

Dec. 27, 1955

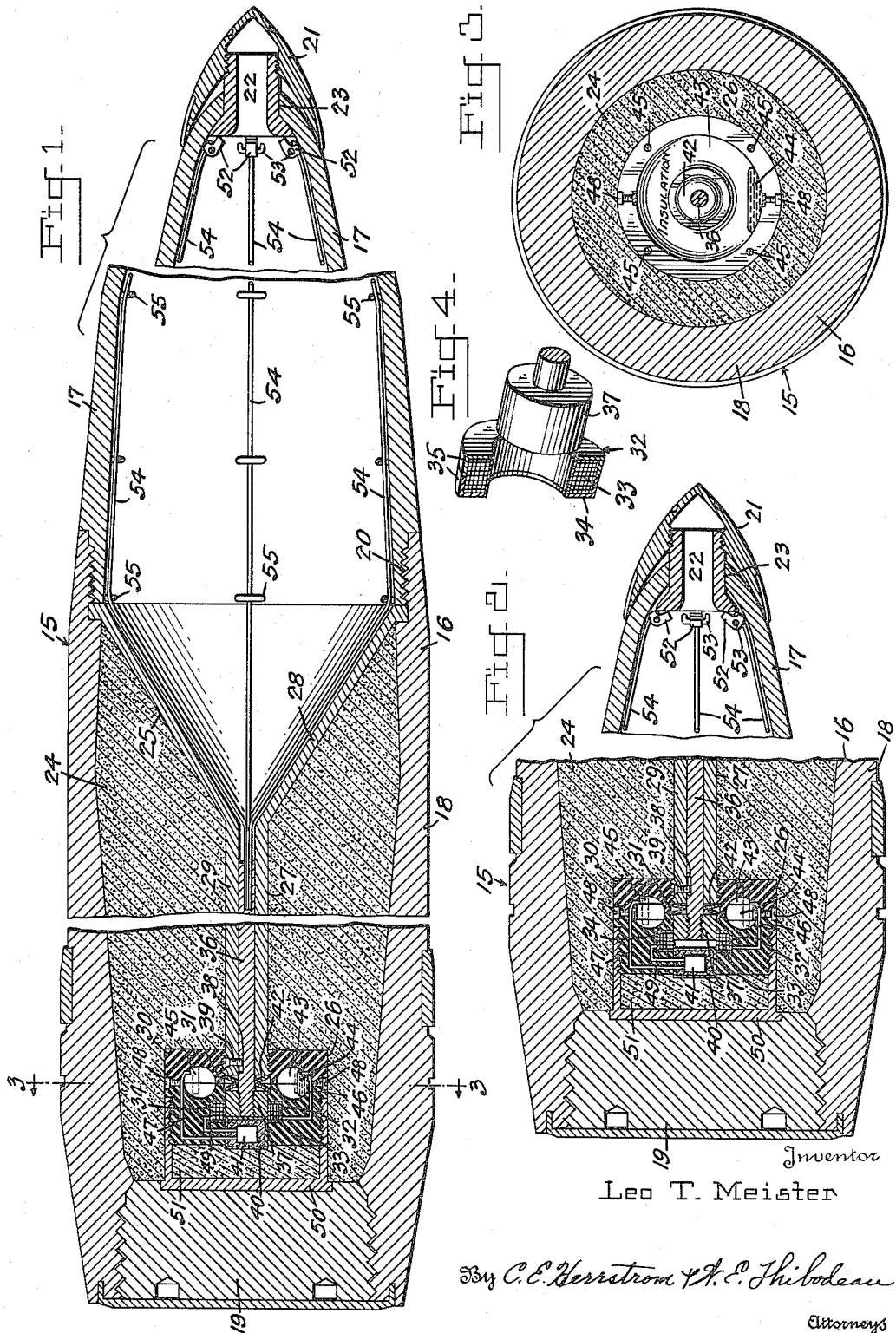
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2,728,296

INSTANTANEOUS DETONATOR FOR HOLLOW CHARGE PROJECTILES

Filed Feb. 27, 1945

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

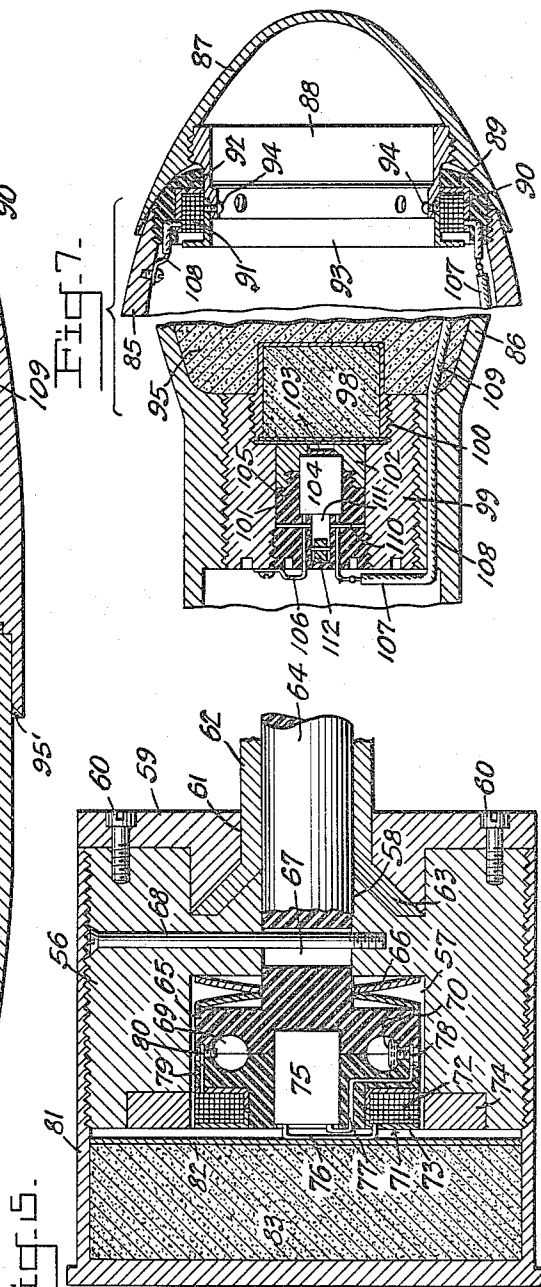
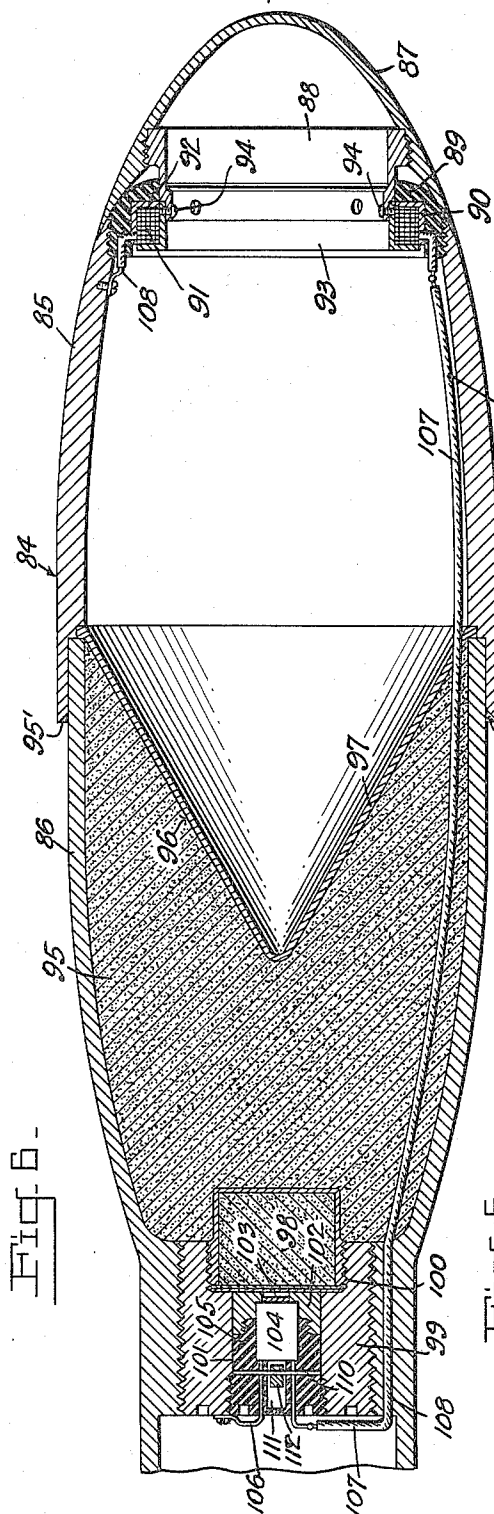
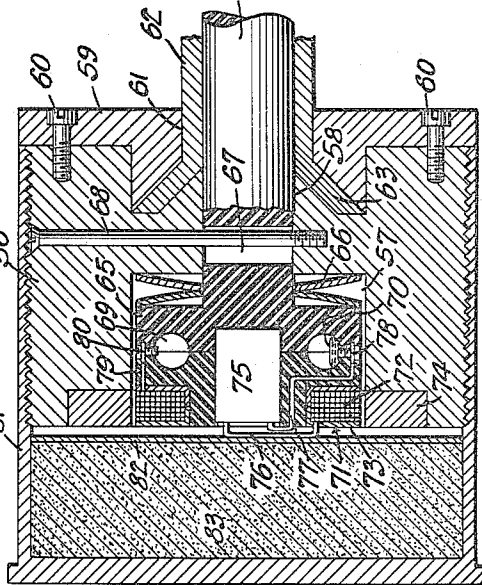


Fig. 5.



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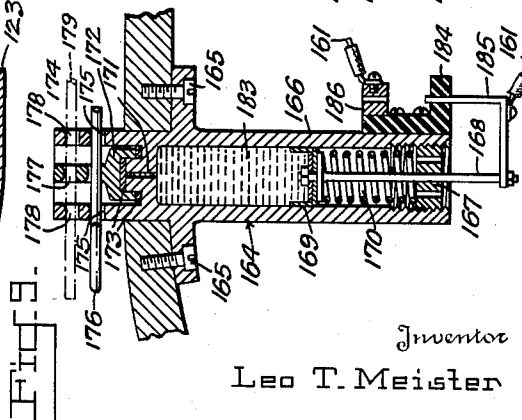
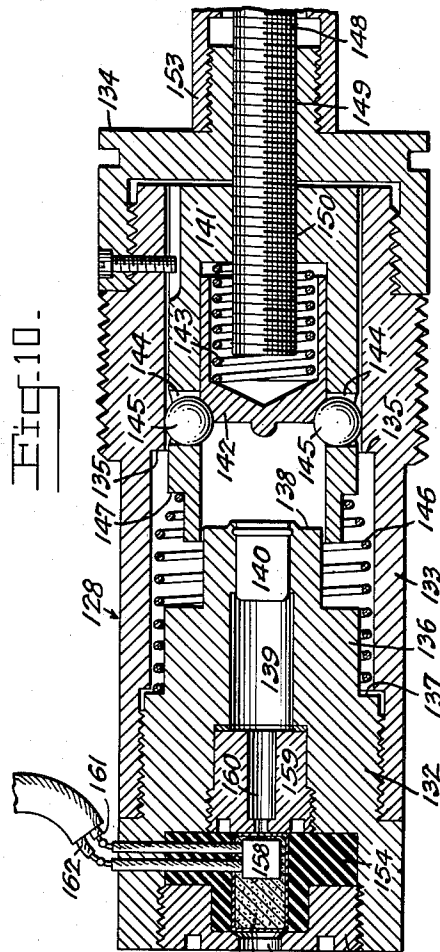
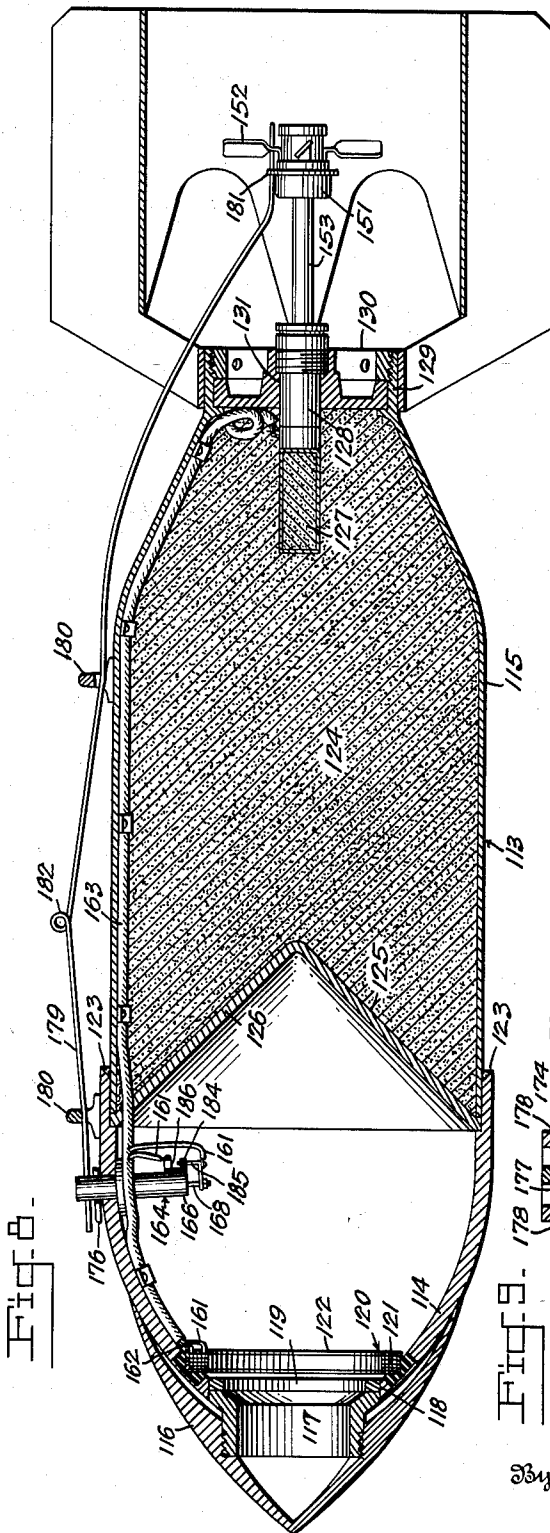
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INSTANTANEOUS DETONATOR FOR HOLLOW CHARGE PROJECTILES

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4 Sheets-Sheet 3



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2,728,296

INSTANTANEOUS DETONATOR FOR HOLLOW CHARGE PROJECTILES

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Application February 27, 1945, Serial No. 580,066

16 Claims. (Cl. 102—70.2)

(Granted under Title 35, U. S. Code (1952), sec. 266)

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

This invention relates to an improved detonator for instantaneously detonating hollow charges of military projectiles such as shells, rockets, bombs, and similar types of devices so that the charge is detonated before the projectile casing can be crushed by impact with the target.

The use of a shaped charge having a conical cavity resulting in a concentration of the blast leaving the cavity into a jet of intense penetrating power has been known for a long time. The development of such a cavity charge for military purposes has only come into general use in the present war and as a result of the discovery of a greatly improved result through the introduction of a thin wall steel cone as a liner for the cavity. These lined cavity charges form jets much more intense and persistent than an unlined cavity. As the present invention does not relate to the charge cavity, per se, a discussion of the cause of the resulting jet will not be undertaken except to state that experiments have proved that it follows a course in axial alignment with the axis of the conical cavity. Likewise, the present invention is not concerned with the angle of the apex of the conical cavity which can be varied, since the critical angle for any particular charge can be readily ascertained by trial and error.

The present invention is principally concerned with providing means for overcoming a serious defect which results when such cavity charges are used in projectiles. This defect arises from two causes. First, with detonators now in use the detonation is not sufficiently quick to occur before the shell case is crushed by impact with the target, and consequently, the cavity of the charge is deformed before the charge occurs thus destroying or practically destroying the resulting penetrating jet. Second, in order for the penetrating jet to function with maximum efficiency a critical standoff distance is essential. This is lost where the nose of the projectile is crushed before the detonation occurs, so that to overcome this and the first mentioned shortcoming of shaped cavity charges, an improved detonator is required which will detonate the charge before the projectile case can be crushed or deformed and before the nose of the projectile can penetrate the target.

It is therefore the primary aim of this invention to provide a detonator for shaped charges which is substantially instantaneous and which will detonate the charge before the projectile case can be crushed to deform the charge cavity and before the nose of the projectile can penetrate the target sufficiently to effect the critical standoff distance of the resulting jet.

As previously mentioned the penetrating jet follows a path corresponding to the axis of the cavity and in order that its maximum effect can be obtained the path of the jet must be unobstructed.

It is therefore a further aim of the present invention to provide a detonator which is so constructed that it will

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not interfere with or in any way obstruct the path of the penetrating jet.

Other objects and advantages of the invention will hereinafter become more fully apparent from a study of the following description in connection with the drawings, which illustrate preferred embodiments of the invention, and wherein:

Figure 1 is a longitudinal substantially central, fragmentary sectional view of one form of the invention incorporated in a projectile;

Figure 2 is a similar view showing the parts in the positions assumed at the instant of detonation;

Figure 3 is a cross sectional view of the detonator taken substantially along a plane as indicated by the line 3—3 of Fig. 1;

Figure 4 is an enlarged fragmentary perspective view of one-half of a field coil and the permanent magnet, shown withdrawn therefrom;

Figure 5 is a fragmentary longitudinal sectional view, on an enlarged scale, of a slightly modified form of the embodiment shown in Figs. 1 to 4;

Figure 6 is a longitudinal substantially central sectional view of a projectile and showing another embodiment of the invention;

Figure 7 is a longitudinal, fragmentary substantial central sectional view of the same and showing the detonator parts in the positions they will assume at the instant of detonation;

Figure 8 is a longitudinal substantially central sectional view of another embodiment of the invention shown in conjunction with an aerial bomb;

Figure 9 is an enlarged central sectional view of a portion of the device shown in Fig. 8;

Figure 10 is a similar view of another portion of the device of Fig. 8;

Figure 11 is an enlarged longitudinal, substantially central section view of a fuse, illustrating another embodiment of the invention, and

Figure 12 is a view similar to Fig. 11 and showing a modification of the fuse disclosed therein.

Referring more particularly to the drawings, wherein like reference characters designate like or corresponding parts throughout the different views, and referring particularly to Figs. 1 to 4, 15 designates generally an artillery projectile including a casing 16 composed of a nose section 17, a trailing section 18 and a plug 19 which threadedly engages and closes the open rear end of the trailing or charge section 18. Section 18 is internally threaded at its forward end to engage the externally threaded rear end of the nose section 17, as seen at 20. The nose section 17 is provided with a movable impact receiving nose portion 21 which is connected to the section 17, for sliding movement relative thereto, by means of a sleeve 22 which slidably engages an opening 23, in the forward end of the nose section 17; and which is provided with a flared inner end which normally bears against the interior of the section 17, to retain the sleeve 22 and the nose portion 21 in position. The trailing section or charge chamber 18 contains a shaped charge of high explosive 24 which is provided with a conical cavity 25 in its forward end, a circular cavity 26 in its rear end and an axially disposed bore 27 connecting the cavities 25 and 26. Cavity 25 is lined with a thin steel wall 28 (shown greatly exaggerated as to thickness in the drawings) which is integral with the tube 29 which lines the bore 27 and which extends slightly into the cavity 26.

Cavity 26 contains a block 30 of insulating material which is shaped to snugly fit the forward part thereof and which is provided with a central bore 31 which aligns with the bore 27 and which has a threaded portion for threadedly engaging the rear end of the tube 29. An annular field coil 32, comprising a winding 33 and an

inwardly opening annular metal channel member 34, is molded in the block 30 around and in communication with the bore 31. As thus seen in Fig. 4, the channel member 34 is divided circumferentially into corresponding sections 35. A rod 36 slidably engages the tube 29 and has one end projecting therefrom into the bore 31, and to which is threadedly connected a permanent magnet 37 which is disposed in the field coil 32 and mounted for movement with the rod 36 relatively thereto. Rod 36 is provided with a longitudinally disposed slot 38 into which extends a guide screw 39, which is mounted in the tube 29, to prevent rotation of rod 36 and the magnet 37. A small booster chamber 40 is mounted in the rear end of the bore 31 and contains a conventional electrical detonator or squib 41 of the type provided with a very light resistance wire, so that a very slight electrical charge is sufficient to detonate the squib 41. Between the rear end of the tube 29 and the magnet 37, one or more spring washers 42 are mounted on the rod 36 to yieldably urge the magnet 37 rearwardly and against chamber 40, to normally hold the magnet in fixed position relatively to the field coil 32. The insulating block 30 is provided with an annular, tubular chamber 43 containing a small quantity of mercury 44. The block 30 is divided transversely through the chamber 43 and connected by fastenings 45 to afford a simple means of forming the chamber 43, but obviously said chamber could be formed in any other suitable manner.

An electrical conductor 46 has one end secured in the chamber 43 and its opposite end connected to the field coil 32. An electrical conductor 47, forming one lead of the electrical detonator 41 has an end extending into the chamber 43, and in spaced apart relationship to the conductor 46. The ends of the conductors 46 and 47 which extend into the chamber 43 are retained therein by set screws 48. A conductor 49, forming the other lead of the detonator 41 extends therefrom to the field coil 32. A cap 50 threadedly engages the rear end of the block 30 and fills the rear portion of the recess 26 and combines with block 30 to form a chamber containing a high explosive forming a booster charge 51. The head of the cap 50 is seated in a recess in the inner end of the plug 19.

A plurality of small bellcranks 52 are fulcrumed at their apexes in the forward end of the nose section 17 by arch-shaped pins 53 which extend into the section 17. The levers 52 have corresponding ends bearing against the inner flared end of the sleeve 22 and the opposite ends of the levers 52 are connected to corresponding ends of wires or flexible members 54. The opposite ends of the wires 54 are secured to the forward end of the rod 36. Wires 54 slidably engage U-shaped guide members 55, the ends of which are secured in the nose section 17 for retaining the wires 54 away from the longitudinal center of the projectile 15, for a purpose that will hereinafter become apparent.

In the form of the invention shown in Figs. 1 to 4, the projectile 15 is of the character adapted to be fired from a rifled barrel and which is rotated thereby in flight. It will be apparent that the projectile 15 prior to being fired is rendered safe due to the fact that the circuit from the field coil 32 to the detonator 41 is interrupted by the gap between the conductor 46 and the conductor 47. Consequently, should the magnet 37 be inadvertently moved relative to the coil 32 the electrical current produced would not be conducted to the detonator 41. Thus, the fuse, constituting the parts contained in the block 30, is in an unarmed condition prior to the time the projectile 15 is fired. Upon being fired, it will be apparent that the projectile 15 will be rotated on its longitudinal axis during flight thus causing the mercury 44, due to inertia, to be spread out into a fine stream or ribbon around the outer part of the chamber 43, as seen in Fig. 2, to thus complete a connection between conductors 46 and 47 through the stream of mercury 44,

In this manner the fuse is armed. Upon striking a target the nose portion 21, on contact with the target, will be forced rearwardly relatively to nose section 17, from its position of Fig. 1, to its position of Fig. 2. This rearward movement of portion 21 will be transmitted to sleeve 22 which in turn will engage and rock the bell cranks 52 to exert a pull on the wires 54 which will be transmitted thereby to the rod 36 and the permanent magnet 37, to move the permanent magnet forwardly, relatively to coil 32. A very slight movement of the magnet 37, much less than that shown between Figs. 1 and 2, is adequate to produce sufficient electrical current in the coil 32 to detonate the squib 41, which will in turn successively detonate the booster 51 and the charge 24. Charge 24 upon being detonated will produce an intense penetrating jet, not shown, which will pass axially through nose section 17, sleeve 22 and the thin forward end of the nose portion 21 and into the target, not shown. The flexible actuating members 54 are extended along the casing section 17 instead of through the center of the projectile 15, so as not to interfere with the jet produced by the charge 24. Furthermore, it will be apparent that the charge 24 is detonated at the instant the nose portion 21 is moved rearwardly by impact, so that the detonation is produced before any part of the projectile casing can be crushed, in order that the cavity 25 will not be deformed; and so that the critical standoff distance between said cavity and the forward end of the projectile will exist at the time of the detonation of the charge 24.

In Fig. 5 a slightly modified form of the embodiment, shown in Figs. 1 to 4 is disclosed. In this embodiment, in lieu of the block 30, a block 56 of non-magnetic material, such as brass, is provided. Block 56 is provided with a recess 57 communicating with a restricted forwardly extending, forwardly opening bore 58. A front plate 59 is secured by fastenings 60 to the forward face of the block 56 and is provided with an opening 61, larger than the bore 58, for receiving a metal liner 62, which replaces the liner 29, and which is provided with a flared rear end 63 which is clamped between portions of block 56 and plate 59. A rod 64, the rear end at least of which is formed of an electrical insulating material, is slidably mounted in the tubular liner 62 and bore 58 and is provided with an enlarged head 65, of the same material, which is reciprocally mounted in the recess 57. Between the head 65 and the inner end of the recess 57 are mounted a plurality of spring washers 66 which urge the head 65 rearwardly and to the position of Fig. 5. The rod 64 is provided with an opening 67 which extends diametrically therethrough, and which is relatively wide in a direction lengthwise thereof. A pin 68 is disposed in the block 56 and extends loosely through opening 67 to limit the reciprocating movement of the rod 64 and its head 65, and to prevent rotation of either the rod or head.

Head 65 is provided with an annular chamber 69, formed in the same manner and for the same purpose as the chamber 43, and containing a small quantity of mercury 70. A field coil 71 is mounted in a recess of the head 65 and includes a winding 72 and an outwardly opening channel member 73 of metal in which the winding is contained. A permanent annular or ring shaped magnet 74 is seated in the block 56 and defines the outer end of the recess 57 and encompasses the field coil 71. Head 65 is provided with an outwardly opening recess for containing an electrical detonator 75, corresponding to the detonator 41, and having an electrical conductor 76 leading therefrom to the coil 71, and a second electrical conductor 77 leading therefrom to a contact 78, which extends into the annular chamber 69. An electrical conductor 79 leads from the field coil 71 to an electrical contact 80, which likewise extends into the annular chamber 69, and which is remotely disposed relatively to the contact 78. A cap 81 is threadedly connected to the block 56 and has a closed end spaced therefrom. A wall or

partition 82 forms a chamber in the outer end of the cap 81 which contains a charge of high explosive forming a booster charge 83 positioned to be exploded by the detonator 75.

In the embodiment disclosed in Fig. 5, the functioning of the nose portion 21 and the wires 54 will be the same as heretofore described, as well as the detonation of the explosive charge, and the jet produced thereby. The fuse structure of Fig. 5 will function in a slightly different manner due to the fact that the field coil 71 is operatively connected to the rod 64, so that coil 71 will be moved forwardly, relatively to the permanent magnet 74, by the pull exerted on the rod 64 through the wires 54, not shown in Fig. 5. This movement of the coil 71, relatively to the magnet 74, will produce the electric current for detonating the squib 75 by the circuit previously described. It will be understood that the fuse assembly shown in Fig. 5 is likewise intended to be mounted in a rotating type projectile so that at the time the rod 64 is actuated the mercury 70 will be making an electrical connection between the spaced contacts 78 and 80, to complete the circuit between the coil 71 and the detonator 75. Squib 75 will detonate the booster 83 which in turn will detonate the explosive charge, not shown. The pin 68 will prevent rotation of the rod 64 and the head 65 to thereby prevent any rotation of the coil 71, contained in the head 65, relatively to the magnet 74, which might otherwise cause premature detonation of the projectile while in flight.

Figures 6 and 7 show another embodiment of the invention incorporated in a projectile of the rocket type and which is characterized by being of a non-rotating construction. In Fig. 6, 84 designates generally the forward end of such a projectile and which includes a nose section 85 and a trailing section 86. The nose section 85 is provided with a movable nose portion 87 which is hollow and to which is threadedly connected an annular member 88, preferably formed of brass. The forward end of the projectile casing 84, formed by the nose section 85, is open and internally threaded to receive and threadedly engage a plastic ring member 89, in which is seated a field coil 90, composed of a winding 91 which is mounted in a metallic member 92, which is angular in cross section. The member 92 has one side thereof forming the periphery of the coil 90 and an inwardly disposed flange, forming the forward end of the coil 90, so that the inner side and the rear face of the winding 91 is exposed. A ring magnet 93 is reciprocally mounted in the field coil 90 and includes an annular portion which is disposed within the coil 90 and an outwardly projecting flange which normally bears against the inner exposed side of said winding. The annular member 88, at its inner end, is offset inwardly to overlap a portion of the permanent magnet 93, and is secured thereto by fastenings 94. The enlarged rear end of the nose section 85 is internally recessed to provide a seat for the open, forward end of the trailing section 86 and the joint thus formed is secured in any suitable manner as by welding at 95'. Section 86 forms a chamber for a charge of high explosive, designated 95, which is provided with a conical cavity 96 at its forward end provided with a lining 97 of steel, which is relatively thin. The conical lining 97 has a flanged mouth which is clamped in the joint formed by the sections 85 and 86. The opposite end of the charge 95 is recessed to partially receive a booster charge 98. Section 86 is provided with a restricted rear portion which is internally threaded to receive and engage a fuse housing 99 which in turn contains a forwardly opening recess 100 for threadedly engaging the rear end of the booster chamber 98, and into which opens the forward end of a bore 101 that extends longitudinally through the housing 99. Bore 101 contains a recessed insert 102, in the forward end thereof, having an opening 103 which communicates with the booster charge 98 and which is recessed to seat the forward end of an electric detonator

or squib 104 and to threadedly engage the forward restricted end of an insert 105, which is formed of an electrical insulating material. One of the conductors 106 of the detonator 104 is grounded to the casing of the projectile 84 and the other conductor 107 thereof extends forwardly through a bore 108, in the restricted rear part of the section 86, through the charge 95 and the wall 97, and through the interior of the nose section 85, and is connected at its opposite end to the field coil 90. Another conductor 108 leads from the field coil 90 and is grounded to the projectile casing. The conductor 107 is provided with a casing of insulating material 109 to electrically insulate it from the projectile casing. A shorting wire 110 has its ends embedded in the insert 105 and extends across and is in electrical contact with the conductors 106 and 107, and therebetween, extends across a chamber 111 in insert 105. Chamber 111 contains a setback operated weight 112 which is loosely mounted therein and through which the intermediate portion of the shorting wire 110 extends.

In order to assemble the projectile 84, the plastic ring 89 is first applied after which the annular member 88 is connected to the magnet 93. The conductor 107 is then connected to the coil 90 and the conductor 108 of the coil is connected to the projectile casing, after which the nose portion 87 is applied. The lining 97 is seated in the nose section 85, after conductor 107 has first been passed therethrough and through the bore 108, after which the section 86 is seated in the section 85 and the annular weld 95' is then formed. The charge 95 is then inserted through the rear end of the section 86 and tamped in place and the booster recess formed therein; after which the booster and the fuse housing 99 are applied, with their inserts 102 and 105. The conductor 106 can then be connected to the projectile casing and a connection made between the ends of the conductor 107, adjacent the detonator 104.

From the foregoing, it will be obvious that parts of the projectile 84 will be in the positions, as seen in Fig. 6, prior to the time the projectile is propelled from a launcher tube or rails, not shown. Consequently, although the nose section 87 is frictionally held against movement relative to the nose section 85, by frictional contact with the plastic member 89 of the forward part 85, should relative movement occur which would produce an electric current in the coil 90, the wire would short this current to prevent the detonator 104 from being energized so that the shorting wire 110 functions as a safety means to maintain the fuse in a disarmed condition, prior to discharge of the projectile. Upon discharge of the projectile, the weight 112 will be set back, shearing the shorting wire 110, between the conductors 106 and 107, as seen in Fig. 7, to thereby destroy the function of the shorting wire 110, and to arm the fuse. Upon impact of the nose portion 87 with a target, said nose portion 87 will be forced rearwardly relative to the nose section 85, as seen in Fig. 7, for transmitting this rearward motion to the permanent magnet 93 through the annular member 88. This will cause magnet 93 to move rearwardly relative to the coil 90, and a very slight movement of the magnet 93 is adequate to produce a sufficient electric current in the coil 90 to energize and detonate the squib 104, which is of the same type as squib 41. The type of coil and magnet shown in Figs. 6 and 7 is especially effective due to the fact that an air gap is created along each edge of the magnet, which materially increases the electric current produced. The detonation of the squib 104 detonates the booster 98 which in turn detonates the charge 95. As in the form of the invention previously described, the cavity 96 results in an intense penetrating jet being produced by the charge 95, which is projected axially through the forward part of the projectile 84 and through the nose portion 87. In order that the conductor 107 will not be in the path of this jet, not shown, said conductor extends along the projectile casing wall, as seen in Fig. 6.

As in the previous embodiment of the invention, it will be readily apparent that this detonation of the charges 95 will be produced at substantially the instant of impact of the nose portion 87 with the target, and before any part of the projectile casing can be crushed and before and substantial penetration of the target occurs, so that the cavity 96 will not be deformed, and the critical standoff distance for the charge will still exist at the time that the jet is produced.

In Figs. 8, 9 and 10 another embodiment of the invention is disclosed and in conjunction with an aerial bomb, for which said embodiment is especially adapted. The bomb, designated generally 113, is provided with a casing including a nose section 114 and a trailing section 115. A movable nose portion 116 is reciprocally mounted relatively to the section 114 and is connected thereto by means of an annular member 117, which threadedly engages the nose portion 116 and which frictionally engages the open forward end 118 of the nose section 114. Member 117 is formed of a non-magnetic material such as brass. A permanent ring magnet 119 is frictionally retained in the opening 118 and is disposed directly behind the member 117. A field coil 120, comprising an annular winding 121 and an annular inwardly opening channel member 122, in which the winding 121 is seated, is seated in a non-magnetic wall in the interior of the nose section 114 and adjacent its open forward end 118. The open rear end of the nose section 114 is internally recessed to receive the open forward end of the trailing section 115 which is seated therein, and said sections are secured together by an annular weld 123. The section 115 forms a charge chamber for a charge of high explosive 124 which is provided with a forwardly opening conical recess 125 having a thin walled steel lining 126, the flanged open end of which is clamped between the sections 114 and 115. The rear end of the charge 124 is recessed to receive a booster 127 and a fuse housing 128. The casing 115 is provided with a restricted open rear end which is annular and internally threaded, as seen at 129, to receive a recessed plug 130, which is threadedly engaged therewith, and which is provided with a central opening 131 through which a portion of the housing 128 extends and which is threadedly secured thereto.

Referring particularly to Fig. 10, housing 128 is formed of a forward section 132, an intermediate section 133 and a rear section 134. Section 132 is provided with a restricted intermediate portion which extends into and threadedly engages the internally threaded open forward end of the section 133. Section 133 is hollow throughout its length and is provided with a forwardly facing step or shoulder 135, intermediate of its ends. The inner end of the forward section 132 is provided with an annular restricted portion 136, forming a rearwardly facing shoulder 137 and a restricted rear end 138. Section 132 is provided with a bore 139 which extends longitudinally therethrough, and the inner end of which is restricted to form a seat for a percussion cap 140. A hollow sleeve member 141 is slidably mounted in the section 133 and has reciprocally mounted therein a cup-shaped firing pin 142. The nipple of the firing pin 142 faces toward and is aligned with percussion cap 140 and upon forward movement is disposed to engage and detonate the percussion cap. The hollow interior of the firing pin 142 houses and seats an expansion spring 143 which bears against the forwardly facing shoulder, adjacent the rear end of the sleeve 141, for normally urging the firing pin forwardly. Sleeve 141 is provided with radial openings 144 containing solid balls 145, which bear against the interior of the section 133, rearwardly of the shoulder 135, and which are held thereby so as to partially extend into the interior of the sleeve 141, to engage the forward end of the firing pin 142 to form detents for holding the firing pin in a retracted position and against the action of the spring 143. An expansion coil spring 146 has one end seating against the shoulder 137 and

the convolutions thereof, at the opposite end of said spring, are reduced in diameter to bear against the forwardly facing shoulder 147, of the sleeve 141, for urging the sleeve rearwardly of the housing 128.

A shaft 148 is provided with a forward end having a left hand thread which extends through and threadedly engages a threaded opening 149, in the section 134, and a threaded opening 150, in the rear end of the sleeve 141. The shaft 148 is journaled adjacent its rear end in a bearing 151 and behind said bearing an arming vane 152 is keyed to the shaft. The blades of the arming vane 152 are pitched so that during the descent of the bomb 113 the arming vane 152 will be rotated by the pressure of the air impinging thereon to turn the shaft 148, so as to unscrew the shaft from the threaded portion 150. The arming vane 152 is rotated sufficiently to unscrew the shaft 148 from the threaded opening 150 of the sleeve 141 during approximately the first 600 feet descent of the bomb 113, for arming the mechanical fuse mechanism, previously described, so that upon impact of the bomb with a target, the sleeve 141 will be driven forward by inertia and against the action of the spring 146. When the sleeve 141 moves forward sufficiently so that the spheres 145 pass the step formed by the shoulder 135, said spheres will be projected radially outward by the pressure of the spring 143, bearing on the firing pin 142, to permit it to be projected forwardly in the sleeve 141 and into engagement with the primer 140, for detonating the primer. The bearing 151 is supported by a sleeve 153, as best seen in Fig. 10, through which the shaft 148 extends. Bearing member 151 contains reduction gears, not shown, and which form no part of the present invention.

The forward fuse housing section 132 contains an electric detonating means which is mounted in the enlarged forward end of its recess 139 and which is contained in a block 154, of an insulating material, which is held in the forward part of the recess 139 by a threaded block 155 having a centrally disposed opening 156 which communicates at its forward end with a booster 127 and at its rear end with a secondary booster 157, in which is disposed an electric detonator or squib 158, corresponding to the squib 41, previously described. Behind the block 154, the recess 139 is provided with an insert 159 having a passage 160 extending therethrough, to combine with the rear portion of the recess 139 and the opening 156 to form a flash passage from the primer 140 to the booster charge 127.

Two electrical conductors 161 and 162 extend from field coil 120 along the interior of the wall of the bomb casing and through the conical lining 126 and the charge 124 and are connected to and form a part of the two electrical conductors of the detonator 158. Between the coil 120 and the fuse housing 128 the conductors 161 and 162 are encased in a tube of electrical insulating material 163.

A safety device, designated generally 164, is mounted intermediate of its ends in the nose section 114, by means of the fastenings 165, and extends through the casing thereof. Said safety device 164 includes a cylinder 166 which extends through the casing section 114 and which, at its inner end, is provided with a threaded plug 167 which is threaded therein and adjustable relatively thereto. Plug 167 provides a bushing for a reciprocating rod 168, which extends therethrough and which is connected at its inner end to a hydraulic piston 169. An expansion spring 170 abuts against the plug 167 and against the piston 169 for urging the piston inwardly of the cylinder 166, and said plug 167 is provided with openings, as seen in Fig. 9, for venting the cylinder 166 behind the piston 169. Cylinder 166, adjacent its opposite end, is provided with a restricted outlet port 171, normally sealed by a closure 172 containing sealing gaskets 173. Closure 172 is slidably mounted and is provided with an eye 174 in its head which registers with aligned openings 175

in the outer part of the cylinder 166, when the closure 172 is in a fully seated position, to receive a safety pin 176. Pin 176 positively retains the closure 172 in sealing engagement with the port 171. Beyond the opening 174 the closure 172 is provided with a second eye 177 which aligns with corresponding openings 178 in the outer part of the cylinder 166 for receiving an end of an arming wire 179. The arming wire 179 extends through and slidably engages guide members 180 which are mounted exteriorly of the bomb casing. The opposite end of the arming wire 179 extends through and slidably engages an opening or notch, not shown, in the flange 181 of the bearing 151 and through one of the blades of the arming vane 152, or between the blades thereof, to prevent rotation of the arming vane 152 while the arming wire 179 is applied, as seen in Fig. 8. Between the guide members 180, the arming wire 179 is provided with an eye 182 which is adapted to be connected to flexible anchor means, not shown, attached to an aircraft, not shown, from which the bomb 113 is to be launched for a purpose hereinafter to be explained. Referring back to the cylinder 166, said cylinder contains a hydraulic fluid as indicated at 183 which is held under pressure by the spring pressed piston 169, and it will be readily apparent that the pressure of the fluid can be varied by advancing or retracting the plug 167, relatively to the cylinder 166. A bracket 184, of insulating material is fastened to the exterior of the cylinder 166, adjacent its inner end, and provides a guide for one end of an angular electrical contact 185, the other end of which is secured to the outer end of the piston rod 168. A fixed electrical contact 186 is fastened to the bracket 184, above and normally spaced from the upstanding end of the contact 185. The conductor 161 is divided intermediate its ends and has one end thereof connected to the fixed contact 186 and its other end connected to the movable contact 185, as best seen in Fig. 8.

The bomb 113 is assembled in the same manner as the projectile 84, as previously described.

As previously mentioned the bomb 113 is intended to be launched from an aircraft in any conventional manner, not shown, but prior thereto the safety pin 176 is removed. A flexible connector, previously mentioned and not shown, attaches the arming wire 179 to the aircraft so that when the bomb 113 is launched the arming wire 179 will be stripped therefrom. This will cause one end of the arming wire to be moved out of engagement with the openings 178 and the opening 177 of the closure 172, to release said closure, which is being held by the arming wire 179, after removal of the safety pin 176. The pressure of the fluid 183 will force the closure 172 away from the port 171 to expose this port to allow the fluid 183 to be ejected therethrough thus permitting the piston 169 to move inwardly of the cylinder 166 under the action of the spring 170. As the piston 169 moves inwardly, the piston rod 168 will move therewith carrying the movable contact 185 which will be moved thereby into engagement with the contact 186 for completing the circuit between the field coil 120 and the detonator 158. Likewise, the arming wire 179 when stripped from the bomb 113 will release the arming vane 152 which will be actuated, as previously described, to arm the mechanical fuse shown in Fig. 10, in the manner heretofore described. The arming vane 152 requires approximately six seconds to arm the mechanical fuse and by adjustment of the plug 167, the length of time required, for the piston 169 to move sufficiently to permit contacts 185 and 186 to close the circuit between the coil 120 and the detonator 158, can be adjusted to arm the electric fuse at approximately the same time.

Upon impact of the nose portion 116 with a target, said nose portion will move inwardly relative to the nose section 114 thereby forcing the annular member 117 inwardly, which in turn will move the permanent magnet 119 toward the field coil 120 to produce an electric cur-

rent through the conductors 161 and 162 to energize and detonate the squib 158. This will occur at substantially the instant of impact so that the charge 124 will be detonated through the boosters 157 and 127 for producing the penetrating jet, in the same manner as previously described in the description of the projectiles 15 and 84, before the cavity 125 can be crushed or before the stand-off distance can be varied sufficiently to affect the penetrating power of the jet. This electrical detonation will occur before the mechanical fuse can function in the manner as previously described, so that the mechanical fuse will perform no function if the electrical detonation occurs. Should the electrical detonator fail to function for any reason, which is improbable, the mechanical fuse will function in the manner previously described and the flash from the primer 140 will detonate the boosters 127 and 157 to detonate the charge 124 to produce a slightly delayed explosion of the bomb 113.

In Fig. 11, another embodiment of the electric instantaneous fuse is disclosed, including an outer fuse housing 187 which is adapted to be screw threaded into the trailing end of a projectile, not shown, such as projectile 15. The housing 187 is provided with a rearwardly opening internally threaded recess 188 for receiving a plug 189, forming a carrier for the fuse assembly which is contained in an annular cavity 190 thereof. The fuse assembly includes the annular tubular member 191 of insulating material, similar to the tubular member 43 and containing a small quantity of mercury 192, and provided with spaced electrical contacts 193 and 194 which extend into the tube. The plug 189 is provided with a central cavity 195 containing an electric detonator or squib 196, corresponding to the squib 41, and having one electrical conductor 197 thereof connected to the contact 193 and its other electrical conductor 198 connected to a field coil 199. Field coil 199 is of annular formation and is disposed in the inner part of the cavity 190 and includes an annular winding 200, contained in an annular, forwardly opening channel member 201 of electrical conducting material. A conductor 202 connects the field coil 199 to the contact 194. The recess 188 extends inwardly or forwardly beyond the forward face of the plug 189 to form a chamber 203 in which is loosely disposed an annular permanent magnet 204, the diameter of which is only slightly less than that of the chamber 203 but the thickness of which is substantially less than the thickness of the chamber, so that the magnet 204 is capable of sliding movement longitudinally of the fuse housing 187 but incapable of any sliding movement transversely thereof. A retaining pin 205 is mounted in the housing 187 and extends into a recess 206 in the periphery of the magnet 204. Recess 206 is elongated in a direction transversely of the magnet 204 to permit said magnet to move in a direction lengthwise of the fuse, but said pin effectively prevents any rotation of the magnet within the chamber 204.

The forward, restricted end 207 of the fuse housing 187 is externally threaded to be engaged by a cap 208 the closed end of which is spaced from the forward end of the extension 207 to form a chamber containing a booster charge 209. Extension 207 is provided with a centrally disposed flash passage 210 which communicates with the cavity 203, the opening through the center of magnet 204 and the cavity 195 to form a continuous flash passage between the detonator 196 and the booster 209. The extension 207 contains a plurality of inwardly extending radially disposed and inwardly spring pressed pins 211 having beveled inner ends which bear against a beveled edge of the periphery of the magnet 204 to normally retain said magnet in a fixed position against the field coil 199. The springs 212 of the pins 211 are held under tension by bearing against portions of the cap 208. The extension 207 is provided with a substantially radially disposed internally threaded opening 213 which communicates with the passage 210 and in which is seated a recessed plug 214, forming a seat for an expansion coil

spring 215 and a guide for a slidably mounted substantially radially disposed partition or closure 216. Closure 216 has an inner end which is substantially half circular in cross section and which extends through and closes flash passage 210, intermediate the ends thereof, and which is held normally in a closed position, as seen in Fig. 11, by the pressure of the spring 215.

The fuse shown in Fig. 11 is adapted to be mounted in a rotatable type projectile such as the projectile 15. The fuse is normally maintained in a safe, disarmed position by the circuit breaker formed by the spaced contacts 193 and 194 which prevents an electric current being transmitted from the field coil 199 to the squib 196. Also, the pin 205 and the pins 211 function to normally prevent any movement of the magnet 204 to provide a further safety feature; and still another safety feature is afforded by the partition 216 which seals the passage between the squib 196 and the booster 209. When a projectile, with the fuse shown in Fig. 11 mounted therein, is fired, the rotation of the projectile on its longitudinal axis will cause the mercury 192 to complete the electrical circuit between the contacts 193 and 194, in the manner previously described; will cause the pins 211 to be retracted against the action of their springs 212 to release the magnet 204; and will cause the partition 216 to be retracted into the guide 214 and against the action of spring 215 to open the flash passage 210, all by centrifugal force. The magnet 204 will be held against any forward sliding movement by inertia during the flight of the projectile, but upon impact of the projectile with its target, said magnet will be moved forward in the chamber 203 by the force of inertia to produce an electric current in the coil 199 to detonate the squib 196 and the booster 209 for instantaneously exploding the charge, not shown, in the projectile in which the fuse is mounted, to thereby accomplish the same result as the fuses shown in the other embodiments, previously described.

Fig. 12 shows a slightly modified form of the fuse structure shown in Fig. 11 and wherein a housing 217 is adapted to be screw threaded into the trailing end of a rotatable type projectile, such as the projectile 15 of Fig. 1. The housing 217 is provided with a hollow forward portion containing an annular tube 218 of insulating material which functions in the same manner and for the same purpose as the tube 191. An electrical field coil 219, corresponding to the field coil 199, is moulded into an electrical insulating block 220, in which the tube 218 is formed, and is connected in the same manner to the contacts of the tube and to an electric detonator or squib 221. The squib 221 is mounted in the central opening of the coil 219. The forward end of the opening, formed by the coil 219, is sealed by a closure 222, and forwardly of said coil, the insulating block 220 and the forward end of the housing 217 combine to form a cavity 223, for the same purpose as cavity 203, which contains a permanent magnet 224 mounted therein, in the same manner and for the same purpose as the magnet 204, and retained relatively thereto, in the same manner and for the same purpose, by a pin 225, corresponding to the pin 205, and spring pressed pins 226, corresponding to the pins 211. The block 220 combines with the rear part of the housing 217 to form a chamber for a booster charge 227, and said block 220 is provided with a centrally disposed flash passage 228 normally closed by a partition 229, mounted in the same manner and for the same purpose as the partition 216.

Thus it will be apparent that when the fuse of Fig. 12 is rotated in flight in a projectile, not shown, in which it is mounted, the contacts of the tube 218 will be electrically connected by the mercury contained therein, the pins 226 will be retracted, and the partition 229 will likewise be retracted, all by centrifugal force, for arming the fuse ready to be discharged upon impact of the projectile with its target. Upon such impact, a forward movement of the magnet 224 by inertia will produce the

electric charge for detonating the squib 221, the booster 227 will be detonated thereby to produce a flash which will burst the perimeter of the booster casing in all directions to uniformly detonate the main projectile charge, not shown, at its rear end to produce a very uniform explosion of the charge. The invention as embodied in Figs. 11 and 12 forms the subject of my divisional application Serial Number 115,307, filed September 12, 1949, now Patent 2,688,921, dated September 14, 1954.

Various other modifications and changes in the embodiments of the invention as herein disclosed are contemplated and may obviously be restored to without departing from the spirit and scope of the invention as hereinafter defined by the appended claims, as only preferred embodiments of the invention have been illustrated and described.

I claim:

1. A projectile fuse comprising in combination with an electric detonator and electrical means connected therewith and energized by the impact of the nose of the projectile with a target for exploding the detonator; a centrifugally operated switch interposed in the circuit of the detonator and electrical means, and including an annular tube of insulating material containing a small quantity of mercury, and spaced contacts connected to parts of the circuit and extending into the tube, said mercury reacting to the rotation of the projectile in flight to form a ring electrically connecting the contacts for closing the switch.

2. An aerial bomb fuse comprising in combination with an electric detonator, electrical means connected therewith and energized by the impact of the bomb with a target for exploding the detonator, and a strip wire carried by the bomb and connected to an airplane from which the bomb is launched and stripped from the bomb by the movement of the bomb relatively to the airplane; an arming switch interposed in the circuit between the electrical means and detonator, a body of fluid under pressure normally holding said switch in open position, and means operated by the removal of said strip wire to release the pressure of said fluid and thereby permit movement of said switch toward a closed position for arming the bomb fuse at a predetermimed time after the bomb is launched.

3. A projectile having a movable nose portion and a shaped charge provided with a forwardly opening conical cavity; comprising mechanically operated electrical means, an electric detonator electrically connected thereto, said electrical means being disposed in the tail end of the projectile, said mechanical means connecting the electrical means to said movable nose portion of the projectile for energizing the electrical means when the nose portion is actuated by impact with a target, said mechanical means being disposed out of alignment with the axis of the projectile.

4. In a projectile, the combination of a casing, a shaped charge in the rear portion of said casing and shaped to provide a forwardly-directed cavity, an electrically-operated detonator at the rearward portion of and in detonating relation with said charge, electrical induction means for energizing said detonator, a hollow nose supporting portion secured to said casing forwardly of said charge, a nose movably attached to said portion and adapted to be moved relative thereto upon impact, and means connecting said nose to said induction means to energize said detonator upon said relative movement of said nose upon impact, said connecting means extending along and closely adjacent the inner side walls of said casing in the space between said shaped charge and said nose, whereby said space is substantially unobstructed.

5. In a projectile, the combination of a casing, a shaped charge therein and having a conical cavity at one end, an electrically-operated detonator in said charge spaced from the apex of said conical cavity, a hollow

member secured to said casing in the vicinity of said conical cavity and extending beyond said charge, a nose member movably attached to said hollow member and adapted to be moved relative thereto upon impact of the projectile with an object, an electrical coil means secured to one of said members, an electrical circuit connecting said coil means to said detonator, a magnetic means movably associated with said electrical coil means for generating current therein and secured to the other of said members, a device associated with said electrical circuit to prevent the flow of current therein to said detonator, means connected with said device adapted to become activated after movement of the projectile has been initiated and before impact of the same to render the device inoperative to prevent the flow of current to the detonator whereby upon impact said nose will cause relative movement between said coil and magnetic means thereby generating current to energize said circuit to explode said detonator and thereby said charge.

6. In a projectile, the combination of a casing, a shaped charge therein and having a conical cavity at one end, an electrically-operated detonator in said charge spaced from the apex of said conical cavity, a hollow member secured to said casing in the vicinity of said conical cavity and extending beyond said charge, a nose member movably attached to said hollow member and adapted to be moved relative thereto upon impact of the projectile with an object, an electrical coil means secured to one of said members, an electrical circuit connecting said coil means to said detonator, a magnetic means movably associated with said electrical coil means for generating current therein and secured to the other of said members, whereby upon impact said nose will cause relative movement between said coil and magnetic means generating current to energize said circuit to explode said detonator and thereby said charge.

7. In a projectile, the combination of a casing, a shaped charge in the rear portion only of said casing and provided with a forwardly-directed conical cavity, an electrically-operated detonator mounted in said charge, electrical means for energizing said detonator, a hollow nose supporting portion secured to said casing in the vicinity of said cavity and extending forwardly of said charge, a nose movably attached to said portion and adapted to be moved relative thereto upon impact, means connecting said nose with said electrical means whereby upon said relative movement of said nose upon impact said electrical means will operate to energize said detonator to explode the same and thereby the charge, said last-named means extending along and closely adjacent the inner side walls of said casing in the space between said shaped charge and said nose, whereby said space is substantially unobstructed.

8. In a projectile, the combination of a casing, a shaped charge therein provided with a forwardly-directed cavity, an electrically-operated detonator mounted in the rear portion of said charge, electrical means for energizing said detonator, a device associated with said electrical means for rendering the same inoperative to affect said deonator, means attached to said device adapted, after movement of the projectile has been initiated and before impact of same, to render said device inoperative whereby said electrical means is placed in an operative condition to energize said detonator, a hollow nose supporting portion secured to said casing in the vicinity of said cavity and extending forwardly of said charge, a nose movably attached to said portion and adapted to be moved relative thereto upon impact, means connecting said nose with said electrical means whereby upon said relative movement of said nose upon impact said electrical means will operate to energize said detonator to explode the same and thereby the charge, said last-named means being closely adjacent the walls of said casing between said shaped charge and nose to thereby leave unobstructed the space between said charge and nose.

9. In a projectile, a hollow casing, a shaped charge in said casing having a forwardly opening cavity, a nose portion over the forward end of said casing and movable relatively to said casing on impact, an induction coil carried by said casing adjacent said nose portion, a magnet carried by said nose portion in position to induce a voltage in said coil on impact, electrically-energized means for detonating said charge, and a circuit including said coil and means.

10. A projectile comprising a shell casing, a shaped charge in the rear portion of said casing, said charge having a forwardly-opening cavity, a nose carried by said casing and movable with respect thereto on impact, means carried by said nose and casing and cooperable to generate a voltage in response to movement of said nose as aforesaid, a squib in detonating relation with said charge, an electric circuit including said generating means and squib, means normally preventing the flow of current to said squib, and means responsive to movement of said projectile in flight for rendering said flow-preventing means inoperable to thereby arm said projectile.

11. In a projectile fuse for detonating shaped charges, said fuse comprising an electrical coil, a permanent magnet disposed for movement relatively to the coil on impact of the projectile with a target, for producing an electric current in the coil, an electric detonator adapted to explode said charge and electrically connected to the coil, safety means interposed in the circuit of the coil and detonator, actuated after initiation of the movement of the projectile in which the fuse is mounted, for completing a circuit to the detonator whereby the detonator will be discharged by a movement of the magnet relatively to the coil upon impact, said coil being mounted in the nose of the projectile, said projectile nose being provided with a movable impact receiving portion, said magnet being connected to the movable nose portion.

12. In a projectile, a hollow casing, a shaped charge in said casing having a forwardly opening cavity, a nose portion over the forward end of said casing and movable relatively to said casing on impact, an induction coil carried by said casing adjacent said nose portion, a magnet carried by said nose portion in position to induce a voltage in said coil on impact, electrically-energized means for detonating said charge, a circuit including said coil and means, a switch in said circuit, means urging said switch into movement toward closed position, fluid pressure means normally opposing said movement, and means responsive to initial movement of said projectile for releasing the pressure of said fluid pressure means to thereby permit closing of said switch and arming of said projectile.

13. In a projectile, a generally cylindrical casing having an ogival nose portion, a charge in the rearward portion of said casing, said charge having a forwardly-directed cavity, a cap portion over said nose portion and movable rearwardly with respect to said nose portion on impact of said projectile, induction means including a coil carried by one said portion and cooperative to induce a voltage in said coil in response to relative movement of said portions, a primer in detonating relation with said charge, a circuit for detonating said primer, said circuit including said coil and an arming switch, spring means urging said switch into closed position, means including a body of fluid under pressure for resisting the action of said spring means, and means responsive to launching of said projectile for releasing the pressure of said fluid.

14. A projectile comprising a shell casing, a shaped charge in the rear portion of said casing, said charge having a forwardly-opening cavity, a nose carried by said casing and movable with respect thereto on impact, generating means actuated by relative movement of said nose and casing and cooperable to generate a voltage in response to movement of said nose as aforesaid, a squib in detonating relation with said charge, an electric circuit including said generating means and squib, means nor-

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mally preventing the flow of current to said squib, means responsive to movement of said projectile in flight for rendering said flow-preventing means inoperable to thereby arm said projectile, said generating means comprising a solenoid and cooperating magnet movable with respect to said solenoid in response to impact, to generate a voltage therein, lever means carried by said casing and pivoted in response to movement of said nose, and flexible cable means connecting said lever means and magnet to move the latter.

15. In a projectile, a hollow casing, a shaped charge in said casing having a forwardly opening cavity, a nose portion over the forward end of said casing and movable relatively to said casing on impact, an induction coil carried by said casing adjacent said nose portion, a magnet carried by said nose portion in position to induce a voltage in said coil on impact, electrically-energized means for detonating said charge, a circuit including said coil and detonating means, a shorting element electrically connecting the lead wires to said detonating means, and a set-back actuated element engaging said shorting element and operable to shear the same in response to firing of said projectile.

16. A projectile as recited in claim 15, dielectric means forming a toroidal chamber coaxial of the rotation axis

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of said projectile, a globule of electrolytic liquid in said chamber, and first and second electrical contacts in diametrically opposite relation in said chamber and connected in said circuit, said liquid forming a ring in response to spinning of said projectile to electrically connect said contacts and close said circuit.

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