This invention relates to a novel safety device. More particularly this invention relates to a novel connecting device for detonating cord which permits detonation of the cord in only one direction.

It has been the practice in the blasting art for many years to connect two or more explosive charges by means of detonating cord. Occasionally delay type connecting initiators are inserted between pieces of the detonating cord to delay substantially the firing of two or more of the explosive charges. In such a system, using bidirectional connectors, the detonating cord or a portion of it, may inadvertently be detonated in the wrong direction, which may result in the unprogrammed explosion of the explosive charges, thereby resulting in the possible waste of explosive power and injury to personnel.

It is an object of the present invention to provide a novel connecting device for lengths of detonating cord. Another object of the invention is to provide a novel connecting device which permits detonation between two lengths of detonating cord in only one direction. Still another object of the invention is to provide a novel safety device for use with detonating cord.

It is another object of the invention to provide a novel device for controlling the direction of detonation in detonating cords without introducing an appreciable delay in the effective rate of detonation. These and other objects of the invention will be apparent as the invention is described more fully below.

Generally speaking the objects of this invention are accomplished by providing a connecting device for connecting two lengths of detonating cord, the connecting device permitting detonation between the two lengths of detonating cord in only one direction. The novel connecting device is comprised of a tubular metallic shell having a unidirectional detonating unit centrally positioned therein. The inner diameter of the tubular shell is substantially the same as the outer diameter of the lengths of detonating cord to be connected, and space is provided at each end of the tubular shell for inserting the end of each length of detonating cord to abut one side of the unidirectional detonating unit. The unidirectional detonating unit contains in sequence, in the direction of detonation, a water-proofing barrier, a metal baffle, an enclosed air gap of appropriate axial length, an initiating charge and a base charge. When a first length and a second length of detonating cord are connected to the novel connecting device and the first length is detonated, the detonation of the first length is sufficient to expel the water-proofing barrier and metal baffle, propel the initiating charge or detonation “wave” to the explosive initiating charge, which in turn explodes the base charge. The latter explosion is of sufficient strength to initiate detonation in the adjacent second length of detonating cord, which detonates explosively. However when detonation first occurs in the second length of detonating cord, the detonation of the explosives of the connector is insufficient to cross the air gap in the connecting device and to detonate the first detonating cord. As a result, the novel connecting device of the invention permits passage of detonation in one direction between two lengths of detonating cord, but does not permit detonation in the opposite direction. In addition, passage of detonation across the connecting device in the desired direction is effected without appreciable delay in the rate of detonation.

The accompanying drawing will serve to illustrate a specific embodiment of the invention, in order that its utility and function will be more thoroughly appreciated. It will be understood however, that this is by way of illustration only and is not to be taken as limiting the invention in any way.

The drawing shows a novel connecting device 10 of the instant invention comprised of a tubular metallic shell 11 having a unidirectional detonating unit 12 centrally positioned therein. Unidirectional detonating unit 12 is comprised of a baffle section 17 and a detonating charge section 13 which are shown in the form of cylindrical cores having an outside diameter substantially equal to the inside diameter of tubular metallic shell 11. These cylindrical cups enclose an air gap 14. Baffle section 17 has a barrier 18 enclosing the portion of the air gap 14c. Communicating with air gap 14a is the open end of detonating charge section 13 which contains portion of the air gap 14b, an initiating charge 15 and a base or main explosive charge 16.

The components of unidirectional detonating unit 12 are normally assembled within tubular metallic shell 11 in sequential order opposite to the direction of detonation. Crimp 19 or other suitable means for locating the members is placed in tubular metallic shell 11. The closed end of loaded detonating charge section 13 is positioned against the crimp, and the open end of baffle section 17 is then positioned against the open end of detonating charge section 13. Layers 20 and 21 of water-proofing adhesive are formed at each end of unidirectional detonating unit 12 to seal the unit against moisture and the like.

Opening 23 is provided in one end of the connecting device for inserting the first length of detonating fuse and opening 22 is provided in the opposite end of the connecting device 10 for inserting the second length of detonating cord.

More in detail, tubular metallic shell 11 has an inside diameter appropriate for receiving the outside diameters of the detonating cords to be connected. The tubular metallic shell 11 is preferably constructed of aluminum, but any other ductile metal which may be conveniently attached to detonating cord by crimping or stabbing may be employed. The length of the tubular metallic shell 11 is not critical, but it should be sufficiently long to contain a unidirectional detonating unit 12, with sufficient space to permit inserting two lengths of detonating cord. The thickness of the tubular metallic shell 11 is not critical, but should not be too thick to be cramped, as described more fully below.

Unidirectional detonating unit 12 is positioned centrally within the tubular metallic shell 11, and is preferably constructed of two cylindrical cups (baffle section 17 and detonating charge section 13) each having an outside diameter substantially equal to the inside diameter of tubular metallic shell 11.

Main or base explosive charge 16 is positioned in detonating charge section 13 next to the closed end of the cylindrical cup forming the detonating charge section 13. Compounds suitable for use as the main or base explosive charge 16 include compounds such as cyclonite, HMX, tetryl or other stable secondary explosives.

Initiating charge 15 is positioned next to base explosive charge 16. Compounds suitable for use as initiating charge 15 include lead azide, mercury fulminate, lead stibnite, nitromannonite when loaded in compatible metals and with appropriate base charge explosives. If desired, initiating charge 15 and base explosive charge 16 may be admixed prior to adding to detonation charge section 13 to serve as a single explosive compound in the detonating sequence.
Air gap 14 extends a suitable distance from initiating charge 15 to the open end of detonating charge section 13. Baffle section 17, which is preferably a cylindrical cup, is placed adjacent to the open end of detonating charge section 13. Barrier 18 of baffle section 17 encloses air gap 14a, which communicates with the air gap 14b in detonating charge section 13. Barrier 18 is preferably of sufficient thickness to furnish high velocity projectiles when combined with detonation energy to insure initiation of initiating charge 15. If desired, baffle section 17 may be in the form of a disc (not shown) and both air gaps 14a and 14b may then be contained within detonating charge section 13.

Both section 13 and baffle section 17 are preferably formed from aluminum, but any material compatible with the explosives may be used.

In preparing the novel connecting device, a crimp 19 or other suitable means for locating members is placed near one end of tubular metallic shell 11. Detonating charge section is essentially under the trade name charges 15 and which as described above is placed in tubular metallic shell 11, with the closed end next to crimp 19. Baffle section 17 is then placed in tubular metallic shell 11 with its open end next to the open end of detonating charge section 13 to form the unidirectional detonating unit 12.

Layers of water-proofing adhesive 20 and 21 are positioned at each end of the unidirectional detonating unit 12 to seal moisture from the unit, and to lock unidirectional detonating unit 12 within tubular metallic shell 11. Suitable sealing compounds include curable resins such as epoxy resins, urethane rubbers such as those sold commercially under the Adiprene trademark, and lacquers such as plasticized nitrocellulose and ethyl cellulose dispersed in suitable solvents which may be poured or painted into each end of the tubular metallic shell 11 as a liquid, and then allowed to solidify by curing or drying. These layers are shown in the drawing in the shape of discs, but may be any convenient shape for sealing the juncture between tubular metallic shell 11 and unidirectional detonating unit 12, and for locking the two units together. If desired, the water-proofing adhesive 20 may be colored a different color, with a suitable dye or the like, from that of sealing compound 21 in order to indicate to the operator the direction in which detonation can be effected through the novel connecting device. However the unit is normally marked with an arrow indicating the direction that detonation will be transmitted.

When utilizing the novel connecting device, a first length of detonating cord is inserted within opening 23 to abut baffle section 17, and a second length of detonating cord is inserted within opening 22 to abut detonating charge section 13. Both lengths of detonating cord are secured to tubular metallic shell 11 by crimping, or other suitable technique for securing the lengths to the shell.

Typical examples of suitable detonating cords which may be employed in combination with the novel connector of the instant invention include the detonating cord sold commercially under the trade name charges 15 and which is a detonating fuse having a core of PETN enclosed in a fabric covering and having a velocity of around 20,300 feet per second. Cordeau, which is a lead-sheathed cord of somewhat lower velocity, is likewise applicable.

The distance between base charge 16 and the end of the second length of detonating charge secured within opening 22 is critical to the extent that the cord end must be close enough to the base of detonating charge section 13 to insure dependable propagation from base charge 16 to the cord inserted and secured in the opening 22 of tubular metallic shell 11. The axial distance occupied by air gap 14 should be great enough to prevent in an unprogrammed explosion, the transmission of sufficient detonating energy from the combined reaction of the detonating cord in the opening 22 and charges 15 and 16 to initiate the cord in opening 23. On the other hand when a programmed detonation is transmitted through a detonating cord in opening 23, energy is transmitted through baffle section 17 and air gap 14 to initiating charge 15, which in turn detonates the base charge 16, which is of sufficient strength to energize the detonating cord in opening 22. Thus the proper selection of the length of the air gap 14 and the material and construction of the baffle section 17 for use with a given grade of detonating cord secures the dependable functioning of the connecting device indicated by the arrow (i.e. from 22 to 23) and its dependable failure should an attempt be made to transmit detonation in the opposite direction (i.e. from 23 to 22).

From the above it will be obvious to those skilled in the art that by proper coordination of the thickness and material of the baffle disc bottom, of 17, the length of the air gap 14, and the sensitivity of the initiating charge 15, this unidirectional connecting device may be successfully used with low energy detonating cord, i.e., lead tubes containing a core of as little as 2 grams of PETN per linear foot.

The following example is presented to illustrate the invention more fully without any intention of being limited thereby.

**Example 1**

A novel connecting device of the instant invention was constructed for use in connecting two lengths of detonating fuse having a diameter of about 0.234 inch. The tubular metallic shell 11 was constructed of aluminum, and had a length of 3½ inches, and a wall thickness of about 0.015 inch. A cylindrical aluminum cup having an outside diameter of about 0.224 inch and a wall thickness of about 0.015 inch, and a length of about 1½ inches, and being closed at one end, was used to form the detonation charge section 13 of the novel connecting device. This detonation charge section 13 was loaded with the following ingredients in the following order from the closed end: a base charge of about 0.2 gram of cyclonite pressed at approximately 3000 p.s.i. and an initiating charge of about 0.15 gram of dinitramine lead azide topped with about 0.035 gram of lead stearphate and pressed together under a load of approximately 3000 p.s.i. The loaded detonation charge section was then positioned within the aluminum tube having the larger diameter, with the closed end positioned against a convenient restriction about ¾ inch from the end of the outer aluminum tube. A second cylindrical cup, which served as baffle section 17, having an outside diameter of about 0.223 inch, a wall thickness of about 0.015 inch, and a length of about ½ inch, and having one end closed, was then placed inside of the first aluminum tube with the open end abutting the open end of the detonation charge section to yield a unidirectional detonating unit 12 having an overall length of about 1 and 5/8 inches, positioned about ¾ inch from each end of the first aluminum tube. The air gap within the unidirectional detonating unit had an axial length of about 1¼ inches. A thin layer of uncured epoxy resin was then applied to each of the closed ends of the unidirectional detonating unit to prevent moisture from entering the unidirectional detonating unit and to secure the empty baffle cup in position. Standard detonating cords, cut relatively normal to their longitudinal axis were inserted in the ends of the connector and secured by conventional crimping means. When used with the unidirectional commercial Primacord (containing about 50 grams of PETN per linear foot) the detonation passed across the connector when the piece of detonating cord inserted in opening 23 was detonated. For purposes of comparison, when the piece of cord inserted into opening 22 was detonated first, there was no detonation across the connecting device.

Various modifications of the invention, some of which have been referred to above, can be employed without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A connecting device for connecting two lengths of
detonator cord and permitting detonation between the two lengths in only one direction comprising a tubular shell having an inner diameter substantially equal to the outer diameter of the detonator cord and a unidirectional detonating unit positioned within said shell consisting essentially of a baffle section and a detonating charge section, said shell having a sufficient length to provide on each side of said detonating unit a space adapted for the insertion of a length of detonator cord, said baffle section consisting essentially of a first barrier, said detonating charge section comprising in sequence arranged adjacent each other in the direction of detonation an explosive initiating charge, a secondary explosive charge and a second barrier, said first barrier and said initiating charge being spaced apart to define therebetween an enclosed air gap extending from said first barrier to said initiating charge, said first barrier being rupturable by the detonation of a detonator cord adjacent thereto to transmit sufficient detonating energy from the reaction of a detonator cord adjacent said first barrier across said air gap to detonate said initiating charge, the axial distance occupied by said air gap being sufficient to prevent the transmission of sufficient detonating energy from the reaction of the initiating and secondary charges across the air gap to detonate a detonator cord adjacent to the first barrier.

2. The connecting device of claim 1 wherein said enclosed air gap is defined by forming an aluminum container enclosed on all sides and containing said detonating charge section adjacent one end thereof in said shell, said one end of the container forming said second barrier and the other end of said container forming said first barrier.

3. The connecting device of claim 1 wherein the initiating charge and the secondary explosive charge are admixed and used as a single explosive compound in the detonating sequence.

4. A connecting device for connecting two lengths of detonator cord and permitting detonation between the two lengths in only one direction, comprising a tubular metallic shell having an inner diameter substantially equal to the outer diameter of the detonator cord and a unidirectional detonating unit substantially centrally positioned within said shell consisting essentially of, in the direction of detonation, a baffle section and a detonating charge section, said shell having a sufficient length to provide on each side of said detonating unit a space adapted for the insertion of a length of detonator cord, said detonating charge section consisting essentially of a metal cup-shaped container having an open and a closed end and arranged adjacent at the closed end of said container in sequence in the direction of detonation an explosive initiating charge, a secondary explosive charge and a first metal barrier formed by said closed end, said baffle section consisting essentially of a second metal barrier arranged adjacent the open end of said container and closing the same, said second metal barrier and said initiating charge being spaced apart to define therebetween an enclosed air gap extending from said second metal barrier to said initiating charge, said second metal barrier being rupturable by the detonation of a detonator cord adjacent thereto to transmit sufficient detonating energy from the reaction of a detonator cord adjacent said second barrier across said air gap to detonate said initiating charge, the axial distance occupied by said air gap being sufficient to prevent the transmission of sufficient detonating energy from the reaction of the initiating and secondary charges across the air gap to detonate a detonator cord adjacent to the second barrier.

5. The connecting device of claim 4 wherein a sealing compound adheres to each end of said unidirectional detonating unit within said tubular shell.

References Cited in the file of this patent

UNITED STATES PATENTS

2,736,263 Lewis et al. 1956
2,823,609 Johnson et al. 1958
2,919,982 Hayes 1959
3,020,844 Miller 1960

FOREIGN PATENTS

1,086,609 Germany 1960