Nov. 15, 1949 W. W. CARR ET AL 2,487,789

FUSE

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FIG. 2.

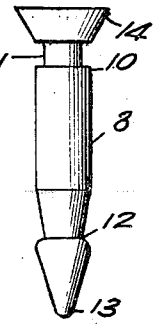
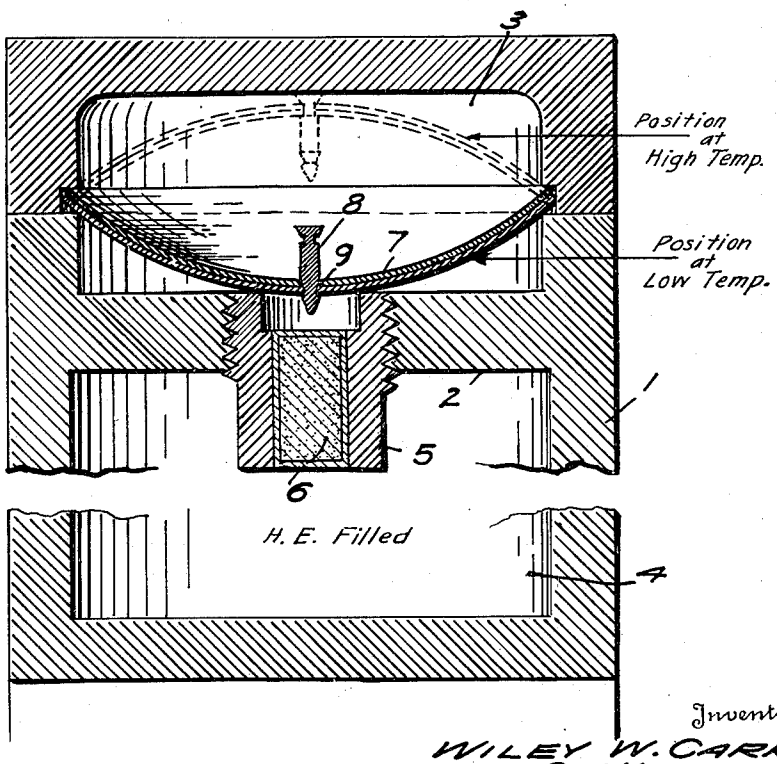


FIG. 1.



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FUSE

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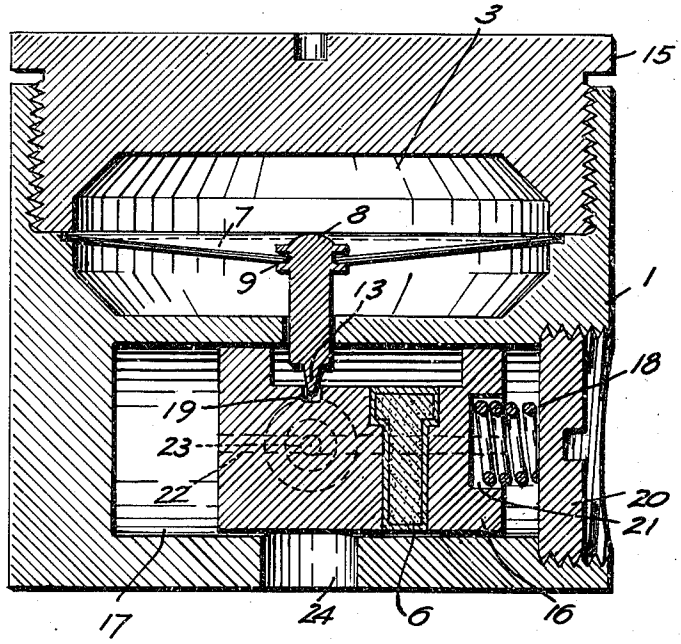
FIG. 3.



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FUSE

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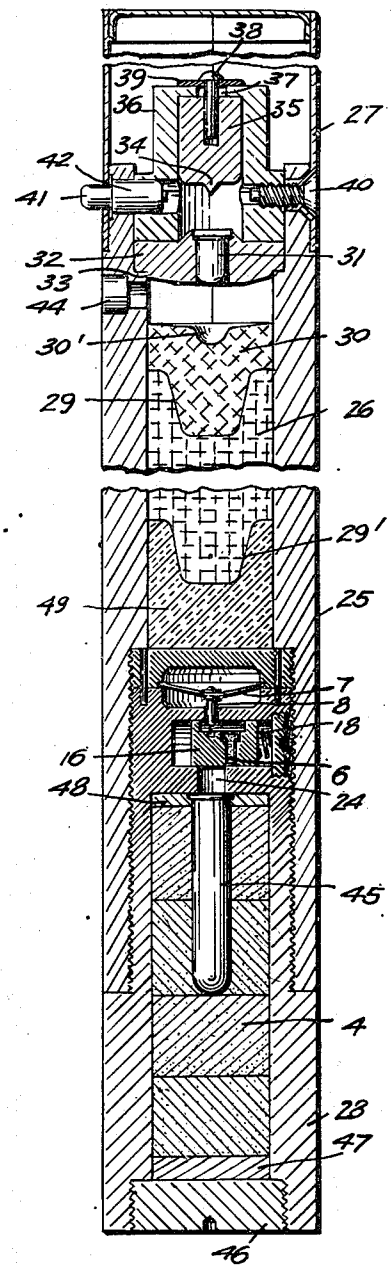

FIG. 4.

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UNITED STATES PATENT OFFICE

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FUSE

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4 Claims. (Cl. 102—70)

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

This invention relates to a fuse mechanism particularly useful for effecting a detonation of an explosive charge in an incendiary munition, such as explosive incendiary bombs.

Explosive incendiary bombs were developed to discourage attempts to extinguish the burning bombs. Such bombs have been designed to be similar in appearance and action to non-explosive incendiary bombs with which they are used but to differ in containing an explosive charge which becomes fired at such a time after burning as to make approach to the bombs hazardous. The explosive incendiary bombs are intended to be deceptive and to run interference, so-to-speak, against firefighting action. However, hitherto developed explosive incendiaries have had the tendency to explode very shortly after their burning action is started, thus depriving the bombs of effective incendiary action, revealing the presence of the bombs, and permitting firefighters to begin extinguishing the bombs at an incipient stage of their action.

The present invention is concerned with providing explosive incendiaries which have a delayed action, which are particularly hazardous when efforts are made to extinguish them, which produce concentrated incendiary effects for a substantial period until they become extinguished, and which avoid revealing their presence by explosion before their incendiary action takes effect.

Accordingly, an object of this invention is to provide a fuse having an automatic delay mechanism which is responsive to predetermined temperature changes for effecting detonation of an explosive charge used in or with an incendiary, or with other types of pyrotechnical munitions.

A further object, more specifically, is to provide a fuse which functions satisfactorily by remaining unarmed when subjected to heat at high temperatures and becoming armed when cooled by involving the use of a suitable thermostatic device, such as a bimetallic disc which undergoes differential expansion with predetermined temperature changes, in association with other firing means.

Further objects will become apparent from the following description taken in conjunction with the drawings, wherein:

Figure 1 is an enlarged vertical sectional view of a simplified fuse having a temperature-responsive delay mechanism embodying features of the invention in combination with an explosive or burster;

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Figure 2 is an exaggerated enlarged view of a form of firing pin used in the mechanism shown in Fig. 1;

Figure 3 is an enlarged vertical sectional view of a temperature-responsive delay fuse particularly adapted for use in an incendiary bomb;

Figure 4 is a vertical sectional view of an explosive incendiary bomb in broken sections with a temperature-responsive delay fuse such as depicted in Figure 3.

A simplified delay fuse combined with a high explosive burster as diagrammatically illustrated in Figure 1 is adapted particularly for use with various heat generating munitions, as for example, pocket incendiaries or small fire starters implaced for sabotage, smoke pots, and the like. It is a device which may be attached to such munitions or be implaced separately, e. g., where it is desired to deter firefighting, salvaging, or interference with the operation of the munitions.

The device shown in Figure 1 comprises a casing 1 divided into principal compartments by partition 2, an upper compartment 3 for housing a firing mechanism activated by predetermined temperature changes and a lower compartment 4 inclosing a high explosive charge of the bursting type, e. g. tetryl, trinitrotoluene, or the like. A hollow plug 5 having a threaded engagement with partition 2 holds a primer or primer-detonator element cap 6 of suitable composition for firing the high explosive charge in compartment 4 upon receiving a point impact from a striker or firing pin firing mechanism in compartment 3. The casing 1 may be made of metal or plastic.

The firing mechanism housed in compartment 3 simply consists in a bimetallic disc 7 constructed to abruptly change its curvature upon predetermined changes in temperature and with these changes to bring a firing pin 8 into a firing action. The bimetallic disc has a small hole 9 through the center. The hole 9 is slightly smaller than the cross section at the shoulder 10 below the notch 11 on the firing pin 8 so that it is relatively easy for the firing pin to be pushed down through the hole until the firing pin 8 is locked in the hole 9 at notch 11.

The mechanism is designed to operate in the following manner:

While the upper compartment 3 is relatively cool, the disc 7 clamped at its periphery in the casing 1 is in a downward position with the firing pin 8 retained in the center hole 9 at the lower

notch 12 so that the point 13 of the firing pin is unable to contact the primer detonator in cup 6. When the compartment 3 becomes heated to a predetermined temperature level, the disc 7, constructed of laminated sheets of metals having relatively high and low coefficients of expansion, snaps into a reverse position due to the relatively greater expansion in the upper sheet or lamina. The upward arching of the disc 7 drives the head 14 of the firing pin 8 against the top of the compartment 3, pushing the firing pin through the hole 9 until the notch 11 is engaged by the disc to lock the firing pin in place. The fuse is now in an armed position and remains thus until compartment 3 becomes cooled to a predetermined temperature level. Upon cooling either naturally or artificially with water or other cooling type extinguishers, the bimetallic disc 7 at a predetermined temperature level snaps back into the original position due to the relatively great contraction of the metal in the upper lamina, and in thus coming back to its original position with the firing pin extended downwardly, the point 13 of the firing pin strikes the primer or primer-detonating material in cup 6 and thereupon detonates the exposive charge in compartment 4. The firing pin 8 preferably has tapered sides between the upper notch 11 and the lower notch 12 to enable the pin to slide more easily into the armed position.

The heat required to operate the mechanism may be derived directly from a munition in which the device is installed or, in special applications, an auxiliary source of heat may be supplied. The simplified device which may be manufactured at low cost and which may be conveniently handled and carried is very useful in connection with fire starters. These devices may be formed as inconspicuously small articles to be placed in strategic positions where a conflagration is to be started so that they will explode when attempts are made to put out the fire, or when the fire subsides sufficiently, if still unexploded, they will tend to scatter the fire and cause further disorder and spreading of the conflagration.

The bimetallic snap disc 7 may comprise a sheet of metal having a relatively high coefficient expansion such as brass, Monel metal or steel laminated to a sheet of metal having a relatively low coefficient of expansion, such as iron, nickel iron, or Invar by welding, brazing, soldering, or riveting. Satisfactory bimetallic discs used in demonstrating the invention are commercially available products sold under the trade name of Klixon. However, it is to be understoood that other types of mechanisms which are similarly responsive to changes in temperature by abrupt shifts in position may also be used.

When the fuse and explosive combinations are to be employed in situations where very high temperatures are not developed, the disc may be made to be more sensitive to temperature changes, and the primer or percussion initiated detonator employed may be selected from a wide variety of commercial primer caps. In certain instances, particularly in adaptations of the device for use in conjunction with incendiary bombs, special primers are preferred or required as will be hereinafter explained.

Referring to Figure 3, the device illustrated has a fuse mechanism which corresponds in a number of features to the fuse mechanism shown in Figure 1. It has a bimetallic disc 7 clamped at its periphery between the threaded plug 15 and

casing 1, but the disc 7 is permanently locked to firing pin 8 by having the groove 11 of the firing pin securely held within a center hole 9. A cavity in the base of the plug 15 and the upper hollow part of the casing 1 form a compartment 3 which provides space for the flexing movement of the disc 7.

The primer 6 is contained in a cylindrical slider 16 disposed to slide or be reciprocated within a cylindrical bore 17 inside the casing 1 when the point 13 of the firing pin 8 is not in a position to obstruct movement of the slider. The slider 16 is held in the unarmed position by the firing pin 8, the point 13 of which fits into a hole 17 in the upper part of the slider. The firing pin 8 is withdrawn from the hole when the curvature of the disc 7 is reversed by heat at a predetermined temperature level and the slider 16 is moved by coiled spring 18 under compression toward the left so that when the disc snaps to the original shape, flexing downwardly on cooling, the firing pin 8 strikes downwardly in alignment with the primer cap 6 and the firing point 13 pierces the primer.

The spring 18 is compressed between the slider 16 and the back side of a threaded plug 20 which acts as a closure for the cylindrical bore 17 in casing 1. A cylindrical depression 21 at the end of the slider 16 serves to hold the spring 18 in a horizontal position. A groove 22 in the slider 16 serves as a guide for a short fixed pin 23 projecting from the wall of the bore 17 and thereby prevents rotation of the slider. A hole 24 in the bottom of casing 1 acts as a passage for a flash produced when the primer's action is initiated so that the action of the primer may be transmitted to a detonator or booster. The assembly that has been explained will be further described with reference to Figure 4 in which it is illustrated as installed in a Thermit-type incendiary bomb.

The Thermit-bomb of a type illustrated in Figure 4 comprises a cast body 25 formed from magnesium alloy, aluminium, steel or other suitable metals, and contains a Thermit-type charge 26. It represents a standardized type of bomb having an overall length of about 21 inches. The body 25 may be cylindrical or hexagonal. It is provided with tail fins 27 of sheet steel and with a heavy steel or cast-iron nose plug 28 for insuring true flight and penetration of the target.

The Thermit charge 26 which forms the main part of the core within body 25 has a composition represented by the following in percentage by weight:

	Per cent
Aluminium, granular	15.7 to 16.3
Iron oxide scale, or iron ore	43.5 to 44.5
Aluminium, grained	8.8 to 9.2
Barium nitrate	28.6 to 29.4
Sulfur	1.9 to 2.1

The weight of the Thermit-type charge 26 in a bomb having a total weight of approximately 4 lbs. with a body weighing about 1 lb. 4 oz. is of the order of 8 to 10 oz. The Thermit charge 26 is loaded into the body 25 in three or four approximately equal increments under a dead load pressure of about 6000 to 7000 lbs. using a ram shaped to form a truncated conical depression corresponding to the shape of the depression shown in Figure 4 at 29 and 29'.

The lower depression at 29' marks the boundary between the Thermit charge 26 and a pressed bed of insulated material, such as asbestos or magnesium oxide which on the bottom side is pressed against the top of plug 15, which forms

the upper part of the fuse mechanism assembly corresponding in structure and function to the assembly illustrated in Figure 3.

A first fire charge 30, adapted to be ignited by a flash from a primer cap 31 and spaced therefrom, is pressed, either loose or in pellet form by a ram above the Thermit charge 26. A satisfactory first fire charge comprises about 25% magnesium powder and 75% barium chromate, about 19 to 21 grams of these ingredients, intimately mixed and pressed by a ram under a dead load of about 6000 to 7000 lbs., the ram being shaped to form a rounded depression 30'.

The primer cap 31 is held in a holder 32 of steel or aluminium, fitted against the shoulder 33 formed in the body 25.

The cap 31 contains a primer or detonator material, such as lead azide or fulminate, which is adapted to be set off or fired when struck by the firing pin 34 projecting from a weight portion or striker 35 downwardly in alignment with the vertical axis of the cap 31. The striker 35 is slidably mounted in a cylindrical holder 36 which is flanged inwardly at the upper end to form a hole 37. The striker 35 is normally retained in the suspended position shown by means of an affixed screw or pin 38 which is supported by a cross-shaped brass member 39 resting above the holder 36. The cross-shaped member 39 is made of brass or similar deformable material, so that upon predeterminated impact of the bomb, the arms of the cross-shaped member fold up and permit the striker 35 to move downwardly toward the cap 31.

The firing pin assembly is held in place by screws 40. A safety pin 41 normally held outwardly bears against a spring within the housing 42 and has an inner projection which extends under the firing pin 35 to block the movement of the firing pin 35 when the pin 41 is depressed. With this type of safety pin, the bomb is adapted to be loaded in clusters of, for example, 50 or more bombs, which fitted together hold the safety pins in an unarmed position. The cluster is adapted to be dropped effectively from bombing aircraft.

In a bombing operation, when a cluster of the bombs is dropped toward a target, shortly after release from the bomb bay of the aircraft, bands holding the bombs together in a cluster are broken, and the clustered bombs thereafter separate from each other. As the bombs separate, the safety pins are forced outwardly by compressed springs within the housings 42 so that their inner projections do not obstruct the movement of the safety pin 35. Upon impact of the nose of a bomb, the inertia of the striker 35 forces it to move abruptly and at the same time to deform the retaining cross-shaped member 39 so that the firing pin 34 pierces the primer in cap 31.

The primer cap 31 when struck a sharp blow by the point flashes back into the depression 30' of the first fire charge 30 which thereupon becomes ignited.

Gaseous products of combustion from the ignition of the first fire charge 30 create sufficient pressure to blow out plugs in the vent holes 44 and thus prevent explosion of the bombs. The plugs placed in the vent holes 44 may be made of rubber, fiber, cork or other yieldable materials, or be pressed in metal cups. In order to make the bomb waterproof, the outside surfaces of the plugs may be coated with a waterproof cement or lacquer, or the plugged holes 44 may be covered with waterproof tape.

The first fire charge mixture 30 is capable of being readily ignited, and burns at a temperature sufficiently high to ignite the adjacent Thermit charge 26.

As previously indicated, the temperature-responsive fuse assembly is attached to the bomb nose plug 28 and operates in the same manner as the assembly described with reference to Figure 3. A firing pin 8 attached to a bimetallic snap disc 7 normally is disposed to prevent movement of the slider 16 so that the primer cup 6 within the slider 16 is held in an unarmed position until the disc 7 snaps upwardly due to heat conducted through the body 25 from the burning Thermit charge. The upward movement of the firing pin 8 with the disc 7 releases the slider 16 so that the compressed spring 18 moves the slider into a position where the primer cup 6 is in alignment with the firing pin 8. After this movement of the slider, when the bomb is cooled naturally or artificially to a predetermined temperature level, the bimetallic disc 7 snaps downwardly and forces the firing pin to strike the primer in cup 6.

Within the lower hollow portion or compartment 4 of the nose plug 28 is placed a charge of high explosives, e. g., tetryl or T. N. T. Near the top of compartment 4 and in alignment with the hole 24, which is directly in line with the primer when it is in the armed position, is placed a booster or detonator tube 45, whichever is needed. For example, with tetryl as the high explosive surrounding the tube 45, the tube 45 having a thin copper wall may contain lead azide; with T. N. T. as the high explosive, the tube 45 may contain an upper layer of lead azide and a lower layer of tetryl as a booster.

The bottom of a nose plug 28 is closed by a threaded steel plug 46. An asbestos pad 47 is placed between the high explosive charge and the plug 46 and another pad 48 of asbestos or similar inert fibrous insulating material is placed at the top of the high explosive charge in compartment 4 so that it surrounds the tube 45.

When the primer in cup 6 flashes through hole 24, the detonator or booster in the tube 45 is detonated, and in turn the high explosive within the compartment 4 undergoes explosive action which shatters nose plug 28 and produces rapid flying metal fragments.

It is important that the primer used with the temperature-responsive fuse assembly be sufficiently insensitive to high temperatures developed in the burning of the bomb incendiary charge and also insensitive to the shock created by impact of the bomb when the bomb strikes the target at high velocities. To some extent the flow of heat from the burning incendiary charge can be retarded by insulation, such as the insulation 49, and other insulation which may be added, but it has been found desirable to use a special type of primer developed for the purpose in hand.

A special primer found to function satisfactorily in conjunction with the temperature-responsive fuse mechanism in an explosive incendiary bomb is prepared by mixing antimony sulfide and potassium chlorate into a thick paste with a solution of cellulose acetate. This mixture is placed in the primer cup 6. In using the described mixture, the point 13 of the firing pin 8 is coated with a mixture of red phosphorus and a heat-resistant abrasive such as Alundum (aluminium oxide), with a high temperature-resistant binder. The

binder may be an alkyd type resin, or thermo-setting resin, which is synthesized or polymerized in the mixture with a solvent such as ethyl alcohol for thinning and a base such as sodium hydroxide solution to cause polymerization. The coated firing pins and the mixture in the caps 6 are baked for sufficient time at a suitable temperature to harden the described compositions, e. g., for six hours at about 100 to 125° C. The resulting flash mixture in the cap 16 corresponds to the composition on the head of a safety match while the hardened coating on the firing pin 8 corresponds to the scratcher mixture which is used with a safety match. Each of these compositions separately is suitably insensitive to heat at high temperatures.

It is to be noted that the top level of the flash composition in the primer cup 6 should be such that the vertical dimension through which the firing pin is caused to travel in firing action is within suitable small tolerances. In general, the travel distance of the firing pin amounts to about 6% of the diameter of the bimetallic disc, unless the movement of the disc is made to impart motion indirectly to the firing pin through a system of levers arranged to magnify the movement of the disc. In other words, the temperature-responsive element may act as a trigger for actuating the movement of the firing means.

Tests conducted on a number of munitions indicate that a high percentage of functioning can be obtained with the described temperature-responsive fuse and consistent good results were obtained with explosive incendiary bombs having the installed fuse. The bombs were tested and found to be practical.

It is understood that the fuse mechanism described is subject to various modifications, including substitutions of equivalent temperature responsive elements, primers, detonants, and explosives, also, in assembly construction. Also it is evident that the temperature-responsive fuse mechanism has wide application in conjunction with various types of bombs and other munitions. Although the invention has been described with reference to exemplary embodiments, different embodiments may be made without departing from the scope thereof.

We claim:

1. In combination with an explosive munition, a temperature-responsive delayed action fuse comprising a bimetallic snap disc, a firing pin attached to said disc, a slidable primer holder disposed in assembly with said firing pin to be held normally in an unarmed position but to be moved into an armed position with the primer subject to striking action by the firing pin when the firing pin is reciprocated with snap-action movement of the disc at a low temperature level.

2. A combination as described in claim 1, in which movement of said primer holder to the armed position is obstructed by the firing pin in an unarmed position.

3. An automatic delayed action fuse and burster unit comprising a casing enclosing two compartments, a bimetallic disc clamped at its periphery in one of said compartments with space for flexing movement of said disc due to differential expansion of laminated metals therein, a high explosive charge in the other compartment, a primer disposed within the casing to detonate the high explosive charge, and a firing pin connected with said disc to be actuated into contact with the primer when the disc is cooled from a high temperature.

4. In combination with an explosive incendiary bomb containing a Thermit mixture charge and a high explosive burster, a temperature-responsive delayed action fuse comprising a curved bimetallic disc which changes its curvature abruptly at predetermined high and low temperature levels, a firing pin attached to said disc, said pin actuated into reciprocatory movement by said disc in its changing of curvature, a slider containing a primer cup in an unarmed position out of alignment with said firing pin and a compressed spring exerting a force on the slider to move it into a position where the primer cup is in alignment with the firing pin when the slider is unlocked from its unarmed position.

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