Feb. 13, 1968 R. L. KLOTZ 3,368,485

NONEXPLOSIVE DETONATING FUSE DIRECTIONAL INTERRUPTER

Filed April 8, 1966

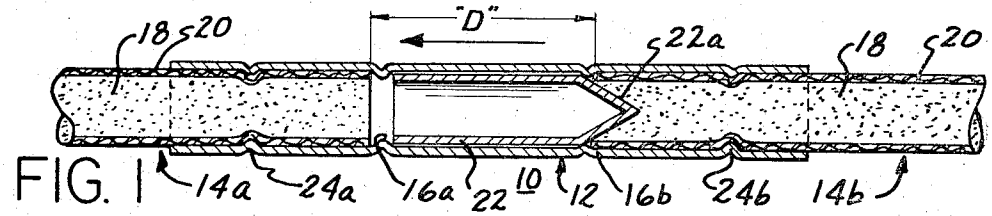


FIG. 1

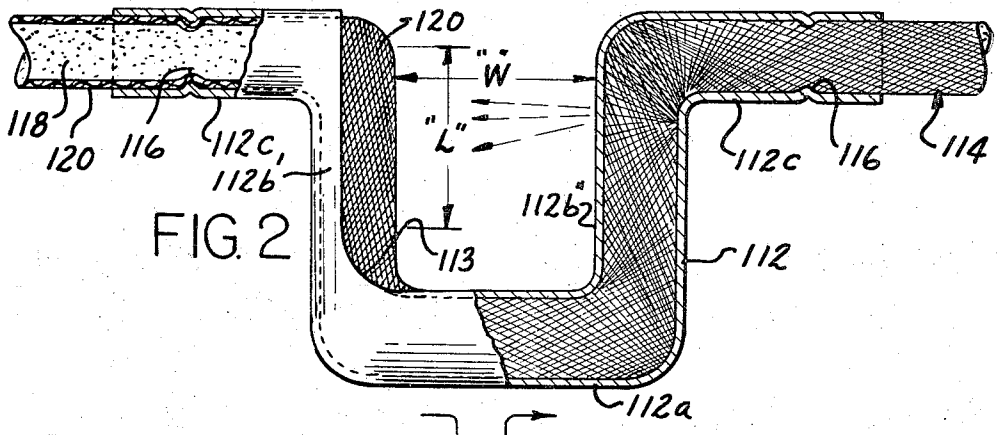


FIG. 2

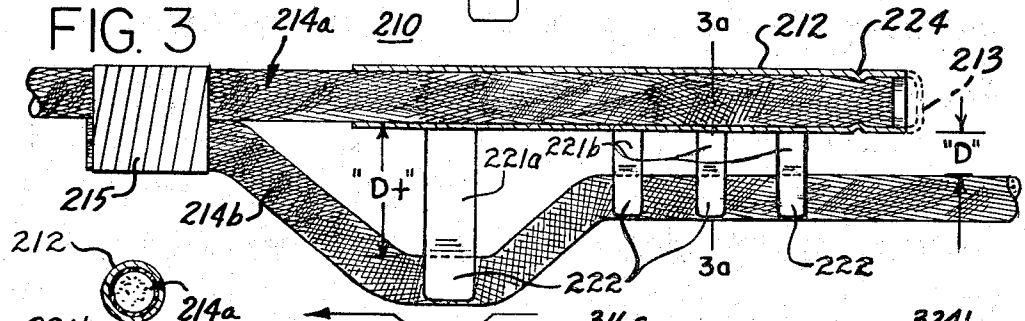


FIG. 3

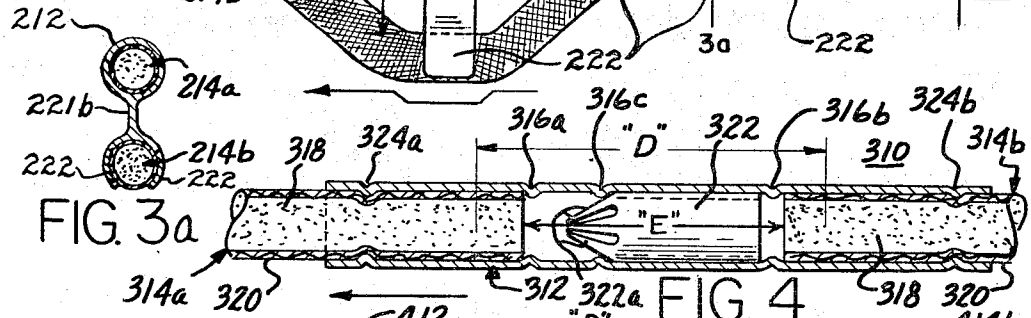


FIG. 3a

FIG. 4

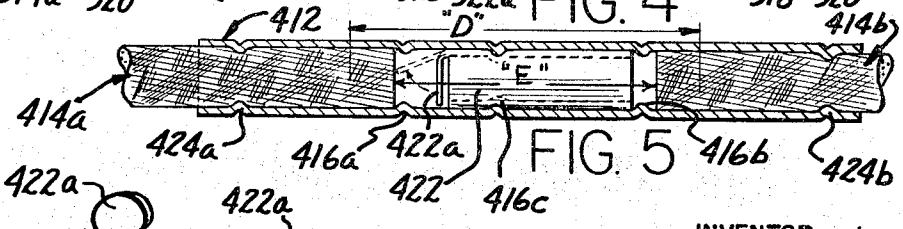


FIG. 5

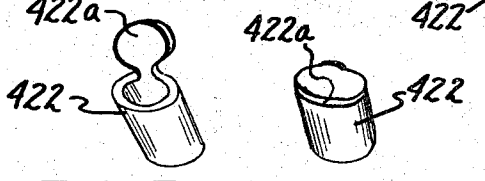


FIG. 5a FIG. 5b

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NONEXPLOSIVE DETONATING FUSE DIRECTIONAL INTERRUPTER

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ABSTRACT OF THE DISCLOSURE

A nonexplosive, unidirectional, detonating wave interrupter for use with a detonating fuse comprising spacer means creating a dual sensitivity in said fuse whereby a detonating wave traveling in one direction through the fuse is continuous, and a wave traveling in the opposite direction will be interrupted. The spacer means includes means holding different portions of the fuse in spaced-apart relation whereby a detonation wave traveling in one direction is transmitted through said spacing to the other portion, while a wave traveling in the other portion, while a wave traveling in the other portion of the fuse is interrupted by the spacing between the fuse portions.

The present invention relates to detonating fuses generally and, more particularly, to a new and improved nonexplosive detonating fuse directional interrupter.

Detonating fuses are widely employed by the users of explosives in many diverse applications, including oil and gas drilling and exploratory operations, mining and excavating operations, and more recently, in the aero space industry for detonating explosive components, such as hatch bolts and the like. In many instances, it is highly desirable, for safety and operating reasons, that a detonating fuse be installed with a unidirectional interrupter whereby detonating wave travel is permitted in only one direction and is blocked out or interrupted when moving in an opposite direction.

Therefore, it is an object of the present invention to provide a new and improved detonating fuse.

More specifically, it is an object of the present invention to provide a new and improved detonating fuse interrupter having a unidirectional characteristic to permit detonating wave travel in one direction only and positively interrupt or cut off a detonating wave impulse moving in the opposite direction.

Still another object of the invention is the provision of new and improved interrupter means for use with a conventional detonating fuse cord for interrupting a detonating wave traveling in one direction therein while permitting the travel of a wave in the opposite direction.

Yet another object of the invention is the provision of a new and improved unidirectional, nonexplosive, detonating wave interrupter which can be easily and rapidly installed in a length of conventional detonating fuse cord without requiring cutting of the fuse cord.

A further object of the invention is the provision of a new and improved unidirectional detonating wave interrupter for use with a detonating fuse which can be easily and rapidly installed in a length of fuse cord and which is completely reliable and safe in operation.

Another object of the invention is the provision of a new and improved unidirectional detonating fuse interrupter which is economical to manufacture, easy and safe to use and install, and highly reliable in operation.

These and other objects of the present invention are accomplished by the provision of a new and improved nonexplosive, unidirectional detonating fuse interrupter for preventing or interrupting the travel of a detonating wave in one direction through the fuse cord while permitting the travel of a wave in an opposite direction. The interrupter means is adapted for use with conventional types of commercial fuse cord and includes a spacer having a projectile-like shape between opposing end portions of a fuse cord adapted to transmit or permit propagation of a detonating wave traveling in one direction along the fuse cord and operable to intercept or cut off the propagation of a detonating wave traveling in an opposite direction.

In one embodiment of the invention, a tubular jacket or spaced, bent in a U-shaped configuration, is adapted to be slipped onto a continuous length of fuse cord without severing the cord, and a portion of the jacket adjacent one leg of the U is cut away to permit the cover of the fuse cord to be exposed to a segment of a cord enclosing, opposite leg of the jacket. When a detonating wave travels along the fuse cord in a direction to pass through the enclosed leg first, fragments of the jacket from the enclosed leg are projected across the space between legs against the exposed cover of the fuse cord in the opposite leg. These fragments serve to cut or mutilate the fuse cord in advance of the traveling wave which is stopped upon later reaching the mutilated portion of the fuse cord. On the other hand, a detonating wave traveling along the cord from an opposite end toward the U-shaped spacer reaches the partially exposed leg first and, because the opposite leg is fully protected, the fuse cord is not severed in advance of the traveling wave front. The opposite legs of the spacer are spaced apart by a distance greater than the propagation distance of the fuse cord so arranged but sufficiently close so that the spacer fragments can sever the cord.

In another embodiment of the invention, the fuse cord is severed to install the unidirectional interrupter, and the ends of the severed cord are inserted into opposite ends of a short, straight, tubular spacer or sleeve. The opposing ends of the severed fuse cord are held in spaced apart relation a distance greater than the normal propagation distance of the fuse cord, and a hollow projectile shaped inner spacer is interposed between the opposing ends. The projectile shaped inner spacer includes a conical projection on one end to form a cavity in the end of a fuse cord segment thereby to intensify and transmit or project the detonating wave impulse to travel across the space between the opposing fuse cord ends. The conical projection of the spacer enhances a wave traveling in one direction so that it reaches the opposing fuse cord end with sufficient intensity to cause ignition thereof; however, when a wave traveling in an opposite direction reaches the other end of the hollow spacer, it is not enhanced or intensified and cannot traverse the space between fuse cord ends with sufficient intensity to initiate wave propagation in the opposite fuse cord segment and, hence, the wave is interrupted.

In other embodiments of the invention the severed fuse cord ends are inserted into opposite ends of a tubular sleeve and are held in spaced apart relation somewhat less than the normal wave propagation distance. A tubular spacer is mounted in the sleeve between opposing faces of the fuse cord segments inserted therein and the spacer is formed with valve means on one end which is opened in response to an impulse traveling in one direction to transmit the detonating wave between the fuse segments. The valve means is closable in response to a wave traveling in an opposite direction and serves to muffle or interrupt the wave so that it will not travel across the space between the fuse segments.

Another embodiment of the invention utilizes a direct splice between severed fuse cord segments and employs spacer means which imparts a controlled bend in one segment of the fuse to enable a detonating wave traveling

in another adjacent straight fuse segment to move ahead of the wave in the bent segment and sever the bent segment ahead of the wave traveling therein by detonation and fragmentations from the wave in the straight segment. This severance action is accomplished when the direction of wave travel is such as to reach the splice between the fuse segments first, before entering the bent segment, and when the detonating wave travels in an opposite direction through the bent section before reaching the splice, it passes through the spliced fuse cord without interruption.

For a better understanding of the invention, reference should be had to the following detailed description taken in conjunction with the drawings, in which:

FIG. 1 is a longitudinal cross-sectional view of one embodiment of a unidirectional detonating fuse interrupter constructed in accordance with the present invention;

FIG. 2 is a side elevational view of another embodiment of a unidirectional detonating fuse interrupter constructed in accordance with the present invention with fragmentary portions of the apparatus shown in section or partially broken away;

FIG. 3 is a side elevational view of yet another embodiment of a unidirectional detonating fuse interrupter constructed in accordance with the present invention with fragmentary portions of the apparatus in section or partially broken away;

FIG. 3*a* is a transverse cross-sectional view of the interrupter taken along line 3*a*—3*a* of FIG. 3;

FIG. 4 is a longitudinal cross-sectional view of still another embodiment of a unidirectional detonating fuse interrupter constructed in accordance with the present invention; and

FIG. 5 is a longitudinal cross-sectional view of a still further embodiment of a unidirectional detonating fuse interrupter constructed in accordance with the present invention.

FIG. 5*a* and FIG. 5*b* show the valve member of FIG. 5 in the open and closed positions respectively.

Referring now, more specifically, to the drawings, in FIG. 1 there is illustrated one embodiment of a unidirectional, nonexplosive, detonating fuse interrupter constructed in accordance with the present invention and indicated generally by the numeral **10**. The interrupter **10** comprises a tubular outer sleeve **12** of copper or other metallic material having open outer ends adapted to receive end portions of a pair of detonating fuse cord segments **14***a* and **14***b*, which may be inserted into the sleeve in the field where the device is to be used. Generally, the fuse cord segments are cut from a continuous length of fuse cord in the field and the cut segments are then forced inwardly into opposite ends of the sleeve **12** until the square cut ends thereof abut against a pair of spaced apart annular ridges or stops **16***a* and **16***b*, respectively, formed in the sleeve by a crimping operation, preferably performed at the place of manufacture and spaced apart by a distance D somewhat greater than the normal wave propagation distance of the fuse cord.

The detonating fuse cord preferably is a conventional type available commercially (for example, detonating fuse made by Ensign-Bickford Co., of Simsbury, Conn. and sold under the trade name "Primacord" by Du Pont & Co. and other companies) and the sleeves **10** are manufactured in suitable sizes to match the diameters or fuse cord sizes on the market. Typically, detonating fuses of this type include an inner powder core **18** encased by an outer jacket **20** of impregnated fabric, and the compositions of the powder core may vary widely to provide for a desired speed of detonating wave or impulse that travels along the length of the fuse when activated. For example, in a given size or diameter of detonating fuse having a core of selected composition and grain size, a detonating wave will travel along the fuse at a desired wave velocity or rate of propagation. The rate of detonating wave propagation is directly related to a functional characteristic of the detonating fuse known as the wave propagation distance, and this distance could be defined as the minimum distance or air gap between spaced facing ends of a fuse core, which would be sufficient to interrupt and stop the detonating wave travel along the fuse, once underway.

Accordingly, the distance D between the annular crimped stops or ridges **16***a* and **16***b* in the sleeve **12** is made long enough so that the opposing, facing ends of the fuse segments **14***a* and **14***b* are spaced apart by a distance slightly greater than the propagation distance of the detonating fuse for which the interrupter **10** is designed. Consequently, a detonating wave originating in the fuse segment **14***a* and traveling toward the segment **14***b* (from left to right in FIG. 1) will not be able to bridge the air gap between the spaced facing ends of the fuse cord segments, and the wave or detonating impulse will be interrupted.

In order that a detonating impulse or wave traveling in an opposite direction from the fuse segment **14***a* toward the segment **14***b* (from right to left, FIG. 1, as indicated by the arrow) will pass or carry across the air gap between the spaced, opposing end faces of the fuse segments, a hollow tubular, inner spacer **22** having a projectile-like shape is mounted in the gap or space between end faces of the fuse cord segments **14***a* and **14***b*. The spacer **22** is held in place in the sleeve **12** by the crimped annular ridges **16***a* and **16***b* and, preferably, is constructed with a cylindrical body portion slightly less than the distance between the ridges. Preferably the projectile **22** is formed of metal, such as lead or copper, and includes a conically shaped closure **22***a* at one end thereof adjacent the end of the detonating fuse segment **14***b*. Because the conical closure **22***a* is the important functional structure of the spacer **22**, the hollow cylindrical body portion thereof could be shortened or eliminated altogether. In this case, the shortened spacer or the conical projection itself could be secured in the tube **12** by another crimping ridge intermediate the ridges **16***a* and **16***b*. The inner spacer **22** is installed in the sleeve **12** at the factory prior to the crimping operation which produces the ridges **16***a* and **16***b* or the intermediate ridge mentioned above, and after the crimping operation, these ridges positively hold the inner spacer in the sleeve and prevent longitudinal movement thereof. Preferably, the detonating fuse is cut into the segments **14***a* and **14***b* in the field, and the cut is made normal or perpendicular to the length of the fuse. Upon insertion of the fuse segment **14***b* into the sleeve **12**, the sleeve is twisted as the fuse segment is inserted and the fuse segment is forced inwardly into the sleeve until the powder core ngages the conical end **22***a* of the inner spacer, as shown. Twisting of the sleeve during fuse insertion permits the conical end **22***a* to bore into the end of the powder core, as shown, and forms a concave conical recess in the core, matching that of the conical end of the inner spacer. After insertion of the fuse segment **14***b* into the sleeve **12**, the fuse segment **14***a* is inserted from an opposite end in a similar manner until it abuts the ridge **16***a*.

Accordingly, when the fuse segment **14***b* carries a traveling detonating wave moving from the right toward the conical end **22***a* of the inner spacer, the wave reaches the conical cavity in the powder core and the cavity produces a directionalized, high intensity jet action or "Monroe" effect, which is capable of bridging or carrying across the air gap between the fuse segments **14***a* and **14***b* with sufficient concentration and intensity so that the detonation of fuse segment **14***a* is initiated thereby and the detonating wave continues on in a direction from right to left through the fuse segment **14***a*.

Thus, the interrupter **10** permits and aids a detonating wave to travel therethrough when the wave is moving from the fuse segment **14***b* toward the segment **14***a*, but positively interrupts or prevents a detonating wave from traveling through the interrupter in an opposite direction

because the distance between the fuse segments 14*a* and 14*b* is greater than the propagating distance or the detonating wave. The interrupter is easy to install in the field and only requires that the detonating fuse be cut and the segments thereof be inserted into the opposite ends of the sleeve 12. After the fuse segments have been fully inserted, the sleeve is crimped in the field with a conventional crimping tool to form a pair of annular ridges 24*a* and 24*b* on the inner surface thereof to hold the fuse segments tightly in the sleeve. The interrupter is now ready for operation and is effective to positively, and nonexplosively, interrupt and terminate a detonating wave traveling through the detonating fuse in one direction while permitting such a wave to travel through the apparatus in an opposite direction.

In FIG. 2 is illustrated another embodiment of a unidirectional, nonexplosive, detonating fuse interrupter constructed in accordance with the present invention and designated generally by the reference numeral 110. The interrupter 110 is adapted for use with a continuous length of detonating fuse 114 and does not require that the detonating fuse be severed or cut into segments, as in the embodiment previously described. The interrupter includes a spacing sleeve 112 of copper or other metallic material, and the sleeve is formed into a generally U-shaped configuration, including a bight portion 112*a*, a pair of spaced apart, parallel side legs 112*b'* and 112*b''* and a pair of outwardly extending legs 112*c*, which are coaxially aligned and parallel to the bight portion 112*a*. The U-shaped sleeve 112 is slipped or laced onto the detonating fuse 114 and moved along its length into the desired position. When properly positioned on the fuse in the field, a crimping tool is used to form inwardly extending annular ridges 116*a* and 116*b* on the inner surface of the sleeve legs 112*c* for engagement with the fuse to hold the interrupter in a selected position. The parallel legs 112' and 112*b''* of the sleeve are spaced apart by a distance W which is greater than the detonating wave propagation distance of the protected portion of detonating fuse 114 in the leg 112*b''* but within mechanical damage or severance distance of the unprotected portion of the fuse in leg 112*b'*.

An opening or cutaway portion is provided in the leg 112*b'* of the sleeve, as at 113, to expose an unprotected portion of the outer jacket or wrapper 20 of the detonating fuse 114, and the opening 113 is directly opposite and facing the opposite parallel protected leg 112*b''*. Accordingly, when a detonating wave or impulse travels through the detonating fuse 114 (from right to left, FIG. 2) and moves downwardly in the leg 112*b''* thereof, fragments of the sleeve are ejected outwardly in a direction indicated by the dotted arrows towards the exposed portion of the cable wrapper 20 in the opening 113 formed in the opposite leg 112*b'*. The opening 113 is substantial in length, as indicated by the letter L, to provide ample opportunity for the fragments ejected from the opposite leg 112*b''* to penetrate the exposed fuse cord in the opening and mutilate or cut it, so that by the time the traveling wave or impluse moves through the fuse from the leg 112*b''* across the bight portion 112*a* of the sleeve and begins to travel upwardly in the exposed leg 112*b'*, the fuse in the exposed leg is sufficiently mutilated, cut, or severed to interrupt and stop the wave travel. On the other hand, when a detonating wave or impulse travels through the detonating fuse cord 114 in an opposite direction (i.e., from left to right), the wave reaches the exposed leg 112*b'* first and moves down the leg, across the bight portion 112*a*, and up the leg 112*b''* without interruption. The leg 112*b''* protects the fuse 114 and shields it from ejected products of detonation and fragments from the opposite leg 112*b'* as the wave propagation proceeds downwardly therein. In addition, because of the cutaway or opening 113, there are few fragments from the sleeve leg 112*b'* available for puncturing or rupturing the opposite protected leg 112*b''* and also, because the legs are spaced apart by a distance W greater than the wave propagation distance of the sleeve protected fuse, wave travel from left to right is not interrupted. The interrupter 110 provides an additional advantage in that it is not necessary to cut the detonating fuse 114 in order to install the interrupted thereon. The interrupter includes only a single member, that being the sleeve 112, and no other parts or components are necessary.

In FIG. 3 is illustrated yet another embodiment of a unidirectional, nonexplosive detonating fuse constructed in accordance with the present invention and designated generally by the reference numeral 210. The interrupter 210 requires the cutting of the fuse cord into two separate segments 214*a* and 214*b*, which are then spliced together in the field with suitable splicing tape 215, wrapped around the body of the segment 214*a* some distance from the end thereof and around a portion closely adjacent the cut end of the fuse cord segment 214*b*, as shown in FIG. 3. The interrupter 210 employs controlled bends in one of the fuse segments to effect the desired unidirectional wave interrupting characteristic and includes a straight, tubular sleeve 212 which is open at one end and can be open or closed at the opposite end, as indicated by the dotted lines 213. This tube may be serrated so as to make it more easily fragmentized by a detonating wave traveling through the fuse segment 214*a*. The free end of the detonating fuse cord segment 214*a* is fully inserted into the sleeve 212 adjacent the opposite end thereof and is then secured in place in the field by means of a crimping tool which forms an annular, inwardly deformed retaining ridge 224.

The interrupter includes a number of outwardly extending spacing projections 221*a* and 221*b*, preferably integrally formed with the sleeve 212 and each projection including a pair of bendable lugs 222 for holding the fuse segment 214*b* in place. After the fuse segments 214*a* and 214*b* have been spliced together with the tape 215 and the segment 214*a* has been inserted into the sleeve 212 and crimped in place, the segment 214*b* is positioned along the outer ends of the projections 221*a* and 221*b*, as shown in FIG. 3, and the bendable lugs 222 are deformed around the fuse segment (FIG. 3*a*) to hold it in place in spaced relation to the sleeve 212. The projection 221*a* is considerably longer than the shorter projections 221*b* and, accordingly, the fuse segment 214*b* is considerably longer between the splice and the first projection 221*b* than is the straight fuse segment 214*a* between these two points. Accordingly, a detonating wave traveling from left to right in the straight fuse segment 214*a* will reach the first projection 221*b* well ahead of a corresponding separate wave traveling from the splice through the bent fuse segment 214*b*. The short projections 221*b* are dimensioned so that a distance D slightly greater than the wave propagation distance of the enclosed straight fuse segment 214*a* is maintained between the adjacent portions of the fuse segments 214*a* and 214*b* in the vicinity of the short projections; however, this spacing is less than the mechanical fragmentation and damage distance of the sleeve enclosed portion of the straight fuse segment 214*a*, so that fragments from a detonating wave therein will mutilate, sever and rupture the exposed adjacent portion of the fuse segment 214*b*. On the other hand, the projection 221*a* is substantially greater than the distance D to provide for a time lag of detonating wave traveling from the splice 215 in the fuse 214*b*, as previously described.

Operation of the interrupter 210 is as follows: When a detonating wave traveling in a direction from right to left (FIG. 3) reaches the splice 215, a second divergent wave is initiated in the fuse segment 214*b*. Because of the projection 221*a*, the wave traveling in the straight segment 214*a* reaches the region adjacent the short spacer

projections 221*b*, and fragments from this wave sever the adjacent portion of the fuse segment 214*b* before the divergent wave reaches the area and, accordingly, the detonating wave travel is positively interrupted. On the other hand a detonating wave traveling from right to left will pass along the fuse segment 214*b*, splice 215, and continue on through the segment 214*a* in the same direction without interruption.

In FIG. 4 is illustrated another embodiment of a unidirectional detonating fuse interrupter constructed in accordance with the present inention, and indicated generally by the reference numeral 310. In many aspects, the interrupter 310 is similar to the interrupter 10 previously described and, accordingly, corresponding parts of the interrupter 310 are numbered with reference numerals 300 higher than those of the interrupter 10. The crimped annular internal ridges 316*a* and 316*b* in the sleeve 312 are spaced apart by a distance E somewhat less than the wave propagation distance D of the enclosed fuse segments 314*a* and 314*b*. A hollow tubular valve member 322 of metal or other material is mounted in the sleeve 312 between the ridges 316*a* and 316*b*, and the member 322 is formed with a plurality of conically inwardiy extending bendable valve forming segments 322*a* adjacent one end thereof. The outer tips of the segments 322*a* are normally closed together, as shown, to form a generally conical projection having a pointing coaxially toward the end fuse of the face segment 314*a*. Another annular internal ridge 316*c* is formed at the factory in the sleeve 312 after the tubular member 322 is inserted therein, and this ridge is adjacent the bases of the segments 322*a* and prevents longitudinal movement of the tubular valve member in the sleeve.

When a detonating wave or impulse travels from right to left (FIG. 4) through the fuse segment 314*b*, it reaches the end of the segment and flows through the tubular member 322 toward the segments 322*a* adjacent the end thereof. These segments are opened outwardly by the wave, permitting the wave to reach the opposite end face of the fuse segment 314*a*. Because the opposing end faces of the fuse segments 314*a* and 314*b* are spaced apart by the distance E, which is less than the normal wave propagation distance D, the wave traveling through the valve member 322 is strong enough to penetrate and initiate detonation of the fuse segment 314*a*, and the wave then progresses on through the fuse segment 314*a* from right to left.

When a detonating wave or impulse travels in an opposite direction (left to right, FIG. 4) through the fuse segment 314*a*, the wave reaches the end face thereof and starts to move across the air gap toward the segmented conical end of the tubular valve member 322. The pressure action of the wave, however, tends to force the segments 322*a* into a tightly sealed conical configuration, and the wave cannot pass through the tubular member and is dissipated or interrupted by outward deflection. Accordingly, the tubular member 322 acts as a check valve to permit passage of a wave traveling from right to left to jump or traverse the air gap E between the end faces of the fuse segments while a wave traveling in the opposite direction is interrupted by the closing or valving action of the conical segments 322*a* and becomes muffled and diverted outwardly away from the fuse segment 314*b* at the opposite end of the air gap. Because of the valving or muffling effect of the conical end segments 322*a*, the gap between the ends of the fuse segments 314*a* and 314*b* can be reduced somewhat below the distance D, as shown, and interruption of a wave traveling from left to right is still positively effected.

In FIG. 5 is illustrated yet another embodiment of a unidirectional, detonating fuse interrupter constructed in accordance with the present invention and indicated generally by the numeral 410. The interrupter 410 is almost identical with the interrupter 310 except for the construction of the hollow check valve member 422 therein and, hence, reference numerals with the prefix 4 will be used on parts corresponding to similar components of the interrupter 310 bearing the prefix 3.

The valve member 422 is illustrated in an open position in FIG. 5*a* and in a closed position in FIG. 5*b* and, as illustrated in FIG. 5, is positioned in the sleeve 412 in the closed position. The valve member includes a single flapper 412*a* at one end which is bendable from the closed position of FIGS. 5 and 5*b* to the open position of 5*a* during operation of the interrupter. As a detonating wave or impulse travels along the fuse segment 414*b* from right to left, it passes through the open hollow body of the valve member 422 causing the flapper valve portion 422*a* to open and permit the wave to reach the end face of the fuse segment 414*a*. Accordingly, the wave will then continue to travel along the fuse segment 414*a* in a direction from right to left, as indicated by the arrow. When a detonating wave travels in the opposite direction in the fuse segment 414*a* from right to left, it is interrupted or muffled upon reaching the closed flapper 422*a* which is forced thereby more tightly against the end of the hollow valve member 422.

While there have been illustrated and described various embodiments of the present invention, it will be apparent that various changes and modifications thereof will occur to those skilled in the art. It is intended in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A nonexplosive, unidirectional, detonating wave interrupter for use with a length of detonating fuse comprising structure for receiving a portion of said fuse inserted therein and including spacing means for maintaining portions of said fuse spaced apart by a distance greater than the detonating wave propagation distance of said fuse, and nonexplosive wave enhancing means associated with said structure for intensifying and transmitting a detonating wave along said fuse across said spacing means when said wave is traveling in one direction therethrough.

2. The interrupter of claim 1 wherein said structure includes a length of tubular sleeve adapted to receive in opposite ends thereof opposing end segments of said fuse, said spacing means comprising means in said sleeve for holding said end segments inserted therein in said spaced apart relation, said wave enhancing means including a concave member inside said sleeve between the ends of said fuse segments positioned to extend inwardly into and form a cavity in the end of one of said segments, thereby producing a "Monroe" effect for carrying said wave across said spacing means.

3. A nonexplosive, unidirectional, detonating wave interrupter for use with a detonating fuse having a selected detonating wave propagation distance comprising nonexplosive spacer means for creating a dual sensitivity in said fuse whereby a detonating wave traveling in one direction through said fuse is continuous and a wave traveling in the opposite direction is interrupted, said spacer means including means holding different portions of said fuse in spaced-apart relation wherein a detonation wave traveling in one portion is transmitted across said spacing to the other portion while a wave traveling in said other portion is interrupted by said spacing between fuse portions.

4. A nonexplosive, unidirectional, detonating wave interrupter as in claim 3 for use with a continuous length of detonating fuse wherein said nonexplosive spacer means comprises a sleeve structure for encasing and bending a length of said fuse extending therethrough, said sleeve structure formed in a U-shaped configuration with a pair of legs having portions spaced apart by a distance slightly greater than the detonating wave propagating distance of said fuse but within the mechanical

fragmentation distance thereof, one of said legs including opening defining means facing an opposite leg to expose a portion of said fuse therein to fragmentation from said opposite leg.

5. A nonexplosive, unidirectional, detonating wave interrupter as defined in claim **3** for use with spliced together segments of a fuse cord wherein said nonexplosive spacer means comprises structure for bending one of said segments in a divergent path away from the other whereby a wave reaching said splice initiates two separate waves traveling in each of said segments, said structure including a plurality of spacers of different length between said fuse segments, a shorter one of said spacers being dimensioned to maintain adjacent portions of said segments spaced by a distance greater than the normal wave propagation distance but less than the mechanical fragmentation distance thereof whereby the diverging one of said segments is ruptured in advance of a separate detonating wave traveling therethrough by the separate detonating wave traveling in the other fuse segment.

6. A nonexplosive, unidirectional, detonating wave interrupter as defined in claim **3** wherein said nonexplosive spacer means comprises structure for receiving a portion of one fuse segment and means for maintaining an adjacent portion of another fuse segment spaced apart by a distance greater than the detonating wave propagation distance of said fuse but less than the mechanical fragmentation distance thereof, means for splicing said fuse segments together externally of said structure, said spacing means including means for bending a portion of said other fuse segment away from said one segment between said splice and said adjacent portion.

7. The fuse interrupter of claim **6** wherein said structure includes a frangible tubular sleeve for receiving a length of said one fuse segment and includes projections of different length extending outwardly of said sleeve and spaced along the length thereof for spacing said other fuse segment away from said sleeve.

8. A nonexplosive, unidirectional, detonating wave interrupter as defined in claim **3** wherein said nonexplosive spacer means comprises a tubular structure for receiving a portion of said fuse inserted therein and means for maintaining segmented end faces of said fuse in spaced apart relation in said tubular structure by a distance less than the wave propagation distance of said fuse and check valve means in said tubular structure between the end faces of said fuse segments operable to close in response to a detonating wave traveling in one direction along said fuse and operable to open in response to a wave in an opposite direction to permit passage of said wave across said spacing distance between the end faces of said fuse segments.

9. The interrupter of claim **8** wherein said check valve means includes a hollow member having valve means at one end comprising one or more movable deflectors movable to close the end of said tubular member in response to a detonating wave traveling in said opposite direction and movable to open the end of said tubular member in response to the travel of said wave along said fuse in said one direction.

10. The interrupter of claim **9** wherein said deflector comprises a plurality of conical segments closable together forming a conical projection extending towards the end of one fuse segment.

11. The interrupter of claim **9** wherein said deflector includes a single circular flapper valve closable against one end of said hollow valve member.

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