July 27, 1965 W. L. DAHL 3,196,746

EXPLOSIVE RELEASE FASTENER

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Fig. 1.

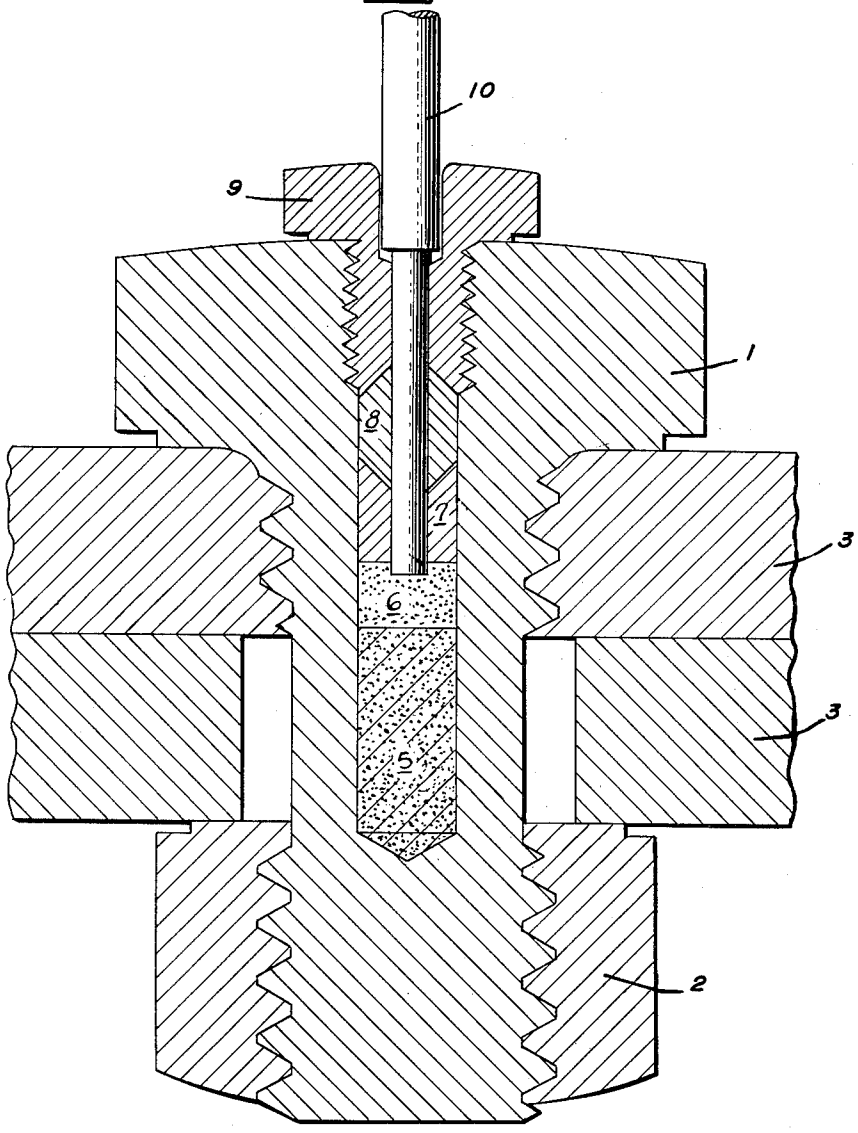

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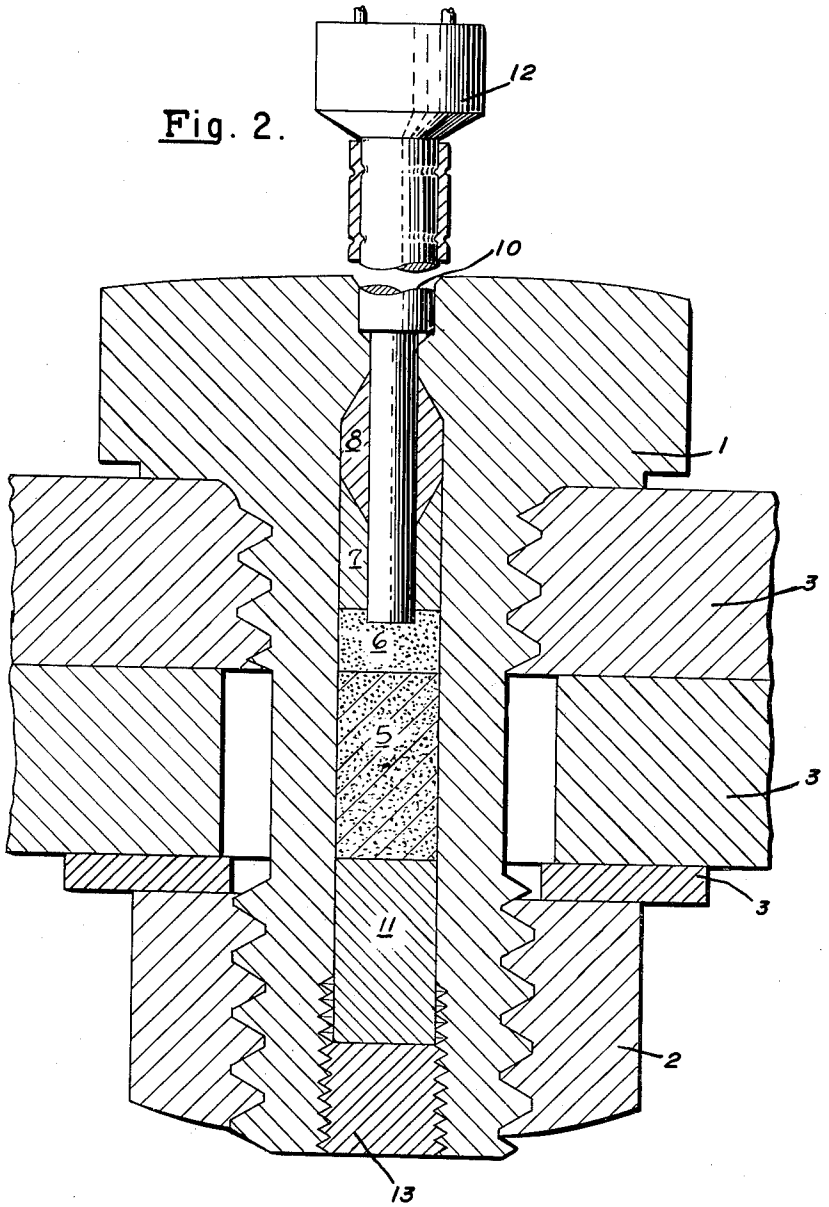
Fig. 2.



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EXPLOSIVE RELEASE FASTENER

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This case relates to releasable fasteners and, more particularly, to fasteners which can be released from an associated member by means of an explosive charge.

Explosive charges utilized in connection with fastening structures are presently known for effecting the quick release of one element from another, e.g., in the aircraft industry for the quick release of closures, canopies and the like and in underwater operations where instantaneous release of assembled parts, for example of parts of a sonar system, is required. Explosive-release fasteners currently available are characterized by either a closed breech system which prevents the escape of gases and "trash" at the breech or by exposed systems which scatter shrapnel, fragments of ignition lead wires, and explosive gases and which are not sealed after detonation occurs. The closed breech systems have been necessary particularly in instances where it is required that the separated objects be recovered intact, and their contents or in other cases the interior of the vessel from which they are separated and/or ejected not be vented to the outside atmosphere, exposed to explosive gases, or, in the case of electronic devices, the presence of loose electrical lead wires blown out of the release. A need exists for a fastener which can be released at a predetermined location by explosive means without destroying or undermining the strength of adjacent parts and without introducing shrapnel or in any way leaking at the initiation aperture either before or after separation. This fastener should not require a separate closed breech system which would materially add to the cost, size, and weight of the fastener. The fastener should be small, controllable in action, and any number of the fasteners should be separable in an essentially simultaneous action. Additionally, the fastener should act with a minimum of violence and should produce no shattering effects on the main assembly.

In accordance with this invention, there is provided a fastener which can be instantaneously severed at a predetermined location and which is characterized by substantially leak-proof and shrapnel-free performance and which may be constructed such that any length or diameter of fastening can be separated at any desired location. This fastener comprises:

(a) An elongated housing adapted to engage with associated elements, said elongated housing having a central longitudinal bore closed at one end and containing in sequence from said closed end,

(b) A base charge of high velocity detonating explosive,

(c) A priming charge in propagating relationship to the base charge,

(d) A rigid compression plunger contiguous to the priming charge, said plunger being slidably mounted in and peripherally engaged by the bore,

(e) A plug of a pressure-extrudable material contiguous to said plunger and peripherally engaged by the bore,

(f) Rigid closure means contiguous to said plug and closing said bore, and

A length of low-energy detonation-transmitting cord which extends through and is peripherally engaged by the rigid closure means, terminating in propagating relationship to the priming charge, said cord comprising a continuous core of explosive encased in a ductile metal sheath, and said plug being in tight peripheral engagement with said sheath.

By the term "associated element" as used herein is meant those structural pieces which are held in a fixed position by the fastener of this invention. This would include metal articles or structures, e.g., of sheet steel, aluminum, machine steel, copper, brass, etc., and other materials which can be machined, e.g., provided with threads, to mate with the elongated fastener housing of this invention.

The term "fastener" as used herein is meant to include bolts, pins, fasteners, electrical connectors, bonds, studs, screws, turnbuckles, shackles and the like.

Preferably, the plug of pressure-extrudable material is elongated and has conically-shaped extremities mating with a compression cone surface in the closure means and with a conical cavity in the compression plunger. For insured nonviolent action, the loading of the base charge in a preferred embodiment of this invention is from about 20 to about 100 milligrams of high velocity detonating explosive, the loading of the priming charge is about 5 to about 20 milligrams of primary explosive, and, in the case of a steel housing, the diameter of the bore of the housing is about ¼ to about ½ the diameter of the housing at the section contiguous the base charge. The length of the explosive bore of a fastener containing such minute loadings is only about ¼ inch to about 1 inch and the diameter of the bore need be only about 1/16 inch to about ⅓ inch.

In order to describe the invention in greater detail, reference now is made to the accompanying drawing in which:

FIGURE 1 is a cross-sectional view of one embodiment of the fastener of this invention, greatly enlarged (scale ≈12.5:1) for clarity,

FIGURE 2 is a cross-sectional view of an alternative embodiment of the fastener of this invention.

In the figures, 1 designates the elongated housing, which mates with associated elements, e.g., nut 2, and plates 3, for example, through screw threads. The housing and associated elements can be attached to structural elements to be joined which may be of any desired configuration. In the bore of housing member 1 are a base charge 5, a priming charge 6, a compression plunger 7, a plug of a pressure-extrudable material 8, and a removable rigid closure means 9 closing the bore. A length of low-energy detonation-transmitting cord 10 extends into the bore and passes through plunger 7, plug 8, and closure means 9. The end of the cord is in direct contact with the priming charge.

In FIGURE 2, the elements are as in FIGURE 1, however, in this embodiment the device is designed for bottom-loading; the closure means below the base charge being removable, plug 13 and the rigid closure means above the compression plunger being integral with the elongated housing. A plug 11 of pressure-extrudable material is present between the base charge and removable plug to retain the base charge in the bore so that any explosive in the threads which mate with the removable plug can be easily removed before the latter is screwed into the bore. Initiator 12 is shown attached to the extremity of the detonation-transmitting cord outside the housing.

In operation, the fastener of this invention is used to connect associated structural elements which may be of any desired configuration, e.g., they may be parts of a sonar system or of a canopy or closure mechanism of an aircraft. At the time the fastener is installed, the low-energy detonation-transmitting cord is connected to a means for initiating a detonation impulse, e.g., an electric initiator as shown in FIGURE 2, another length of cord, a fuse initiator, a percussion element, etc. When a

plurality of fasteners are used in the same proximity, a single initiating means can be used to actuate several lengths of the cord. At the time when the associated structural elements which are connected through the fastener are to be separated, the low-energy cord is initiated. The detonation stimulus transmitted by the cord actuates the priming charge which, in turn, initiates the base charge. Forces exerted by the detonation of the base charge cause the housing to be severed adjacent to the base charge due to weakening of the wall of the housing at this section. When the wall of the housing separates, frame elements are freed and in response to external forces acting thereon, e.g., gravity, mechanical forces, magnetic influences, the detonation forces themselves, etc., become spatially separated. Simultaneously with the severing of the housing, gases produced upon detonation of the base charge and priming charge drive the compression plunger upward and cause the pressure-extrudable plug to flow into any cavity produced around or within the low-energy cord, forming a fluid-tight seal. Consequently, the upper part of the housing element is sealed and structural elements communicating with the upper part of the housing are not exposed to the gases produced by detonation of the charges nor vented to the outside atmosphere. In the embodiment of FIGURE 2, actuation of the device is essentially the same as above.

The housing 1 and rigid closure means can be constructed of any metal, e.g., iron, steel, other ferrous alloys, copper, bronze, aluminum, magnesium, etc., or of a polymeric material such as of poly-tetrafluoroethylene or an acetal resin ("Delrin"), having the structural strength and rigidity to support the load of structural elements which it connects. The thickness and strength of the housing naturally will depend to a large degree upon the nature of the elements to be fastened, i.e., the walls should have the tensile strength, impact strength, and tear strength necessary to withstand vectoral forces exerted by the objects connected. The length of the housing will depend upon the spacing desired between structural elements. The bore provided within the shank of the fastener is preferably made at minimum expense of the fastener strength and provided, at the section where severing of the fastener is desired, with sufficient quantity of high velocity detonating explosive to produce a dynamic pressure pulse of sufficient force to sever, i.e., overcome the strength of, the adjacent fastener walls, yet insufficient to cause brisance injurious to adjacent, connected structures. The term dynamic pressure pulse is used to describe that pressure or stress developed by the detonation of the charge. This pressure is a composite of factors such as the shock wave pressure, expanding gas pressure, piling effects, pressure reflections and the like. Its direct measurement cannot accurately be made due to its transient nature and its exceedingly high magnitudes. If desired, the threads of the housing can be removed or made thinner, e.g., by machining or other suitable means, at the section where separation is to be effected.

In order to insure severing action, the explosive employed as the base or breaking charge must be one which detonates at a high velocity, i.e., at a velocity above 1000 meters per second. While primary detonating explosives such as lead azide may be employed, preferably more powerful explosives for example, pentaerythritol tetranitrate (PETN), cyclotrimethylenetrinitramine (RDX), cyclotetramethylenetetranitramine (HMX), nitromannite, tetryl, or TNT, explosives commonly designated as secondary explosives, are used. As the priming charge to bring about high velocity detonation of these charges, heat-sensitive detonating compositions such as lead azide, diazodinitrophenol, or mercury fulminate can be used. As mentioned above, a quantity as low as 20 milligrams of high explosive in the fastener of this invention is sufficient to sever the fastener at the predetermined section adjacent the base charge yet does not cause undesirable violence or brisance. However, larger quantities, i.e., 100 milligrams or larger, of high explosive can be used, when centrally disposed in a rigid housing, without loss of the nonshattering and sealing characteristics. The loading in the bore will depend upon the structural (strength) characteristics of materials used in making the fastener, free space about the shank of the fastener, external leverage on the fastener, etc.

The compression plunger, which is contiguous to the priming carge in the bore of the housing, should be of a relatively rigid, firm, hard material which is not significantly distorted by the pressure of the detonation gases nor reactive with the priming charge to result in its desensitization. This plunger may be of a hard metal such as of steel, aluminum, magnesium, and the like, of a hard plastic or resin such as of Bakelite, an acetal resin, polytetrafluoroethylene, nylon, etc., or of a sintered material.

The extrudable material disposed between the compression plunger and the rigid plug may be of a soft, ductile metal or plastic which undergoes cold, plastic deformation under pressure. Suitable materials for use as this plug include lead, lead-tin alloys (which may also contain bismuth), copper-base alloys, zinc, and zinc alloys. Preferably, this material is in the form of an elongated mass having essentially conical ends. This configuration facilitates compression and insures that sufficient quantity of the extrudable material will be present to form an effective seal.

The detonation-transmitting cord, i.e., low-energy connecting cord, preferably is that described in U.S. 2,982,-210. This cord comprises a continuous core of a detonating explosive, at a loading of from 0.5 to 2 grains per foot of length, contained within a sheath of ductile metal which may be subsequently covered with one or more layers of reinforcing and/or waterproofing material. However, any covering should be removed from the section of cord which extends into the bore of the fastener so that the plug of pressure extrudable material can tightly engage the ductile metal sheath. Due to the ability of this cord to propagate a detonation impulse without attendant brisance and because it is free of the hazards associated with electrical initiators, this cord is well-adapted for use with the nonviolent explosively released fasteners of this invention. For the minute explosive loadings used in the preferred embodiment of this invention, the cord having a loading of about 0.5 to about 1.0 grain per foot is particularly suitable.

The following example is presented as illustrative of the present invention but is not to be construed as limiting the invention in any way.

Example 1

Eight fasteners, i.e., bolts in this instance, were prepared resembling that shown in FIGURE 2. In each, the shaft was of mild steel 0.690 inch long and its outer diameter at the head was 0.313 inch and at the shank about 0.235 inch. The central bore in the shaft was 0.104 inch in diameter and was 0.500 inch long. The shaft was threaded as shown in FIGURE 2 to mate with associated elements. Within the bore of the shaft was loaded 40 milligrams of HMX and 15 milligrams of lead azide. Above the lead azide and in peripheral engagement with the walls of the bore was positioned a compression plunger of steel, formed with a central bore to admit the detonation-transmitting cord, and an essentially conical cavity formed about this. Above the aperture was a plug of lead which was an elongated mass having a central bore and conical ends to mate with the cavity in the plunger and with an approximately conical cavity in the rigid steel plug engaging with threads at the top of the bore to close the bore. The detonation transmitting cord extending into the bore was that described in U.S. 2,982,210, and had a continuous core of lead azide at a loading of 0.5 grain per foot.

When the fasteners were fired by actuating the low energy detonation transmitting cord, the housing was

severed, nonviolently, at the section adjacent the base charge. Essentially no shrapnel was produced and visual inspection and pressure studies of the fired fasteners revealed that the lead compression element was extruded into the bore for the low energy cord so that no detonation gases could be vented from the fastener. The separated head of the fastener was able to withstand 50 p.s.i. water pressure for 2 hours.

As will be evident to those skilled in the art, various modifications can be made in the light of the foregoing disclosure and discussion without departing from the spirit or scope of the invention.

What is claimed is:

1. A releasable fastener which can be instantaneously severed at a predetermined location and which is is characterized by substantially sharpnel-free and nonleaking operation, comprising:

(a) an elongated housing adapted to engage with associated elements, said elongated housing having a central longitudinal bore closed at one end and containing in sequence from said end

(b) a base charge of a high velocity detonating explosive,

(c) a priming charge in propogating relationship to the base charge,

(d) a rigid compression plunger contiguous to the priming charge, said plunger being slidably mounted in and peripherally engaged by the bore,

(e) a plug of a pressure-extrudable material contiguous to said plunger and peripherally engaged by the bore,

(f) rigid closure means contiguous to said plug and closing said bore, said closure means, plug and compression plunger each having an aperture therethrough which is substantially coaxial with the bore of said housing, and

a length of low-energy detonation-transmitting cord extending through the aperture in the closure means and plug and terminating in propagating relationship to the priming charge, said cord being peripherally engaged by the wall of said aperture in the closure means and comprising a continuous core of explosive encased in a ductile metal sheath, said plug being in tight peripheral engagement with said sheath.

2. A fastener as in claim 1 wherein the diameter of the bore is about ½ the diameter of said housing at the section contiguous to the base charge.

3. A fastener as in claim 1 wherein the loading of the base charge is from about 20 to about 100 milligrams and the loading of the priming charge is from about 5 to about 20 milligrams.

4. The fastener of claim 1 wherein a removable closure means closes the extremity of said bore contiguous to said base charge.

5. The fastener of claim 1 wherein the plug of pressure-extrudable material has conically shaped ends which mate with complementary conical cavities in the rigid compression plunger and the rigid closure means.

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