

[54] **EXPLOSIVE SYSTEM**

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[51] Int. Cl. **F42b 1/00**

[58] Field of Search **102/49.5, 22-24;**
89/1 B, 1.5 F

[56] **References Cited**

UNITED STATES PATENTS

3,311,056	3/1967	Noddin.....	102/27
3,486,410	12/1969	Drexelius et al.....	89/1 B X
3,135,163	6/1964	Mechlin, Jr. et al.	89/1.817 X
3,373,686	3/1968	Blain et al.....	102/22
3,465,482	9/1969	Chandler	102/49.5 X

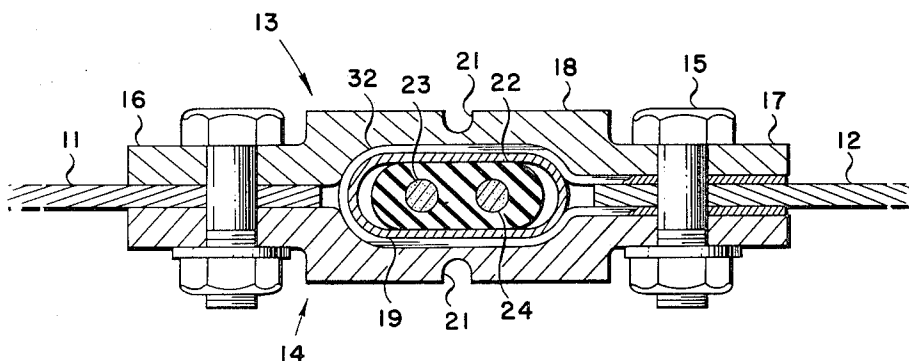
Primary Examiner—Samuel W. Engle

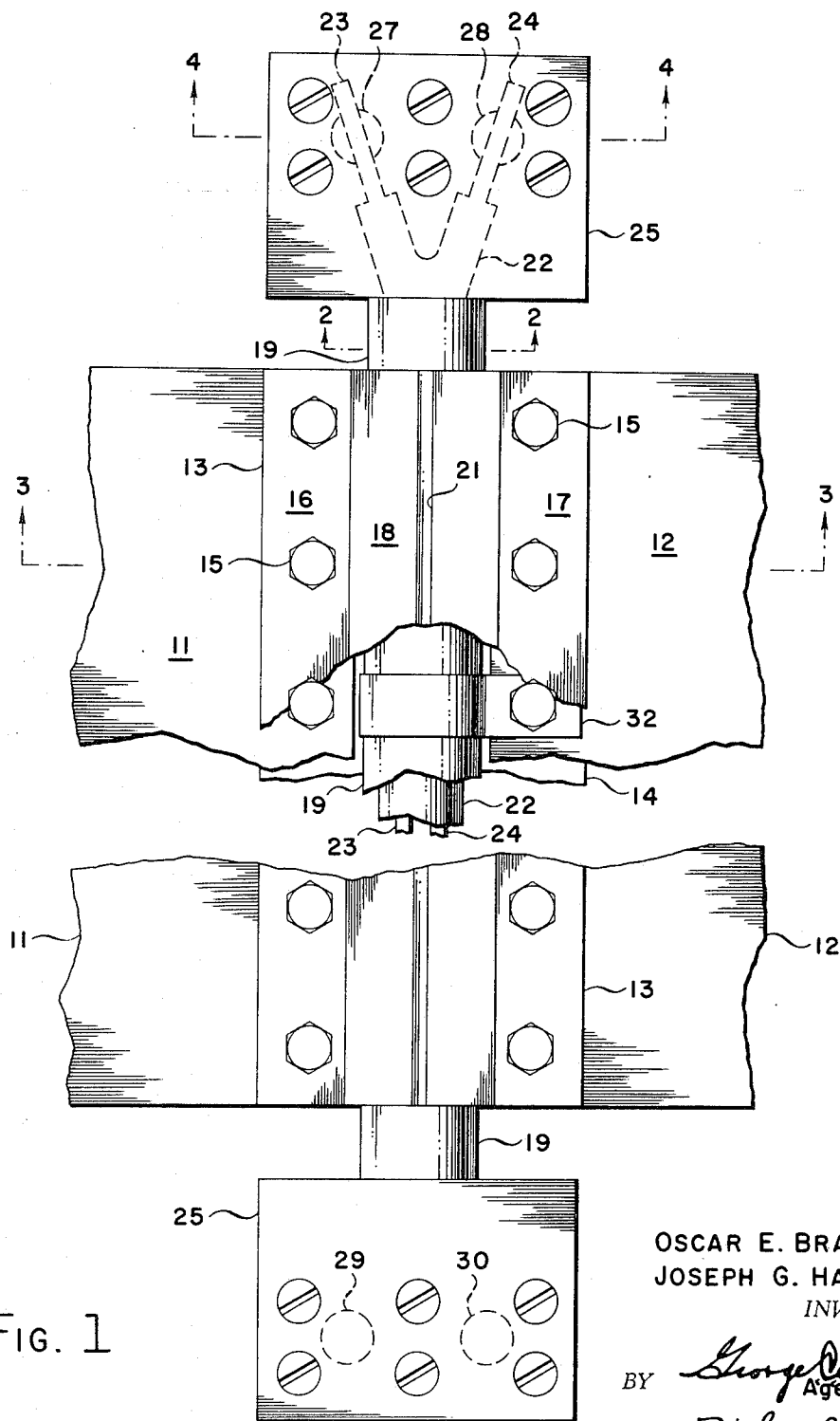
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[57] **ABSTRACT**

A steel tube having a flattened or oval cross section contains a pair of explosive cores. A sheath of pliable material such as silicone rubber surrounds and holds the core separated from each other and generally centered with respect to the steel tube. The rubber (1) protects the explosive cores from environmental temperature changes, and (2) absorbs the shock of detonation such that one of the cores may be detonated while the other remains undetonated as a reserve for redundancy of the system. Upon detonation of an explosive core, the steel tube expands from the flattened or oval cross section to a circular cross section; whereupon a pair of doublers enclosing the tube are fractured and separated along a weakened section underlying a notch or groove which extends longitudinally along a doubler joint and along the steel tube.

7 Claims, 5 Drawing Figures





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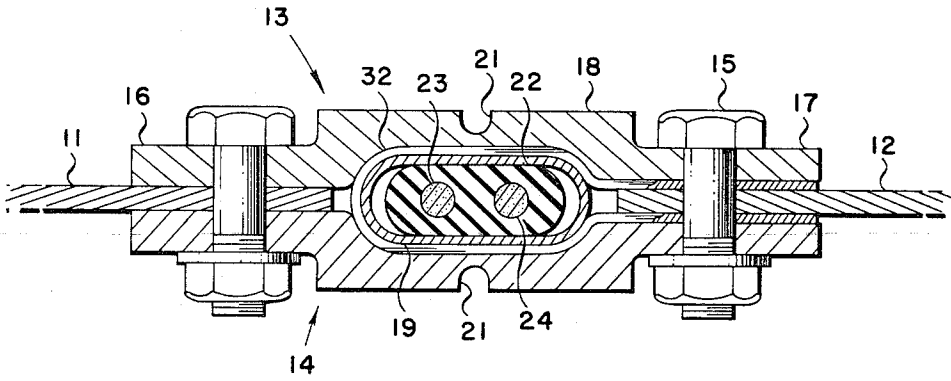


FIG. 3A

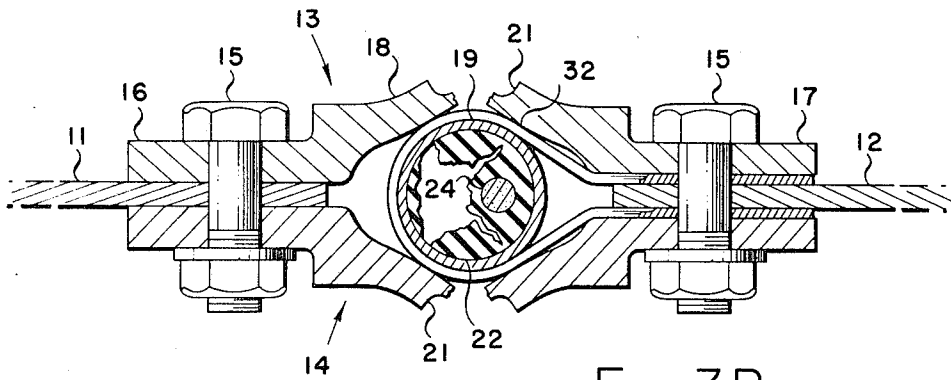


FIG. 3B

FIG. 4

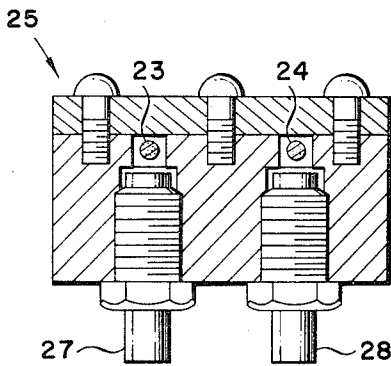
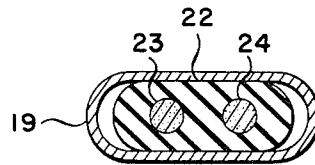


FIG. 2



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EXPLOSIVE SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to an explosive system capable of totally confining the products of explosion; and more particularly this invention provides an explosive separation system which will remain operative in a wide range of environmental temperatures and which will separate the parts with a minimum of shock.

Heretofore, elongated cords or ropes of explosives have been utilized in many types of ordnance devices as well as in missile and satellite separation systems. U.S. Pat. No. 3,373,686 granted to J. W. Blain and A. B. Leaman on Mar. 19, 1968, describes an explosive separation system wherein a core of explosive material is detonated within a radially expandable sheath. The sheath initially encloses the explosive core with a small cross section, and after detonation, the sheath in an expanded cross section continues to contain the gaseous products of the explosion to prevent contamination of the surrounding region.

The configuration described by U.S. Pat. No. 3,373,686 is successful in a limited range of temperatures. Should the ambient temperatures vary greatly above or below a normal room temperature, the configuration will burst or shatter and release contaminants into the surrounding space. In contrast, the instant invention provides a configuration which will remain intact and confine all products of detonation and other contaminants over a temperature range from -300°F to approximately 400° or 500°F .

In explosive systems, it is desirable to have a high degree of reliability. One method for achieving good reliability is through the use of redundancy in the systems. In the event that one part or system fails to function properly, a redundant part or redundant system may provide a back up protection to assure that the particular function is performed and that the overall operation of the ordnance device or missile or space vehicle is not impaired. One method for providing a redundancy is to simultaneously detonate both ends of an explosive cord or explosive core. If the explosive core is defective at one point, this redundancy will provide a proper operation of the system since the two detonations moving from both ends will traverse the entire length of the core and will meet at the defective point. This type of redundancy would fail if there were two or more defective points in the explosive core such that two detonations traveling from the ends would be blocked at different points leaving a segment undetonated and with the parts not completely separated. A further redundancy may be desirable to permit a second detonation in the event that the first detonation is not complete.

It is an object of this invention to provide an improved explosive system wherein more than one explosive core is used within a single steel tube or expandable sheath and wherein the explosive cores are held apart from each other by a shock absorbing material such that the detonation of one core will not cause detonation of the other core.

It is a further object to provide an improved explosive system for separation of parts with a minimum of shock imparted to the parts, and more particularly it is an object to surround the explosive core(s) with a shock absorbing material within an expandable tube,

such that the tube is expanded principally by the gaseous pressure of the products of the explosion and also by shock waves from the explosion.

The ambient or environmental temperatures may vary considerably for ordnance devices or missile or space vehicles, and it is another object of this invention to provide an improved explosive system which will be operative over a wide range of environmental temperature. More particularly, it is an object to encase the explosive core(s) in a thermal insulating and shock absorbing material such that the explosive core(s) will be protected from both external shock and from temperature extremes to remain functional over an extended time period.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the invention, the explosive system comprises an expandable tubular member, for example, an oval or flattened stainless steel tube, positioned against a separation member. The expandable member contains a shock absorbing material such as silicone rubber having two separated cavities to receive cores of an explosive material. In the completed assembly, the cores are encased and held separated from each other by the shock absorbing material which fills the expandable tubular member. Upon detonation of the explosive core, gaseous detonation products expand the tubular member against and rupture the separation member, with the detonation products being contained by the tubular member which upon expansion remains continuous, that is, does not rupture.

DESCRIPTION OF THE DRAWING

The various features and advantages of this invention will become apparent upon consideration of the following description taken in connection with the accompanying drawing of the preferred embodiment of this invention. The views of the drawing are as follows:

FIG. 1 is a plane view of the explosive separation system of this invention;

FIG. 2 is a section along the line 2—2 of FIG. 1 showing in cross section the steel tube with the explosive cores and rubber sheath therein;

FIG. 3A and 3B are similar sections along the line 3—3 of FIG. 1 wherein FIG. 3A is a cross section of the assembly before detonation and separation, and FIG. 3B is a cross section after the detonation of one of the explosive cores and during the separation of parts; and

FIG. 4 is a section along the line 4—4 of FIG. 1 showing a detonator assembly in cross section.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIGS. 1 and 3A, two parts or bulkheads 11 and 12 are connected together by doubler members 13 and 14. The edges of the bulkheads 11 and 12 are sandwiched between the doublers which are fastened together with means such as bolts 15. The doublers are elongated strips or plates of aluminum or other material and may be generally flat or planar as illustrated, or may be of a special shape and configuration required by a missile, space vehicle or any other structure which is to be explosively separated. The doublers may com-

prise two side or edge flanges 16 and 17, with a connecting central part 18 which is offset with respect to the side flanges. When the two doublers 13 and 14 are assembled together with the bulkhead parts 11 and 12, the offset centers provide a space therebetween for containing a stainless steel tube 19.

As shown in FIGS. 2 and 3A, the steel tube 19 is initially in an oval or flattened configuration, and is dimensioned to nearly fill the space between the offset central parts 18 of the doublers 13 and 14. A groove or notch 21 is formed in the doubler members 13 and 14, and extends longitudinally intermediately between the flanges. The section of material underlying the groove 21 is thinner, and therefore weaker, than the other parts of the doubler. Thus, it may be appreciated that the doubler is formed with a weakened central section which is more easily breakable than other parts of the assembly. When the steel tube 19 is expected to a circular configuration as shown in FIG. 3B, the central parts of the doubler members 13 and 14 are forced outwardly, and each doubler will rupture or break along the weakened section underlying the groove 21. With the doublers ruptured as shown, the parts 11 and 12 are separated and are free to move apart from each other.

The stainless steel tube 19, as shown in FIG. 2, is formed generally in an oval shape with two spaced apart flat sides and two semicircular or otherwise rounded edges. A sheath of silicone rubber 22 or other suitable shock absorbing and thermal insulating material is shaped to substantially fill the cavity within the stainless steel tube 19. The rubber sheath 22 contains two cylindrical holes or cavities containing explosive cores 23 and 24. The silicone rubber sheath 22 holds the two cores 23 and 24 approximately centered with respect to the stainless steel tube 19 and spaced apart from each other.

The silicone rubber sheath performs several functions. Firstly, the sheath supports and holds the explosive cores in proper positions, separated from each other and generally centered in the assembly. Secondly, the silicone rubber, as a thermal insulator, protects the explosive cores from sudden temperature variations through which the components of a missile or space craft may pass. Thirdly, the shock absorbing qualities of the rubber will protect the cores from external shock to which a missile may be subjected during launching and during subsequent operations of rocket engines, etc. And fourthly, the shock of detonation of an explosive core is minimized, such that the second explosive core will not be detonated from the shock waves of the detonation of the first explosive core, and such that a minimum shock will be imparted to surrounding parts such as the bulkheads 11 and 12.

As shown in FIG. 1, two detonator blocks 25 and 26 are welded or otherwise attached to the stainless steel tube 19. The ends of the rubber sheath 22 are split apart or bifurcated, such that the two cores 23 and 24 are each extended to a position in spaced relation to a separate detonating fuse 27, 28, 29 and 30. As shown in FIG. 4, the ends of the explosive cores 23 and 24 are extended into close proximity with the ends of the detonator devices 27 and 28. The detonator devices 27 and 28 are of a commercially available type which may be screwed into a threaded opening and will constitute a plug therein. These devices may be detonated electrically from control circuitry not shown.

Since each end of each explosive core 23 and 24 may be separately detonated, a redundancy is provided to improve the reliability of the overall system. In operation, one of the explosive cores 23 may be detonated simultaneously at both ends thereof by the detonators 27 and 29. Obviously, if one of the detonators 27 or 29 failed to operate, the core would be detonated by the other, and the detonation would travel the length of the core to effect the desired separation of parts. Thus, the simultaneous detonation of both ends of an explosive core insures a proper operation of the system even though one of the detonators may malfunction. In the event that there is a break in the explosive core 23, the simultaneous detonation of both ends thereof will insure a proper operation of the system, since the two detonations would, together, traverse the entire length of the core — from each end toward the break point.

The second explosive core 24 provides a further reliability in the system in the form of a back-up protection. Thus, if the detonation of the first core 23 failed or was not complete, the second core 24 could be detonated. In practice, the control circuitry extends through an electrical disconnect junction which would be disconnected and separated when the parts 11 and 12 were separated. The control circuitry will provide a second electrical impulse to cause detonation of the back-up core 24 in 600 to 1,000 milliseconds subsequent to the detonation of the primary core 23. If during this time interval, the first detonation is successful and a separation of parts is effected; then the electrical disconnect will be pulled apart; and the second electrical impulse will not reach the detonator devices 28 and 30, to initiate the second detonation. On the other hand, should the detonation of the first explosive core 23 be faulty; the separation of parts 11 and 12 will not be effected, and the electrical disconnect junction will remain intact such that the second electrical impulse will indeed be transmitted to the detonator devices 28 and 30 for the detonation of the back-up core 24.

As shown in FIG. 3B, the detonation of the first explosive core will cause the stainless steel tube 19 to expand to a circular configuration or cross section. The expansion of the steel tube 19, deforms the central parts of the doubler members 13 and 14, and ruptures the weakened sections underlying the longitudinal groove or notch 21. Since the silicone rubber sheath 22 absorbs much of the shock from the explosive, the principle force causing expansion of the steel tube 19 is the high pressure front generated within the tube by the gaseous products of the explosion. As shown in FIG. 3B, the silicone rubber sheath may be ruptured at various points leaving cracks and fissures in the vicinity of the explosion or the position of the core 23 which was consumed by the detonation. The expansion of the rubber sheath 22 and of the steel tube 19 does not detonate the back-up core 24, which remains encased in silicone rubber as shown in FIG. 3B.

When the doubler members 13 and 14 break as shown by FIG. 3B, the parts 11 and 12 are no longer held together, and presumably there will be an immediate separation with the bulkhead or part 11 moving to the left (in FIG. 3B), and the bulkhead or part 12 moving to the right. The stainless steel tube, containing the unused explosive core 24 and containing the products of the explosion must not be allowed to fall

out of the ruptured cavity between the doublers to become a loose part, free from both the parts 11 and 12. Therefore, bands or straps 32 encircle the steel tube 19 at periodic intervals as shown in FIG. 1 and are fastened to one side only of the doubler assembly. As shown in FIG. 1, 3A and 3B a convenient method for attachment is to extend the ends of each strap under the flange side of the doubler member with a bolt extending therethrough. These bands 32 may be formed of a ductile material such as soft steel which is flexible and capable of expansion as the steel tube 19 expands, such that the bands or straps 32 will not break as the doubler breaks and the parts separate. Ordinarily the bands 32 should be attached to that side of the doubler connected to the part which is to be discarded after separation. Thus, for example, the part 11 may be a portion of a satellite or space vehicle, and the part 12 may be of an early stage rocket engine. After the rocket engine has completed its burn and imparted its thrust to the space vehicle, it will be separated and discarded. Similarly, after the steel tube 19 has expanded and has performed its function, it will likewise be discarded. By strapping the steel tube 19 to the side connected with the part 12 which is to be discarded, the tube with the unused explosive core 24, will likewise be discarded from the still useful part 11 of the space vehicle. The detonator blocks at each end of the tube may be bolted or otherwise attached to the same part as that to which the straps are attached to provide a rigid support for the discarded assembly.

The explosive separation system of this invention provides a reliable means for separating parts with a minimum shock imparted to surrounding structures. The stainless steel tube contains the gaseous products of the explosion after the detonation and separation of the parts which thereby protects other parts and components of the assembly from contamination of the explosive gases. Because of the thermal insulating and shock absorbing qualities of the rubber sheath, the explosive cores are protected from damage due to environment temperature change and due to external shock. These features enhance the reliability of the system, and the reliability is further enhanced by the redundancy provided by a second or back-up explosive core, which need not be detonated at the same time of the detonation of the first or primary core; but may be held in reserve for later time if needed.

What is claimed is:

1. A low shock explosive system comprising:
 - a separation member including an elongated plate with a rupturable weakened section;
 - an expandable metal tubular member;
 - means for closely confining said tubular member adjacent to the weakened section of the separation member in the path of expansion of said tubular member,
 - said tubular member being elongated in one dimension in cross-section;
 - a pair of explosive cores continuously spaced apart in said elongage dimension and positioned within the cavity formed by said tubular member and extend-

- ing continuously through said tubular member;
- a thermal insulating and shock absorbing material surrounding both said explosive cores and encased within and substantially filling the cavity formed by the tubular member,
- said material continuously separating said explosive cores and preventing cross-detonation therebetween;
- and means for separately detonating the explosive cores so that gaseous detonation products expand the tubular member while being contained thereby and so that the tubular member will expand against and rupture the separation member.

2. A low shock explosive system in accordance with claim 1 wherein the separation member comprises two generally planar and parallel doublers fastened together with the tubular member there between, each doubler being an elongated strip and having flange parts along each edge and central part connecting the flanges, said flanges being fastened together and adapted to hold a structural part to be separated therebetween, said central parts being offset from each other to provide sufficient space to contain the tubular member in an initial oval configuration, said central part of each doubler having a weakened section extending longitudinally to provide a line for rupture and separation when the explosive core is detonated and the tubular member expands from the oval configuration to a circular configuration.

3. A low shock explosive system in accordance with claim 2 wherein the weakened section of the doubler comprises a relatively thin section of material which underlies a notch formed in each doubler, said notch being centered in the offset central part midway between the edge flanges.

4. A low shock explosive system in accordance with claim 2 further comprising a plurality of straps encircling the tubular member between the doublers and fastened to the flanges on one side of the doublers, said straps being operable to hold the tubular member to one side of the doubler after detonation of the explosive core and after the doublers have ruptured and separated in two parts.

5. A low shock explosive system in accordance with claim 1 further comprising a detonator assembly attached to the end of the tubular member for initiating detonation of the explosive cores, said detonator assembly containing two electrically actuable detonators, each of the explosive cores having an end extending to a respective detonator.

6. A low shock explosive system in accordance with claim 5 wherein the detonator assembly includes a metal plate to which an end of the tubular member is attached, and wherein the explosive cores extend through a hole in the metal plate to the detonator.

7. A low shock explosive system in accordance with claim 5 wherein two detonation assemblies are provided, one detonation assembly being attached to each end of the tubular member whereby the explosive cores may be detonated simultaneously from both ends.

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