

July 2, 1963

D. L. COURSEN
EXPLOSIVE MEANS

3,095,812

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2 Sheets-Sheet 1

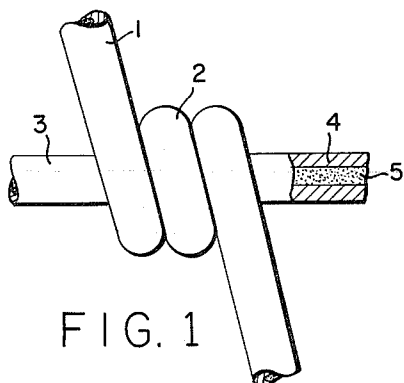


FIG. 1

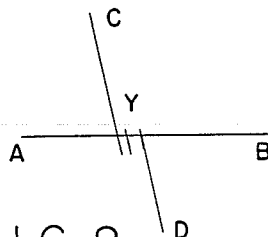


FIG. 2

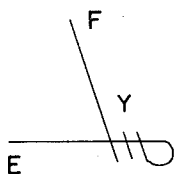


FIG. 3

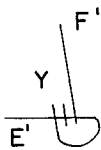


FIG. 4

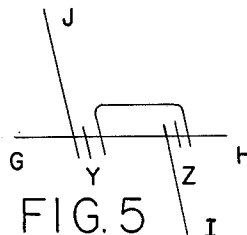


FIG. 5

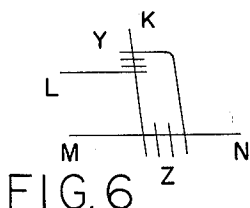


FIG. 6

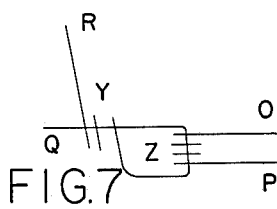


FIG. 7

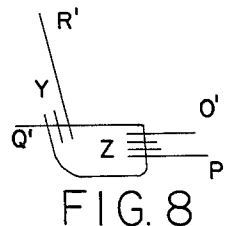


FIG. 8

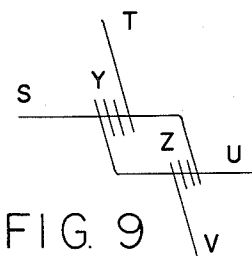


FIG. 9

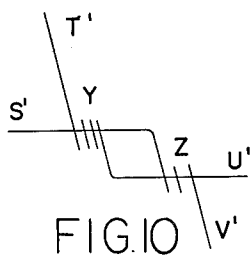


FIG. 10

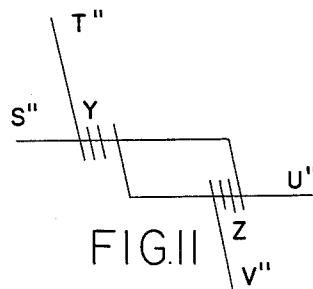


FIG. 11

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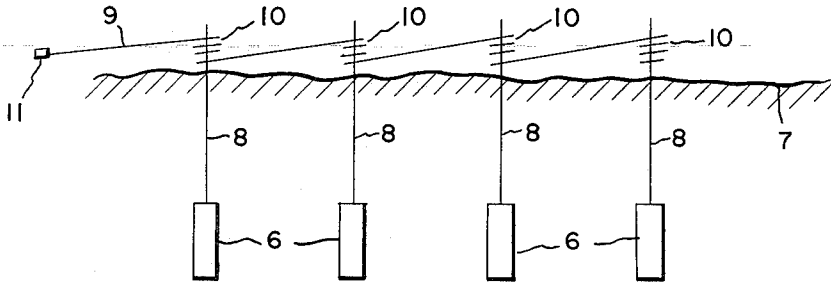


FIG. 12

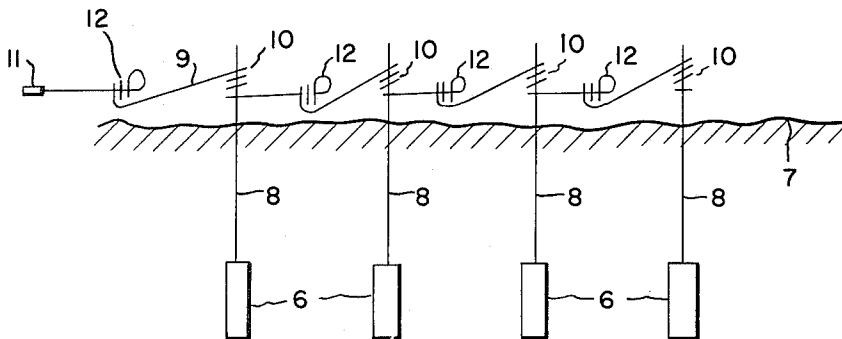


FIG. 13

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EXPLOSIVE MEANS

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5 Claims. (Cl. 102-27)

The present invention relates to explosive devices which function as valves or as relays for detonation. This application is a continuation-in-part of my copending application Serial No. 683,049 filed September 16, 1957, now abandoned.

In a number of applications, signaling or actuating means responsive to impulse from one direction but not from another are widely used. Many electrical devices which function thus are known and used, for example, in computers. A need has existed for an equivalent explosive means which can act as a relay or selective valve.

Accordingly, an object of the present invention is to provide an explosive device which will have directional selectivity. A further object is to provide an explosive device which will transmit detonation impulses only when such impulses reach the device from a predetermined direction. Additional objects will become apparent as this invention is more fully described.

I have found that an explosive device having directional selectivity comprises a sheathed detonating explosive core in helical configuration and a sheathed detonating explosive core axially positioned within the helix, the ratio by weight of the total explosive to the total sheathing for the combination thus formed being within prescribed limits. The described device is the result of my discovery that when the ratio by weight of the explosive and the sheathing is within the prescribed limits, the concentration of explosive energy produced by the progressive detonation of the explosive core in the helical configuration will produce initiation of detonation in the axial explosive core but only in the direction of the axial component of detonation in the helix, i.e., the lateral direction in which the detonation progresses in the helix, and further that a detonation traveling through the axial explosive core will not initiate detonation in the surrounding helical core.

In order to more fully describe the present invention, reference is now made to the accompanying drawings in which:

FIGURE 1 represents a detailed view of two lengths of detonating cord assembled in accordance with this invention;

FIGURES 2 to 11 inclusive are schematic diagrams of explosive core arrangements in accordance with this invention; and

FIGURES 12 and 13 are schematic diagrams showing the use of the present assemblies in blasting set-up.

Referring now to FIGURE 1 in greater detail, 1 represents a length of detonating cord having a portion thereof in the form of a helix 2. 3 represents a second length of detonating cord passing through the helix 2 in axial alignment therewith. 4 represents a sheath, for example of metal such as lead, and 5 represents a detonating explosive, for example PETN, which forms the core of the cords 1 and 3. The construction described forms the basis for all of the arrangements shown in the remaining figures, in which, for simplicity of illustration, only the core, as represented by a line, is shown.

Referring now to FIGURE 2, the following information can be given. A detonation originating at A will continue on to B, and in passing through the helix Y, will pro-

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duce no initiation of column CD, but will destroy the helix Y. Similarly, a detonation originating at B will continue on to A and no initiation of column CD will occur, but helix Y will be destroyed. An initiation originating at C will continue through helix Y and on to D. The cord AB will be initiated inside the helix Y in the direction of B only, i.e., detonation will go on to B but not to A. A detonation originating at D will go on to C, and will initiate a detonation towards A but not towards B.

In the embodiment shown in FIGURE 3, a detonation originating at E will pass through the helix Y and, if the loop is very small, will pass on to F by traversing the helix Y before it is sufficiently destroyed to stop the propagation of detonation. If the loop is larger, the helix will be destroyed before the detonation can be transmitted through the explosive core, and the detonation will cease. A detonation originating at F will always cease in the loop because the core passing axially through the helix is initiated in the direction of the loop and the core in the helix is detonating toward the loop. When the two detonation fronts meet on the loop, propagation of detonation ceases.

The embodiment shown in FIGURE 4 is a variation of that of FIGURE 3. The size of the loop will again control whether detonation can go from E' to F'. However, in this embodiment, detonation originating at F' will be transmitted to E' by initiation of the core leading to E' at the helix Y.

In the assembly shown in FIGURE 5, a detonation originating at either G or H will pass on to H or G respectively without initiating any other cord but destroying helix Y and helix Z. A detonation originating at J will cause initiation of cord GH at helix Y in the direction of H only. If the length of the cord JI between helix Y and helix Z is of greater length than that of GH between the helices, the detonation will continue on to H but not to I. On the other hand, if the length of the cord JI between helix Y and helix Z is less than that of GH between the helices, the detonation will go on to I, but not to H. If the lengths are approximately the same, detonation will go on to both H and I. A detonation originating at I will initiate a detonation on to H and, a short interval later, a detonation on to G, and will continue on to J.

In the embodiment depicted in FIGURE 6, detonation originating at either M or N will pass on to N or M respectively without producing any other initiation but destroying helix Z. Detonation originating at L will produce detonation toward K and toward M but none toward N. Detonation originating at K will cause detonation towards N only.

Referring now to the system shown in FIGURE 7, detonation originating at Q will cease unless the loop is small enough so that it can continue on to R. Detonation originating at R will always cease. Detonation originating at O will go on to P and will initiate detonations to both R and Q. Detonation originating at P will go on to Q and will initiate detonation to Q only.

In the variation shown in FIGURE 8, detonation originating at Q' is as for Q in FIGURE 7. Detonation originating at R' will initiate detonation to Q' only. Detonation originating at O' will go on to P' but will initiate detonation to R' only. Detonation originating at P' will go on to O' but will initiate detonation to Q' only.

In the embodiment shown in FIGURE 9, detonation originating at S will go on to V, the detonation induced in cord TU towards T being interrupted by the destruction of helix Y. Similarly, detonation originating at U will go only to T. Detonation originating at T will go on to U and will initiate detonation on to S only. Detonation

originating at V will go on to S and will initiate detonation on to U only.

In the variations shown in FIGURE 10, detonation originating at S' will go on to V' and will initiate detonation on to U' only. Detonation originating at V' will go on to S' and will initiate detonation on to T' only. Detonation originating at U' will go on to T' and will initiate detonation on to S' only. (Obviously, variations in the lengths of the two cords between helices will cause variations in the directions in which detonation will go. For example, if the length of T'U' between helices is greater than that of S'V', detonation originating at V' will initiate detonation toward T', but the prior detonation of the cord to S' will destroy helix Y so that the detonation toward T' will be cut off.)

In the arrangement shown in FIGURE 11, detonation originating at S'' will go on to V'', all other detonations failing. Detonation originating at T'' will go on to U'', all other detonations failing. Detonation originating at U'' will go on to T'' and will initiate detonation towards S'' only. Detonations originating at V'' will go on to S'' and initiate detonation to U'' only.

Obviously the foregoing represent only a few of the multitude of combinations which can be produced, but serve to illustrate the many possibilities inherent in this invention. The detonating cords can be used to actuate assemblies, the sequence or selection depending on the source of the signal.

FIGURES 12 and 13 illustrate the application of the devices of the present invention to make blasting safer. In the figures, 6 represents an explosive charge in a bore-hole, 7 represents the surface of the earth, 8 represents a "down-line" of detonating cord, 9 represents a surface trunk line of detonating cord, 10 represents a one-way detonating valve in accordance with this invention, 11 represents a conventional initiator, and 12 represents a "stop-go" device in accordance with the present invention.

When trunk line 9 is initiated by detonation of initiator 11, the passage of detonation through units 10 initiates the "down-lines" 8, thus initiating charges 6. If one of charges 6 or "down-line" 8 is accidentally initiated, the detonation of "down-line" 8 in unit 10 will not initiate a detonation in the trunk line 9, thus eliminating the danger of the accidental detonation of one charge causing the premature detonation of other charges. When units 12 are inserted as shown in FIGURE 13, the additional factor is introduced that only detonation from the direction in which the initiator 11 is located can be transmitted along the trunk line 9.

In order to more fully illustrate the present invention, reference is now made to the following examples. In each case, the direction of detonation was determined either by means of impressions produced on a lead block or by X-ray pictures taken during detonation.

EXAMPLE 1

A large number of units were prepared having the configuration shown in FIGURES 1 and 2. Both the helix and the central column were prepared from a lead-sheathed explosive core consisting of a mechanical mixture of 98 parts of finely-divided PETN and 2 parts of Fe_3O_4 . The explosive mixture was present in the amount of 0.0042 gram per centimeter of length, and the lead sheath was present in the amount of 0.0615 gram per centimeter of length evenly distributed about the explosive core. Thus the sheath to explosive weight ratio in each assembly formed was about 14.6 to 1.

In the following tests, the unit was initiated by means of an electric blasting cap positioned at the point labeled in FIGURE 2. The helix had an inner diameter substantially equal to the outer diameter of the central column, so that no air gap existed between the helix and the central column, and the turns of the helix were adjacent to each other, so that no air gap existed between the turns.

Table I

Number of Turns in Helix	Number of Units	Number of Detonations Arriving at—			
		B only	D only	B and D	Other
1	6	0	4	2	0
1½	6	0	2	4	0
2	45	0	5	40	0
2½	6	0	0	6	0
3	7	6	0	1	0
3½	6	6	0	0	0

¹ Figure 2 illustrates 2 turns.

When the foregoing tests were repeated under identical conditions except that the turns of the helix were separated from each other by approximately 0.10 centimeter, thus providing an average air gap of 0.10 centimeter in all cases the detonation arrived at D only, i.e., the central column was not initiated.

In ten units in which the helix consisted of 2 turns with no air gap, and initiation was at point A rather than point C, detonation arrived at point B only.

EXAMPLE 2

In units identical to those described in Example 1 (turns of helix in contact with each other) except that the lead sheathing on the straight column amounted to 0.452 grams per centimeter of length, the following results were obtained when the unit was initiated at C. In each case the ratio of the sheath weight to explosive weight in the assembly was about 22 to 1.

Table II

Number of Turns in Helix	Number of Units	Number of Detonations Arriving at—			
		B only	D only	B and D	Other
1½	6	0	4	2	0
2	6	5	0	1	0
2½	6	6	0	0	0
3	6	6	0	0	0
3½	6	6	0	0	0

Detonation arrived at only B when the unit was initiated at A.

EXAMPLE 3

A number of units having the configuration shown in FIGURE 3 were prepared using a lead-sheathed explosive core consisting of the 98% PETN-2% Fe_3O_4 mixture, the explosive loading corresponding to 0.0042 gram per centimeter of length and the sheath corresponding to 0.0615 gram per centimeter of length. In all dimensions, detonation initiated at F stopped in the loop and did not propagate to E. When the loop had a diameter of less than 1.8 centimeters, and detonation was initiated at E, the detonation was propagated to F. When the loop had a diameter greater than 1.8 centimeters, detonation initiated at E was not propagated to F.

The foregoing examples illustrate that, under proper conditions, a helix of a sheathed detonating explosive core having a sheathed detonating explosive core aligned axially within the helix produces a one-way valve or relay for detonations. The experimental evidence shows that for consistent useful results, the helix must consist of more than one turn of the sheathed explosive core and that the turns must be essentially in contact with each other. The sheathing of the helical explosive core should be essentially in contact with the sheathing of the axial explosive core.

As shown, the detonation traveling through the axial explosive core does not initiate a detonation of the explosive core in the helix, although the helix is blown apart, and thus rendered non-functioning. A detonation traveling through the explosive core forming the helix

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will initiate detonation in the explosive core in the axial column, but only in the lateral direction of detonation of the explosive core of the helix. If the helix has from $1\frac{1}{2}$ to $2\frac{1}{2}$ turns, the detonation will continue through the helix. If, however, the helix has 3 or more turns, the detonation will not continue through the helix but only in the explosive core of the axial column. Presumably, this is due to destruction of the end portion of the helix by detonation of the explosive core of the axial column so that further propagation of detonation through the helix is not possible.

In the examples, I have illustrated the use of a PETN explosive core in a lead sheath to form both the helix and the axial column. This form of explosive cord is particularly adaptable for use in preparing the devices of the present invention because of the ease of handling and working. Preferably, the explosive core will contain from 0.0021 to 0.021 gram of a crystalline, cap-sensitive, high-velocity detonating explosive per centimeter of length. PETN, RDX, lead azide, and tetryl are examples of crystalline, cap-sensitive, high-velocity detonating explosives which can be used. The sheathing will preferably be of a ductile metal, e.g., lead, tin, copper, aluminum, for ease in handling and to provide confinement for the explosive core. Additional experimental work has shown that the combined weight of sheathing on both the explosive core in the helix and the explosive core in the axial column should be from 5 to 50 times the combined weight of explosive core in the combination thus formed. Under these conditions, initiation of one core will not occur from detonation of the other core when they are simply adjacent to or cross over each other, but will occur when the detonating core is in the form of a helix.

Instead of the metal-sheathed explosive core I may use the conventional fabric covered detonating fuse containing from 0.064 to 0.160 gram of explosive per centimeter of length, provided sufficient additional sheathing is applied to provide the required mass ratio between the sheathing and the explosive. Commercial 50 grain per foot "Primacord" (manufactured by the Ensign-Bickford Co.), conventionally used in blasting operations, has an explosive loading of 0.106 gram of PETN per centimeter of length and a sheathing mass of 0.131 gram per centimeter of length. Thus the sheath to explosive weight ratio of an assembly prepared from such cord would be only about 1.22 to 1 and the directional selectivity would not be obtained. This explains why knots can be used to transmit detonation from one line to another in ordinary blasting practice.

If desired, the devices of the present invention may

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be prepared in the form of a unitary package by potting the valve in cement or in a synthetic potting resin. Such procedure would be necessary only if rough handling might otherwise disturb the configuration of the valve.

The present invention has been described in detail in the foregoing. Many applications of the explosive valves will become apparent to those skilled in the art. Accordingly, I intend to be limited only by the following claims.

I claim:

1. An explosive device having directional selectivity comprising in combination a length of a sheathed detonating explosive core in helical configuration consisting of a plurality of turns and a second length of a sheathed detonating explosive core axially positioned within said helical configuration, the said helical configuration being such that the sheathing of each turn of said explosive core therein is in contact with the sheathing of its adjacent turn and with the sheathing of the said axial core, the ratio of the weight of sheathing to explosive in said explosive device being between 5 and 50 to 1.

2. An explosive device as claimed in claim 1, wherein both lengths of detonating explosive cores consist of from 0.0021 to 0.021 gram per centimeter of length of a cap-sensitive detonating explosive within a metal sheath.

3. An explosive device as claimed in claim 1, wherein the explosive is PETN.

4. An explosive device as claimed in claim 2, wherein the metal sheath is lead.

5. An explosive device as claimed in claim 1, wherein the length of sheathed detonating explosive core in helical configuration and the second length axially positioned within said helical configuration are joined by a length of sheathed detonating explosive core which connects an end of said length of core in helical configuration with an end of said axially positioned core.

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