanism is in operative condition, and particularly with small shells, the fly wheel may be omitted, especially if the screw carrier is provided with a boring end as above described, since this tends to prevent too rapid screwing down.

Detent means are provided to prevent the movable carrier from turning to move out of safety position prior to firing the projectile. Such means may take the form of a coiled spring 92 secured at one end to the cross head 87, and having its free end 93 bent to enter any one of the recesses 94 in the fuse plug. This device operates like a ratchet, permitting the carrier to be screwed forward into safety position but preventing its being screwed rearwardly. In safety position the spring is strongly compressed, and turning movement of the carrier rearwardly is resisted by the spring. As long, therefore, as the bent end of the spring lies in one of the recesses 94, the carrier member cannot screw back through the partition plug. The spring is so designed, however, that set-back pressure of firing will compress it still further and release the bent end 93 from its locking engagement with the fuse plug, thus permitting rearward screwing movement of the carrier to occur.

Figs. 12 and 13 illustrate another construction in which the carrier member does not have to bore its way through the booster

charge in moving back into operative position. In this embodiment of the invention, the rear end of the movable carrier 72 is provided with a flanged tail-piece 95 suitably secured thereto and fitting loosely within a longitudinally movable tube 96 which is internally flanged at 97 and 98 for engagement with the flange of the tail-piece. The tube telescopes inside of a stationary cup 99, constituting a part of the end plug of the fuse stock 20. As here shown said end plug screws into the fuse stock on a left hand thread as at 100. Suitable apertures closed by threaded plugs 101 are provided for filling the booster chamber with explosive after the parts have been assembled.

In this construction, when the movable carrier travels rearwardly, the tail-piece slides freely within tube 96 until it reaches the rear flange 98, whereupon further travel of the carrier moves the tube also, causing it to telescope within cup 99 and to leave the vent opening 82 of the screw carrier in free communication with the booster charge 24, the final position of the parts being as shown in Fig. 13. It is evident that this booster charge 24 can be packed preliminarily to just the proper density; consequently it is not in any way disturbed by, and offers no obstruction to, the rearward movement of the detonator carrier. This arrangement therefore has advantages in some respects and for certain purposes over that previously described.

In Fig. 11 is illustrated an embodiment of certain principles of the invention in which the firing mechanism takes a somewhat simpler form, the arrangement shown being especially adapted for small shells and for shells used on land. In this construction the booster charge and the means for cutting out the delay action train are dispensed with. The casing 102 screws into the nose of the torpedo or high explosive shell 103 as before, but does not extend rearwardly beyond partition plug 23, which now also constitutes the rear end closure of the fuse stock and separates the safety or expansion chamber from the main shell chamber containing the burster charge 104 of trinitrotoluol or other suitable explosive. The movable detonator charge carrier therefore screws rearwardly from safety position through plug 23 directly into the burster charge. The construction of said movable carrier and its method of control may be as hereinbefore explained in connection with Figs. 1 and 2. Fig. 11 illustrates the position of the parts after the shell has been fired and has left the gun. Fuse plug 105 corresponds closely to fuse plug 25. Head plug 106 comprises in this instance the well known "combination" fuse, including an adjustable time train automatically set in action upon firing, and a percussion device (not shown) operable by impact. The usual timing rings are indicated at 107. Both said time train and percussion device vent into a reservoir 108 of quick-burning powder which blows through the central bore of fuse plug 105 and ignites delay action train 63′, from which in turn flame is transmitted as before described by pellets 65, 67 to the charge in movable carrier 72. The delay action train element 63′ may be omitted, in which case explosive in 108 flashes directly across to the movable carrier charge, with or without the aid of auxiliary quick-burning pellets such as 65, 67. If the delay action element 63′ is employed, it is ordinarily designed for a very brief delay, say one one-hundredth of a second, sufficient merely to permit the shell to bury itself after impact with the ground, for example, before exploding. The calibration of the timing rings will of course take account of the employment or omission of the delay action train 63′.

The advantages attending the association, in a projectile, of the described safety chamber and movable detonating charge carrier, with the usual "combination" fuse, or with any fuse embodying an adjustable time train, are evident. Accidental explosion of the shell charge in handling the projectile prior to firing, or explosion after firing but before the shell has left the gun, both occasioned by premature explosion of the detonating charge or booster, are both effectively guarded against and prevented by the present construction. Just as in the construction of Figs. 1 and 2, the movable detonator charge must remain in the safety chamber within casing 102 until the projectile is fired and is safely away from the gun; so that if by some accident the "combination" fuse be prematurely set in action, the movable detonator or exploder charge will explode harmlessly in the heavy walled safety chamber without affecting the main shell charge.

It is evident that the described safety device may also be employed in other types of projectiles, such as shrapnel, to safeguard the operation of firing mechanism ordinarily employed in such projectiles.

The operation of the illustrated embodiments of my invention has been largely explained in connection with the foregoing description of constructional details, but for the sake of clearness the operation will be here summarized.

Referring first to that form of the invention embodying fuse mechanism of the type shown in Figs. 1 to 10 inclusive, and assuming the parts to be in their normal positions prior to firing, as appearing in Figs. 1 and 5, the firing of the associated projectile from a gun will occasion the following operations: The setback pressure of firing overcomes the resistance of spring 49, permitting arms

39 of the T-shaped punch and vent member to engage surfaces 44, to slide upon the same with a turning movement, and then to drop off said surfaces rearwardly into cross-channel 52, said member coming to rest in the position of Fig. 2, with vent 41 and pellet 51 in operative relation to passage 37 and the punch end resting on the bottom of recess 53 of the fuse plug, whereby flame-transmitting communication is established between cap 35 and delay action train 63. The hammer block is now free to move forward upon suitable retardation of the projectile to force cap 35 against firing pin 36. Recess 56 in the punch member is in alinement with conical end 29 of the impact pin. The mechanism for setting the delay action train in operation, and also the mechanism for cutting it out, are now ready to operate instantly when the proper conditions arise.

In the meantime the locking spring 92 has been compressed by the setback, thus releasing carrier member 72, which is forced rearwardly by the setback, screwing through safety partition 23 and projecting into the booster chamber, this movement being timed and regulated as before explained, and, in the case of certain constructions within the scope of the invention, being aided more or less by the shell spin also, if the gun rifling is effective. The charge 70 of fulminate or other suitable explosive and the booster charge 82 are thus placed in operative relation to each other, and operative communication with cap 35 and its associated train mechanism is also established. The projectile being now well away from the gun and in flight, with the parts of the fuse mechanism occupying the relative positions shown in Fig. 2, said mechanism is ready to operate in any one of several ways, depending upon the character of the target struck by the projectile.

Assume first that the projectile strikes water. The shock is not sufficiently intense to detonate the charge 70 or any other charge contained in the projectile. Impact pin 28 is not driven in and hence the delay action train is not cut out. By reason of its inertia, the hammer block forces cap 35 sharply against firing pin 36. The resultant flame shoots rearwardly through passage 37, and is guided by groove 42^a against pellet 51, which flashes through 41 to the delay train 63. The delay train may burn for say half a second, for example, at the end of which time the pellets 65, 67 blow across the intervening gap to pellet 76 which ignites charge 70, the latter in turn flashing through opening 82 into the booster 24 which instantly explodes, bursting its inclosing walls and detonating the burster or main shell charge.

The only part of the complete train connecting cap 35 with the burster charge, which consumes more than a negligible time in flame transmission, is the half-second delay action element 63. Consequently the projectile explodes almost exactly half a second after it strikes the water, or after such other period of delay as the delay action element may be designed for. If the projectile be of the diving type, such as that disclosed in my copending application Serial No. 872,816 filed Nov. 18, 1914, (Patent No. 1,188,178, granted June 20, 1916), for example, the projectile will make an under-water run of half a second and will then explode with the same destructive effect as a mine or a torpedo.

Assume now that the projectile strikes squarely thin armor, that is, armor half an inch or less in thickness, or a target offering a resistance of similar intensity. If the charge 70 be designed strictly in accordance with the definition of a "semi-insensitive charge" hereinbefore given, it will not be detonated by the resultant shock. The impact pin will be instantly driven in, however, and, with its conical inner end 29 entering recess 56 of the T-shaped punch member and forcing said member rearwardly, will cause the hard steel punch end 54 to cut through the thin section 55 of relatively soft metal holding the delay train in position, thus exposing pellets 65, 67 to the direct flash from pellet 51, which in the meantime has been ignited by percussion device 35, 36. The delay being thus cut out, the explosion of the burster charge occurs almost instantaneously. Evidently the cutting out of the delay action train would occur in the manner described also in case the charge 70 were either more or less sensitive than a "semi-insensitive charge."

Assume finally that the projectile strikes squarely against heavy armor. The charge 70, if semi-insensitive or of higher sensitiveness and if properly proportioned as hereinbefore explained, will crowd forward against the rear end of plug 79 with such force as to telescope the capsule casing 71 over said plug, thereby developing an intensity of pressure on charge 70 which exceeds the critical explosion pressure for said charge. Said charge will therefore be instantly exploded, sending off the booster and thereby causing substantially instantaneous explosion of the shell charge. The casing 71 may be weighted at the rear to further insure development of pressure of the requisite intensity upon impact with armor. The delay cut-out and percussion device will be operated too, of course, but the shock detonation of charge 70 slightly precedes their operation which is therefore without effect.

If the impact with heavy armor be glancing but sufficiently intense to deform the shell, shock explosion of the detonator charge will occur exactly as in the case of

solid or head-on impact of less intensity. Glancing impact with either heavy or light armor will cause operation of the percussion device 35—36 by reason of the longitudinal component of the resulting retardation of the projectile; and at the same time the lateral component of retardation will cause the reduced rear portion of the fuse plug to break off at the small section connecting it to the forward portion, thereby cutting out the delay action element and insuring practically instantaneous explosion of the main or burster charge of the shell, even though the impact pin may not be driven in.

It is evident therefore that the described construction provides for a delayed explosion of the shell when it strikes water, and for substantially instantaneous explosion thereof when the shell strikes a target of solid material, whether its impact be square or glancing.

The operation of the construction of Figs. 12 and 13 prior to impact has been fully explained in the description of said construction hereinbefore given. Its behavior upon and after impact is the same as described for the construction of Figs. 1 to 10.

In the construction of Fig. 11, the time fuse train (including delay action element 63′, if employed) is not set in operation by impact primarily, but its action is initiated automatically in a well known manner as the projectile is leaving the gun. Prior to firing, the movable charge carrier occupies the same position as shown in Fig. 1, and its movement rearwardly into operative position occurs in exactly the same way as above explained in connection with Figs. 1 and 2. If no impact occurs within the period of time for which the timing device is set, then at the end of that period pellets 65, 67, or their equivalent, are ignited and flash across to the movable detonator charge, which latter, being now in free communication with burster charge 104 detonates the burster instantly. If impact occurs prior to expiration of the time set and no delay action element 63′ is employed, the explosion will be substantially instantaneous due to operation of the percussion device (not shown) included in the "combination" fuse. Or explosion will occur after the small fraction of a second delay occasioned by such delay element if used.

From the foregoing, it is apparent certain features of my fuse mechanism, such as the movable charge carrier and its controlling mechanism, for example, are capable of use separately and apart from certain other features shown combined therewith in Figs. 1 and 2; and the invention is therefore to be understood as extending to such use.

While I have specified certain materials as entering into practical constructions embodying the principles of my invention, nevertheless it is not to be inferred that the invention is in any sense limited to the use of these specific materials, since they are herein mentioned only for the purpose of disclosing the best form of the invention at present known to me. It is evident too that by suitably modifying the constructions here shown by way of examples, the broad principles of the invention can readily be embodied in a base fuse instead of in a nose fuse. The invention is therefore to be understood as including broadly all combinations in this art fairly coming within the appended claims.

What I claim is:—

1. In a shell, the combination, with a burster charge and a detonator charge, said charges being normally in inoperative relation to each other, of means operable directly by set-back pressure of firing to establish operative relation between said charges, and means for controlling the rate at which such relation is established.

2. In a shell, the combination, with a burster charge and a detonator charge, said charges being normally in inoperative relation to each other but being relatively movable into operative relation, of means operable directly by set-back pressure of firing to effect such relative movement into operative relation, and means for controlling the rate of such movement.

3. In a shell, the combination of a burster charge, a movable detonator charge, a safety chamber wherein said detonator charge is normally maintained in inoperative relation to said burster charge, a carrier member movable directly by set-back pressure of firing to transfer said detonator charge from said safety chamber into operative relation to said burster charge, and an inertia speed governor associated with said carrier member and arranged to control the movement thereof.

4. Firing mechanism for projectiles comprising, in combination, a safety chamber, a detonator charge normally maintained therein but movable out of said chamber by firing of the projectile from a gun, and a delay action train arranged to be set in action by impact with water and to explode said detonator after a delay of at least about one-half second.

5. Firing mechanism for projectiles comprising, in combination, a safety chamber, a detonator charge normally maintained therein but movable out of said chamber by firing of the projectile from a gun, a delay action train arranged to be set in action by impact with water and to explode said detonator after a delay of at least about one-half second, and provision for eliminating the delay when the projectile strikes a solid target.

6. In a shell, the combination of a burster

charge, a safety chamber having a suitable wall traversed by a passage, and a movable detonator charge carrier closing said passage and normally located in said safety chamber in inoperative relation to said burster charge but rotatable directly by set-back pressure through the passage in said wall into operative relation to said burster charge.

7. In firing mechanism, the combination of a strong-walled safety chamber, a threaded passage extending through a wall of said chamber, and a threaded charge-carrier fitting and movable within said passage.

8. In a shell, the combination, with a burster chamber, of a detonator safety chamber normally isolated therefrom, and means operable directly by set-back pressure of firing to establish communication between said chambers.

9. In a shell, the combination, with a burster chamber, of a detonator safety chamber normally isolated therefrom, and a threaded member adapted to screw through a threaded passage in a wall of said safety chamber and thereby to establish communication between said chambers.

10. Firing mechanism for projectiles comprising a walled safety chamber, a hollow carrier member normally within said chamber but movable by setback through a wall thereof and having a detonation aperture, and a detonator capsule disposed within said hollow carrier member and exposed through said aperture only to the interior of the safety chamber when the carrier member is in safety position, and exposed outside the safety chamber when the carrier member has moved through the safety chamber wall.

11. Firing mechanism for projectiles comprising a walled safety chamber, a detonator charge therein, and a member fitting within a passage through a wall of said safety chamber and normally preventing communication between the interior and exterior of said chamber by way of said passage, said member being movable in said passage directly by set-back pressure of firing to establish such communication.

12. Firing mechanism comprising a fuse stock containing a walled safety chamber, a threaded charge carrier arranged normally to maintain a detonator charge inoperative within said chamber but adapted to screw through a wall of said chamber and thereby to render said detonator charge operative, and a boring end on said charge carrier.

13. Firing mechanism comprising a fuse stock containing a safety or expansion chamber, and a charge carrier arranged normally to maintain a movable detonator charge in non-detonating position within said chamber, but capable of a screwing movement through a wall of said chamber to bring said charge into detonating position.

14. Firing mechanism comprising a fuse stock containing a safety or expansion chamber, a charge carrier arranged normally to maintain a detonator charge in non-detonating position within said chamber, but capable of a screwing movement through a wall of said chamber to bring said charge into detonating position, and a controlling member so connected with said carrier as to be rotated by the screwing movement of said carrier and thereby to affect the speed of said movement.

15. In a shell, the combination of two chambers separated by a wall and normally substantially non-communicating, and means fitting in a passage extending through said wall, said means being movable in said passage directly by set back pressure of firing to establish communication between said chambers, provision being also made to control the rate of movement of said means.

16. In a shell, the combination with a burster charge, a safety chamber, and a detonator charge normally maintained inoperative within said safety chamber, of means operable by motion of the projectile in flight to move said detonator charge into operative relation to said burster charge, and provision for controlling the rapidity with which such transfer may be effected.

17. Firing mechanism comprising a fuse stock containing a safety or expansion chamber, a charge carrier having a screw portion movable longitudinally of the fuse stock through a screw-threaded aperture at the rear of said chamber, a member rotatable with respect to said fuse stock but incapable of more than slight longitudinal movement relatively thereto, and a sliding connection between said member and said carrier whereby screwing movement of the carrier produces rotational movement of said member.

18. Firing mechanism comprising a fuse stock containing a safety or expansion chamber, a charge carrier having a screw portion movable longitudinally of the fuse stock through a screw-threaded aperture at the rear of said chamber, a member rotatable with respect to said fuse stock but incapable of more than slight longitudinal movement relatively thereto, and a cross-head on said carrier slotted to engage a longitudinal key on said member, whereby screwing movement of the carrier produces rotational movement of said member.

19. Firing mechanism comprising a detonator charge containing fulminate of mercury arranged in a column of such length as to be explosible by shock of impact against heavy armor, but not to be explosible by shock of impact against water.

20. Firing mechanism comprising a detonator charge of fulminate of mercury arranged in a column of such length as to be explosible by shock of impact against heavy armor, but not to be explosible by shock of impact against water, and means whereby said charge may be automatically moved from a non-detonating to a detonating position when the projectile with which the firing mechanism is used is fired.

21. In a shell, the combination, with a burster charge not explosible by shock of impact against heavy armor, of a detonator charge comprising a body of explosive containing fulminate of mercury arranged in a column of such length as not to be explosible by shock of impact against water but to be explosible by shock of impact against heavy armor.

22. In a shell, the combination, with a burster charge not explosible by shock of impact against heavy armor, of a detonator charge comprising a body of fulminate of mercury arranged in a column of such length as not to be explosible by shock of impact against water but to be explosible by shock of impact against heavy armor, said detonator charge being normally incapable of detonating said burster charge, but being arranged to be automatically rendered capable of such detonation when the shell is fired from a gun.

23. In a shell, the combination, with a burster charge not explosible by shock of impact against heavy armor, of a detonator charge arranged in a column of such length as to be explosible by shock of impact against heavy armor, but not explosible by shock of impact against water, said detonator charge being normally out of detonating relation with respect to said burster charge but being arranged to assume such relation automatically when the shell is fired from a gun.

24. In a shell, the combination, with a burster charge not explosible by shock of impact against heavy armor, of a detonator charge arranged in a column of such length as to be explosible by shock of impact against heavy armor, but not explosible by shock of impact against water, said detonator charge being normally maintained in a position such that explosion thereof would not detonate the burster charge, but being movable by motion of the shell in flight into detonating position.

25. An explosive projectile comprising a burster charge, a combined time and percussion fuse device adapted to produce delayed explosion upon impact with water and substantially instantaneous explosion upon impact with solid material, a detonator charge operatively associated with said fuse device, and a safety chamber in which said detonator charge is normally maintained out of detonating relation to said burster charge, said detonator charge being movable into detonating relation to said burster charge by firing of the projectile from a gun.

26. Firing mechanism for projectiles comprising a cylindrical safety chamber having a rear wall, a device rotarily movable through said rear wall to establish communication between the interior and exterior of said chamber, a governor member rotatable within said safety chamber, and a spline connection between said device and governor member.

27. Firing mechanism for projectiles comprising a cylindrical safety chamber having a rear wall, a charge carrier for normally maintaining a charge in communication only with said chamber, but arranged to be moved rotarily through said rear wall by firing of the projectile to place such charge in communication with the exterior of said chamber, a cylindrical governor located within said chamber and rotatably bearing against said rear wall, and means coupling said charge carrier and said governor while permitting their relative longitudinal movement.

28. Firing mechanism for projectiles comprising a cylindrical safety chamber having a rear wall, a charge carrier for normally maintaining a charge in communication only with said chamber, but arranged to be moved rotarily through said rear wall by firing of the projectile to place such charge in communication with the exterior of said chamber, a cylindrical governor located within said chamber and rotatably bearing against said rear wall, means coupling said charge carrier and said governor while permitting their relative movement, and means for locking said carrier against reverse movement after its rearward movement is completed.

29. Firing mechanism for projectiles comprising a cylindrical safety chamber having a rear wall, a hollow externally threaded charge carrier for normally maintaining a detonator charge in detonating communication only with said chamber, but arranged to screw through said rear wall automatically when the projectile is fired to establish detonating communication between said charge and the exterior of said chamber, a relatively heavy rotatable cylindrical governor within said chamber, an anti-friction thrust bearing between said governor and said rear wall, an abutment limiting forward movement of said governor, and a crosshead rigid with said carrier and slotted to engage a longitudinal rib on said governor, said crosshead having a beveled surface at its forward end, said rib being of such length that when said carrier has reached approximately the limit of its rear-

ward movement, the connection between said governor and crosshead is broken, whereby the governor may rotate after the carrier has stopped, thereby causing the governor rib to ride up over the beveled surface of the crosshead and jam the governor between the crosshead and said abutment.

30. Firing mechanism for projectiles comprising a fuse stock containing a safety chamber, a detonator charge normally maintained within said safety chamber but rotatably movable therefrom into detonating position, and means controlled by said carrier and arranged to facilitate its movement through material outside said chamber.

31. Firing mechanism for projectiles comprising the combination, with a delay action train arranged to be set in action by impact with material offering relatively low resistance, of a detonator charge arranged to be ignited by said train, a safety chamber within which said charge is normally maintained inoperative, means operable automatically upon firing of the projectile to establish detonating relation between said charge and the exterior of said chamber, and means operable by impact with metal or the like to substantially eliminate the delay action of said train.

32. Firing mechanism for projectiles comprising the combination, with a delay action train arranged to be set in action by impact with material offering relatively low resistance, of a detonator charge arranged to be ignited by said train, said charge being movable from non-detonating to detonating position, and means operable by impact with metal or the like to substantially eliminate the delay action of said train.

33. Firing mechanism for projectiles comprising the combination, with a delay action train, of a detonator charge arranged to be ignited by said train, said charge being movable from non-detonating to detonating position, and means operable upon impact of the containing projectile with a solid target to eliminate the delay which would be caused by said delay action train.

34. Firing mechanism for projectiles comprising the combination, with a delay action train, of a detonator charge arranged to be ignited by said train but normally in non-detonating or inoperative position, of a device operable upon impact of the containing projectile with a solid target to eliminate the delay which would be caused by said delay action train, said device being normally in inoperative position, both said detonator charge and the train-shortening device being arranged to assume operative position automatically upon firing the containing projectile from a gun.

35. Firing mechanism for projectiles comprising the combination, with a safety chamber, of a detonator charge normally in communication only with said safety chamber, means operable by set-back pressure of firing to establish communication between said detonator charge and the exterior of said safety chamber, and means for timing such operation.

36. In firing mechanism for projectiles, a detonator charge carrier comprising an elongated member inclosing a charge cavity extending obliquely to the longitudinal axis of said charge carrier to a vent opening in the carrier wall.

37. An explosive projectile comprising the combination, with a high explosive charge, of a detonator capsule, and a hollow carrier member containing said detonator capsule, and normally maintaining the same in non-detonating relation to said charge, but movable by the set-back due to firing of the projectile from a gun to bring said detonator capsule closely adjacent to said charge and directly exposed thereto through a vent opening provided in said carrier member.

38. An explosive projectile comprising the combination, with a high explosive charge, of a safety chamber, and a movable detonator carrier provided with a detonator cavity having a vent opening, a detonator capsule in said cavity, said carrier being normally in such position that said vent opening leads only into said safety chamber, but being movable directly by the set-back due to firing of the projectile into detonating position with said high explosive charge and said detonator capsule in direct communication through said opening.

39. In firing mechanism for projectiles, the combination with a delay action train, of means operable upon impact to shorten said train, said means comprising two members normally out of coöperating relation, but arranged to be brought into coöperating relation automatically by firing of the projectile from a gun.

40. In firing mechanism for projectiles, the combination, with a delay action train, of a train-cutting member normally out of operative position but arranged to move into operative position automatically upon firing of the projectile from a gun, and an impact member arranged to transmit the force of a suitably intense impact to said train-cutting member after the latter has assumed its operative position.

41. In firing mechanism for projectiles, the combination with a delay action train, of a train-cutting member normally out of operative relation to said train but rotatable by set-back pressure of firing into operative relation thereto, a relatively fixed impact pin arranged to be unaffected by impact with water but arranged to be driven in by impact with solid material and thereby

to transmit the force of such impact to said train-cutting member after the latter has assumed its operative position.

42. In firing mechanism for projectiles, the combination, with a delay action train, and percussion means for setting said train in action, of a vent member having a main vent channel and adapted to establish communication between said percussion means and said train, said vent member being provided with a secondary vent for the escape of air or other gas trapped in that end of the vent channel next to said train.

43. Firing mechanism for projectiles comprising ignition means including a cap, a detonator charge movable with respect to said ignition means from a safety or non-operative position into an operative position, barrier means confining said charge but provided with a restricted ignition passage, and a body of quick-burning explosive movable with said charge and arranged to receive the flash from said ignition means and to direct it to said passage.

44. In a projectile, the combination with a burster charge, of a detonator charge normally out of operative relation thereto, means operable by firing of the projectile from a gun to establish operative relation between said charges prior to impact, a time train operable to ignite said detonator and arranged to be set in action by impact with material offering relatively low resistance, and means operable only by impact of higher intensity to eliminate the delay action of said train.

45. In a projectile, the combination with a burster charge, of a detonator charge normally out of operative relation thereto, means operable by firing of the projectile from a gun to establish operative relation between said charges, a delay action train operable to ignite said detonator, and means operable by impact of the projectile with a solid target to shorten said delay action train.

46. In a projectile, the combination, with a relatively insensitive explosive charge, of a safety chamber, a relatively sensitive explosive charge normally in explosive relation to said safety chamber but not to said relatively insensitive charge, a carrier member for said relatively sensitive charge, said carrier being automatically rotatable by firing of the projectile from a gun to establish explosive relation between said charges, and means for controlling the rate of carrier rotation.

47. Firing mechanism for projectiles comprising, in combination, a relatively sensitive explosive charge, a relatively insensitive explosive charge, a safety chamber, said relatively sensitive charge being normally in explosive relation to said safety chamber but not in explosive relation to said relatively insensitive charge, means automatically operable by firing of the projectile from a gun to establish explosive relation between the two charges, and means for producing either delayed or substantially instantaneous explosion of said relatively sensitive charge according to the character of the target struck by the projectile, the arrangement being such that said explosion is delayed when the projectile strikes water but is substantially instantaneous when it strikes metal.

48. Firing mechanism for projectiles comprising, in combination, a relatively insensitive explosive charge, a relatively sensitive explosive charge for detonating said relatively insensitive charge but maintained normally out of explosive relation thereto, means automatically operable by firing of the projectile from a gun for establishing explosive relation between said charges, and means for timing the operation of the first means.

In testimony whereof I hereunto affix my signature.

WILLARD S. ISHAM.