Aug. 9, 1966 R. E. BETTS 3,264,990

FOCUSED EXPLODING BRIDGE WIRE

Filed April 13, 1965

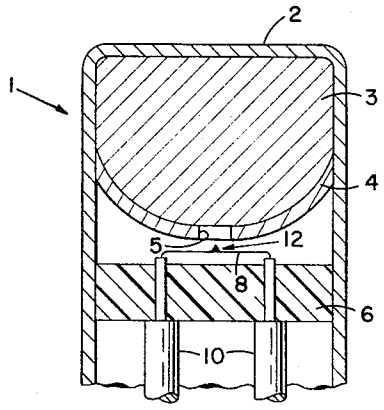


FIG. 1

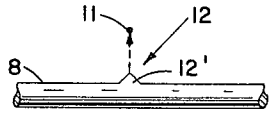


FIG. 2

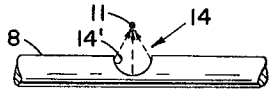


FIG. 3

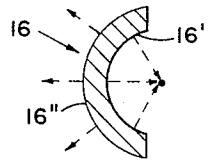


FIG. 4

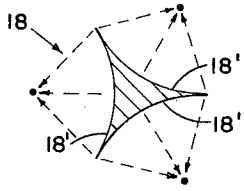


FIG. 5

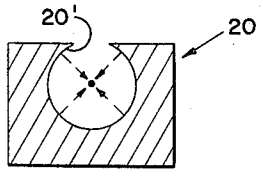


FIG. 6

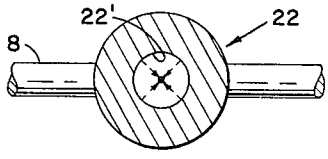


FIG. 7

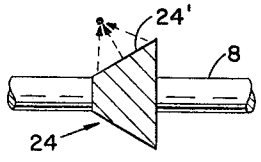


FIG. 8

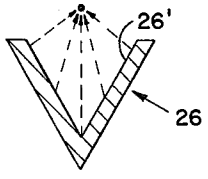


FIG. 9

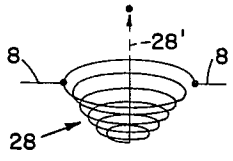


FIG. 10

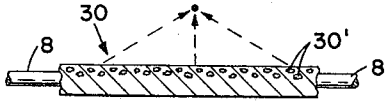


FIG. 11

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3,264,990

FOCUSED EXPLODING BRIDGE WIRE

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11 Claims. (Cl. 102—28)

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

This invention relates to an improved exploding type bridge wire for use in electric igniters, squibs, detonators and the like devices. More particularly, the present invention is drawn to a focused exploding bridge wire having the feature wherein the energy or products of bridge wire explosion are concentrated and directed to a predetermined point or portion of the pyrotechnic.

A focused exploding bridge wire according to this intion may be used advantageously in the missile field for initiating the burning of solid propellants in igniting rocket engines and for activating pressure vessels, switches and the like devices. For example, the improved bridge wire is particularly adapted for use in causing separation of various stages of a rocket.

Moreover, a bridge wire according to the present invention is particularly adapted for use in an electric squib of the general type as disclosed in applicant's prior Patent No. 3,100,447. In this type squib, wherein the bridge wire must literally explode to ignite the explosive charge, explosion is effected by a sudden surge of very high electrical energy in the bridge wire. Thus, the primary design criteria for the exploding bridge wire of a squib of this type is controlled by matching the pyrotechnic and the bridge wire explosion. Another critical factor lies in controlling the size or volume of the chamber or air space between the bridge wire and the pyrotechnic, since the results of the ignition depends largely on the pressure build-up and the temperature in this space surrounding the bridge wire. Further, in such applications and in numerous other applications wherein an exploding type bridge wire is utilized, it has become an ever increasing problem to design an efficient and dependable igniter which will direct the high pressure and high temperature explosion to a particular, predetermined area of the pyrotechnic. Additionally, there has developed an increased need for an exploding bridge wire which may be used effectively for ignition of secondary explosives through barriers, thus, obviating the need for using highly sensitive primary explosives.

Accordingly, in view of the above, it is an object of the present invention to provide an improved exploding type bridge wire with the feature wherein the wire is provided with integral or built-in means for directing or focusing the products of wire explosion to a particular predetermined point or area of the pyrotechnic.

Another object of this invention is to provide an improved exploding bridge wire wherein the explosive effect thereof is capable of being easily predetermined prior to assembly thereof within an igniter or the like device.

It is a further object of the present invention to provide a focused exploding bridge wire capable of use in firing secondary explosives through a barrier solely with the use

of the exploding bridge wire, i.e., without the need for a primary explosive.

A still further object of the invention resides in the provision of an improved exploding bridge wire which is simple in construction and particularly adapted for use as a research tool.

A further object of the present invention resides in the provision of an exploding bridge wire which will explode simultaneously along its entire length.

The foregoing and other objects of this invention will become more fully apparent from the following detailed description and from the accompanying drawing, wherein:

FIGURE 1 is an elevational, sectional view of a typical electric igniter utilizing one form of exploding bridge wire in accordance with the invention;

FIGURE 2 is an enlarged side view of a portion of the focusing bridge wire of FIGURE 1;

FIGURE 3 is an enlarged side view of another form of exploding bridge wire according to the invention, this form having a concave cavity formed therein;

FIGURE 4 is an enlarged cross-section of a focusing portion of a further form of a moon-shaped bridge wire;

FIGURE 5 is an enlarged cross-section of a focusing bridge wire having a plurality of concave focusing portions;

FIGURE 6 is an enlarged cross-section of a focusing bridge wire having a hollowed focusing portion;

FIGURE 7 is an enlarged elevation of a bridge wire having a ring or doughnut-shaped focusing portion, shown in section, intermediate the ends thereof;

FIGURE 8 illustrates a further embodiment of the invention, this form being wedge or cone-shaped;

FIGURE 9 shows a still further embodiment of the invention, this form being V-shaped;

FIGURE 10 illustrates another embodiment wherein the bridge wire has intermediate the ends thereof a spiral helix configuration; and

FIGURE 11 is a cross-sectional view through a bridge wire having focusing elements embedded therein.

Referring to the drawing, FIGURE 1, wherein for the purpose of illustration, there is shown a typical igniter or squib **1** having the elements thereof housed in a casing **2**, which may be formed of a metal, such as aluminum. A suitable pyrotechnic **3** is retained in the closed end of the casing preferably by a suitable retainer element **4** which has an aperture **5** provided therein. An end plug **6**, of phenolic or the like insulating material, is normally disposed for enclosing the opposite or open end of the casing. To effect ignition of the pyrotechnic, an exploding bridge wire **8** having a focusing portion or means **12** is interposed between the inner face of the end plug and the pyrotechnic retainer element. The focusing portion of the bridge wire is positioned in direct alignment, in this example, with the aperture in the retainer plate, as will be explained more fully hereinafter. To supply an activating current to the bridge wire from a controlled source of power (not shown), a pair of insulated lead wires **10** extend through the end plug and interconnect the opposite ends of the bridge wire.

In operation of an igniter device such as that shown in FIGURE 1 and utilizing an exploding bridge wire such as that shown, for example, in enlarged form in FIGURE 2, a source of power (not shown) is connected to the lead wires. When the required electric pulse reaches the

bridge wire, the wire reaches a super heated condition to the extent that the wire explodes. According to this form of the invention, focusing portion **12**, which is an integrally formed teat or blob **12'**, concentrates or focuses the explosive energy or products of explosion radially outwardly, as indicated by the arrow in FIGURE 2, to a desired point or specific zone **11** on the pyrotechnic. As depicted in FIGURE 1, the explosion is directed through aperture **5**. Hence, in application of the present invention to a squib of the type illustrated, the need for a confining chamber or space for pressure build-up between the bridge wire and the pyrotechnic is obviated, since the explosion is concentrated to a desired point or area on the pyrotechnic solely by the integrally formed directing or focusing means. Moreover, a secondary explosive might be ignited without the use of a highly sensitive primary explosive. It is, thus, seen that a highly reliable squib having true detonation is provided by the invention. The improved exploding bridge wire according to the present invention is usable with any arrangement wherein an explosive is to be ignited, the igniter example of FIGURE 1 being merely a single, typical application. For example, the improved wire could be positioned in proximity with a molded, solid propellant grain which is not encased. Since no particular related igniter structure is critical to the use of the improved wire, the effects thereof may be readily predetermined by measuring the intensity of the wire explosion and the directivity thereof.

Several embodiments of the improved bridge wire, utilizing the principles of the invention, are illustrated in FIGURES 3–10. FIGURE 3 depicts a focusing means **14** defined by a concave cavity **14'** formed in the peripheral portion of the wire facing the pyrotechnic to be ignited. FIGURE 4 depicts a half-moon shaped focusing portion **16** of the wire whereby the focusing effect may be directed at a point of area from the concavity **16'** thereof and/or radially outwardly from the circumference of the outer, convex, half-circle **16''**. In the FIGURE 5 embodiment, there is shown three concave outer surfaces **18'** on focusing portion **18** of the exploding wire. FIGURE 6 depicts a square or box-like shaped focusing wire portion **20** having a circular hollowed interior **20'** for focusing the explosion to the center of the hollowed portion. In the embodiment of FIGURE 7, a ring or doughnut shaped focusing means **22** is integrally interposed intermediate the opposite ends of the bridge wire, and the focusing effect is toward the center of the ring or doughnut-shaped portion from surface **22'**. FIGURE 8 depicts a wedge or conically shaped directing wire portion **24** having an external focusing surface **24'**. The directing or focusing portion of the bridge wire may be channel shaped, for example, V-shaped, as shown in FIGURE 9. In the embodiment of FIGURE 9, focusing portion **26** has an interior focusing surface **26**. FIGURE 10 illustrates another form of focusing bridge wire wherein an intermediate portion, i.e., a portion between the ends of the wire is spirally configurated, the helix **28** having a center post **28'** for directing the explosion. This latter form of the invention will also function without the center post to direct the explosion toward the apex or small diameter end of the helix. The embodiment of FIGURE 11 illustrates a still further form of the invention wherein the shape or location of various embedded elements **30'**, such as gases, solid non-wire particles, or liquids, within the focusing portion **30** of the bridge wire yield the desired focusing effect.

It is, thus, apparent that the operation of the various forms of the invention depicted in FIGURES 3–11 is the same as that of FIGURE 2 as described hereinabove. Accordingly, in each embodiment the bridge wire is provided with built-in focusing means intermediate the ends thereof whereby upon energization of the wire to the point of explosion, the explosive energy or products of explosion are concentrated and focused by the focusing means to a predetermined point or zone of an explosive charge placed in proximity thereto. The desired direction of the explosion is indicated in the various embodiments by the broken arrows.

From the foregoing description it will be readily apparent that a new and improved bridge wire for electric igniters is provided wherein the explosion of the bridge wire is focused to a predetermined point or zone by means integral therewith. A focusing bridge wire may be used with existing igniters for yielding improved results. Further, since the products of explosion are concentrated, it is possible, in many applications of the inventive concept, to utilize a relatively low electrical impulse for heating the bridge wire. Moreover, a device according to the invention may be utilized for effectively igniting explosive charges through barriers by reason of its concentrating effect. It is believed obvious that a bridge wire according to the present invention may be used as the exploding wire molded within a solid propellant grain, if desired. Additionally, it will be obvious that a plurality of focusing means may be employed; for example, in the embodiment of FIGURE 2, a plurality of blobs **12'** might be utilized.

It is to be understood that the forms of the invention shown and described herein are preferred embodiments, and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention, or the scope of the subjoined claims.

I claim:

1. A focused exploding bridge wire adapted for use in igniting a pyrotechnic position in proximity therewith, means integral with said bridge wire and intermediate the ends thereof for directing explosive energy therefrom, said means having an orientation with respect to said pyrotechnic whereby explosive energy resulting from the explosion of said wire upon energization thereof by a source of electrical energy connected therewith is directed by said means from said wire to a predetermined area of said pyrotechnic.

2. A focused exploding bridge wire according to claim **1** wherein said directing means is defined by a portion of said wire facing the pyrotechnic having a concave cavity formed therein, said cavity being oriented toward a predetermined area of said pyrotechnic whereby the explosive energy from the exploding bridge wire will be focused radially outwardly from said cavity to said predetermined area.

3. A focused exploding bridge wire according to claim **1**, wherein said directing means is defined by a portion of said wire which faces the pyrotechnic being part moon-shaped with one focusing face thereof being convex and the other focusing face thereof being concave.

4. A focused exploding bridge wire according to claim **1** wherein the directing means is defined by an intermediate portion of said wire being formed on the circumference thereof with a plurality of concave cavities disposed in circumferentially spaced relationship about the periphery of the wire, said cavities facing radially of the wire axis whereby the explosion is focused to a plurality of zones on the pyrotechnic.

5. A focused exploding bridge wire as defined by claim **1** wherein the directing means is defined by an intermediate portion of said wire being substantially box-shaped with a circular, hollowed-out portion whereby the explosion is focused radially inwardly toward the center of said box-shaped portion.

6. A focused exploding bridge wire according to claim **1** wherein the directing means is defined by an intermediate portion of said wire being ring-shaped with the axis of said ring-shaped portion being normal to the axis of the running wire whereby the explosion is directed to the center of the ring-shaped portion.

7. A focused exploding bridge wire as defined by claim **1** wherein a portion of the wire is formed with a protuberance on the circumference thereof for focusing the explosion radially outwardly thereof.

8. A focused exploding bridge wire according to claim 1 wherein said directing means is defined by a portion of the running wire being shaped as an elongated cone.

9. A focused exploding bridge wire according to claim 1 wherein said directing means is defined by a portion of the wire being channel shaped.

10. A focused exploding bridge wire according to claim 1 wherein the directing means is defined by a portion of the wire intermediate the ends thereof having a spiral helix configuration, said helix including a center post extending axially thereof.

11. A focused exploding bridge wire according to claim 1 wherein the directing means is defined by embedded, non-wire elements within a portion of said wire intermediate the ends thereof.

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