March 8, 1966 R. C. ALLEN 3,238,873

DETONATING FUSE TERMINATION

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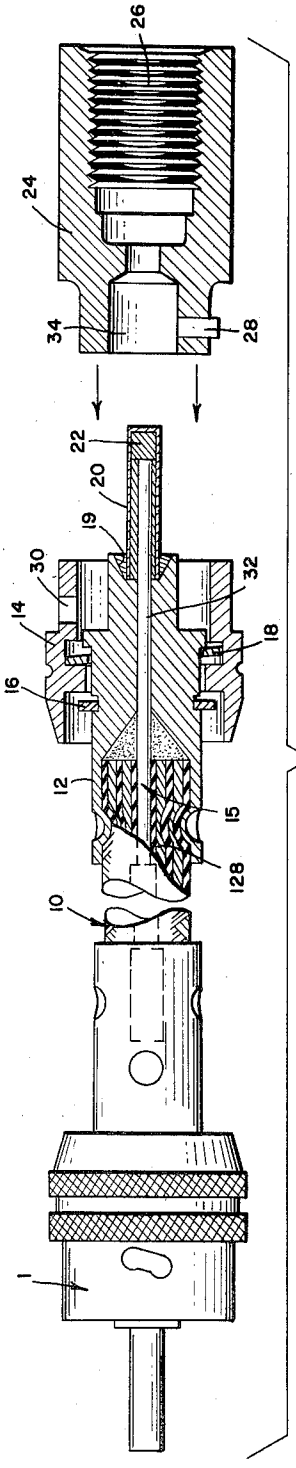


FIG. 1

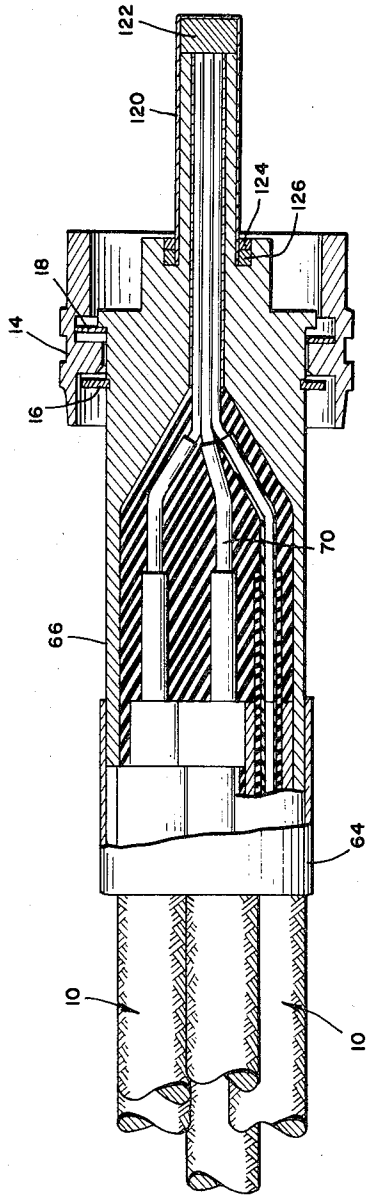


FIG. 5

INVENTOR

ROBERT C. ALLEN

BY Semmes & Semmes

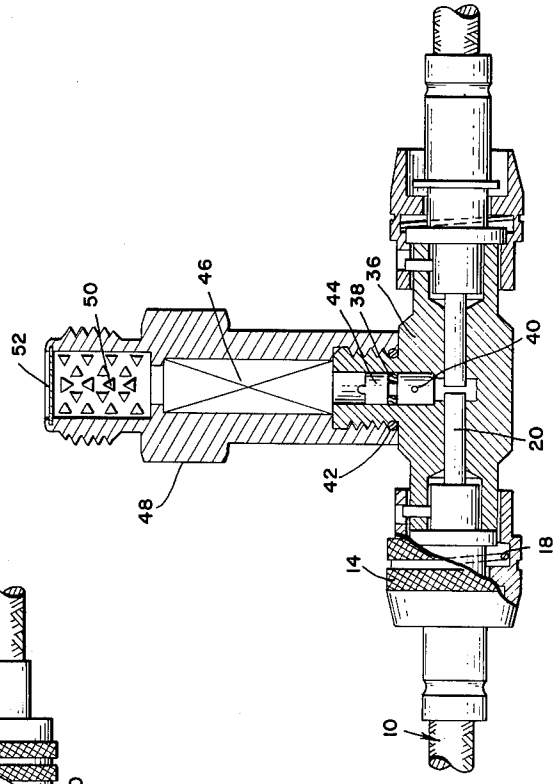
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FIG. 2



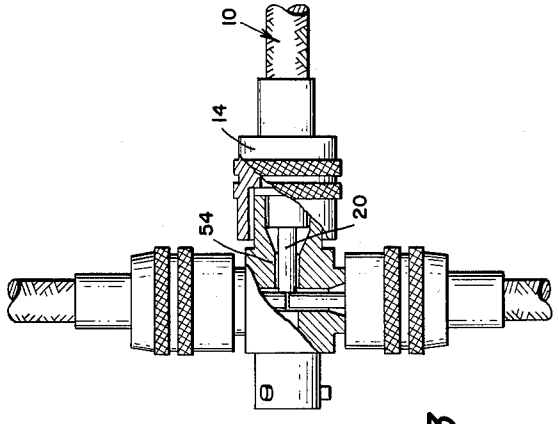


FIG. 3

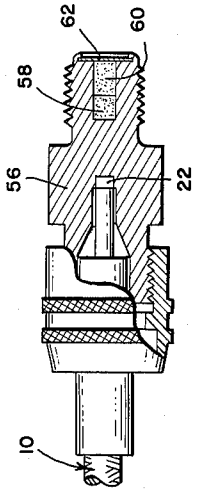


FIG. 4

INVENTOR

ROBERT C. ALLEN

BY Semmes & Semmes

ATTORNEYS

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DETONATING FUSE TERMINATION

Robert C. Allen, Hollister, Calif., assignor to Teledyne, Inc., Hollister, Calif., a corporation of Delaware

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10 Claims. (Cl. 102—27)

The present application relates to a method for readily terminating confined detonating fuse within an explosive train or explosive-mechanical component, while preventing the emanation of explosive particles during detonation.

Numerous previous inventors have devised means for terminating detonating fuses in an explosive or explosive-mechanical system. However, these inventors have not been able to contain effectively the potentially hazardous particles generated when the confined detonating fuse and subsequent explosive charges are detonated. In an effort to contain these particles some terminating assemblies have been provided with threaded fittings of the type used on high pressure tubing. These threaded fittings are not only expensive but, inconvenient and time consuming to attach to mating receptacles.

According to the present method an end of the confined detonating fuse is reduced in cross-sectional area, then sealed as an elongated probe and enclosed in a quick disconnect coupling. Similarly, the pickup charge in the mating explosive train attachment is reduced in cross sectional area. By reducing the cross-sectional area of the detonating fuse and the explosive train to the appropriate minimum required to reliably propagate a detonation, there is achieved a corresponding reduction in total quantity of gas generated. As a result there is achieved transmission of detonation through small diameter probes into the mating receptacle. According to modifications of the method dual confined detonating fuses of reduced diameter cross section may be supported in an igniter delay mechanism, a plurality of confined detonating fuses of reduced diameter cross section may be supported in a manifold in end to end relationship, a plurality of confined detonating fuses may be terminated within a single reduced diameter probe and a confined detonating fuse of reduced area cross section may be mated to an explosive train having a baffle intermediate the pickup charge and the probe end.

Accordingly, it is an object of invention to provide a method for safely terminating confined detonating fuses in quick disconnect assemblies.

Another object of invention is to provide a method for terminating one or more confined detonating fuses in a single probe of reduced area cross section.

Another object of invention is to provide a method for terminating confined detonating fuses in quick disconnect fittings, while eliminating the emanation of potentially hazardous particles during detonation.

Yet, additional objects of invention will become apparent from the ensuing specification and attached drawings wherein:

FIG. 1 is a front elevation, partially in section showing a suggested quick disconnect confined detonating fuse termination, manufactured according to the present method.

FIG. 2 is a modification of invention wherein dual confined detonating fuses terminate in an igniter delay housing;

FIG. 3 is another modification wherein a plurality of confined detonating fuses terminate in a manifold;

FIG. 4 is another modification wherein the confined detonating fuse reduced diameter portion terminates in a through bulkhead initiator;

FIG. 5 is another modification wherein a plurality of

confined detonating fuses terminate in a single probe of reduced diameter cross section.

The present method reduces the cross-sectional areas of both the linear explosive and end attachment exposed to the detonating or deflagrating bootser charges, thus reducing the forces on the attachment assembly during detonation or deflagration to a level that can be easily retained by the relatively low strength rapid disconnect type fittings. The invention specifically relates to a unique mehtod for designing the terminating explosive charges or end closures for use on linear detonating fuse such as mild detonating fuse (MFD), these linear detonating fuses manufactured under the trademarks Pyrocore, Primacord, and all types of flexible linear shaped charges. By reducing the cross-sectional area of the terminating charge, relatively low strength retainer methods may be applied to completely contain the potentially hazardous particles generated by the detonating or deflagrating explosive charges.

In FIG. 1, a confined detonating fuse generally designated as **10** is shown as terminating in a coupler or probe body **12** having a reduced diameter axial bore **32**. Fuse **10** reduced diameter portion **15** extends through axial bore **32** beyond coupler body **12** as a probe **20** where it is sealed environmentally by means of an aluminum or stainless steel fitting. An end booster charge **22** may or may not be employed. A conventional quick disconnect fitting of the bayonet type **14** may be employed together with optional retaining ring **16** and springs **18**. The entire quick disconnect assembly may be mated within the adjacent explosive strain attachment **24** having complementary female recesses **34**. explosive train chamber **26** and pins **28** for engagement with corresponding apertures **30** in the quick disconnect coupling **14**.

In FIG. 2 identical dual confined detonating fuses **10** terminating in end probes **20** of reduced diameter cross-section are shown placed in end to end relationship within an igniter delay assembly comprising a steel cadmium plated base **36** fitted to an upper steel cadmium plated housing **48** by means of O-rings **38** and **42**. A piston **44** mounted upon shear pin **40** may be placed beneath percussion initiated delay assembly **46** which is adjacent main charge **50**. A closure **52** may be applied at the top of main charge **50**.

In FIG. 3, a further modification is illustrated wherein four confined detonating fuses **10** are capable of quick disconnect fitting within a four way manifold **54**.

Yet another object of invention is illustrated in FIG. 4 wherein the confined detonating fuse **10** is shown as mated to a through bulkhead initiator **56** having pick-up charge **58**, pressure charge **60** and end closure **62**. This type of thorough bulkhead initiator is disclosed in applicant's co-pending application Serial No. 314,676, filed October 8, 1963, and entitled Method for Through Bulkhead Shock Initiation.

Yet another modification of invention is illustrated in FIG. 5 wherein a plurality of confined detonating fuses **10** terminate in a Teflon boot **64** which in turn engages a probe body **66** which may be of aluminum. Potting may be employed to enclose the reduced diameter individual fuse portions **70** which are concentrically arranged within a single probe **120** of reduced cross section which extends through the probe body **66**. A booster charge **122** may be employed at the probe **120** end. Potting **124** and swage ring **126** may be employed to secure probe **120** to the probe body **66**. Probe **120** may then be attached to an explosive train of reduced diameter or cross-section as in the other modifications of invention.

The unique feature of the present method resides in reducing to an absolute minimum the area exposed to the pressure generated by the detonating or deflagrating charges. This is accomplished by reducing the column

diameter of the explosive at the terminating attachment to the approximate minimum required to reliably propagate a detonation. For large detonating fuse such as that trademarked and known commercially as "Primacord" this will require reducing the quantity of explosive distributed linearly at the attachment. For small detonating fuse such as MDF this may require simply reducing the cross-sectional area to the bare metal covered explosive core. For instance, the assembly shown in FIG. 1 incorporates confined detonating fuse **10**, which has an as-made cross-sectional area of .07 sq. in. This has been reduced to the bare metal covered MDF explosive core, **20**, with a cross-sectioned area of only .0017 sq. in. at the attachment.

This reduction in explosive cross-section not only reduces the total quantity of gas generated for large linear charges but also allows transmitting the detonation through small diameter "probes" into the mating receptacle. A typical mating receptacle for use with the invention is shown also in FIG. 1. The gas or shock generated by the detonation of a *booster charge*, **22**, on the end of the installed probe or additional detonating or deflagrating charges contained in the receptacle assembly is restricted by the receptacle design to act only on the area equivalent to the cross-sectional area of the probe. With such a small area exposed to the shock and/or high pressure a relatively small, light weight, retaining coupling is required to keep the probe and any other potentially hazardous particles and gases from being explosively expelled from the retainer. For instance, only a standard Bendix "Pygmy Type PT" bayonet quick-disconnect shell, **14** is required to retain a typical linear charge attachment designed in accordance with the teachings of this invention. Only slight modifications in the probe **20**, such as substitutiing steel for aluminum will provide enough strength to the thin wall probe so that the expansion of the probe by the detonating column of explosive contained therein will actually rivet and/or weld the installed probe into the mating receptacle **24**, assuring even a more positive retaining action and frequently resulting in no force being applied to retainer **14** during detonation of the assembly. Retainer **14** in this case acts only as a means for assembling and maintaining the linear explosive attachment installed in the mating receptacle.

The assembly shown in FIG. 1 incorporates a potting well **128** in the coupler **12** body to accommodate the fabric and plastic covering on the confined detonating fuse **10**. Tests have proven the method of attachment shown in FIG. 1 to be capable of retaining the confined detonating fuse before and after firing even at cryogenic temperatures of —343° F. The ability of this type attachment method to retain the fired confined detonating fuse is attributed directly to the reduction of the cross-sectional area of the CDF exposed to the detonating shock and pressure.

Obviously, a number of methods may be utilized to attach and retain the reduced diameter end probe assembly to the linear explosive or to assemble and retain the attachment body to the mating receptacle. Also, the invention obviously may be utilized in conjunction with practically any linear explosive charge. Previous tests have been restricted to, and proven successful with, (1) potting and/or mechanical crimping methods of attaching the assembly to the linear explosive, (2) one to six linear fuse assemblies terminating in a single attachment as illustrated in FIG. 5, (3) PETN and RDX core detonating fuse, 1 and 2 grains per foot (4) with, and in special cases, without an area restricting baffle in the mating receptacle, (5) aluminum and steel retainer bodies and (6) with and without a supplementary booster charge **22** incorporated into the probe.

In view of the previous work in the industry with threaded high pressure type retainers the invention is directed to utilization of only rapid or quick-disconnect type retainers on the attachment assemblies or only low strength threaded retainers. Practically any pneumatic, hydraulic, or electrical quick or rapid connect-disconnect assembly can be readily adapted for use with the invention.

A few of the components that may be readily adapted for assembly with and actuated by the invention are represented in FIGS. 2–5. Complete networks for accomplishing a number of one-time functions utilizing the invention for coupling the various linear explosive transfer lines may also be employed. Detonation of such systems will prevent shrapnel or hazardous particles from being generated except at those locations requiring that such particles be generated such as explosive bolts, destruct units, and separation charges.

Manifestly, various types of fitting materials may be employed, the degree of reduction in cross-section of both the confined detonating fuse and the explosive train may be varied without departing from the spirit and scope of invention, as defined in the subjoined claims.

I claim:

1. A detonating fuse termination comprising:

(A) a detonating fuse;

(B) a coupler body supported about the end of said detonating fuse and having an axial bore of reduced cross-section with respect to the end of said detonating fuse;

(C) a linearly extending, reduced diameter portion of said detonating fuse extending as a probe through and beyond said coupler body;

(D) an environmental seal fixed to that portion of said reduced diameter probe extending beyond said coupler body;

(E) a quick disconnect fitting attached about said coupler body;

(F) said fuse comprising an explosive core, the portion of the explosive core defined by said reduced diameter portion of said detonating fuse having a cross-sectional area which is relatively smaller than the cross-sectional area of said explosive core defined by the unreduced portion of the detonating fuse.

2. A detonating fuse termination assembly as in claim **1**, including a booster charge positioned at the exposed end of said probe and wherein said coupler body is potted to the end of said confined detonating fuse.

3. A detonating fuse termination attachment as in claim **2**, said probe being mated to an attached explosive train has an initial explosive pickup of reduced diameter cross section and having a complementary quick disconnect fitting.

4. A detonating fuse termination attachment as in claim **2**, wherein a plurality of reduced diameter probes are positioned within an inert manifold in end to end relationship.

5. A detonating fuse termination attachment as in claim **2**, wherein dual detonating fuses with reduced diameters end probes are supported by quick disconnect fittings in a confined igniter delay housing.

6. A detonating fuse termination assembly as in claim **2**, wherein said detonating fuse, reduced diameter end probe is mated by a quick disconnect means into an explosive train having a baffle between said probe and a pickup charge.

7. A detonating fuse termination assembly as described in claim **1**, including a booster charge positioned at the exposed end of said probe.

8. A detonating fuse termination assembly as described in claim **1**, wherein said coupler body is potted to the end of said detonating fuse.

9. A detonating fuse termination attachment as in claim **8**, wherein a plurality of reduced diameter probes are positioned within an inert manifold in end to end relationship.

10. A detonating fuse termination attachment as in claim 8, wherein dual detonating fuses with reduced diameters end probers are supported by quick disconnect fittings in an igniter delay housing.

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BENJAMIN A. BORCHELT, *Primary Examiner.*

SAMUEL FEINBERG, *Examiner.*

R. V. LOTTMANN, *Assistant Examiner.*