

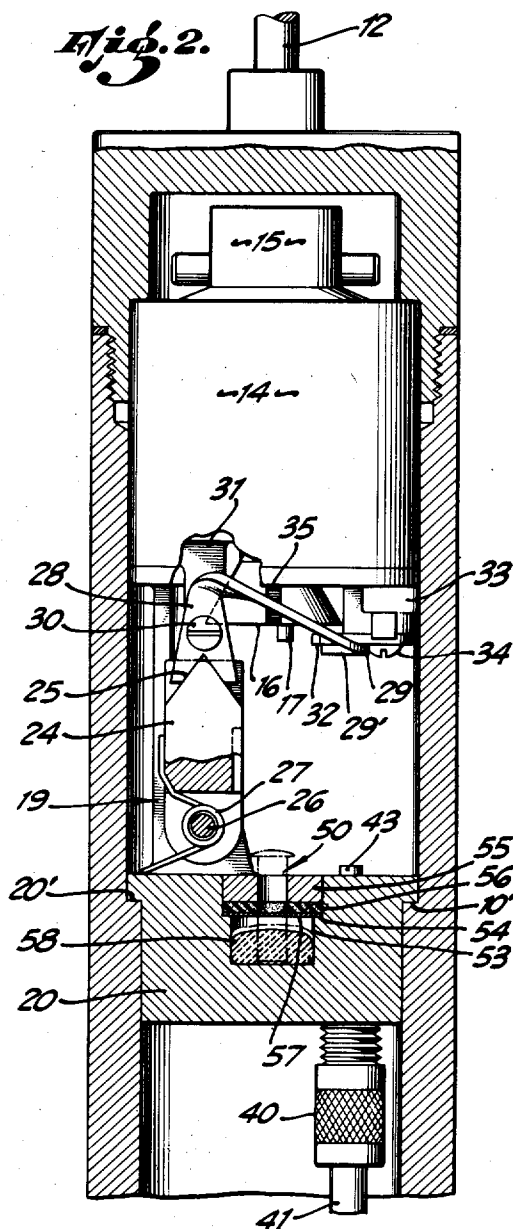
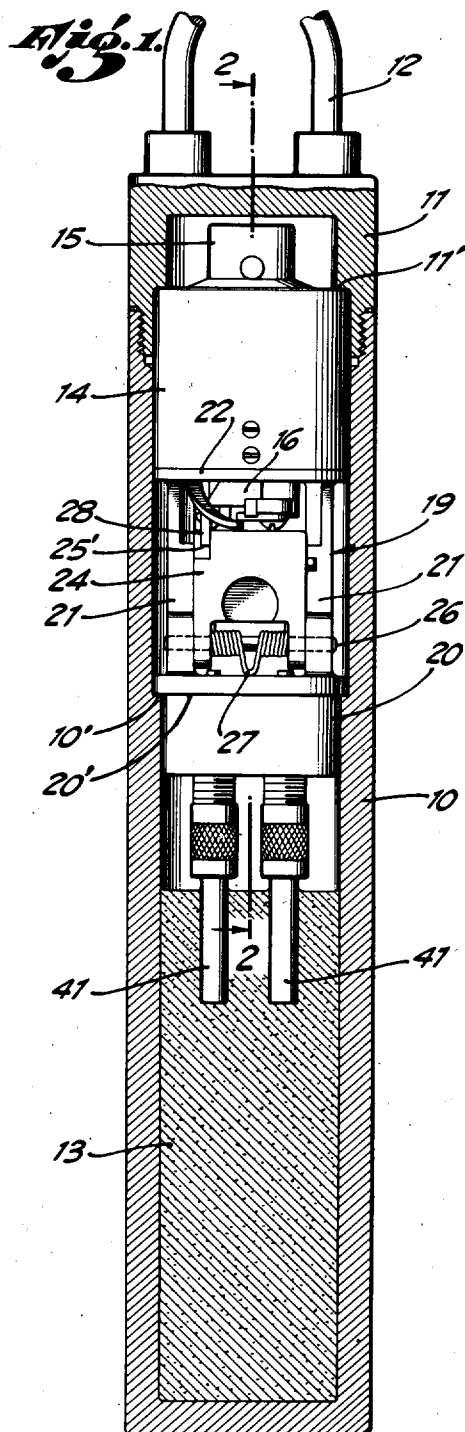
Feb. 23, 1954

G. O. SHULL ET AL
SAFETY DEVICE

2,669,929

Filed March 13, 1947

2 Sheets-Sheet 1



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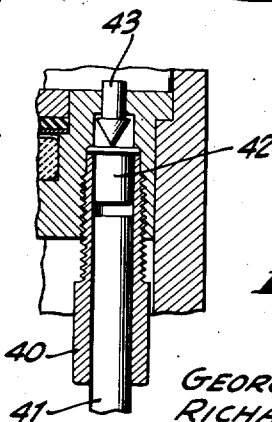
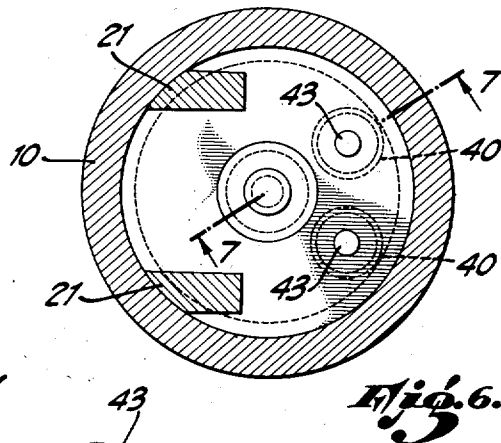
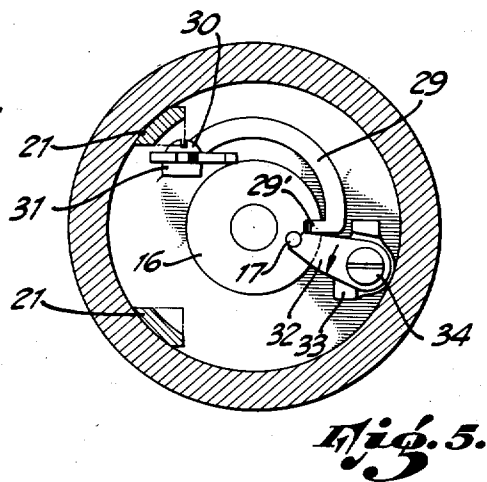
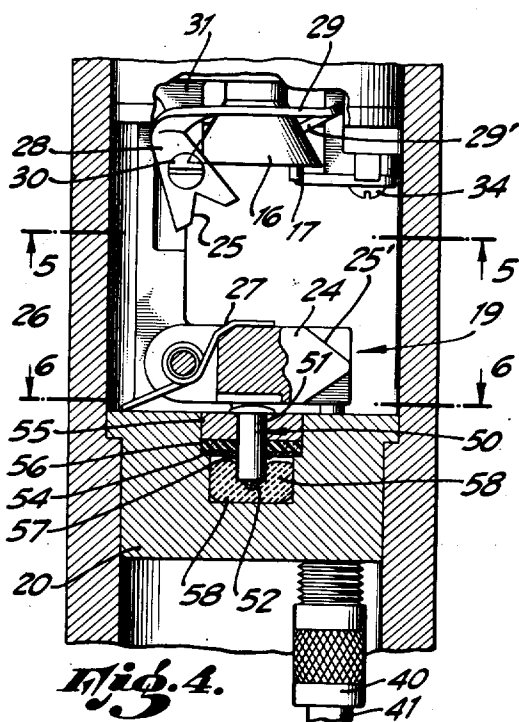
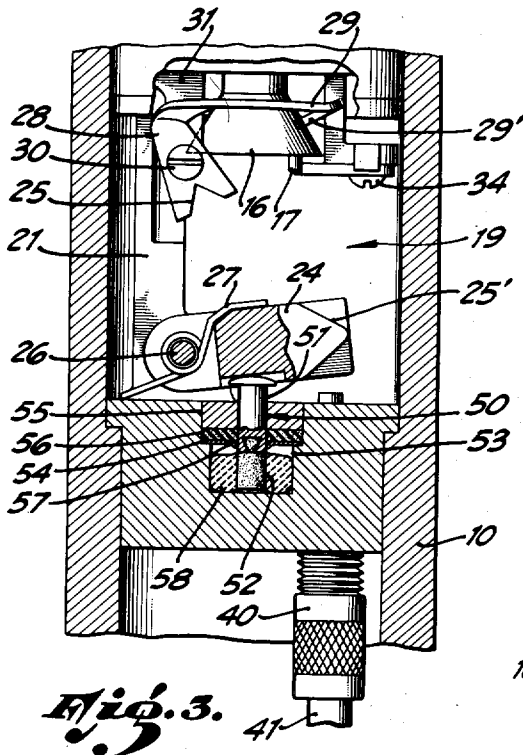
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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SAFETY DEVICE

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6 Claims. (Cl. 102—20)

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The present invention relates generally to timing mechanisms and safety devices for preventing the premature operation of delayed action apparatus, and more particularly to timing mechanism and a safety element adapted to be incorporated in torpedoes used in oil well shooting. It is to be understood that the safety device described herein is suitable for use in various types of delayed action mechanisms, and is not limited to the specific use illustrated herein.

Oil well torpedoes of the class above referred to are used to shatter the surrounding structure at the oil-producing level in wells whereby to increase the accumulation of oil, and for other purposes. The usual practice is to lower one or several containers of nitroglycerine to the desired level in the well and then to superimpose thereon a time bomb or torpedo containing an explosive such as blasting gelatin or TNT which detonates after a predetermined delay time and fires the nitroglycerine.

The torpedo described herein and incorporating the safety device of the invention is of the general class wherein detonation is effected by one or more percussion caps which are fired by a spring operated hammer. The hammer is held in a cocked position by a primary timing device and released after a predetermined delay time has elapsed.

The present invention deals with safety means for rendering the firing mechanism of the time bomb or torpedo inoperative for a predetermined, initial "safety" period during which the torpedo is being lowered into the well.

The primary time delay in some torpedoes of the class described is achieved by means of a spring wound clock which is arranged to trip a hammer which fires the percussion cap or caps at a predetermined time as above described.

Since oil well torpedoes are expendable items, the clocks used therein are preferably of inexpensive construction. Furthermore, these clocks are occasionally subjected to somewhat rough handling such as may damage the mechanism. If part of the clock escapement is damaged in this manner, the clock may "race" and produce a premature detonation of the torpedo with obvious disastrous results.

To prevent such accidents it is desirable that a safety device be installed in the torpedo to act independently of the timing mechanism to prevent detonation within a predetermined safety period. Furthermore, such a safety device should positively prevent contact of the hammer with the firing pins or other detonating elements.

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It has been the usual practice to incorporate safety devices which merely act to block the delay mechanism and prevent tripping of the detonating hammer, rather than to prevent contact of the hammer with the firing pin. Such operation is not completely satisfactory, however, since the hammer may be dislodged and fall without operation of the tripping mechanism.

It is a major object of the present invention therefore, to provide a safety element which positively blocks the action of a time delay mechanism even if the latter should accidentally operate either from damage to the timing mechanism, or from any other cause.

It is another object of the invention to provide such a device in which the "safety" period is of uniform and a predetermined duration and relatively unaffected by aging, mechanical shock, weather conditions, presence of moisture, etc.

It is still another object of the invention to provide a safety element of the class described which is extremely simple and relatively inexpensive to manufacture, small, and convenient to handle.

A further object of the invention is to avoid the use of volatile liquids or highly corrosive acids or caustic solutions which have sometimes been used heretofore in time delay devices.

An additional object of the invention is the provision of a device of the nature described, which is adapted for use in a percussion fired bomb.

A still further object of the invention is the provision of a delay mechanism employing a clock which is adapted to operate free from friction load substantially until the termination of the delay time.

It is a still further object of this invention to provide a safety time delay element which is certain to become ineffective at the end of the "safety" period so as not to block the normal firing of the detonator and produce thereby, a "dud" bomb.

The foregoing and other objects and advantages will become apparent from the following description of an oil well torpedo embodying the invention.

Briefly, the timing mechanism disclosed herein comprises a clock which rotates a member adapted to operate a trigger, release a sear and drop a hammer at the termination of the desired delay period. Provision is made to allow the aforesaid rotating member to rotate completely free from frictional resistance until just prior to firing.

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The safety element under discussion makes use of a solid, hammer-blocking pin constructed in part of amalgam, alloy, or pure metal, which element is soluble in mercury. A blocking element so constructed is installed in the torpedo at the time it is armed, and the clock or other primary timing device is set in operation. A small reservoir of liquid mercury alloy or pure mercury is provided in the torpedo which is brought into contact with the blocking element at the time it is installed and gradually dissolves the same. The time required for complete dissolution is determined by the composition of the blocking element itself and the relative purity of the mercury. Once the blocking element is dissolved, its effectiveness is destroyed and the hammer is free to effect detonation. A "safety" period is predetermined so as to be less than the normal delay of the primary timing unit, and in this manner the blocking unit is always completely ineffective at the normal time of firing.

Should the hammer, for any reason, fall accidentally prior to the normal firing time, it is prevented by the blocking element from reaching the firing pin. Subsequent dissolution of the blocking element lowers the hammer gently and does not fire the percussion cap. Thus the detonator operates at substantially the normal time or not at all.

For a more detailed description of the invention, reference should now be had to the attached drawings in which:

Figure 1 is a partial elevational section taken on a longitudinal medial plane through an oil well torpedo embodying the invention;

Figure 2 is an enlarged partial elevational section taken on the line 2-2 in Figure 1;

Figure 3 is an elevational section similar to Figure 2 but with the firing mechanism shown in a prematurely tripped position;

Figure 4 is a section similar to Figure 3 but with the mechanism in a normally fired position;

Figure 5 is a transverse section taken on the line 5-5 in Figure 4;

Figure 6 is a transverse section taken on the line 6-6 in Figure 4; and,

Figure 7 is a section taken on the line 7-7 in Figure 6.

Referring now to Figure 1 of the drawings, it will be noted that the torpedo embodying the invention is housed in a casing 10 of steel or other similar material provided with a screw cap 11 and a lifting bail 12. The lower portion of the casing 10 is filled with a charge of blasting gelatin 13 or other explosive material suitable for detonating a charge of nitroglycerine (not shown).

The firing mechanism is indicated generally by the number 19 and is supported within the casing 10 by an outwardly projecting flange 20' thereof which rests on an internal shoulder 10' in the casing. The firing mechanism 19 is securely held in place by a shoulder 11' formed in the screw cap 11 and which bears downwardly on the upper edge of the firing mechanism.

The various parts of the firing mechanism are mounted in a framework which includes a lower transverse shelf 20 connected by a pair of struts 21 to an upper transverse shelf 22. A clock 14 having a setting knob 15 is supported above the upper shelf 22 and operates to drive a rotor 16 located immediately below the upper shelf 22. The rotor 16, upon reaching a predetermined point in its rotation, operates to move a trigger and release the firing mechanism. The direc-

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tion of rotation is indicated in Figure 5, and details of the firing operation will be described later herein.

A firing hammer 24 is mounted for downward swinging motion about a transverse shaft 26 supported between the struts 21. A double helical spring 27 also mounted on the shaft 26 urges such swinging motion of the hammer 24 from its cocked position (shown in Figures 1 and 2) to a "fired" position illustrated in Figure 4. The motion of the hammer 24 is subject to the intervention of the safety element to be described presently.

The hammer 24 is held in its cocked position by means of a sear 28 pivotally secured by means of a shoulder screw 30 to a downwardly projecting lug 31 formed in the upper shelf 22. The sear 28 is formed with a V-shaped notch therein adapted to engage a V-shaped nose 25 formed in the hammer 24.

The sear 28 is also formed with an arcuate arm 29 which projects to the right as viewed in Figure 2. As will be noted from an examination of Figure 2, the urging of the spring 27 is such as to cause counterclockwise rotation of the sear 28 about the axis of the screw 30. Such counterclockwise rotation is prevented, however, by a pivotally mounted trigger 32 secured by a shoulder screw to a lug 33 formed in the upper shelf 22. As can be seen best in Figure 5, the trigger 32 is adapted to be swung in a clockwise direction about the screw 34 to bring it above the arm 29 as shown in Figure 2. When the trigger is swung in a counterclockwise direction as indicated by the arrow in Figure 5, it moves away from the arm 29 and permits the latter to swing upwardly, thus permitting counterclockwise rotation of the sear 28 and release of the hammer 24.

Swinging of the trigger as indicated in Figure 5, is achieved by rotation of the rotor 16 in a clockwise direction. A pin 17 projects downwardly from the rotor, and as the clock progresses, engages a notch in the forward end of the trigger as just described.

Should the trigger 32 become dislodged due to shock or other causes prior to the conical member 16 and pin 17 carried thereby reaching the position indicated in Figure 5, the sear 28 would be prevented from complete operation by an inwardly projecting finger 29' which is positioned to engage the rotor as shown in Figure 2. A channel 35 is formed in the rotor to clear the inwardly projecting finger 29' when the mechanism is in the "fire" position indicated in Figure 5, thus to allow the hammer to fall.

Thus the sear is supported below the rotor 16 and out of friction contact therewith permitting free and frictionless rotation of the clock until just prior to the time of firing. The arrangement just described makes for accuracy of the delay period.

When the hammer 24 is allowed to fall at the normal firing time it strikes on a pair of firing pins 43 as seen in Figure 7. In order to insure against failure of detonation the firing elements are duplicated as best seen in Figure 1. Since the elements are identical, description of the set is deemed sufficient to make clear the operation of the invention.

As shown in Figure 7, each set of firing elements includes a cylindrical holder 40 threaded into a suitably threaded aperture in the lower transverse member 20, securing therein a conventional percussion cap 42, which in the present

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instance is of the type used in the base of a shot-gun cartridge. The cap 42 is positioned immediately below the conical point of the loosely held firing pin 43 whereby the downward impact of the hammer 24 striking the firing pin 43 fires the cap 42. Immediately below the cap 42 is situated a blasting cap 41 which is fired by the percussion cap 42 and serves to detonate the charge 13.

As thus far described, the operation of the device is as follows. The hammer 24 is cocked by swinging it upwardly into the position indicated in Figure 1, which operation forces the right-hand end of the sear arm 29 downwardly into the position shown in Figure 2. With the sear in this position, the trigger 32 may be pushed over the same to hold it in place and to thereby hold the hammer in a cocked position. At the same time the trigger is swung into position above the sear and the clock 14 is set to a predetermined delay time, this operation being performed by counterclockwise rotation of the rotor 16 through the setting knob 15. Such counterclockwise rotation moves the pin 17 away from the forward end of the trigger 32, and thus permits it to be swung into cocked position as previously described. Counterclockwise rotation of the knob 15 also winds the clock 14.

With the hammer in the cocked position, the percussion caps 42 are loaded into the holders 40, together with the blasting caps 41 and the holder and caps screwed into place as indicated in Figure 7.

When the progression of the clock 14 has brought the rotor 16 to the "fire" position shown in Figure 5, the trigger 32 is swung away from the sear, the arm 29 permitting it to swing upwardly, release the hammer as shown in Figure 4, whereby to detonate the charge 13 as previously described.

In order now to prevent the accidental firing of the charge should the firing mechanism operate prior to the normal firing time, a safety pin 50 is installed in the firing mechanism after cocking the same but prior to inserting the caps. The safety pin 50 is comprised of an upper steel portion 51 and a mercury-soluble portion 52. The pin is installed in a cavity 53 formed in the lower shelf 20 and having a small predetermined amount of mercury 58 disposed therein. The upper end of the cavity 53 is closed by a steel bushing 55 provided with a gasket washer 56 and a thin membrane seal 57 of ethyl cellulose or similar material. Prior to the insertion of the pin 50, the membrane seal 57 forms a complete closure for the cavity, being secured in place against a shoulder 54 formed in the cavity 53 by the downward pressure of the bushing 55 which is a press fit in the member 20. Insertion of the pin 50 punctures the seal 57 as shown in Figure 3, and permits the mercury-soluble portion 52 of the pin 50 to come into contact with the mercury 58. The mercury acts on the portion 52 to gradually dissolve the same as shown in Figure 4. Until the mercury-soluble portion 52 is substantially completely dissolved, however, it is of ample strength to support the hammer 24 in the position shown in Figure 3. Therefore if the hammer falls prematurely, that is, before the amalgam or other mercury-soluble material has been dissolved, it is prevented from firing the caps and detonating the charge.

Should the hammer fall prematurely and be supported in the position shown in Figure 3, the subsequent dissolution of the mercury-soluble

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portion 52 will slowly lower the hammer into the position shown in Figure 4, and since no impact is produced thereby, the caps 42 will not fire.

Various materials are suitable for use in the construction of the mercury-soluble portion 52 of the pin 50. Among such materials are cadmium amalgam; zinc amalgam; silver amalgam; and pure silver zinc or cadmium. The various materials just listed have various characteristics such as make them individually suitable for different specific applications. In oil well shooting, however, it is particularly important that the rate of dissolution of the mercury-soluble portion 52 be relatively unaffected by temperature since fairly high temperatures are often encountered in oil wells. It is realized, of course, that once the torpedo has been lowered into the well, the danger to personnel from premature explosion is substantially eliminated. It is still desirable, however, that a premature explosion be avoided until the torpedo has been lowered into its proper position in relation to the nitroglycerine charge and the lowering cable removed from the well.

Taking into consideration all of the desirable characteristics of the soluble safety pin such as rate of dissolution, strength, ease of manufacture, etc., we have found that a cadmium-mercury amalgam containing approximately 66% by weight of mercury and 34% by weight of cadmium is a particularly suitable material for use in safety pins for oil well shooting torpedoes.

It has been found that a mercury-cadmium amalgam of suitable compressive strength and molding characteristics may be conveniently produced by the following procedure. A master alloy containing 42% cadmium is first made by heating together small pieces of clean cadmium metal and mercury in the proper proportions.

After the cadmium has completely dissolved in the mercury, the mixture is granulated by stirring it as it cools. Granules coarser than about fifteen to twenty mesh are sieved out and remelted.

A molding alloy from which the actual pins are to be produced may then be compounded by rubbing in a mortar, four parts of master alloy by weight with one part of mercury. This mixture is filled into molds and pressed into the desired shape. Molded parts can be knocked out of the molds immediately after pressing.

The proportions given in the foregoing example are not critical and may be varied considerably and still give satisfactory results.

For some time after molding, a change in the alloy gradually takes place at normal ambient temperatures. These changes cause an increase in the dimensions and a reduction in the rate of solubility. The molded amalgam can be stabilized, however, by suitable heat treatment. Such a heat treating schedule is as follows:

Twelve hours at 45 to 50° centigrade, followed by
Twelve hours at 55 to 60° centigrade, followed by
Twelve hours at 65 to 80° centigrade.

Suitable heat treatment is not limited to the foregoing schedule which is given by way of general illustration only.

It has been found convenient to mold the amalgam just described directly onto the steel pin portion 51, thus to form a pin 50 of the characteristics previously described. In order to achieve a strong bond between the mercury-soluble portion 52 and the steel portion 51 of the pin 50, the latter portion may be formed with an inverted

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cone-shaped recess in its lower end as indicated in Figure 3.

It has been found that the rate of dissolution of the amalgam described can be controlled with a considerable degree of accuracy. In fact, this accuracy is such that where exact detonation time is not a factor in the operation, the clock mechanism described herein may be replaced by a single soluble pin similar to that just described.

The safety period will, of course, be equal to the maximum time required to dissolve the portion 52 at ambient temperature conditions, less a factor occasioned by the increase of dissolution rate due to temperature increase. Thus the safety period is adjusted by varying the alloy or physical proportions of the portion 52 until the safety period is equal to, or preferably slightly less than the primary delay time.

The soluble safety block described herein is adaptable for use not only in connection with percussion fire bombs of the class described, but is suitable for use with other time delay mechanisms having movable members. For example, the hammer 24 could, instead of firing a percussion cap, be adapted to close an electric circuit upon making contact with the firing pin 43, which in such case would be the equivalent of a fixed terminal of a switch, the hammer 24 corresponding to a movable blade of such switch. A circuit incorporating such a switch is, of course, applicable for actuating various devices and for firing electrically fired bombs. Obviously the soluble safety element 50 could be incorporated in the same manner in a switch of this type to prevent the premature closing of the circuit.

While the safety device shown and described herein is fully capable of achieving the objects and providing the advantages hereinbefore stated, it is capable of considerable modification and of other uses within the spirit of the invention, and for this reason we do not mean to be limited to the form shown and described herein, but rather to the scope of the appended claims.

We claim:

1. In a percussion fired bomb of the class described: an enclosed casing; a body of explosive disposed within said casing; a percussion cap disposed in detonating position adjacent said explosive; a firing pin in operative position adjacent said percussion cap; a hammer adapted to strike said firing pin whereby to fire said percussion cap and detonate said explosive; a spring to urge firing motion of said hammer; a sear to hold said hammer in cocked position; clockwork mechanism to release said sear and to permit firing of said hammer at a predetermined time after the cocking thereof; means in said bomb forming a cavity adjacent said firing pin; mercury disposed within said cavity; means sealing said cavity; and a safety pin having a portion thereof constructed of mercury-soluble material, said pin being adapted to be inserted through said sealing means into said cavity whereby to bring said mercury-soluble portion into contact with said mercury and having a head portion adapted to project beyond said cavity whereby to support said hammer away from said firing pin, said mercury-soluble portion of said pin being proportioned and adapted to be dissolved by said body of mercury within a predetermined period, whereupon to render said safety pin ineffective and to permit said hammer to strike said firing pin.

2. A bomb comprising: an enclosed body of explosive at least a portion of which is percussion-

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sensitive to detonate the same; firing means mounted adjacent said percussion-sensitive portion and including a spring-urged hammer adapted to strike and detonate said portion; timing means including a sear to hold said hammer in cocked position and clockwork mechanism to move said sear and release said hammer a predetermined time after cocking the same; means forming an enclosed cavity adjacent said percussion-sensitive portion; a solid mercury-soluble metal safety member inserted in said cavity abutting therein, and positioned in the path of said hammer to prevent the latter from reaching and striking said explosive portion, said safety member being an unsecured part whereby to permit insertion of the same at the time of cocking said hammer; and a body of liquid mercury in said cavity to dissolve said safety member at a predetermined time after insertion in said cavity to unblock said hammer.

3. In a percussion fired bomb of the class described: an enclosed casing; a body of explosive disposed within said casing; a percussion cap disposed in detonating position adjacent said explosive; a firing pin in operative position adjacent said percussion cap; a hammer adapted to strike said firing pin whereby to fire said percussion cap and detonate said explosive; a spring to urge firing motion of said hammer; a sear to hold said hammer in cocked position; a clockwork mechanism to release said sear and permit firing of said hammer at a predetermined time after the cocking thereof; means in said bomb forming a cavity adjacent said firing pin; a solid mercury-soluble metal safety member with an end abutting in said cavity and a portion positioned in the path of said hammer to prevent the latter from striking said firing pin, said safety member being an unsecured part to permit insertion of the same at the time of cocking said hammer; and a body of liquid mercury in said cavity to dissolve said safety member adjacent said abutting end at a predetermined time after insertion in said cavity to unblock said hammer.

4. A percussion fired bomb of the class described: a casing; explosive means in said casing including a percussion sensitive detonating portion; firing means including a hammer, firing pin, means to urge firing motion of said hammer to strike said firing pin into said detonating portion; a sear to hold said hammer in cocked position; a mechanical timer to move said sear and release said hammer a predetermined time after cocking thereof; means in said bomb forming a cavity adjacent said detonating portion of said explosive means; means sealing said cavity; and a safety pin having a portion thereof constructed of mercury-soluble material, inserted through said sealing means into said cavity and abutting therein whereby to bring said mercury-soluble portion into contact with said mercury, said pin having a head portion adapted to project beyond said cavity whereby to support said hammer away from said firing pin, said mercury-soluble portion of said pin being proportioned and adapted to be dissolved by said body of mercury within a predetermined period, whereupon to render said safety pin ineffective and to permit said hammer to strike said firing pin.

5. Impact detonating apparatus comprising: frame means including a transverse shelf adapted to receive and support a percussion detonator; a hammer mounted in said frame means for movement from a cocked position to a firing position against said shelf; means to urge said hammer

from said cocked position toward said firing position to impinge against the latter with inertia impact; releasable means to hold said hammer in said cocked position; time delay means associated with said holding means and adapted to effect release of said hammer at a predetermined time after cocking thereof; means forming an enclosed cavity in said shelf adjacent said firing position; a solid mercury-soluble safety element abutting in said cavity and projecting therefrom into the path of said hammer to obstruct and hold the same slightly away from said firing position; and a body of liquid mercury in said cavity in contact with said element to dissolve the same and remove the obstruction to the effective operation of said hammer.

6. Impact detonating apparatus comprising: frame means including a transverse shelf adapted to receive and support a percussion detonator; a hammer mounted in said frame means for movement from a cocked position to a firing position against said shelf; means to urge said hammer from said cocked position toward said firing position to impinge against the latter with inertia impact; releasable means to hold said hammer in said cocked position; time relay means associated with said holding means and adapted to effect release of said hammer at a predetermined time after cocking thereof; means forming an enclosed cavity in said shelf, having a restricted bore opening adjacent said firing position of said hammer; a body of liquid mercury partially filling

said cavity; rupturable sealing means closing said bore to retain said mercury in said cavity; and a solid metallic safety element adapted to be received in said bore, rupture said sealing means, rest on the bottom of said cavity, and project from said bore into the path of said hammer to prevent the same from striking said firing position with inertia impact when said hammer is released as aforesaid, said safety element being soluble in mercury whereby to be dissolved and rendered ineffective a predetermined time after insertion into said cavity.

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