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FASTENING DEVICE

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ABSTRACT OF THE DISCLOSURE

A fastening device having a pair of fastening segments which are held together by an internally fitted fracturable insert. Each segment carries a piston which closes one end of an explosion chamber into which the blast from an explosive cartridge is expelled. The pistons are prevented from advancing into the chambers by stop means and are maintained a predetermined distance apart by force transfer means which extend through the insert, so that when a force is applied to one piston it is transferred to the other piston and the fastening segment containing that other piston. Accordingly, even when only one of the cartridges is triggered the segments will be forced apart and the insert will be fractured.

This invention relates in general to fastening devices and more particularly to fastening devices which sever in response to elevated pressures.

Explosive nuts, bolts and similar fastening devices offer quick release of fastened elements in response to a signal generated at a remote location. Conventional explosive fastening devices, however, release considerable debris when triggered. Some of this debris constitutes the spent gases of the explosive charge, and these gases can be obnoxious as well as harmful when released into a confined space such as the interior of a space craft. Still other portions of the debris are in the form of jagged fragments which are propelled at high velocities by the explosive charge. Consequently, a very real danger exists for anyone in the vicinity of a conventional fastening device when it is triggered.

Moreover, conventional explosive fastening devices generally employ only a single explosive charge and therefore do not possess the so-called functional redundancy which is required in space craft applications.

One of the principal objects of the present invention is to provide a quick release remotely actuated fastening device. Another object is to provide an explosive fastening device which does not release debris when severed. A further object is to provide an explosive fastening device which employs two explosive charges, either one of which will sever the device when ignited. An additional object is to provide a fastening device which is extremely compact and light in weight. Still another object is to provide a fastening device which is capable of exerting high clamping forces, is simple and rugged in construction, and is economical to manufacture. These and other objects and advantages will become apparent hereinafter.

The present invention is embodied in a fastening device including a pair of fastening segments which are held together by a fracturable insert. At least one of the segments is provided with a chamber which is closed at one end by a piston and means are provided for inducing pressures higher than ambient in the chamber so as to create a force on the piston. Force transfer means transmit the force on the piston to the opposite segment so that the segments are forced apart and thereby fracture the fracturable element.

The invention also consists in the parts and in the arrangements and combinations of parts hereinafter de-

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scribed and claimed. In the accompanying drawing which form part of the specification and wherein like numerals and letters refer to like parts wherever they occur:

FIG. 1 is a longitudinal sectional view of a fastening device constructed in accordance with and embodying the present invention and shown clamping two structural members together,

FIG. 2 is an end view of the fastening device,

FIG. 3 is a longitudinal sectional view of a modified fastening device shown holding two tubular members together, and

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3.

Referring now in detail to the drawings, 2 designates a fastening device for securing structural members 4 and 6 to one another at registered apertures 8 and 10 formed therein.

The fastening device 2 includes a bolt 12 formed from a pair of axially aligned bolt segments 14 and 16, having shank-forming cylindrical nose portions 18 which slidably fit within the apertures 8 and 10 and endwise abut at the interface of the members 4 and 6. At their outer ends, each bolt segment 14 and 16 is integrally provided with a cartridge housing 20 having an axially extending threaded outer bore 22 which opens outwardly. At their inner ends each threaded bore 22 opens into an explosion chamber 24 which terminates at a shoulder 26 where the chamber 24 opens into an enlarged cylindrical cavity 28. The cavities 28, in turn, merge into threaded inner bores 30 which are presented opposite to and axially align with one another. Externally the bolt segment 14 is integrally provided with an abutment flange 32 beyond its cylindrical nose portion 18, while the cylindrical nose portion 18 of the bolt segment 16 merges into external threads 34, which are sized for insertion through the apertures 8 and 10.

The bolt segments 14 and 16 are held together by a fracturable threaded insert 36 which is formed from a material capable of fracturing transversely into halves when subjected to elevated tensile forces. Steel has been found suitable for this purpose. The insert 36 is threaded into the opposed inner bores 30 until the end faces of the nose portion 18 come into snug abutment. At the interface formed by the abutting nose portions 18 the insert 36 is relieved in the provision of an annular groove 38 which forms a point of weakness therein. The insert 36 is further provided with an axial center bore 40.

The cylindrical cavities 28 of each bolt segment 14 and 16 contain pistons 42 fitted with O-ring seals 44 which wipe the cylindrical walls defining the cavities 28. Each of the pistons 42 integrally merges into an axially extending shank 46 which projects into the center bore of the insert 36. When the bolt segments 14 and 16 snugly abut as illustrated in FIG. 1, the end faces of the shanks 46 on the pistons 42 will abut one another, while the pistons themselves will be presented adjacent to the shoulders 26 in their respective cavities 28. Moreover, a clearance space will exist within each cavity 28 between the inner face of the piston 42 therein and the end face of the insert 36.

Threaded into the outer bores 22 are explosive cartridges 48 which are conventional in design and manufacture. Therefore, they will not be described in further detail, other than to note that their explosive charges are ignited by electrical impulses received through wires connected to terminals on the outer ends thereof.

The fastening device 2 further includes a washer 50 and a nut 52, the former being sized to fit over the nose portion 18 and threads 34 of the bolt segment 16, while the latter is engageable with the threads 34.

The bolt 12 is installed in structural members 4 and 6 by passing the shank formed by the nose portions 18 and external threads 34 through the apertures 8 and 10 until

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the flange 32 abuts against the outwardly presented surface of the structural member 4. The axial dimension of the nose portion 18 on the bolt segment 14 is preferably the same as the thickness of the structural member 4 so that the interfaces formed by the abutting structural members 4 and 6 on one hand and by the abutting end faces on the nose portions 18 on the other will be close enough to be effectively coplanar. The washer 50 fits over the threads 34 and nose portion 18 of the bolt segment 16 until it bears against the outwardly presented face of the structural member 6, while the nut 52 engages the threads 34 and bears against the washer 50 such that the structural members 4 and 6 are clamped securely between the flange 32 and nut 52.

Finally, the fastening device can be optionally provided with a pair of retainer plates 54 and 56 having enlarged outwardly bowed center sections which are provided with apertures 57. The aperture 57 of the plate 54 is sufficiently large to accept the outer end of the bolt segment 14 beyond the annular flange 32 but not the flange 32 itself, while the aperture 57 of the plate 56 is large enough to accommodate the threads 34 but not the nut 52. The outer ends of the retainer plate 54 are clamped against the outwardly presented surface of the member 4 by means of bolts 58 so that the flange 32 on the bolt segment 14 is captured between the bowed center section of the plate 54 and the member 4. Similarly, the outer ends of the retainer plate 56 are secured against the outwardly presented surface of the member 6, also by bolts 58, so that the washer 50 and nut 52 are clamped between its center section and the member 6.

When it is desired to separate structural members 4 and 6, the electrical terminals of the explosive cartridge 48 are placed at an electrical potential different from that of the cartridge body, and this ignites the explosive charges within the cartridges 48. The expanding gases and other debris associated with the ignition are expelled from the cartridges 48 into the explosion chambers 24 where they impinge against the outer end faces of the pistons 42. The expanding gases in the chambers 24 of the bolt segments 14 and 16 generate oppositely directed axial forces which act upon the pistons 42 and urge them toward one another. The pistons 42, however, are immovable with respect to one another, inasmuch as their shanks 44 endwise abut, and accordingly the inwardly directed forces generated by the two explosive charges from the cartridges 48 offset each other. The expanding gases within the chambers 24 also operate in the opposite direction and in so doing urge the two cartridges 48 outwardly away from each other. Since the cartridges 48 are threaded into the bolt segments 14 and 16, they too are urged apart, placing the center portion of the insert 36 under tension. This tensile force will be sufficient to fracture the insert 36 at its weakest point, that is at the annular groove 38. When this occurs the bolt segments 14 and 16 separate, leaving the structural members 4 and 6 free of the clamping force formerly exerted.

Inasmuch as the insert 36 fractures into halves at the groove 38 and each of these halves is captured in one of the bolt segments 14 or 16, a multitude of high velocity fragments is not dispersed as is true of many conventional explosive fasteners. Moreover, the O-ring seals 44 wipe the walls of the cavities 28 and prevent the gas and debris of the explosion from escaping. Accordingly, the emission of obnoxious fumes and other debris of ignition is reduced to an absolute minimum.

Since the retainer plates 54 and 56 clamp the bolt segments 14 and 16 to their respective structural members 4 and 6, the bolt segments 14 and 16 will not be propelled outwardly at high velocities after the threaded insert 36 severs, but instead will remain with the members 4 and 6.

If for some reason the explosive charges in one of the cartridges 48 fails to ignite, the ignition of the explosive charge in the other cartridge 48 will still fracture the insert 36 and separate the bolt segments 14 and 16. For

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example, if the charge in the cartridge 48 of the bolt segment 16 fails to explode, but the one in the bolt segment 14 does, then the expanded gases will fill only the explosion chamber 24 of the bolt segment 14. Those gases will bear against the piston 42 and the cartridge 48 in bolt segment 14, and the force imparted in the latter instance will urge the bolt segment 14 away from the bolt segment 16. The force acting in the opposite direction against the piston 42 will be transmitted to the other bolt segment 16 by way of the two abutting shanks 44 and the remaining piston 42 which cooperate to form force transfer means. The piston 42 of the bolt segment 16 in turn will bear against the stop formed by the shoulder 26 therein and will force the bolt segment 16 in the opposite direction. This, of course, will fracture the insert 36 and part the bolt segments 14 and 16. The same would be true if only the cartridge 48 of the bolt segment 16 ignited.

It is possible to provide a modified fastening device 60 for holding a pair of tubular members 62, 64 together in endwise abutment. Fastening device 60 includes a connecting plug 65 composed of a pair of plug segments 66 and 68 sized for snug-fitting insertion into the members 62, 64. The plug segments 66, 68 are provided with an explosion chamber 70 into which threaded ports 72 open laterally, and threaded into the ports 72 through the walls of the tubular members 62, 64 are conventional electrically ignited explosive cartridges 74. The chambers 70 open axially into cylindrical cavities 76 at shoulders 78, and the cavities 76 in turn merge into opposed threaded inner bores 80, the threads of which engage and retain a threaded insert 82, which like the insert 36 is fractureable and has an annular groove 84 located at the interface formed by the abutting ends of the plug segments 66 and 68. Similarly, retained in the cylindrical cavities 76 are pistons 86 having integrally formed shanks 88 which extend into the insert 82 and abut one another in the vicinity of the groove 84. The plugs 66 and 68 are securely retained within the interior of the tubular members 62 and 64 by means of transversely extending retaining pins 90, which are installed such that the end faces of tubular members 62 and 64 and the plugs 66 and 68 form a continuous planar interface.

When the cartridges 74 are ignited the expanding gases resulting from the ignition are expelled into the chamber 70 and urge the plug segments 66 and 68 away from each other. Since the insert 82 is threaded into both the segments 66 and 68 it will fracture at its groove 84, thereby freeing the tubular members 62 and 64 from one another. The pistons will be captured intermediate shoulders 78 and remaining portion of the insert 82 so that the gases and debris resulting from the ignition will not escape from the severed plug segments 66 and 68. Again if one of the cartridges 74 fails to ignite, the ignition of the remaining cartridge will be sufficient to fracture the insert 82 and free the tubular members 62 and 64 from each other. The retaining pins 90 prevent the plug segments 66 and 68 from parting with their respective tubular members 62 and 64 when the cartridges 74 are ignited.

This invention is intended to cover all changes and modification of the example of the invention herein chosen for purposes of the disclosure which do not constitute departures from the spirit and scope of the invention.

What is claimed is:

1. A fastening device for carrying a force, said fastening device comprising a pair of fastening segments positioned adjacent each other in the direction of the force, a fractureable element fitted into and secured firmly to each segment for normally holding the segments rigidly together, a cavity in each segment beyond the fractureable portion of the fractureable element and extending in the direction of the force, an abutment at the end of each cavity, a piston in each cavity, each piston when not restrained being shiftable within its cavity from the abutment toward the other fastener segment, a piston rod project-

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ing from each piston into the fracturable element, the piston rods endwise abutting within the fracturable element and cooperating to position the pistons adjacent the abutments of their cavities so that an unoccupied portion of each cavity exists between the piston therein and the fracturable element, the piston rods being further secured against complete withdrawal from the portions of the fracturable element through which they extend, and means for inducing elevated pressures in the portion of each cavity located beyond the pistons so as to urge the pistons away from their abutments and toward the fracturable portion of the fracturable element, whereby when an elevated pressure is induced in either or both cavities the segments will be drawn apart and the fracturable insert will sever, leaving the fastening device in two separate sections.

2. A fastening device according to claim 1 wherein the means for inducing elevated pressures are explosive charges carried by the segments and being in communication with the cavities.

3. A fastening device according to claim 1 wherein the pair of fastener segments abut; and wherein the fracturable element extends across the abutment of the two fastener segments and is removably secured to each fastener segment.

4. A fastening device according to claim 3 wherein the fracturable element is threaded into each fastener segment.

5. A fastening device according to claim 4 wherein the fracturable element at its fracturable portion is provided with a line of weakness which is located at the abutment of the two fastener segments, and wherein the piston rods also endwise abut at the abutment of the two segments.

6. A fastening device according to claim 1 wherein the piston rods are attached to the pistons so that they are secured against complete withdrawal from the portions of the fracturable element through which they extend when the fracturable element severs, whereby the piston rods do not form debris.

7. A fastening device according to claim 6 wherein the ends of the fracturable element extend across the ends of the cavities located opposite to the abutments and prevent the pistons from leaving the cavities when elevated pressures are induced in the cavities.

8. A fastening device according to claim 6 wherein the means for inducing elevated pressures are explosive

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charges secured to the fastener segments and communicating with the cavities therein.

9. A fastening device comprising a pair of abutting fastening segments each having a cavity, one of the segments being externally provided with a flange and a nose portion leading from the abutment of the segments to the flange, the other segment having a threaded portion which forms a continuation of the nose portion on the flanged segment, a fracturable element connecting the fastener segments, a piston in each cavity and closing one end of the cavity into which it is fitted, stop means in each segment for preventing movement of the piston in each cavity beyond a predetermined point, means for inducing elevated pressures in the cavities and thereby creating forces on the pistons, force transfer means extending between the pistons and maintaining the pistons in predetermined spaced relation so that when a force is applied to either or both of the pistons, the pistons will be urged toward one another and the fastener segments will be urged apart, whereby the fracturable element will sever and free the segments from one another without exposing the cavities, and a nut engaging the threads of the segment having the threaded portion so that at least two members can be clamped between the flange and the nut.

10. A fastening device according to claim 9 and further characterized by first and second retaining means, the first retaining means clamping the flange against one of the members and the second retaining means clamping the nut against another of the members, whereby the segments will not be propelled away from the members when the fracturable element severs.

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