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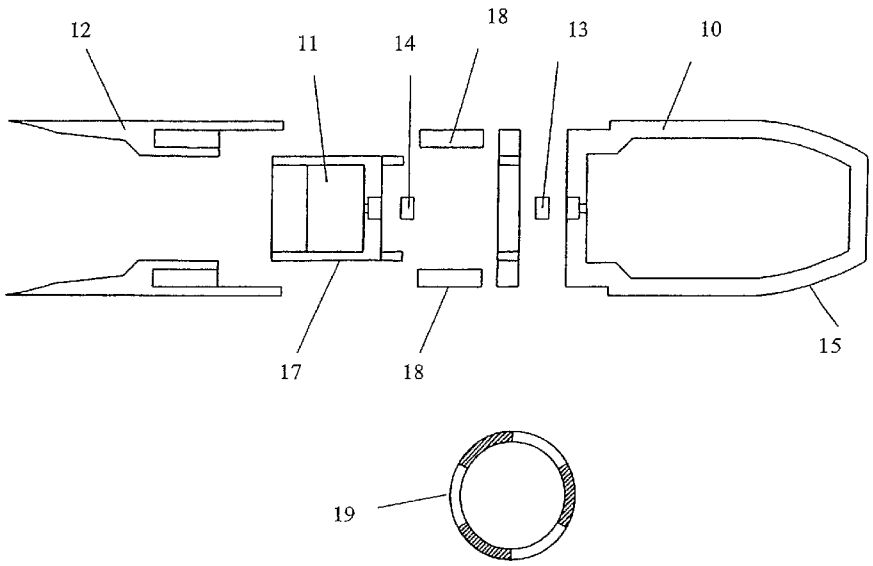
(54) **Title:** PROPELLANT SEALING SYSTEM FOR STACKABLE PROJECTILES



(57) **Abstract:** A projectile for use in a barrel with stacked projectiles, particularly for a weapon which can be reloaded by a user in the field. The projectile includes a chamber containing a propellant charge, with an exit from the chamber for release of propulsion gases into the barrel. A seal blocks the exit and is opened by ignition of the propellant within the chamber but is resistant to gases produced by ignition of propellant in other projectiles in the barrel. The exit and seal are provided in a range of different forms. The exit may be an aperture in a wall of the chamber with the seal as a moveable barrier, such as a valve-like structure, for example. The seal may also include a rupturable or deformable barrier across the aperture. Alternatively the seal is a thin barrier around the charge such as a wax coating and the exit involves a disintegrable character of the barrier. The seal may also be an inherent property of the geometry of the chamber.

WO 2007/095673 A1

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PROPELLANT SEALING SYSTEM FOR STACKABLE PROJECTILES

FIELD OF THE INVENTION

This invention relates to systems for sealing of propellant charges in relation to stackable projectiles, particularly to a system for sealing of a propellant charge inside a projectile to prevent ignition of the charge by gases resulting from ignition of the leading projectiles in the stack. More particularly the invention relates to projectiles which may be loaded into a barrel assembly in the field.

BACKGROUND OF THE INVENTION

A wide range of sealing systems have been developed for weapons having stacked projectile arrangements or barrel assemblies, such as the "wedging" systems described in WO 94/20809 and WO 97/04281, and the "projectile-to-projectile" sealing arrangements which in WO 03/089871, for example. The projectiles in these weapons are generally caseless and temporary seals are therefore required to prevent blow-back of ignition gases down the barrel. If no sealing system is present, hot pressurised gases from ignition of a leading projectile in a stack will usually cause uncontrolled ignition of the propellant in a trailing projectile.

Wedging systems generally form seals by interaction between successive projectiles in a stack. An axial force down the barrel causes the interaction either when the stack is loaded in a barrel or when projectiles are fired from the barrel, or both. The interaction causes a collar or tail on each projectile to expand into tight contact with the bore of the barrel, preventing blow-back past that point. Depending on the pressures involved, the expanding part of each projectile is typically a soft metal or plastic which deforms into a circumferential contact with the barrel. Various "forward", "reverse", "nose-to-tail" and "stick" systems have been developed.

Weapons that use wedging systems can be difficult for a user in the field to reload and generally require loading in a factory or other specialised environment. A large force is usually required to form the seal and the surfaces that interact within the barrel must be sufficiently clean. Special tools may be required. Subsequent shocks or vibration may weaken the seals and reduce the reliability of the weapons. Long cartridges containing pre-stacked projectiles are used for reloading in the field, but when partially empty these may be problematic for the user.

Systems that utilise projectile-to-projectile sealing form seals by interaction between successive projectiles. These also are not generally suitable for reloading in the field.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an improved sealing system for stacked projectiles, or at least to provide an alternative to existing systems.

In one aspect the invention may be said to reside in a projectile for use in a barrel with stacked projectiles, including: a chamber containing a propellant charge for the projectile, an exit from the chamber for release of propulsion gases into the barrel when the propellant is ignited, and a seal blocking the exit which is opened by ignition of the propellant within the chamber but is resistant to gases produced by ignition of propellant in other projectiles in the barrel.

In one embodiment the exit is an aperture in a wall of the chamber and the seal is a moveable barrier in the aperture, such as a valve-like structure. In another embodiment the exit is an aperture in a wall of the chamber and the seal is a rupturable barrier across the aperture. In a further embodiment the seal is a deformable barrier across the aperture. In a still further embodiment the seal is a thin barrier around the charge such as a bag, wrapping or coating and the exit involves a disintegrable character of the barrier. In a further embodiment the seal is an inherent property of the geometry of thee chamber.

Preferably the seal not only resists gases produced by ignition of other projectiles in the barrel, but the action of the seal is also enhanced by the pressure of the gases. In the case of a seal formed by a moveable barrier for example, the gas pressure may urge the barrier into still closer contact with adjacent parts of the chamber.

Preferably the opening of the seal in a projectile does not create debris which might impede the passage of subsequent projectiles inside the barrel. In the case of a seal formed by a rupturable barrier for example, the ruptured portions of the barrier remain attached to the chamber and are carried out of the barrel by the projectile. In the case of a seal having a disintegrable character, the seal should be largely or entirely destroyed or consumed when the propellant inside the chamber is ignited.

In another aspect the invention resides in a sealing system for a propellant charge, including: a container for the charge, and exit means for release of combustion gas from the container when the charge is ignited, wherein the exit means is opened by ignition of the charge within the chamber but is resistant to ignition of charges outside the container.

Preferably the container is a chamber formed in a larger structure such as a projectile or barrel assembly. The exit means is typically an aperture that is closed by a moveable, rupturable or deformable barrier. Alternatively the container may be a relatively thin barrier around the charge such as a bag or wrapping, and the exit means includes rupture, burning or other disintegration of the barrier. The sealing may also be an inherent property of the chamber.

The invention also resides in a barrel assembly containing stacked projectiles with independent sealing as defined above, and in methods of loading and firing projectiles having sealing systems as indicated above.

These sealing systems can function to isolate propellant charges independently of other sealing interactions between adjacent projectiles or between projectiles and the barrel. A

sealing action of this kind will assist the design of stacked weapons which are individually reloadable.

The invention also resides in any alternative combination of features that are indicated in this specification. All equivalents of these features are deemed to be included whether or not explicitly set out.

LIST OF FIGURES

Preferred embodiments of the invention will be described with respect to the accompanying drawings, of which:

Figure 1 shows a stackable projectile having a generalised burner system,

Figures 2a, 2b show how propellant gases typically flow in a barrel when a stacked projectile is fired,

Figures 3a-d show a burner system with a moveable seal,

Figures 4a-d show a variation on the burner in Figure 3,

Figures 4e-f show a further variation,

Figures 5a, b show a further variation on the burner in Figure 3,

Figures 6a-c show a further burner with a moveable seal,

Figures 6d-f show a further variation,

Figures 7a-c show a burner system with a pivoting seal,

Figures 8a-d show a burner with a rupturable seal,

Figures 9a, b show a variation of the burner in Figure 8a-d,

Figures 9c, d show a further variation,

Figures 10a, b show a further burner with a rupturable seal,

Figures 11a, b show a variation on the burner in Figure 10,

Figures 12a, b show a further burner with a rupturable seal,

Figures 13a-c show a further burner with a rupturable seal,

Figures 14a, b show rupture details for Figures 13a-c,

Figures 15a, b show a burner with a consumable seal,

Figures 16a, b show a burner with a deformable seal,

Figures 17a, b, c show a burner with a moveable seal,
Figures 18a, b show a burner with a deformable seal,
Figures 19a, b show a burner with a deformable seal,
Figures 20a, b show a burner with a deformable seal,
Figures 20c, d show a projectile with the burner in Figures 20a, b,
Figures 21a, b show a burner with a rupturable seal,
Figures 22a, b, c show a burner with a deformable seal,
Figures 23a, b show a projectile with the burner of Figures 22a,b,
Figure 24 shows a tailpiece including a rupturable seal,
Figure 25 shows an alternative projectile, and
Figures 26a, b show stacking of the projectile in figure 25.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the drawings it will be appreciated that the invention may be implemented in a range of different ways for a range of different projectiles and barrel assemblies. These embodiments are given by way of example only. Systems related to the weapon which fires the projectiles will appreciated by a skilled person and need not be described in detail.

Figure 1 shows a typical projectile for a stacked projectile weapon, in a cross sectional exploded form. The projectile includes a payload container 10, such as a warhead, a propellant charge 11, and a tail assembly 12. Primer 13 activates the warhead and primer 14 ignites the propellant. The projectile is adapted to be stackable nose to tail with a number of identical projectiles in the barrel of the weapon. Nose portion 15 has a roughly convex outer surface shaped to correspond with a roughly concave inside surface of the tail assembly. Various other features may also be provided, such as driving bands which improve the efficiency of firing, and a system for connecting the projectiles together.

Because the projectile in Figure 1 is to be used in a stack the propellant must be sealed against ignition gases which fill the barrel of the weapon after each projectile is fired. In this example the propellant is sealed within a burner or casing 17 which is resistant to the

ignition gases produced by other projectiles. The casing provides a chamber and typically includes a seal portion which moves, ruptures, deforms, disintegrates or otherwise opens under the higher pressures inside the casing which are produced when propellant 11 is ignited. However, the seal is either unaffected or is enhanced by an increase in pressure outside the casing. A range of other systems such as wedge sealing between projectile and barrel, or between nose and tail of adjacent projectiles, may be employed in addition to the internal casing system.

In Figure 1 the projectile is fired from the weapon by way of an inductive system having an inductor 18 which interacts with a corresponding inductor in the barrel, and a signal detector 19 which receives output from the inductor 18 and determines whether the projectile is required to fire. The detector is typically programmed with a code and on receiving a signal containing the code from the inductor, the detector triggers the primer 14 to ignite the propellant. The detector may also arm the warhead and enable primer 13. Otherwise the detector generally remains idle. Firing systems of this kind are known and need not be described in detail. A range of other electrical or mechanical firing systems are also possible for stacked projectile weapons.

Figures 2a, b indicate how propellant gases are typically distributed in the barrel of a stacked projectile weapon, particularly a weapon which is designed to be reloaded or unloaded in the field. Tolerances between the projectiles and the bore of the barrel are generally large enough to enable a sliding fit of projectiles into the bore. Projectiles 20 and 21 are leading and trailing projectiles respectively, stacked nose to tail in barrel 22. Inductors 23 outside the barrel interact with corresponding inductors in the projectiles to initiate the firing process. A breech plug 24 supports projectile 21 at the base of the stack. The projectiles fit closely within the barrel, and usually include driving bands, but there is generally enough tolerance within the bore of the barrel for hot, high pressure propellant gas from a leading projectile to circulate past trailing projectiles when the leading projectile is fired. In Figure 2b the gas (shaded) from ignition of propellant in the burner of projectile 20 blows backwards down the barrel past the body of projectile 21 and

reaches the outside surface of burner in projectile 21. Without sealing, there is a tendency for ignition of the propellant in projectile 21.

Figures 3a-d shows a burner system suitable for use as the burner 17 in Figure 1, in order to provide sealing against ignition of the propellant by other projectiles in a stack. The burner includes a generally cylindrical casing 30 and moveable slab 31 which encase the propellant. Exit vents 32 around the casing are normally blocked by the slab and prevent ignition gases produced by other projectiles from entering the casing. The slab has an edge face 35 which abuts a corresponding face 36 inside the casing 30 to assist the seal. An increased pressure caused by gases outside the casing serves to compress the faces 35 and 36 together more closely. A spring 33 and retainer 34 hold the slab in place within the casing as shown in Figure 3b. When fired, the spring is compressed or crushed by the slab and the ignition gases produced within the burner are able to escape, as shown in Figure 3c. The projectile is then propelled by gas pressure within the barrel.

A section though a coil spring 33 is shown in Figure 3d is shown as an example, although other spring types such as a disc spring or belleville washer could be suitable. Gases outside the casing 30 are able to more freely through the spring.

Figures 4a-d show a variation on the burner system in Figures 3a-d. The system now includes a crush ring 40 which prevents the slab 31 from compressing the spring 33 until a predetermined pressure has been reached inside the casing. This ensures that on ignition of the propellant inside the casing, the resulting gases burn cleanly and are not released into the barrel to propel the projectile until the predetermined pressure has been reached. The ring 40 may take a range of structures and operate in a range of different ways. Figure 4d shows a circular grill structure which contains the spring 33 and allows throughflow of gas, by way of example.

Figures 4e-g show a further variation on the burner system in Figures 3a-d. The system now includes a sprung disc 45 such as a belleville washer between slab 31 and the retaining ring 34. In this example, a second disc 46 has also been included with an

orientation which is inverted relative to disc 45. As in Figures 4a-d the discs compress the slab inwards to form a seal with the casing until a predetermined pressure has been reached inside the casing. Figure 4g shows the burner after ignition of the propellant and opening of the seal. The discs 45, 46 have been crushed into a flat configuration.

Figures 5a, b show a further variation on the burner system in Figures 3a-d. Slab 31 in Figure 3a takes the form a disc with a bevelled edge which abuts a corresponding surface of the casing, effectively forming a wedge. Slab 51 is a simple disc shape without the bevel. Both slabs seal against a flange inside the casing to prevent entry of gases from the barrel and the greater the external pressure the stronger the sealing action. The slab 51 in Figure 5a is considered to be less effective in forming a seal with the casing than the slab 31 in Figure 3a. Figure 5b shows a series of underside views of the casing with the slab 51, a crush ring 40 and retainer 34 in place.

Figures 6a-c show a further alternative to the burner system in Figures 3a-d. In this system the casing 60 contains a panel 61 with two or more vents 62. A moveable slab 63 includes corresponding keys 64 which occupy the vents and seal propellant inside the casing. A crush ring 65, spring 66 and retainer disc 67 are provided as before. External pressure caused by ignition gases outside the casing urges the keys further into the vents to improve the sealing action. On ignition of propellant inside the casing, the keys are forced out of the vents and the slab compresses the ring 65 and spring 66. Figures 6b and 6c show the casing before and after firing of the propellant respectively.

Figures 6d-f show a further alternative burner system. In this system a seal with the casing is provided by a sprung disc 67, typically a belleville washer, located on a slab 68 which is typically threaded into the casing. The edges of the disc abut the casing to prevent flow of external ignition gases into the casing 60 through vents 69. The crush resistance of the disc is calculated to provide a predetermined internal pressure at which the disc is distorted and ignition gases produced inside the casing are released.

Figures 7a-c show a further alternative burner having a moveable seal, suitable for use as the burner 17 in Figure 1. In this example the burner has a casing 70 and a moveable seal 71 in a flower form having leaves 72. Gas pressure outside the burner serves to maintain the leaves together while ignition of propellant inside forces the leaves to open. Once again the stronger the gas pressure outside the casing 70 the stronger the sealing action of the leaves. A range of different valve seals of this general kind may be envisaged. Figures 7b and 7c show the leaves in an open position.

Figures 8a-d show an alternative burner having a rupturable seal, also suitable for use as the burner 17 in Figure 1 to resist blow-back of external propellant gases. The burner includes a generally cylindrical casing 80 which contains propellant, and a series of metal discs which form a closure for the casing. Vent disc 81 includes four vents 82 while burst disc 83 includes corresponding sealing portions 84 which cover the vents. A retainer ring 85 holds the discs within the casing and provides openings 86 to allow the burst disc to operate. Pressure from ignition gases external to the casing is reduced by the overall volume available in the barrel, and is resisted by the burst disc. However, pressure caused by combustion of the propellant inside the casing causes the disc to rupture, releasing gases which propel the respective projectile. The burst disc is scored or otherwise constructed in a way which ruptures in a predictable fashion, generally at or above a predetermined pressure and/or temperature, and leaves no significant debris in the barrel of the weapon. Figure 8d shows several scoring patterns, by way of example.

Figures 9a, b show a variation on the rupturable burner in Figures 8a-d. In this example, the vent disc 90 includes a single central aperture 91 as the vent. The remaining components are substantially similar to the previous example. Burst disc 83 and retainer 85 are provided as a seal over the vent disc with the retainer typically being threaded into the casing to hold the burst disc in place. Various structures of this kind are envisaged to enable accurate tailoring of the burner system to suit particular projectile types and environments.

Figures 9c-d show a further variation on the rupturable burner in Figures 8a-d. In this system the retainer 95 cooperates with the burst disc 96 to reduce the likelihood that debris will be left in the barrel after the respective projectile has been fired. The retainer takes the form of an annulus or ring as before, but the inner edge 97 of the ring is sloped or otherwise shaped to provide a supporting stop for the sealing portions 98 of the burst disc. The sealing portions are scored to bend or break from the burst disc and their movement away from the vents 82 is limited by the inner edge of the retainer. The sealing portions contact the sloped surface of the retainer and are stopped before they break free of the burst disc.

Figures 10a, b show an alternative to the rupturable burner in Figures 8a-d. A casing 100 and jacket 101 fit together to enclose a burst ring 102. The casing and jacket include vents 103 and 104 respectively which have corresponding seal portions 105 on the burst ring. An indent at the foot of the casing creates the enclosure for the burst ring. In this example the ring is simply a band of a suitably composed metal or non-metallic substance. External pressure caused by ignition gases from leading projectiles in the stack is resisted by the seal portions. Internal pressure arising from ignition of propellant within the casing causes the seal portions to rupture outwards, releasing gas into the barrel to propel the projectile.

Figures 11a, b show a variation on the burner in Figures 10a, b. In this example the burst ring 112 has a pair of flanges 113 which clamp the ring in place between the casing 110 and the jacket 111. These flanges assist the sealing action of the burst ring inside the casing.

Figures 12a, b show a further rupturable burner system. A casing 120 is surrounded by burst jacket or sleeve 121. A disc 122 closes the casing once propellant has been loaded. The casing includes vents 123 which are sealed by respective portions 124 in the jacket. Figure 12b shows typical scoring patterns on the jacket, arranged in correspondence with the vents 123. External pressure caused by ignition gases from leading projectiles in the stack is resisted by the jacket. Internal pressure arising from ignition of propellant within

the casing causes the jacket to rupture outwards in the vicinity of the vents, releasing gas into the barrel to propel the projectile.

Figures 13 a, b show a further rupturable burner system in which the casing 130 itself includes rupture portions 131. A disc 132 closes the casing once propellant has been loaded. Each portion 131 is formed as an approximately U shaped area surrounded by a channel 133 or otherwise asymmetrically weakened structure in the casing. The detailed structure of the rupture portions is intended to break more readily under outward rather than inward pressure, as an inherent property of the geometry of the chamber. Multiple rupture portions are formed around a circumference in the casing. The seal which is effectively formed by the casing itself is broken when pressure inside the casing rises after ignition of the propellant, but remains unbroken by relatively lower pressures outside the casing caused by ignition of the other propellant in the barrel. Figure 13c shows the structure and rupture action of the casing in more detail.

Figures 14a, b show alternative scoring patterns for the casing in Figures 13a, b. In Figure 14a a pattern of grooves 140 have been formed on the outside surface of the casing, in relation to a pattern of cavities 141 on the inside surface. The patterns are symmetrical around the cylindrical axis of the casing in this example. Relatively thin portions of material 142 inside the casing between the grooves lines and cavities are intended to rupture more readily in an outwards direction under pressure of ignition gases inside the burner. The geometry of the score lines and cavities is indicated in see-through view of Figure 14b.

Figures 15a, b show a burner having a disintegrable seal 151 around a propellant charge 152. The seal may take various structures such as a wax coating which is consumable in nature. A range of compositions and thicknesses of material may be suitable. The charge is confined by casing 153 and a retainer disc or ring 154. An aperture 155 in the disc allows combustion gases to escape after ignition of the propellant 152. However, the nature of the seal and the aperture 155 prevent gases produced external to the burner from disrupting the seal and exposing the propellant to unintended ignition.

Figures 16a, b show a burner having a casing 160 containing a propellant charge 162. A closure 163 completes the casing and includes a series of apertures 164. The seal takes the form of a deformable ring 161 covering the apertures 164. A primer is typically located in a chamber above the charge. On ignition of the charge in Figure 16b, the ring 161 is deformed into an annular space 165 formed outside closure 161 by the shape of the casing, allowing the ignition gases to escape through vents 165 in the closure. The casing may be formed separately or integrally with the projectile.

Figure 16a shows an internal sealing system implemented by an deformable annular ringsleeve. The annular ring sleeve is press fitted over the annulus withwith a generally cylindrical casing with exit vent holes in it. and then tThe top and bottom portions of the unit are connected to the projectile via means not shown in this diagram. When the propellant is ignited by the primer the pressure develops inside the unit to the predetermined pressure at which the annular ring is designed to deform outwards and allow expanding propellant gases to vent through the exit vent holes in the annulus. The supporting walls of the upper portion of the unit are angled and positioned appropriately in order that the annular ring deforms only to a predetermined position and is retained. Propellant gases are redirected downwards by the supported angled surface of the deformed annular ring and are typically directed through a further series of vent ports in the lower portion of the unit before entering the barrel and propelling the projectile from the barrel. Figure 1b shows the unit in used state when the annular ring has been deformed. This embodiment of the invention requires only a few parts with just the annular sleeve and the preferably also the outer cylindrical surface over which the sleeve is fitted requiring specific attention during manufacture. Furthermore, should the sleeve fracture it will be retained within the projectile. Another advantage of the deformable sleeve version of this embodiment is the build up to the predetermined pressure resulting in a better gas pressure release profile. The annular chamber defined in part by the angled supporting wall furthermore results in more even venting of gas from the further series of vent ports. The downward or axial direction of the further series of vent ports doesn't direct gases directly onto the bore walls. The gas pressure release profile can be easily varied by simply changing the annular sleeve. Whereby the projectile can be easily modified for use with different propellents or for predetermining a different gas release pressure profile.

Figures 1c and 1d illustrate shows the annular ring sleeve setup seal of Figures 16a and 1b2 in a fashion that demonstrates that it is most likely that where both the upper and lower portions of the unit will arebe integral with other pieces of the tail assembly of a stackable projectile. This embodiment reduces the number of parts for a projectile even further.

Figure 17a shows an internal sealing system implemented by a 'disc springwasher' shaped moveable member. The moveable member may be a A disc spring is press fitted onto a 'bolt' shaped member. The disc spring may be press fit onto the bolt or arrangement and can be further held in place by a sandwiching 'nut.' or both. The nut may be threaded onto the bolt or press fit. The bolt is then threaded into position such that the disc spring seals against the lower surface of the flange on the upper portion of the unit. In this version of this embodiment operation the primer ignites the propellant through vent ports in the top portion of the 'bolt'. arrangement and oOnce the burning propellant has reached the predetermined pressure set by the spring rate of the disc spring, the unit opens and vents. The pressure at which the disc spring opens and vents can be further preset be backing off or advancing the bolt. The unit can be designed such that the upper surface of the bottom portionhead of the 'bolt' arrangement provides a horizontal support for the disc spring (Figure 2b) such that it will may return to its original position after firing. Alternatively or that the upper surface of the bottom portion of the 'bolt' arrangement head may is downwardly slopes downwardly (Figure 2c). such that tThe disc spring of the embodiment in figure 2c may be a bi-stable spring whereby it will invert and stay in inverted position after venting has occurred.

Figures 18a and 18b illustrate show a similar unit embodiment to Figure 2 with the difference that the disc spring (or Belleville washer) is replaced with a non-springy regular washer and designed towhereby the 'washer' shaped moveable member will permanently deform at a predetermined pressure set by the thickness and other properties of the washer in order to vent rather than flex in order to vent.

Figures 19a and 19b illustrate show a similar unit embodiment to Figure 3 whereby with the difference that the washer and bolt arrangement are combined the 'washer' shaped member and 'bolt' are formed into one piece. This embodiment reduces the number of parts for a projectile even further.

As with the embodiment of figure 1, the embodiments of figures 2 to 4 are easy to manufacture and vent gas evenly. The gas pressure release profile of the embodiments of figures 2 to 4 can be easily varied by simply changing the 'washer'shaped member or the embodiment of figure 4, the bolt. Whereby the projectile can be easily modified for use with different propellents or for predetermining a different gas release pressure profile.

Figures 17a, b, c show a burner having a casing 170 containing a propellant charge 172. A closure 173 completes the casing and defines an exit 174 for ignition gases. The seal is a spring loaded or otherwise flexible ring 171 blocking the exit 174. The ring has a generally annular shape made of metal or plastic or other suitable material. In this example the ring has a stable configuration as shown in Figure 17a, with the exit blocked. On ignition of the propellant gases, the ring temporarily adopts an unstable configuration as shown in Figure 17b or 17c, with the exit open. Once ignition has taken place, and the pressure of escaping

gas is reduced, the ring returns to the stable configuration. A collar 175 may optionally be included to hold the ring in place. These components may be threaded, press fit or otherwise held in place by suitable means.

Figures 18a, b show a burner alternative to Figures 17a, b, c. A casing 180 and closure 183 form a chamber which holds propellant 182, with an exit 184. In this case the seal is a deformable ring 181 which blocks the exit, optionally held in place by a collar 185. As before the ring has a generally annular shape made of metal or plastic or other suitable material, and preferably formed separately from the other components. On ignition of propellant 182 the ring deforms under gas pressure to a new configuration as shown in Figure 18b, opening the seal.

Figures 19a, b show a variation on the burner in Figures 18a, b. as before casing 190 and closure 193 form a chamber with an exit 194, containing propellant 192. In this case, the seal is a deformable flange 191 formed integral with the closure 193. On ignition of the propellant, the flange deforms into exit 194 allowing the ignition gases to escape. A collar is unnecessary to hold the seal in place.

Figures 20a, b show a burner having a compound casing 200 formed by a generally cylindrical insert 206 surrounded by a shell 207. The insert might be formed from a conventional shell casing while the shell might be formed separately or integrally with the projectile. A closure 203 blocks an otherwise open end of the insert, held in place by a plug 208 containing vents 209. Propellant 202 is contained in the chamber formed by the casing and closure. The insert is deformable in the vicinity of the closure and on ignition of the propellant, as shown in Figure 20b, spreads outwards into an annular space 205 formed by the internal shape of the shell 207. Ignition gases then escape through the vents to fire the projectile fro the barrel.

Figures 20c, d show how a burner based on Figures 20a, b may be incorporated in a stackable projectile. In this example the closure 203 and plug 208 are integral with the, preferably plastic, tailpiece of the projectile. The casing press fits into the tailpiece from

above, and propellant can be loaded into the casing before insertion of the primer. The tailpiece is then engaged with the warhead. Figure 20b is a cross section through the projectile showing the burner sealed with propellant and then after the propellant has been ignited. Figure 20d has corresponding end views of the tailpiece, showing a change in shape of the vents caused by deformation.

Figures 21a, b show a casing 210 and closure 213 containing propellant 212. The closure is formed by a burst disc 215 located beneath a panel 211 with vents 219. A retainer disc 216 holds the burst disc and the panel in place within the casing. The casing may be formed from a conventional shell, for example, with the otherwise open end 217 of the casing being crimped to confine the retainer disc. On ignition of the propellant, a seal formed by the burst disc is opened by deformation to release ignition gases through the vents. Ruptured portions 213 of the burst disc are urged outward and are confined by the internal shape of the retainer disc. The burst disc may be weakened in a central region 214, or using an alternative pattern, to enable and control the rupture.

Figure 22a shows an alternative casing 220 with a simple closure 223, containing propellant 222. The otherwise open end of the casing is crimped to confine the closure which preferably disintegrates on ignition of the propellant. Figure 22b shows a further alternative casing 224 which is simply deformed at the otherwise open end 226 to contain the propellant 225, and does not require a separate closure. Figure 22c shows the open form of these casings after ignition of their respective propellant. Figures 23a, b show how burners formed according to Figures 22a, b respectively may be located in stackable projectiles.

Figure 24 shows how a rupturable burner alternative to Figures 13a, b, c may be formed. In this example the burner is integral with a tailpiece 245 for the projectile. The casing 240 contains propellant 242 and includes rupture portions 241. Each portion is formed by a relatively thin corner 243 which ruptures under pressure caused by ignition gases. Outside the rupture portions the tailpiece includes vents 244. On ignition of the propellant the rupture portions are opened and deform into the volume available in the vents, but leaving

an exit for escape of the gases. As before, ignition gases released by other projectiles in a stack remain outside the casing and do not affect the rupture portions.

Figure 25 shows a further stackable projectile as a non-explosive smaller calibre alternative to the projectile of Figure 1. These projectiles are also intended to be loadable and if necessary unloadable in the field. In this example, the projectile has an integral outer casing 250 which contains propellant 251, an inductor and detector system 252, primer and retaining ring 253 actuated by the detector system, and a sealing valve 254 shown in schematic form. The valve may take a variety of structures based on those shown above.

Figures 26a, b show how the projectile in Figure 25 may be stacked. Projectiles 260 and 261 are leading and trailing projectiles respectively, stacked nose to tail in barrel 262. Inductors 263 outside the barrel interact with inductors in the projectiles to initiate the firing process. A breech plug 264 supports projectile 261 at the base of the stack. The projectiles generally have a sliding fit within the bore of the barrel, and usually include driving bands, but there is generally enough tolerance within the bore of the barrel for hot, high pressure propellant gas from a leading projectile to circulate past trailing projectiles when the leading projectile is fired. In Figure 26b the gas (shaded) from ignition of propellant in the burner of projectile 260 blows backwards down the barrel past projectile 261. Without sealing, there is a tendency for ignition of the propellant in projectile 261. Conventional forms of sealing such as nose to tail wedging may also be employed.

CLAIMS

1. A projectile for use in a barrel with a plurality of stacked projectiles, including:

a chamber containing a propellant charge for the projectile,

an exit from the chamber for release of propulsion gases into the barrel when the propellant is ignited to fire the projectile,

a moveable seal blocking the exit which is opened by ignition of the propellant within the chamber but is resistant to ignition of other propellant in the barrel, and

a bias member which urges the seal into engagement with the exit.

2. A projectile according to claim 1 wherein the seal is a moveable slab and the bias member is a spring, a Belleville washer, or a crushable member located beneath the slab.

3. A projectile according to claim 1 further including vents located below the moveable seal which are opened by movement of the seal.

4. A projectile for use in a barrel with a plurality of stacked projectiles, including:

a chamber containing a propellant charge for the projectile,

an exit from the chamber for release of propulsion gases into the barrel when the propellant is ignited to fire the projectile,

a seal blocking the exit which is opened by ignition of the propellant within the chamber but is resistant to ignition of other propellant in the barrel, and

wherein the seal is deformable between a closed condition and an open condition.

5. A projectile for use in a barrel with a plurality of stacked projectiles, including:

a chamber containing a propellant charge for the projectile,

an exit from the chamber for release of propulsion gases into the barrel when the propellant is ignited to fire the projectile,

a seal blocking the exit which is opened by ignition of the propellant within the chamber but is resistant to ignition of other propellant in the barrel, and

wherein the seal is opened by motion about a pivot connection.

6. A projectile for use in a barrel with a plurality of stacked projectiles, including:

a chamber containing a propellant charge for the projectile,

an exit from the chamber for release of propulsion gases into the barrel when the propellant is ignited to fire the projectile,

a seal blocking the exit which is opened by ignition of the propellant within the chamber but is resistant to ignition of other propellant in the barrel, and

wherein the exit includes one or more vents and the seal includes one or more flaps over the vents which are ruptured by outward passage of ignition gas.

7. A projectile for use in a barrel with a plurality of stacked projectiles, including:

a chamber containing a propellant charge for the projectile,

an exit from the chamber for release of propulsion gases into the barrel when the propellant is ignited to fire the projectile,

a seal blocking the exit which is opened by ignition of the propellant within the chamber but is resistant to ignition of other propellant in the barrel, and

wherein the seal is integral with the chamber but is ruptured along one or more points or lines of weakness.

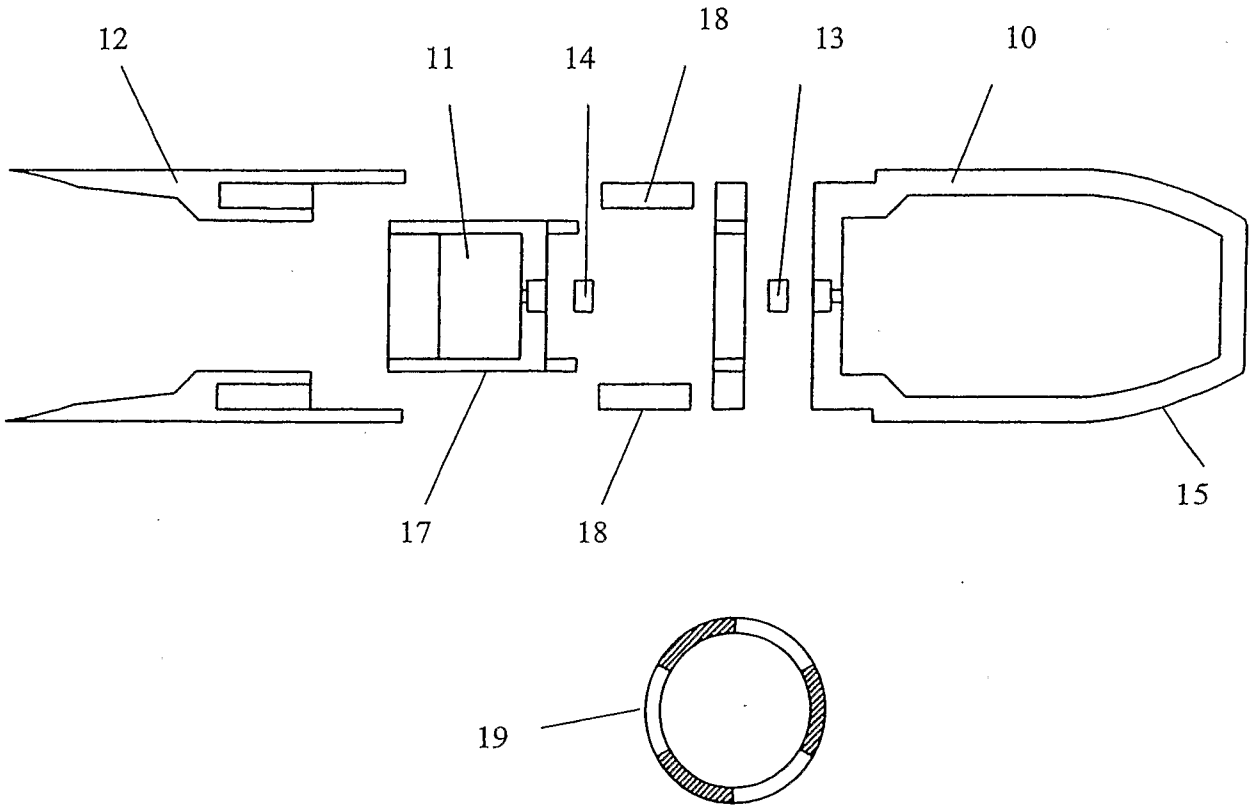


FIGURE 1

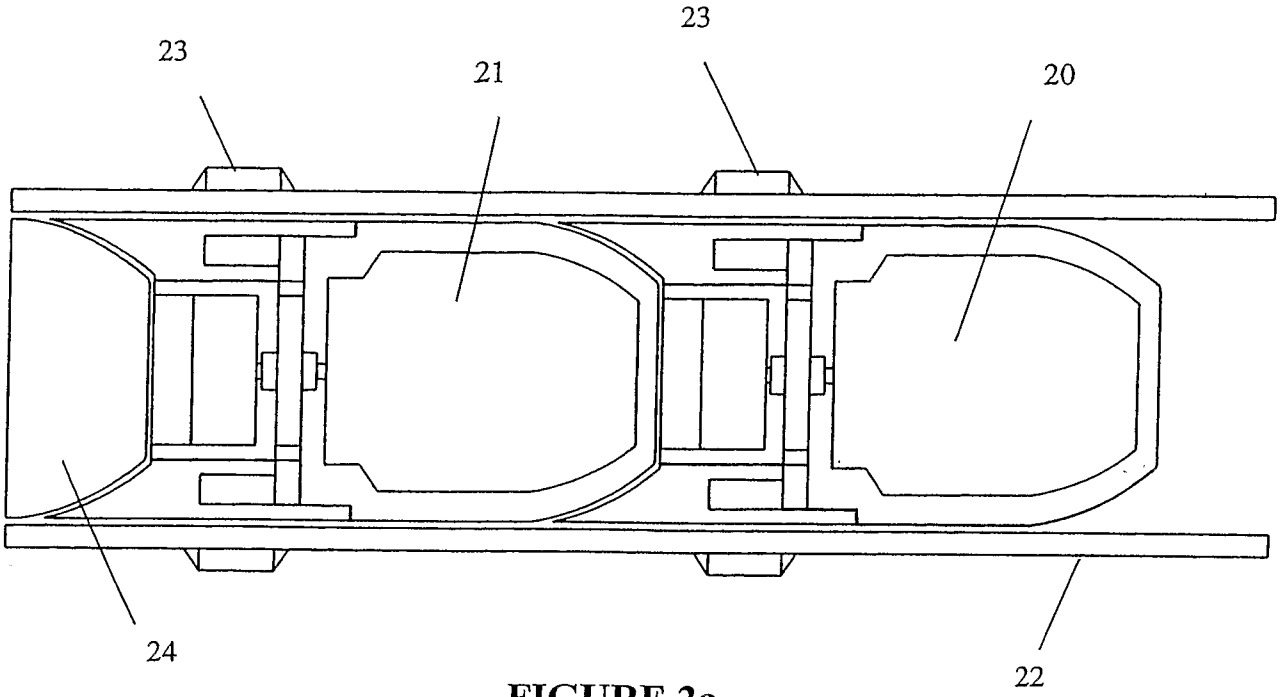


FIGURE 2a

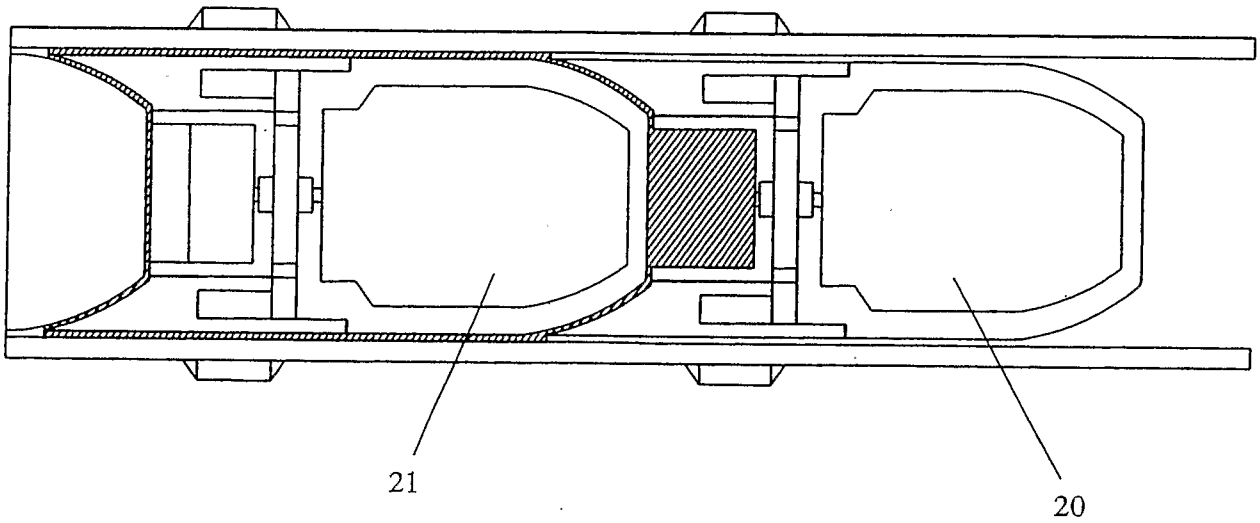


FIGURE 2b

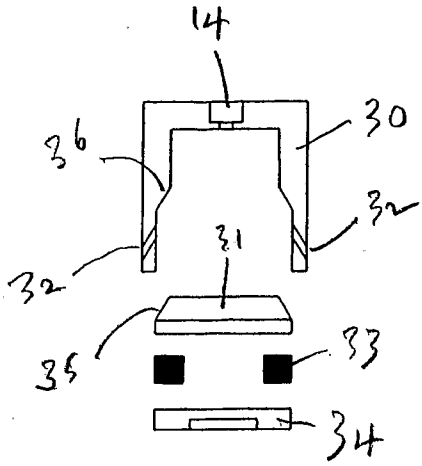


FIGURE 3a

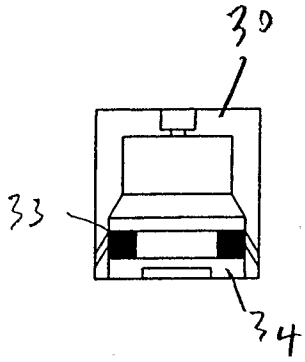


FIGURE 3b

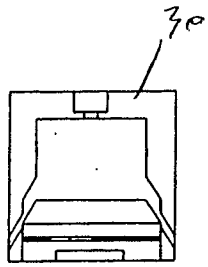


FIGURE 3c

FIGURE 3d

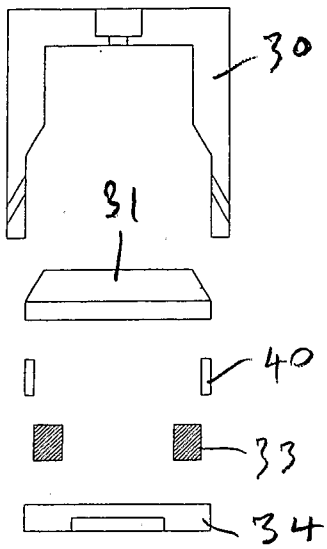


FIGURE 4a

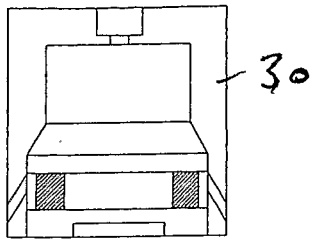


FIGURE 4b

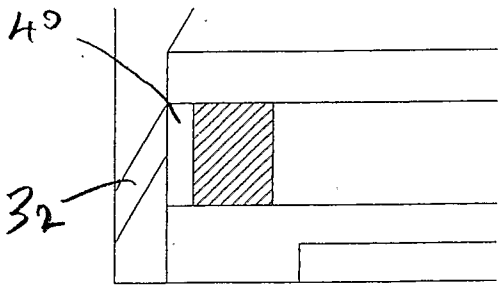
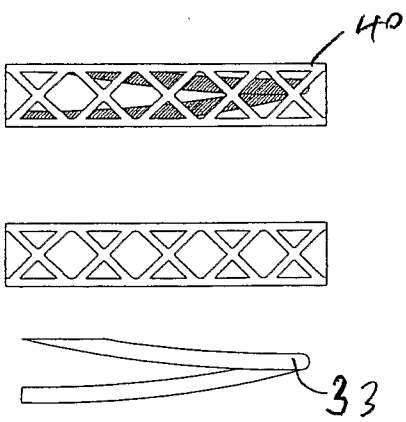


FIGURE 4c



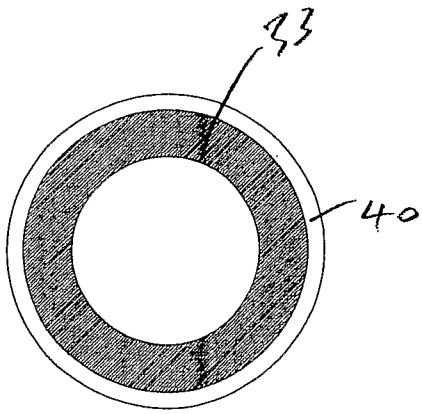


FIGURE 4d

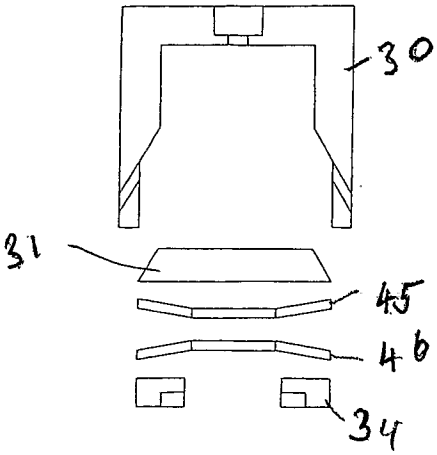


FIGURE 4e

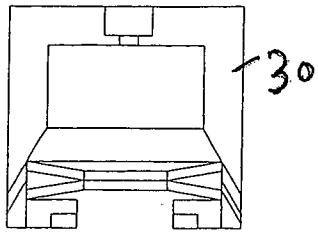


FIGURE 4f

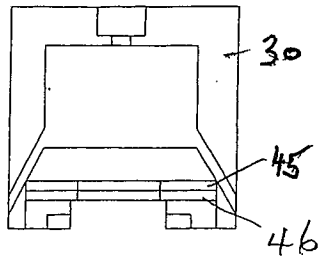


FIGURE 4g

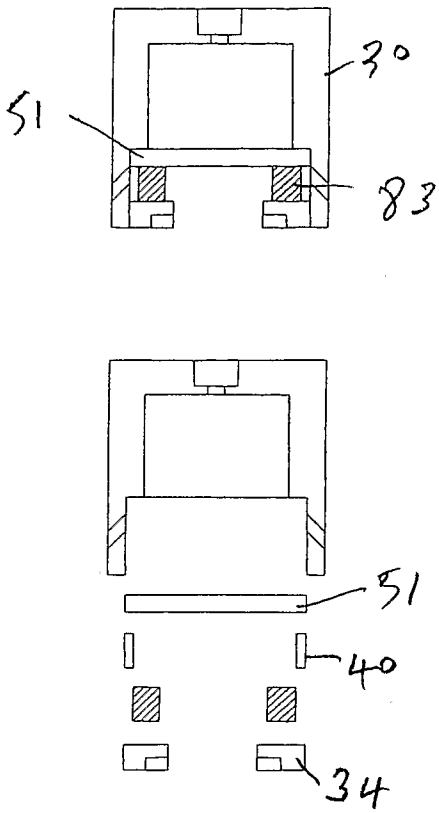


FIGURE 5a

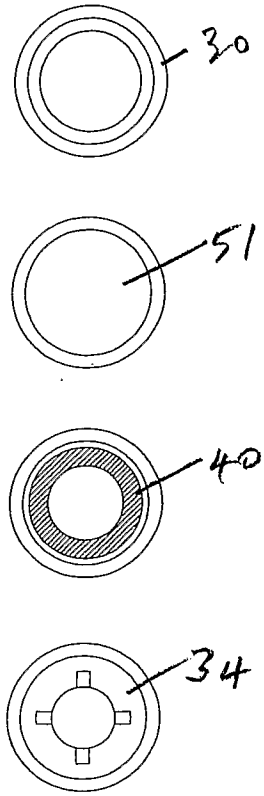


FIGURE 5b

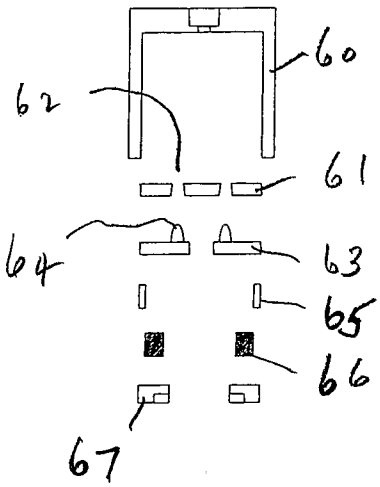


FIGURE 6a

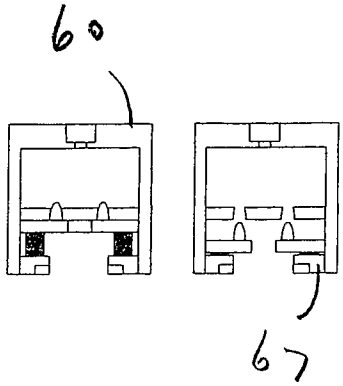


FIGURE 6b

FIGURE 6c

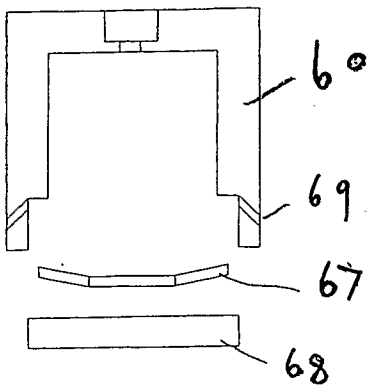


FIGURE 6d

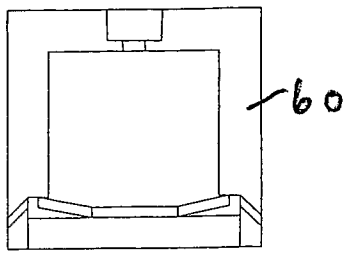


FIGURE 6e

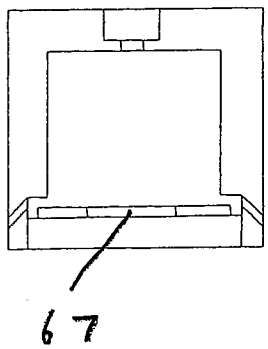


FIGURE 6f

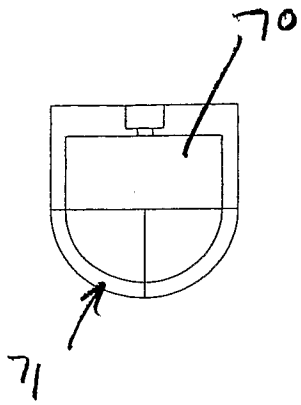


FIGURE 7a

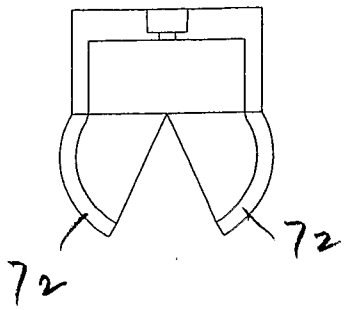


FIGURE 7b

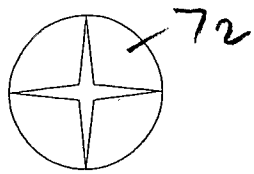


FIGURE 7c

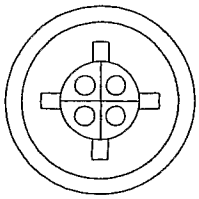


FIGURE 8a

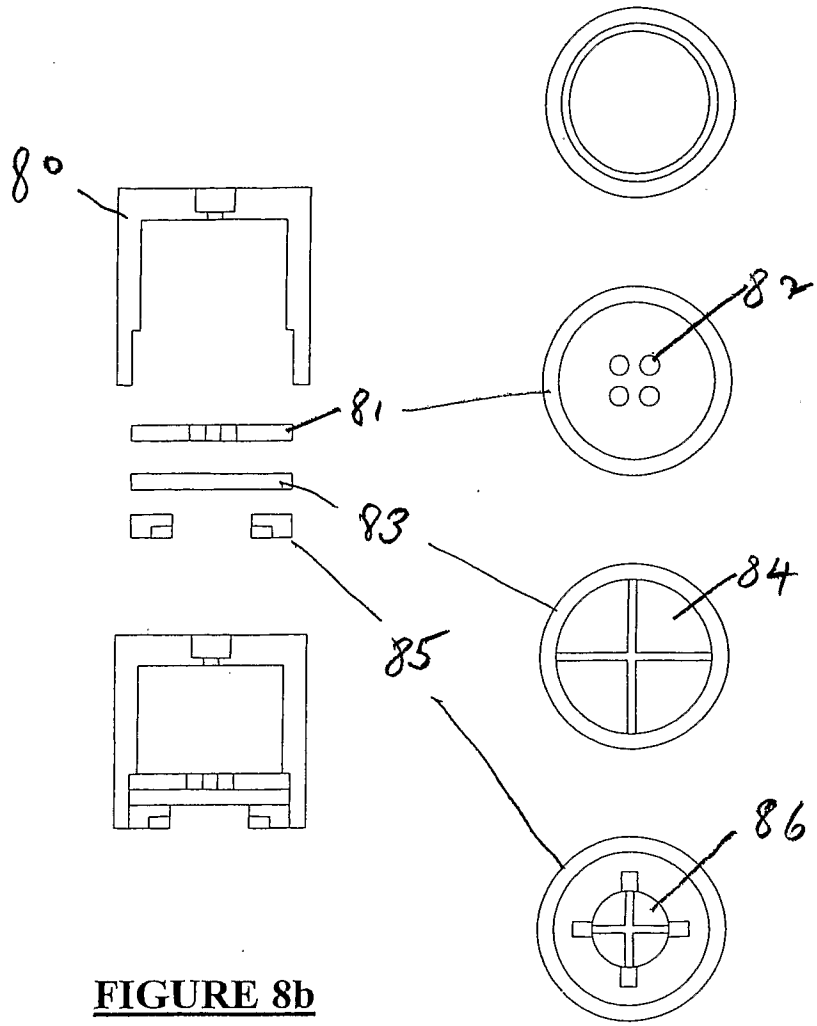
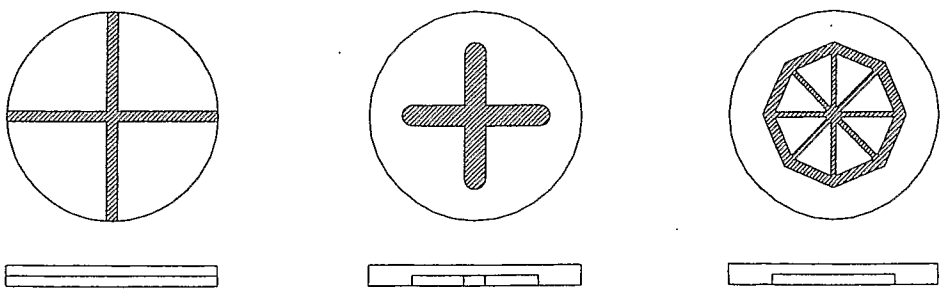


FIGURE 8b

FIGURE 8c

FIGURE 8d



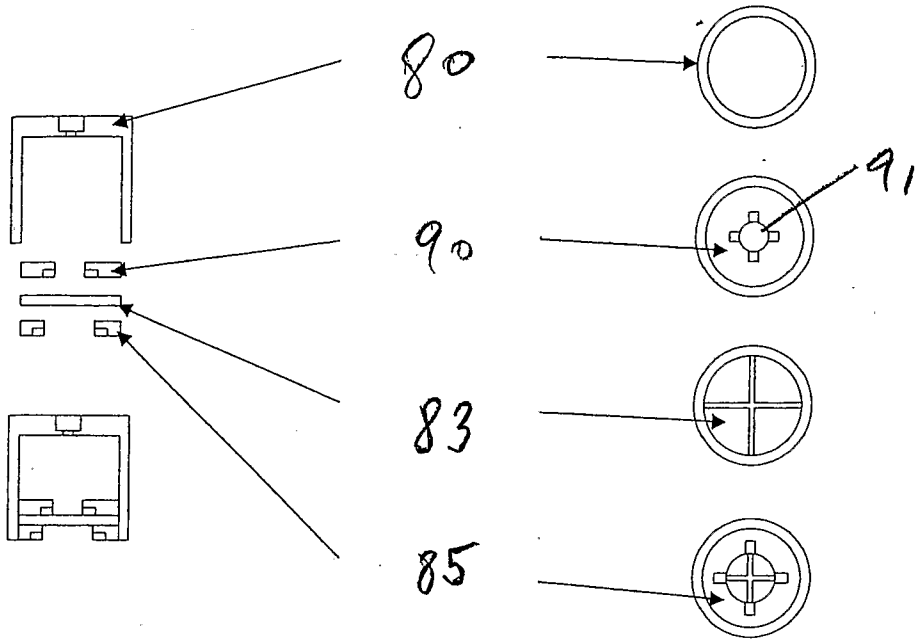
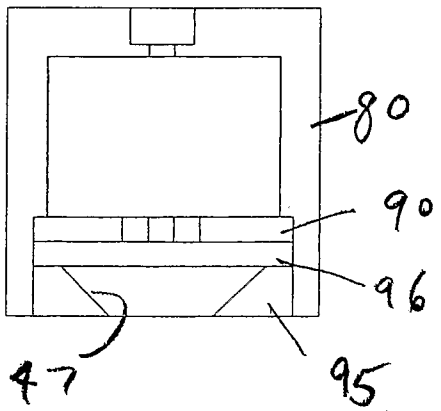


FIGURE 9a

FIGURE 9b



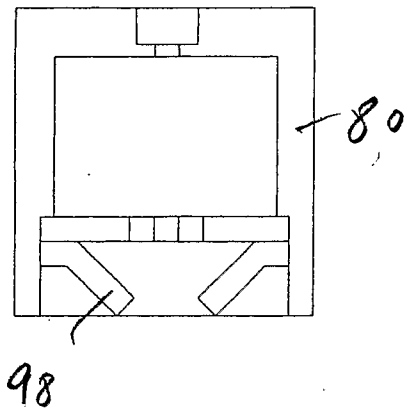


FIGURE 9c

FIGURE 9d

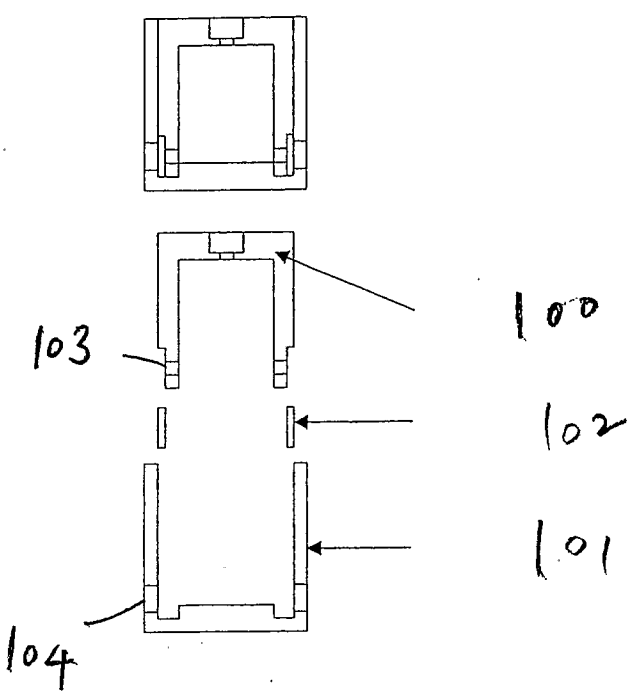


FIGURE 10a

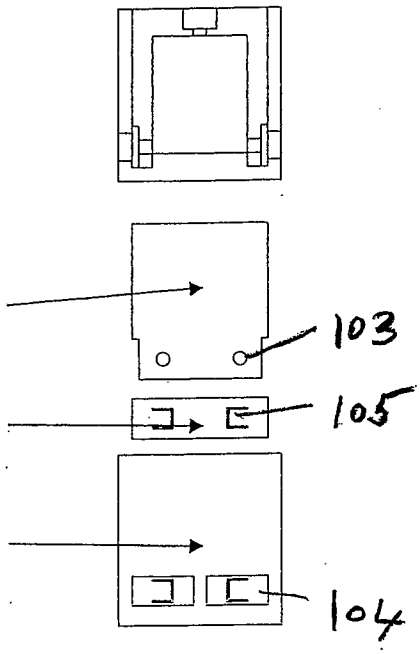


FIGURE 10b

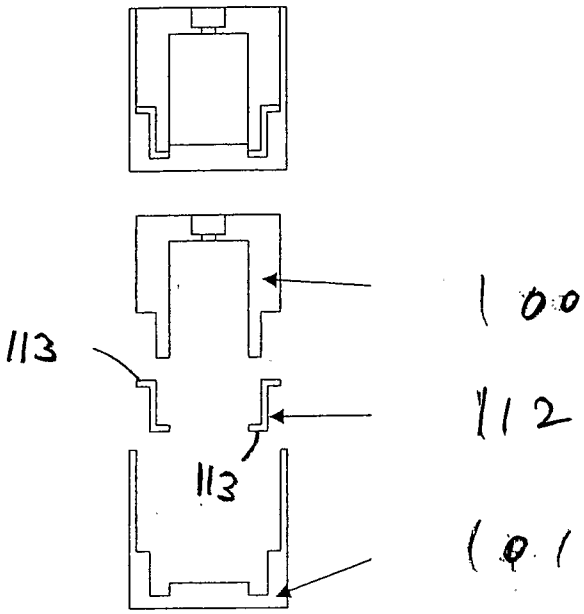


FIGURE 11a

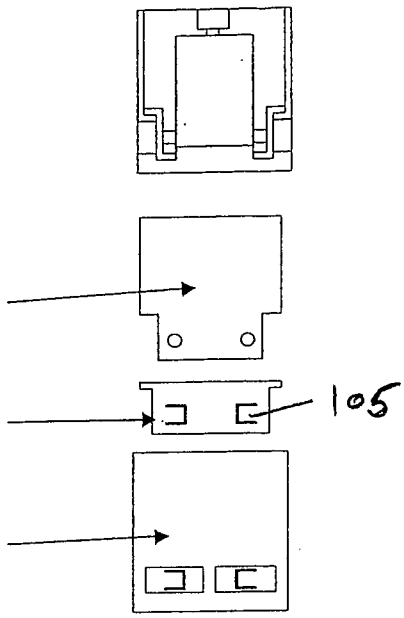


FIGURE 11b

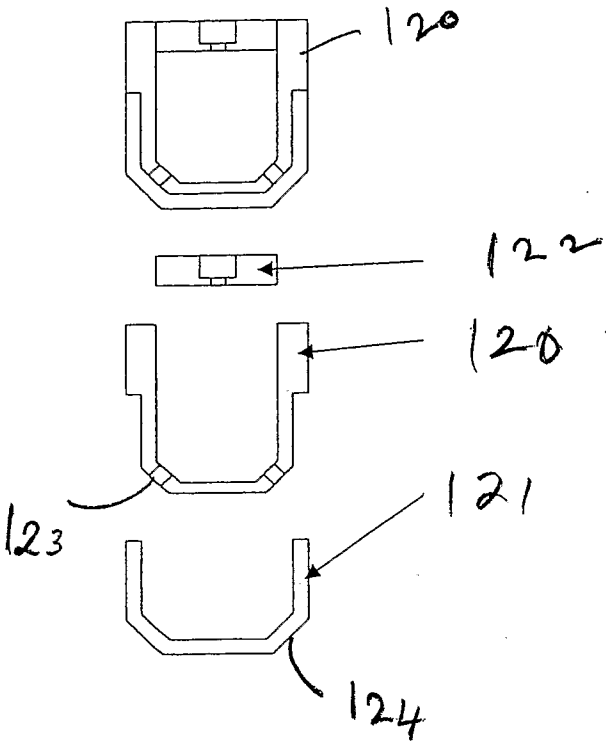


FIGURE 12a

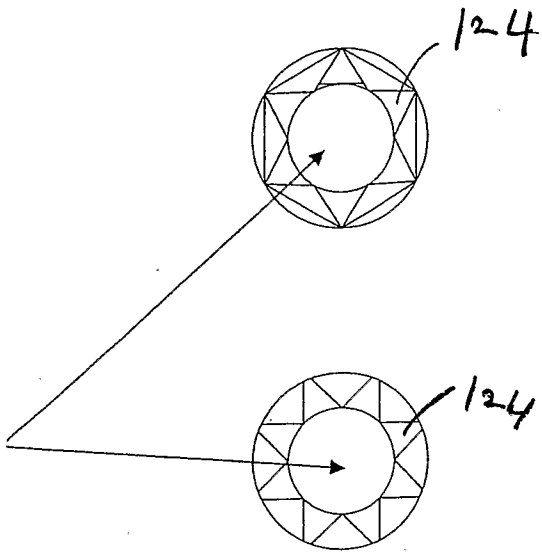


FIGURE 12b

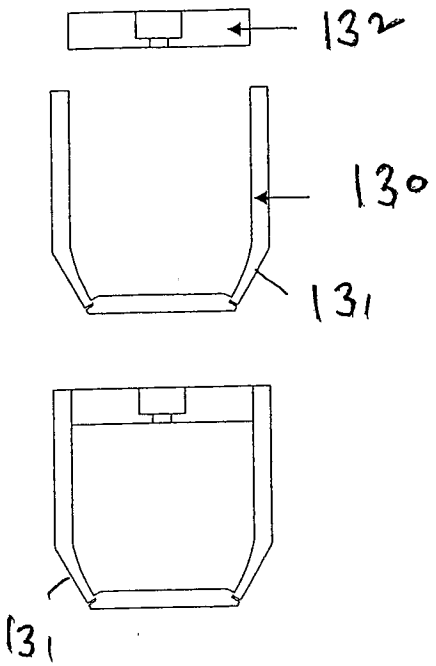


FIGURE 13a

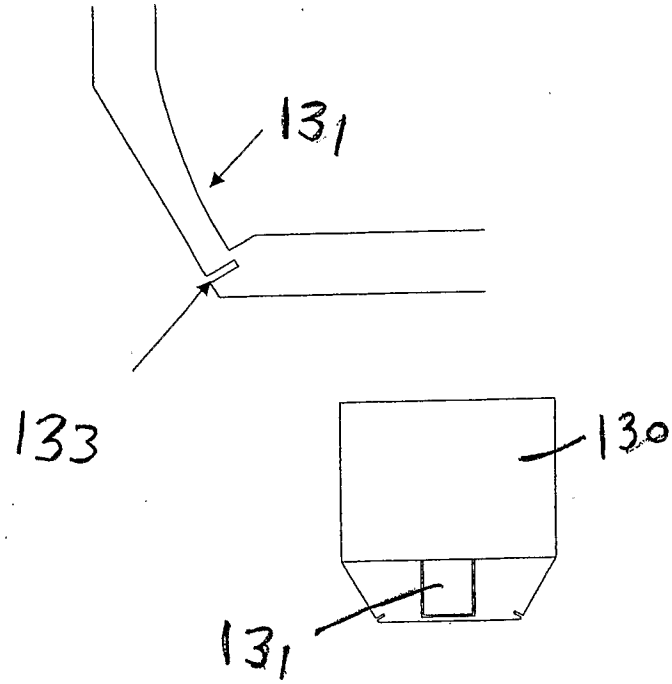
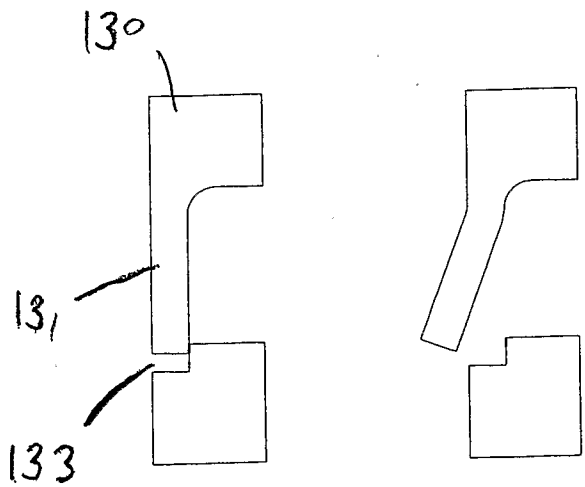


FIGURE 13b

FIGURE 13c



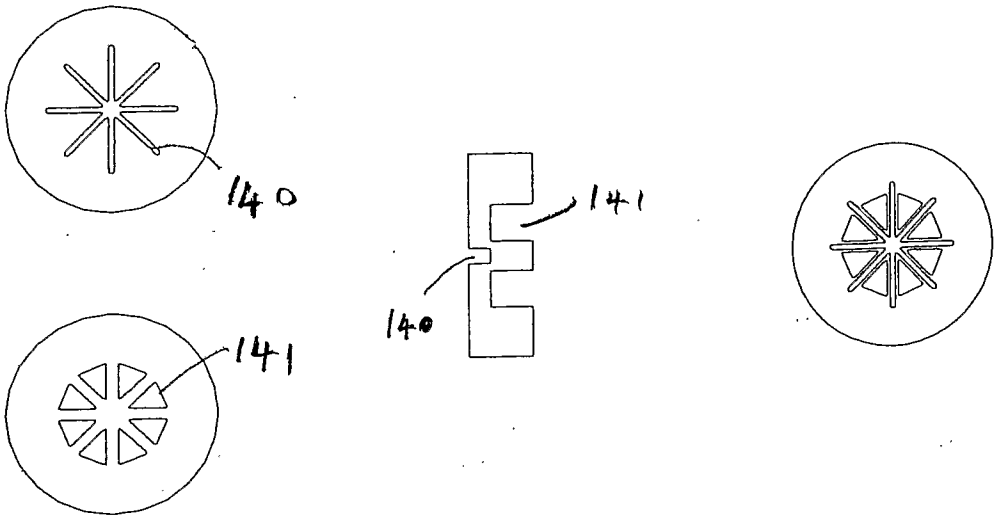
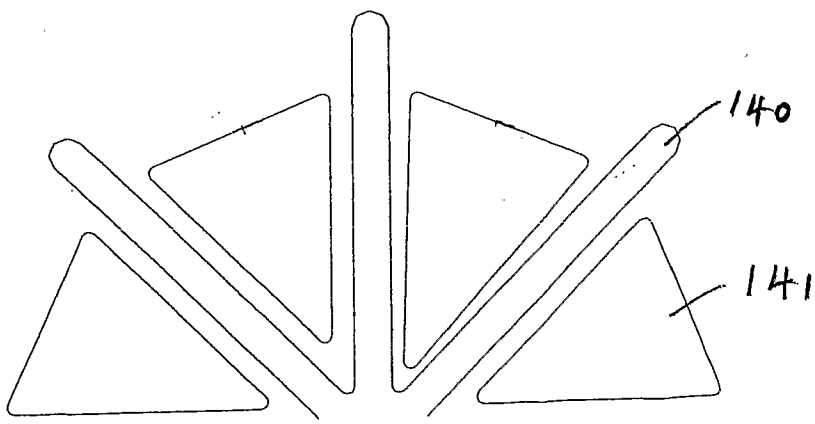


FIGURE 14a

FIGURE 14b

Figure 1



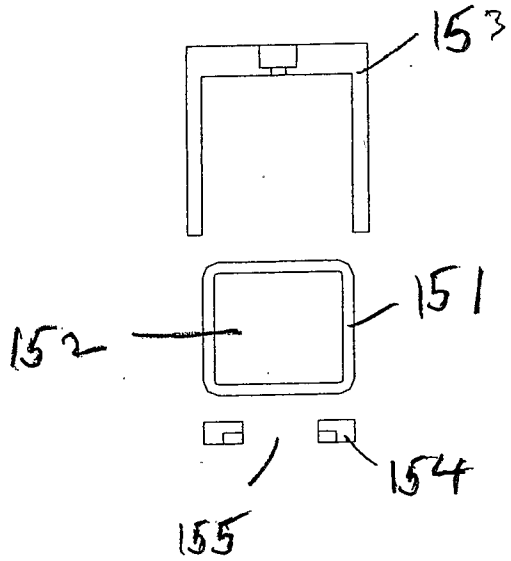


FIGURE 15a

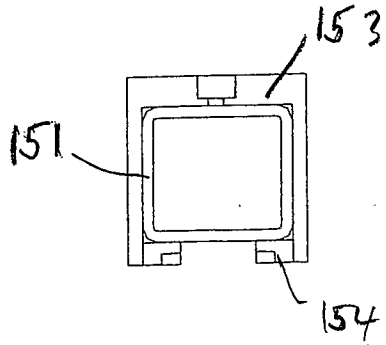


FIGURE 15b

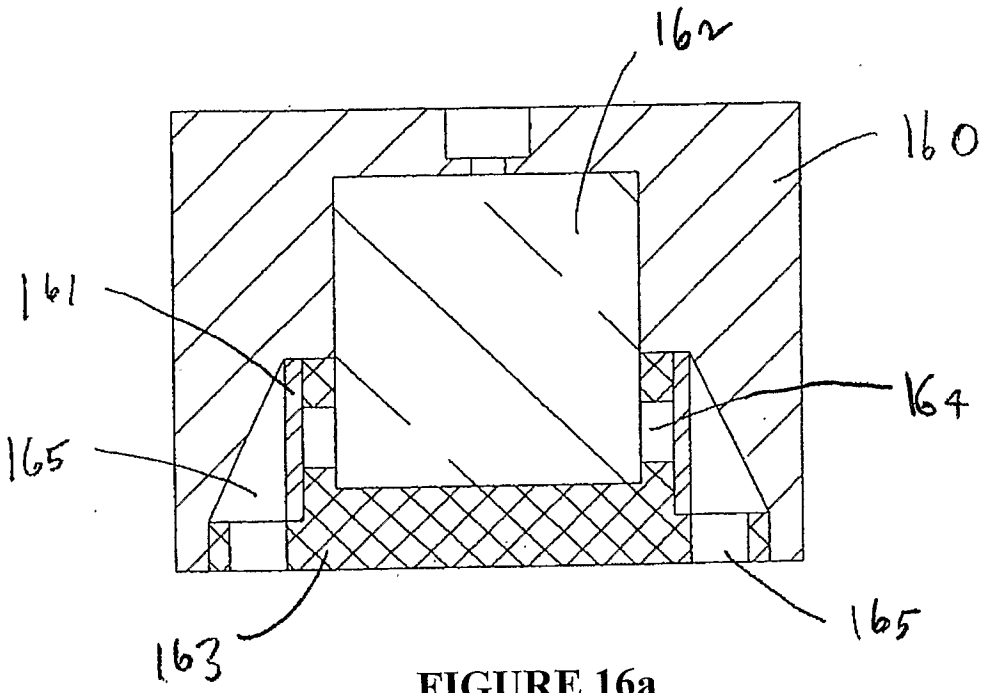


FIGURE 16a

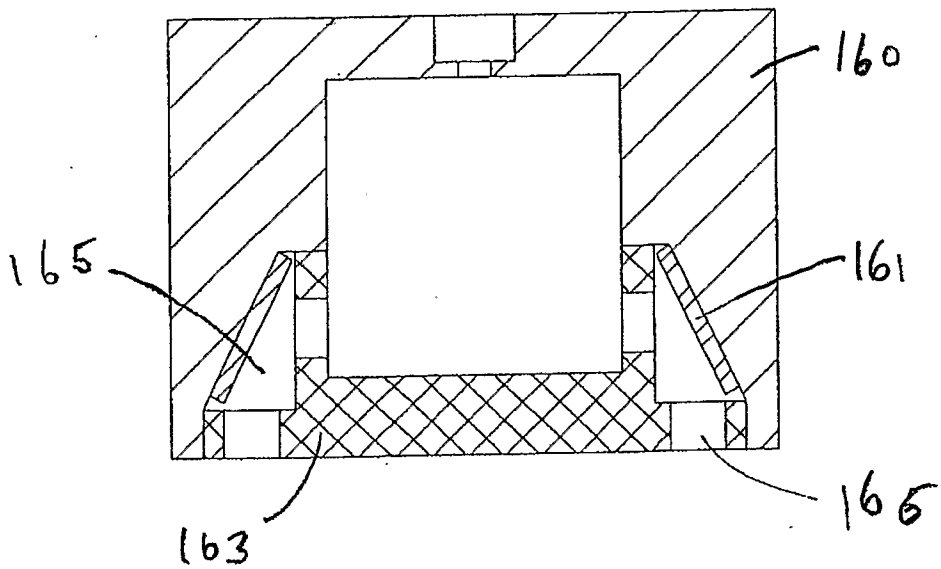


FIGURE 16b

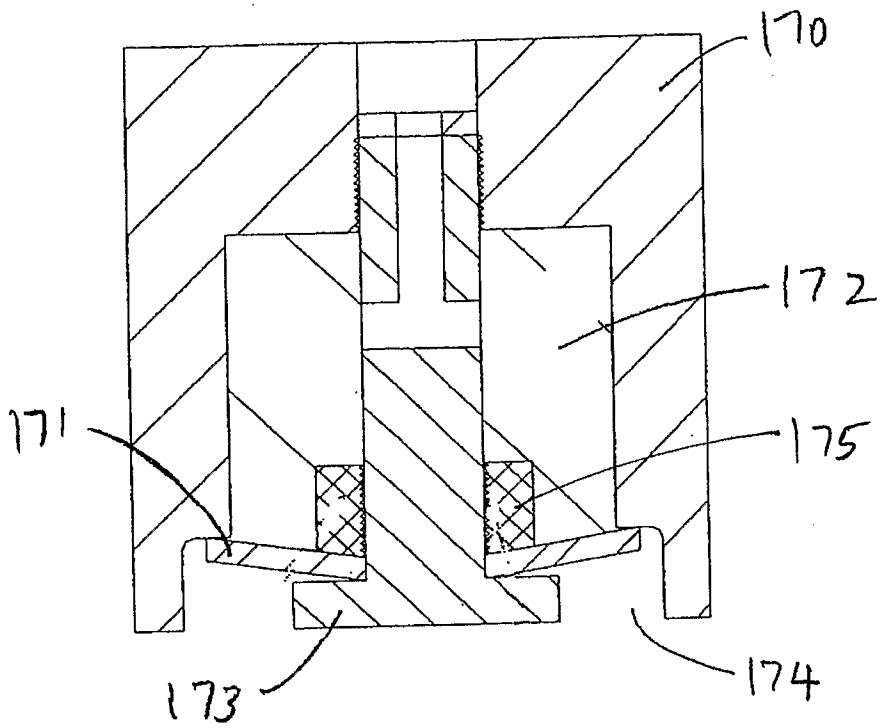


FIGURE 17a

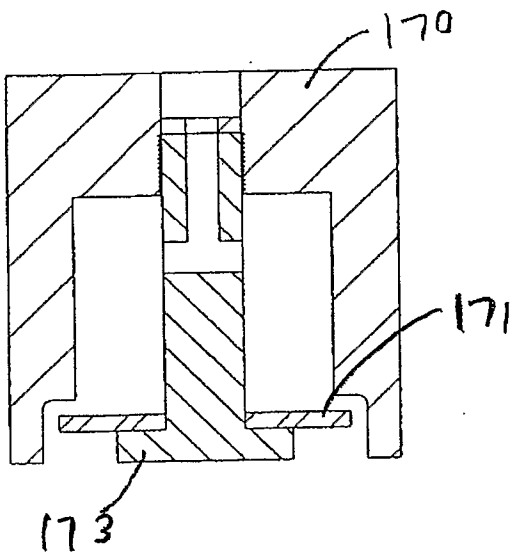


FIGURE 17b

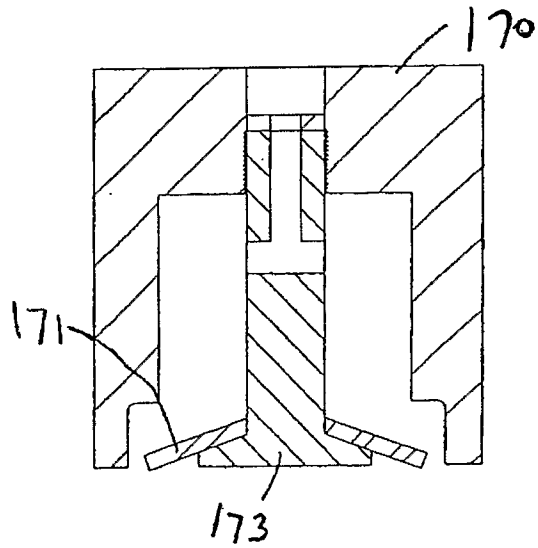


FIGURE 17c

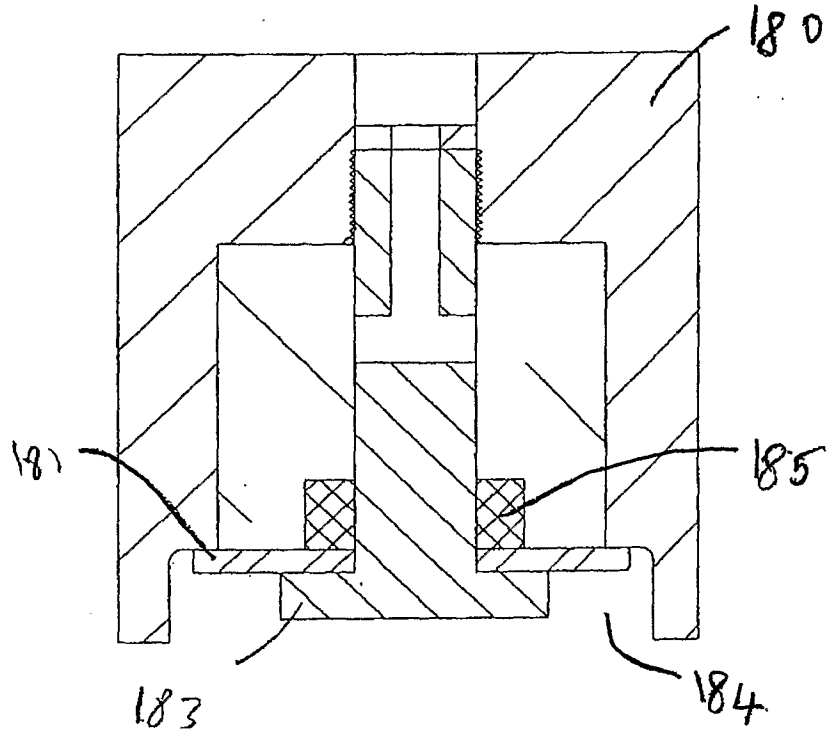


FIGURE 18a

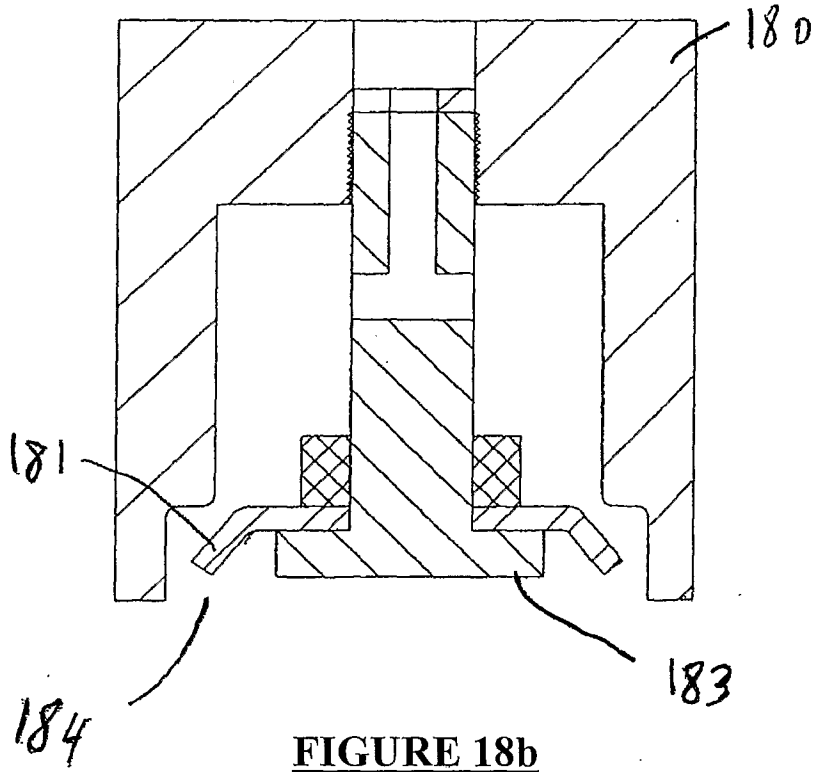


FIGURE 18b

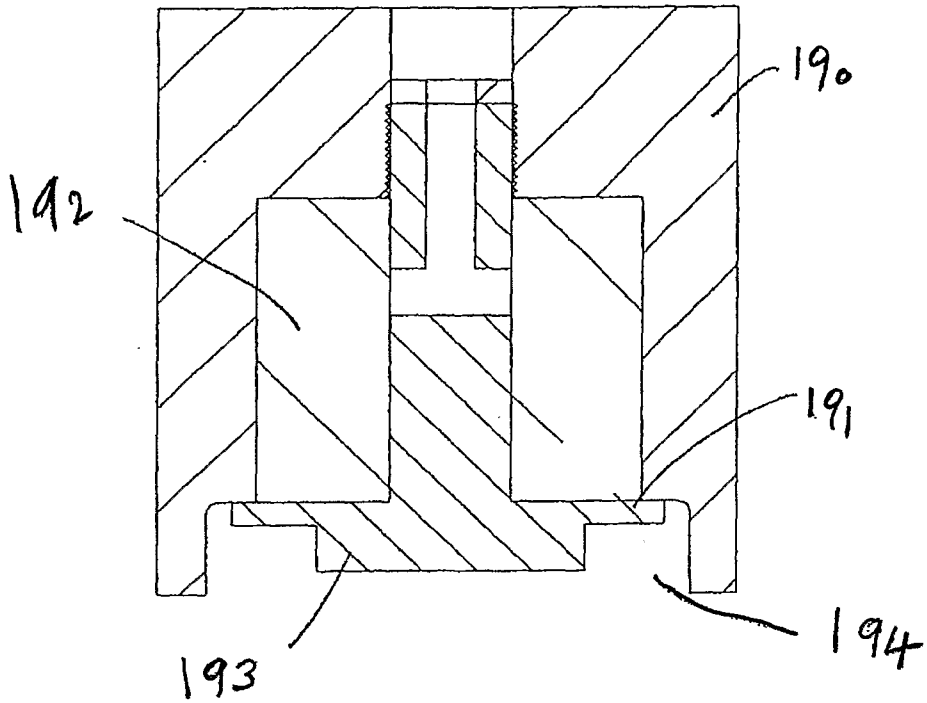


FIGURE 19a

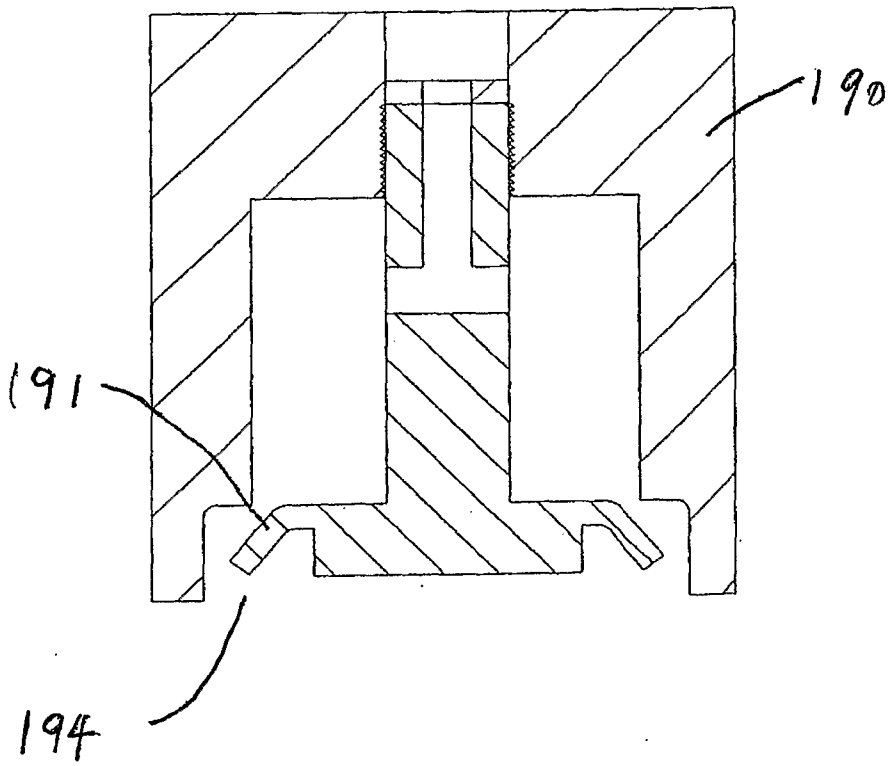


FIGURE 19b

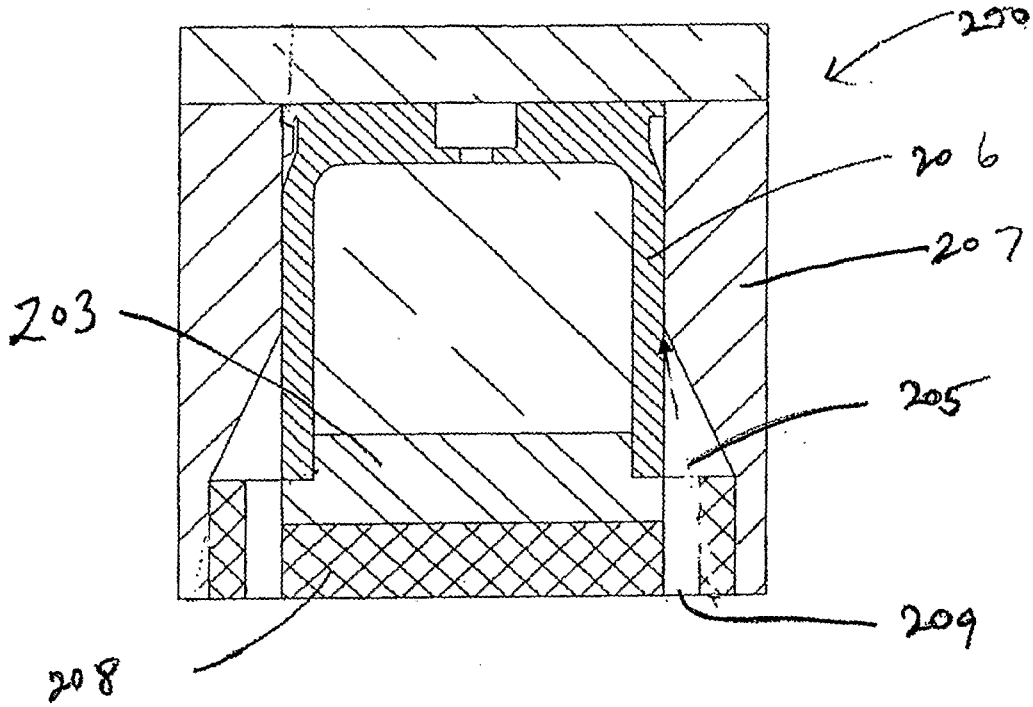


FIGURE 20a

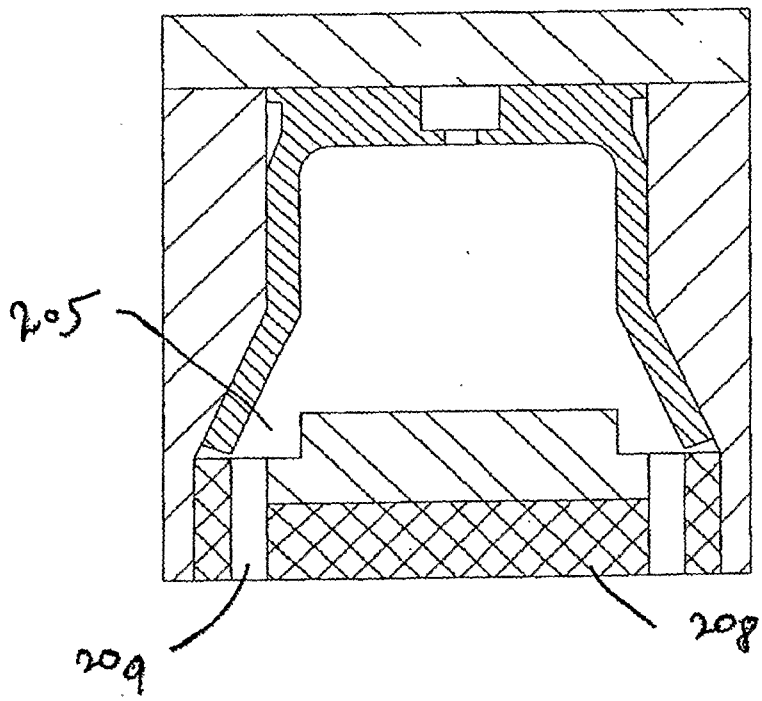


FIGURE 20b

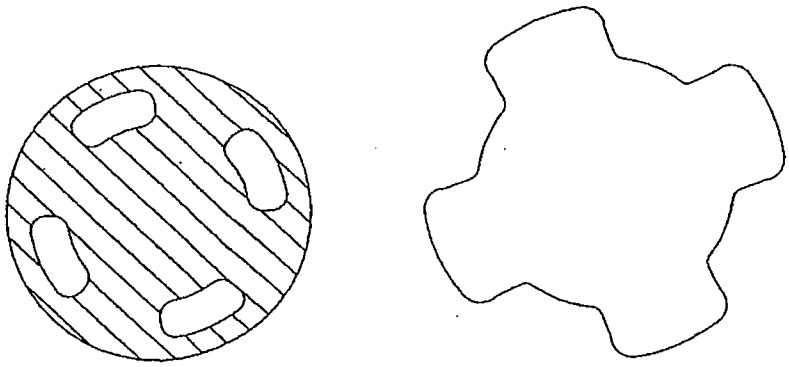
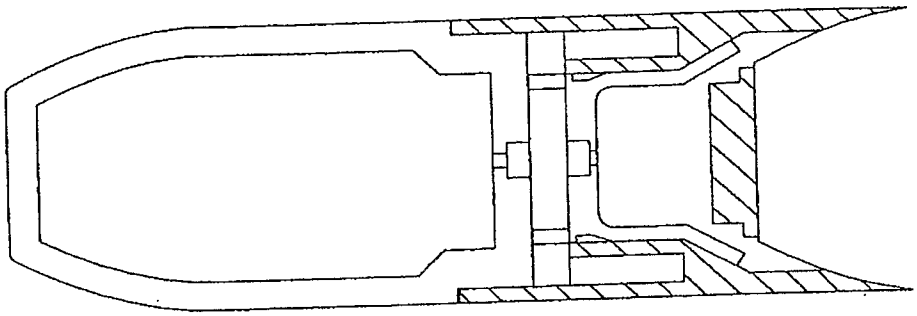


FIGURE 20d



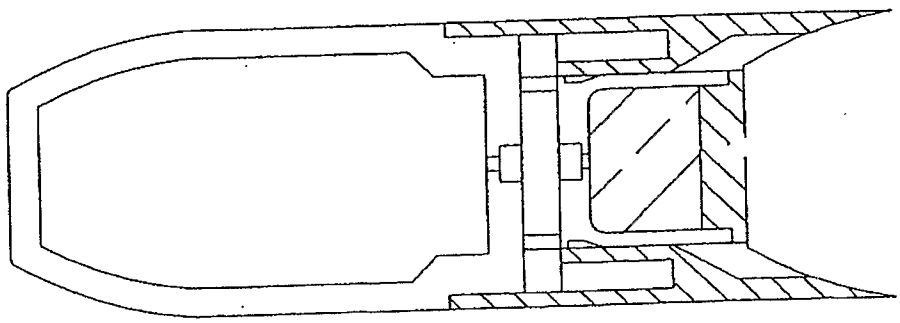


FIGURE 20c

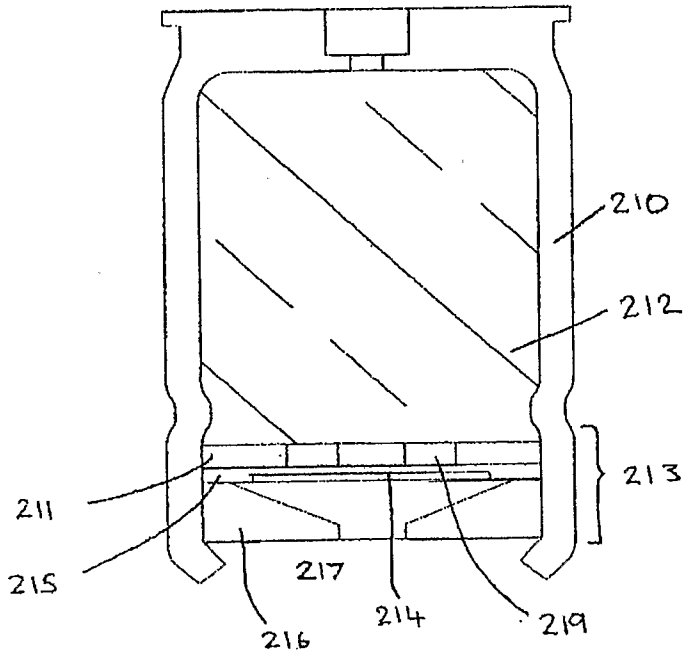


FIGURE 21a

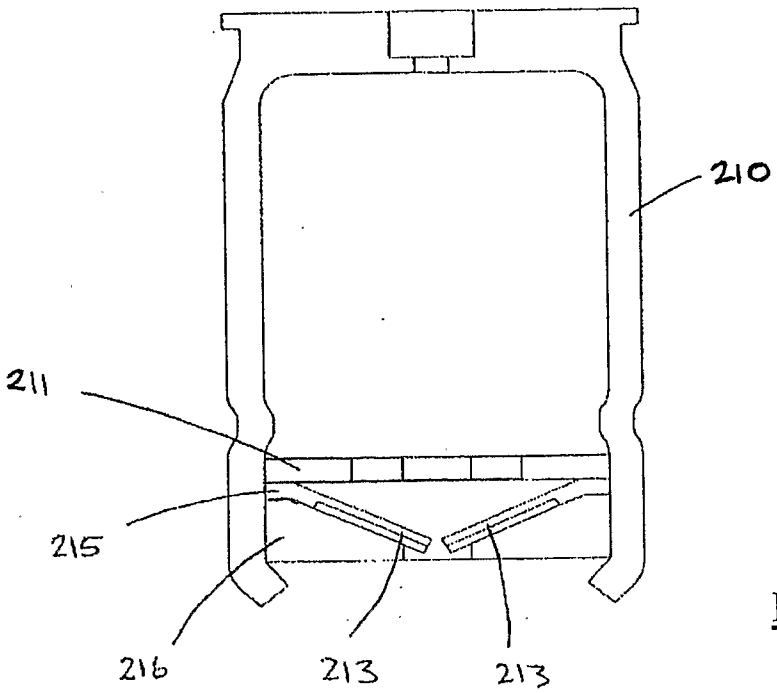


FIGURE 21b

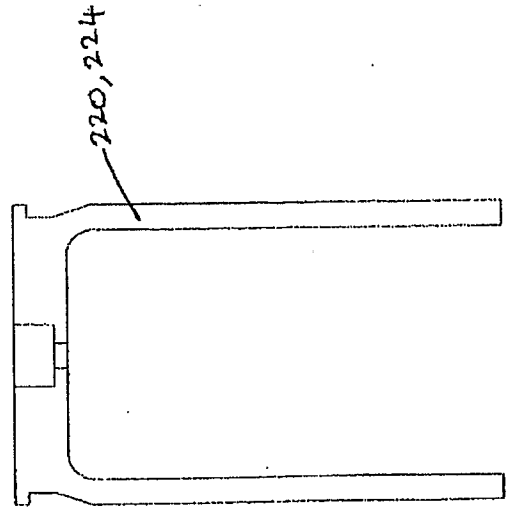


FIGURE 22c

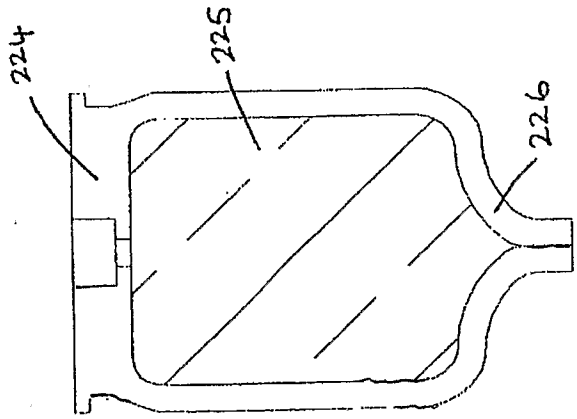


FIGURE 22b

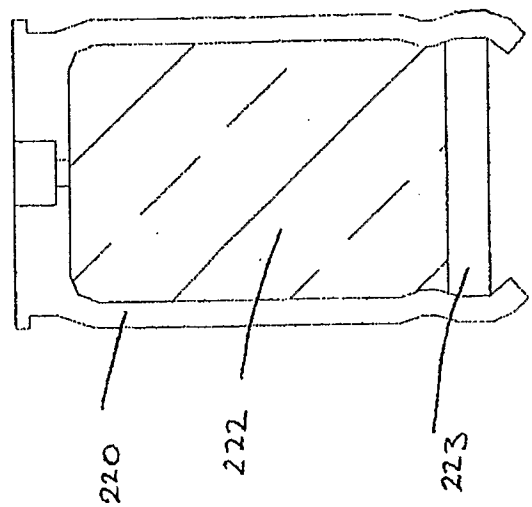


FIGURE 22a

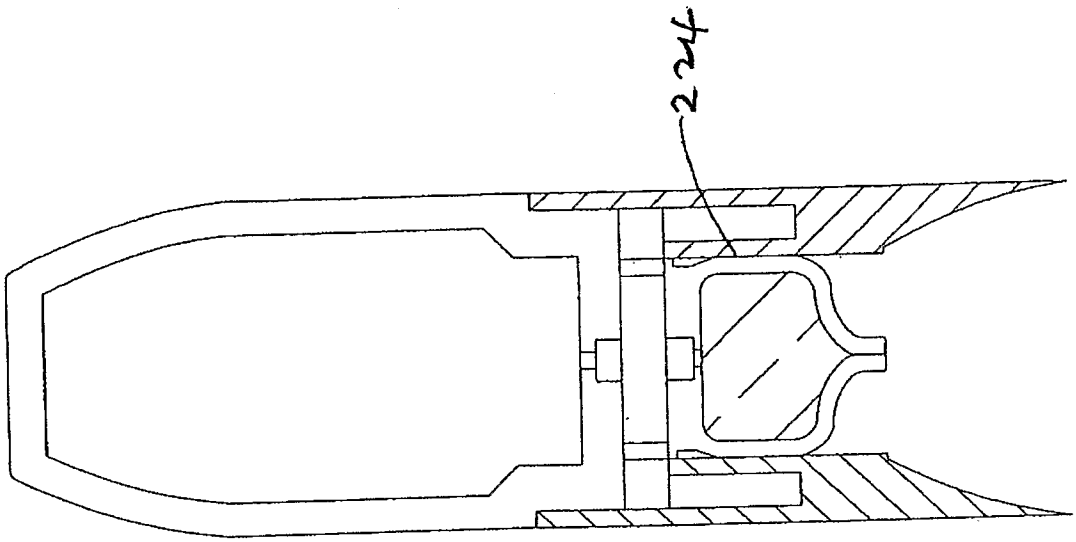


FIGURE 23b

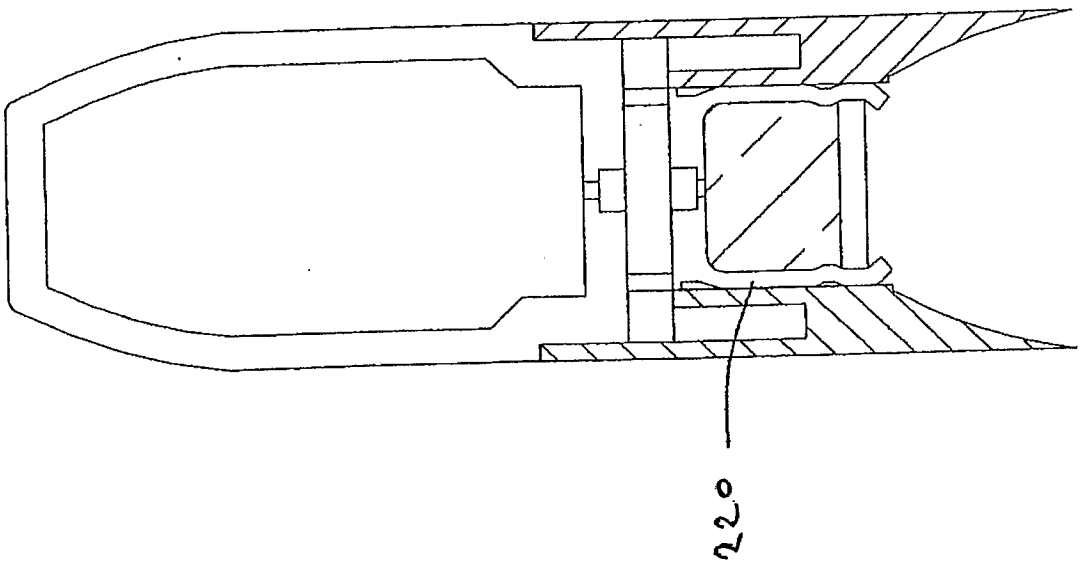


FIGURE 23a

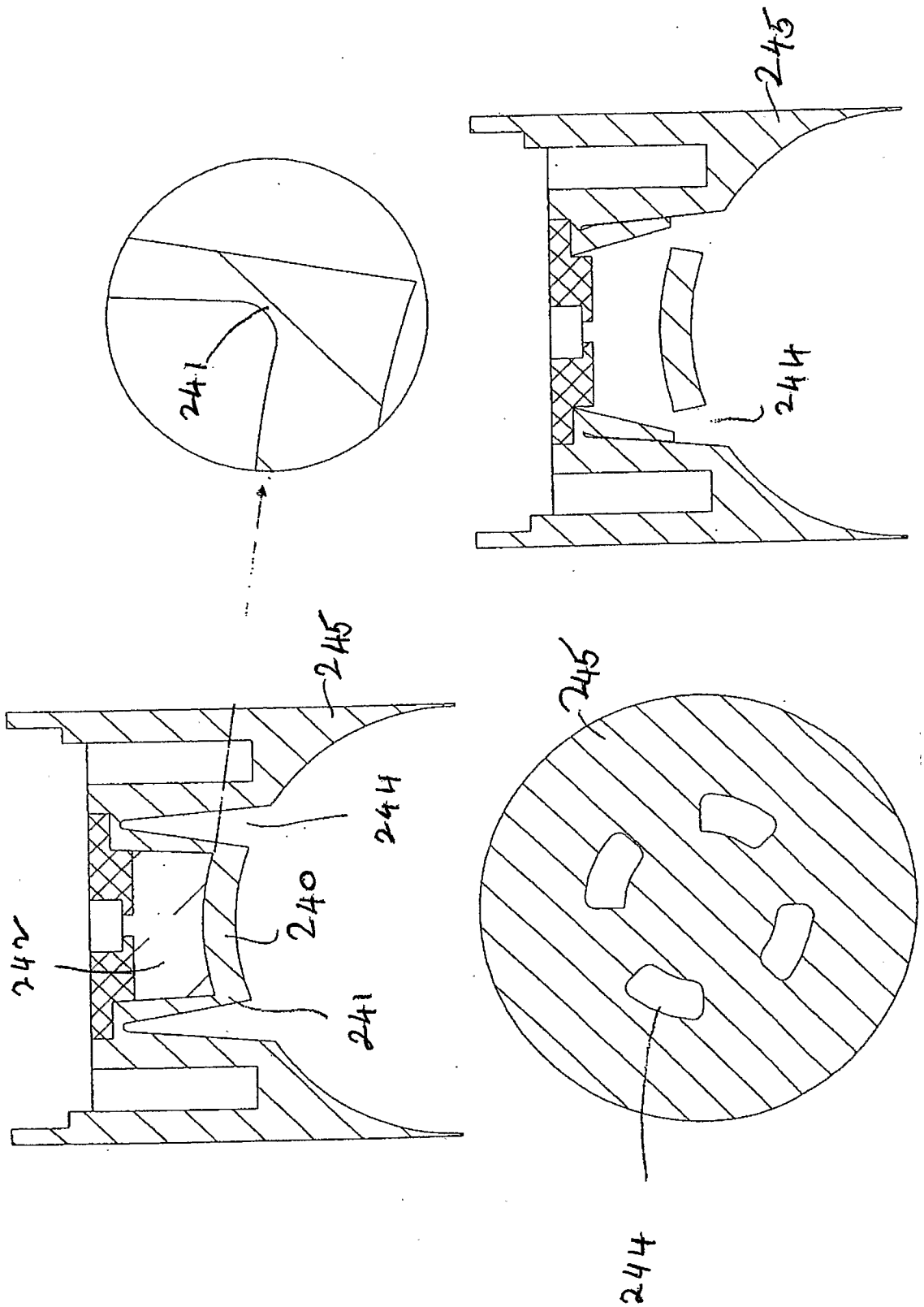


FIGURE 24

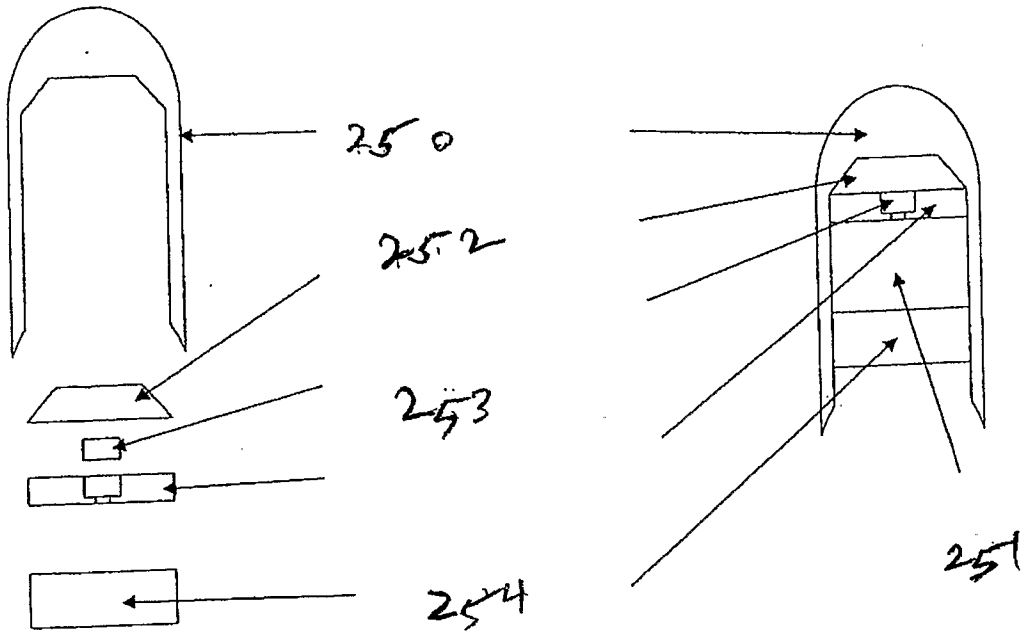


FIGURE 25

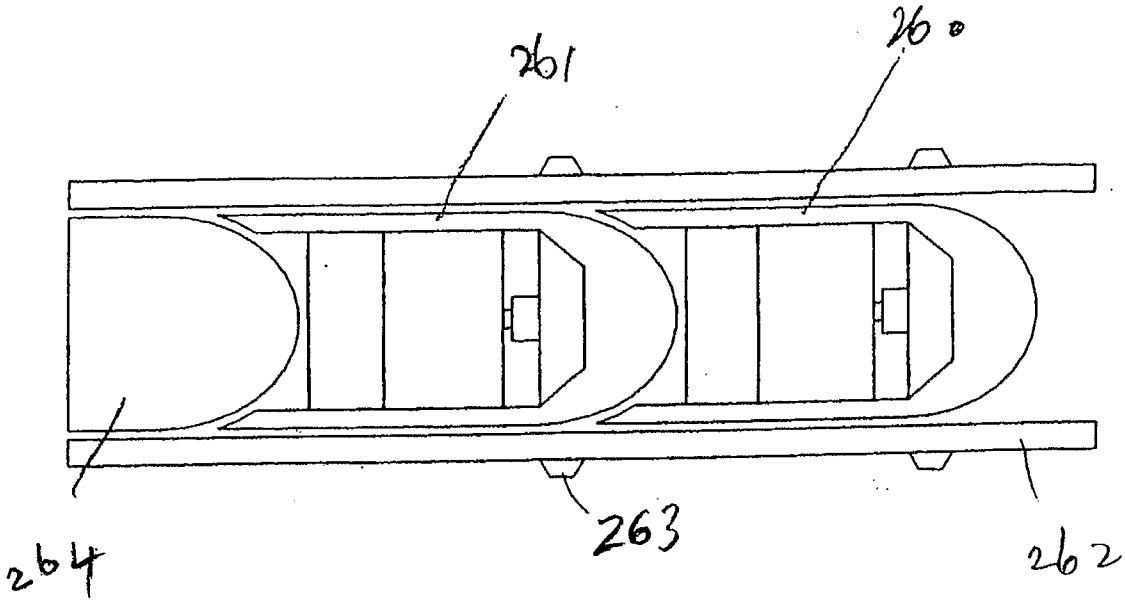
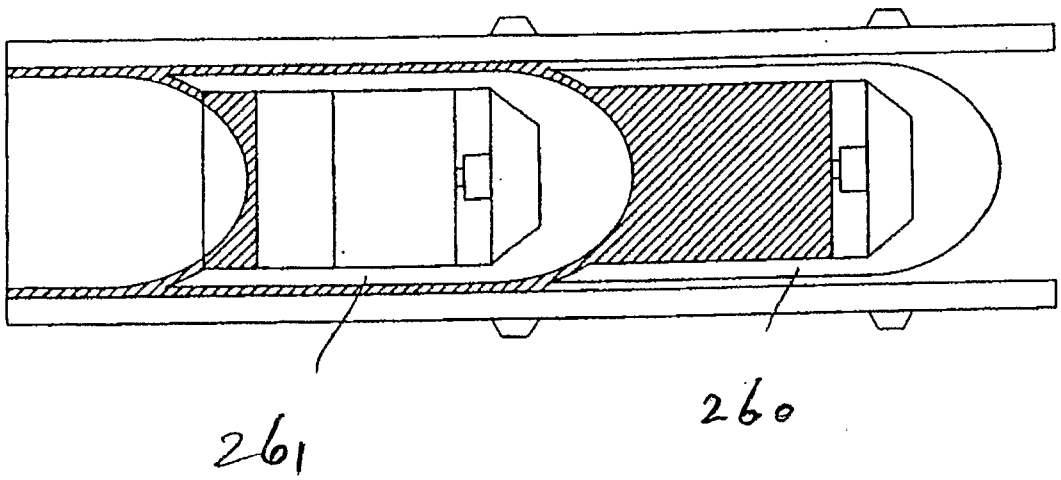


FIGURE 26a

FIGURE 26b



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/000184

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

F42B 5/03 (2006.01) ***F41A 21/00*** (2006.01) ***F42B 30/00*** (2006.01)
F41A 1/00 (2006.01) ***F42B 14/00*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI –Q79/DC & keywords: projectile, missile, ammunition, round, ordnance, shell, stackable, tandem, plurality, multiple, array, propellant, charge, explosive, sealing, o-ring and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/070307 A1 (METAL STORM LTD) 19 August 2004 Whole document (especially Figures 2a-3a and page 6, line 31-page7, line 9)	4, 7
X	WO 2003/089871 A1 (METAL STORM LTD) 30 October 2003 Whole document (especially Figures 6 and 7)	4, 7
X	WO 2002/097357 A1 (METAL STORM LTD) 5 December 2002 Whole document	4

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 March 2007	16 APR 2007
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **D.R. LUM** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2544

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/000184

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2099993 A (TAUSCHEK) 23 November 1937 Whole document (especially Figures 9, 15)	4
A	US 3815271 A (LYNN) 11 June 1974 Whole document (especially Figures 2-4, 12)	
A	WO 2004/102108 A1 (METAL STORM LTD) 25 November 2004 Whole document	
A	WO 2004/097326 A1 (METAL STORM LTD) 11 November 2004 Whole document	
A	WO 2000/062005 A1 (METAL STORM LTD) 19 October 2000 Whole document	
A	WO 2001/090680 A1 (METAL STORM LTD) 29 November 2001 Whole document	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/000184

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

(See in the Supplemental Box)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: (III lack of unity)

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are different inventions as follows:

- Claims 1-3 are directed to a stackable projectile including a chamber containing a propellant charge, an exit from the chamber and a seal blocking the exit wherein the seal is movable and with a bias member. It is considered that the moveable seal with a bias member which urges the seal into engagement with the exit comprises a first distinguishing feature.

- Claim 4 is directed to a stackable projectile including a chamber containing a propellant charge, an exit from the chamber and a seal blocking the exit wherein the seal is deformable. It is considered that the seal being deformable between a closed condition and an open condition comprises a second distinguishing feature.

- Claim 5 is directed to a stackable projectile including a chamber containing a propellant charge, an exit from the chamber and a seal blocking the exit wherein the seal is opened by motion about a pivot connection. It is considered that the seal being opened by motion about a pivot connection comprises a third distinguishing feature.

- Claim 6 is directed to a stackable projectile including a chamber containing a propellant charge, an exit from the chamber, the exit includes one or more vents, a seal blocking the exit wherein the seal includes one or more flaps. It is considered that exit including one or more vents and the seal including one or more flaps over the vents which are ruptured by outward passage of ignition gas comprises a fourth distinguishing feature.

- Claim 7 is directed to a stackable projectile including a chamber containing a propellant charge, an exit from the chamber, the exit includes one or more vents and a seal blocking the exit wherein the seal is integral with the chamber and is ruptured along one or more points or lines of weakness. It is considered that the seal being integral with the chamber and ruptured along one or more points or lines of weakness comprises a fifth distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

The only feature common to all of the claims is a projectile for use in a barrel with stacked projectiles, including: a chamber containing a propellant charge for the projectile, an exit from the chamber for release of propulsion gases into the barrel when the propellant is ignited, and a seal blocking the exit which is opened by ignition of the propellant within the chamber but is resistant to gases produced by ignition of propellant in other projectiles in the barrel. However this concept is not novel in the light of: WO 2004/070307. This means that the common feature can not constitute a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art.

Because the common feature does not satisfy the requirement for being a special technical feature it follows that it cannot provide the necessary technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a posteriori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2007/000184

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2004070307	AU	2004209562	AU	2004234424	BR	PI0407222
		CA	2515140	CA	2524398	CN	1759292
		EP	1595104	EP	1625341	KR	2005010349
		MX	PA05008497	RU	2005127428	WO	2004097326
		WO	2004097331				
WO	03089871	AU	2003227084	AU	2004100128	BR	0309429
		CA	2482783	CN	1646876	EP	1497607
		MX	PA04010335	RU	2004130847	US	2005268807
WO	02097357	BR	0210084	CA	2448269	CN	1527930
		EP	1390685	MX	PA03010773	RU	2003136146
		US	2004231219	ZA	200309157		
US	2099993	NONE					
US	3815271	NONE					
WO	2004102108	AU	2004238889	CA	2525724	EP	1629249
		US	2007056460				
WO	2004097326	AU	2004209562	AU	2004234424	BR	PI0407222
		CA	2515140	CA	2524398	CN	1759292
		EP	1595104	EP	1625341	KR	2005010349
		MX	PA05008497	RU	2005127428	WO	2004070307
		WO	2004097331				
WO	0062005	AU	14774/02	AU	45232/00	AU	2004201568
		BR	0011194	CA	2368893	CN	1351704
		CN	1740731	EP	1175589	MX	PA01010054
		RU	2005105420	US	6722252	US	2007039456
WO	0190680	AU	10129/02	CA	2407787	CN	1432124
		EP	1283979	RU	2002130579	US	2003127010
		ZA	200208760				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX