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(54) **PROJECTILE SEALING ARRANGEMENT**

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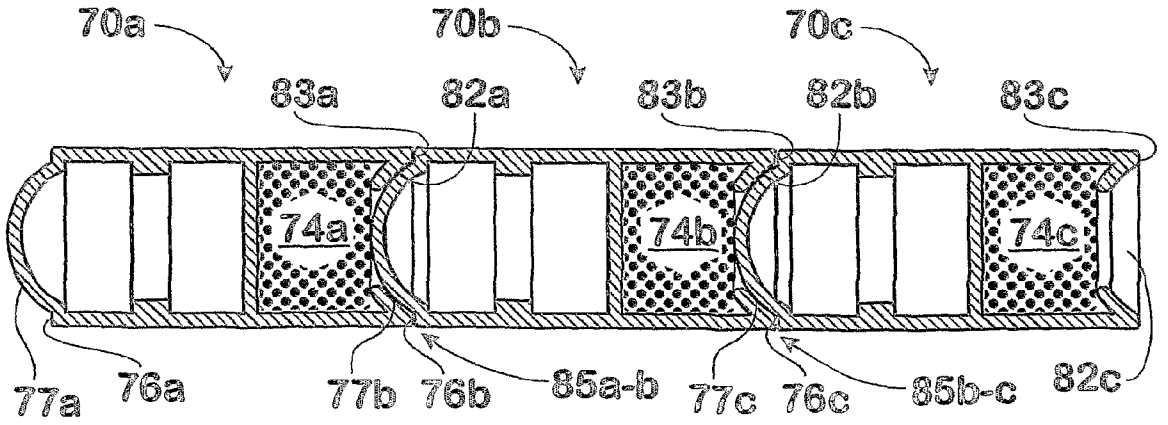
(57) **ABSTRACT**

A projectile sealing arrangement for a barrel assembly of a weapon in which a plurality of projectile assemblies are axially disposed in abutting relationship within a barrel. Each projectile assembly is associated with a discrete propellant charge. The sealing arrangement includes a rearward opening communicating with a cavity provided in each projectile assembly for containing the discrete propellant charge, and a forward portion of an abutting projectile assembly arranged for operative sealing engagement with the rearward opening. During application of a compressive load to abutting projectile assemblies, the discrete propellant charge is sealed within the cavity.



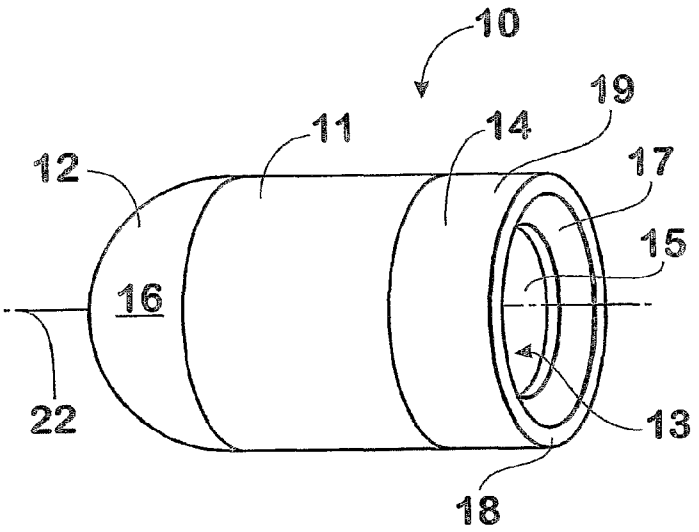

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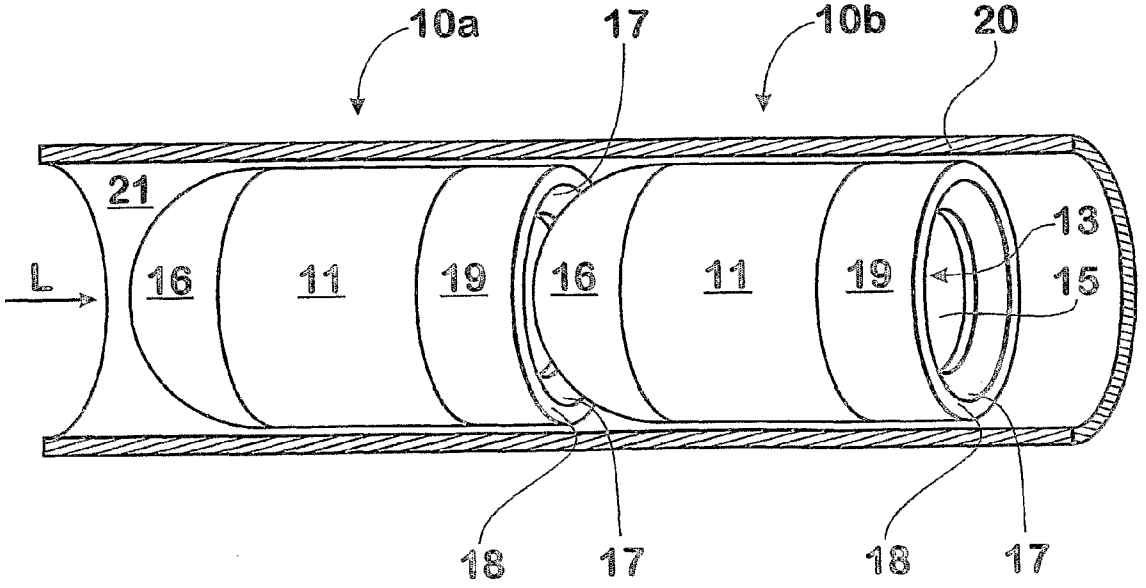
Fig. 1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10b
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Fig. 2

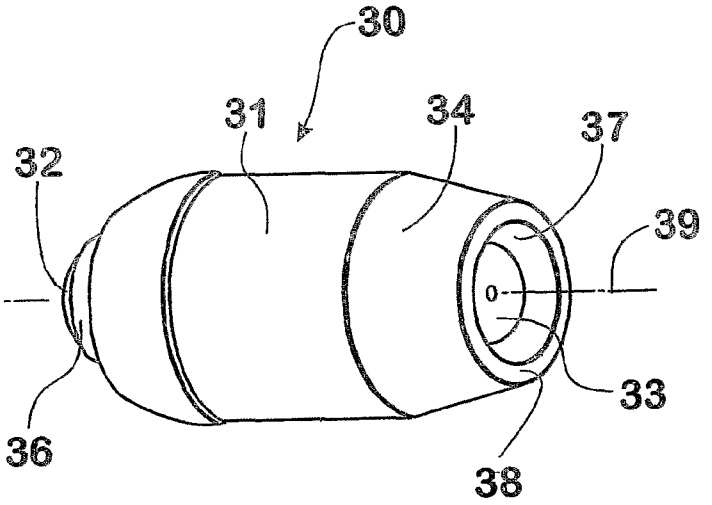


Fig. 3

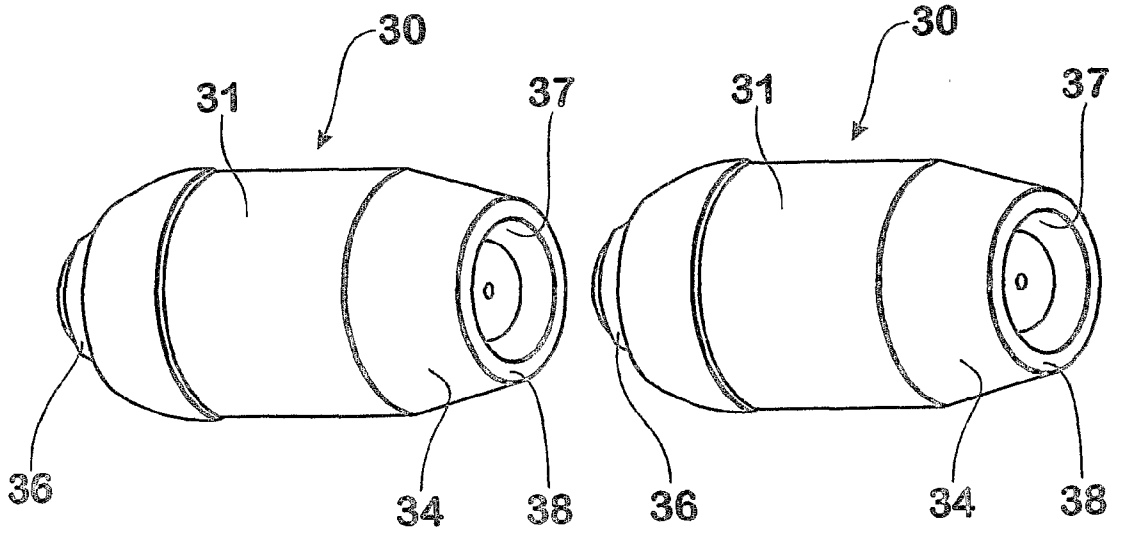


Fig. 4

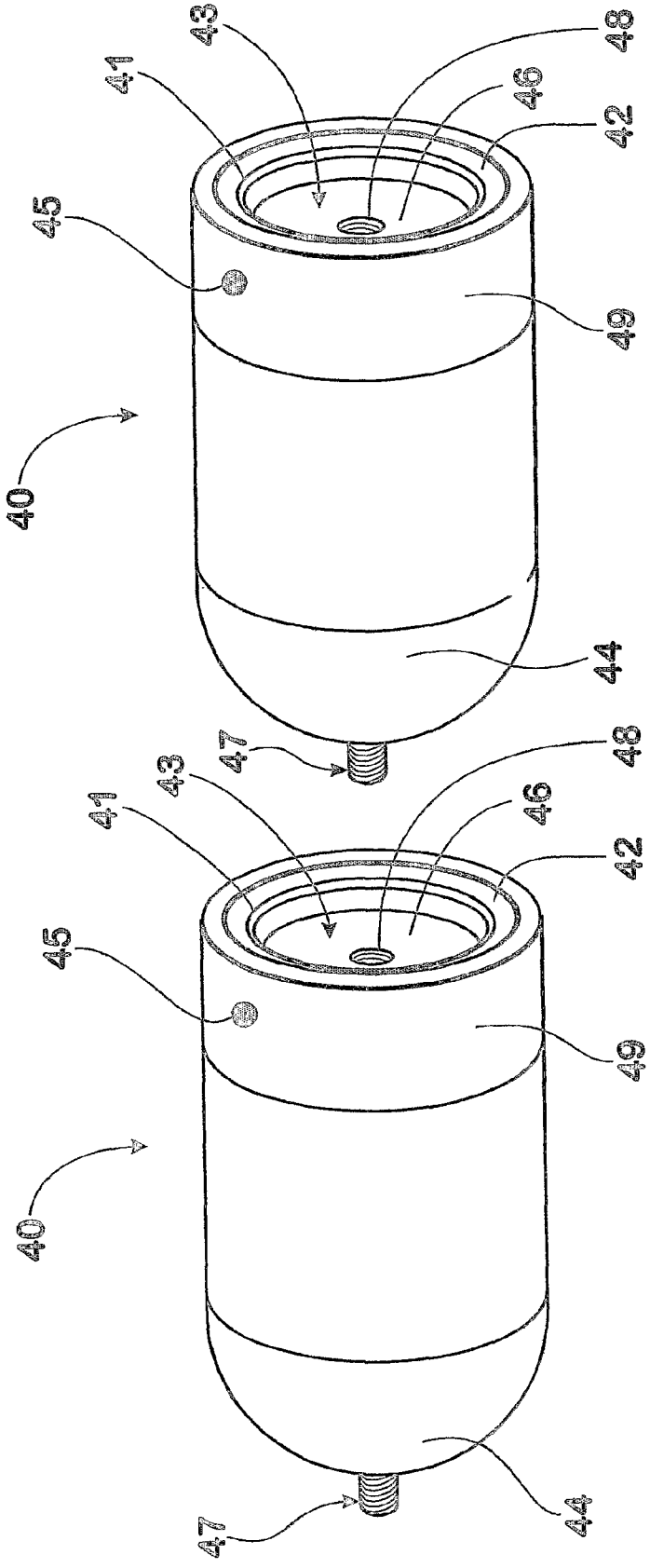
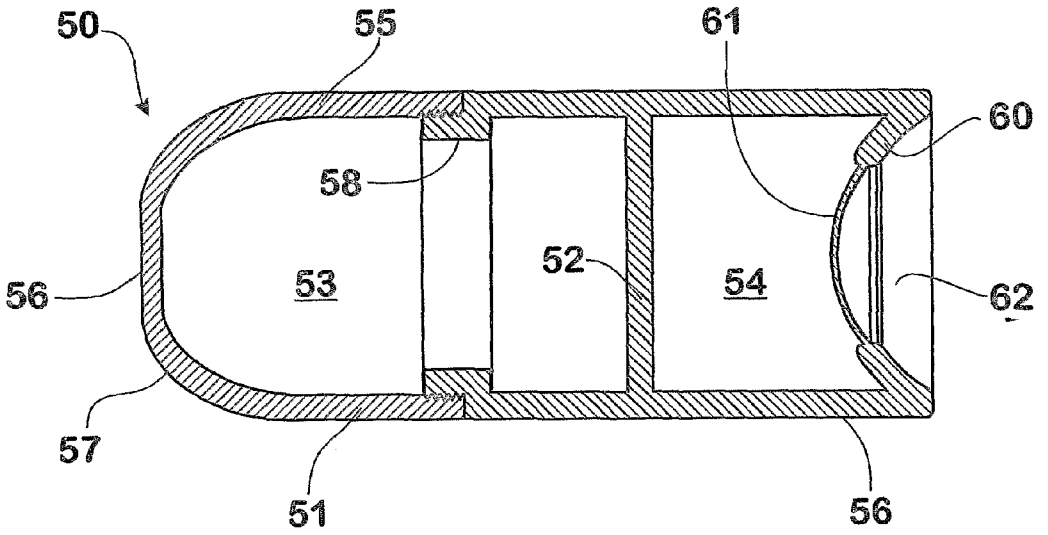


Fig. 5


50
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51
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Fig. 6

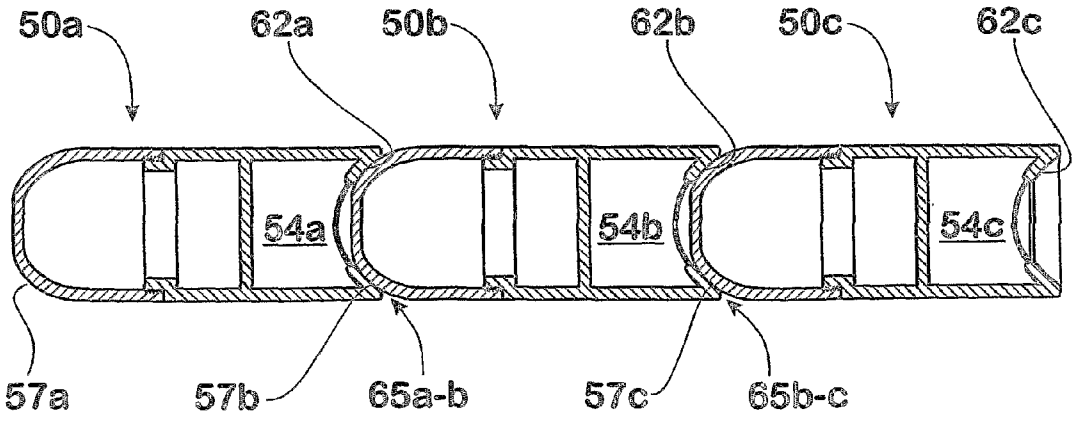
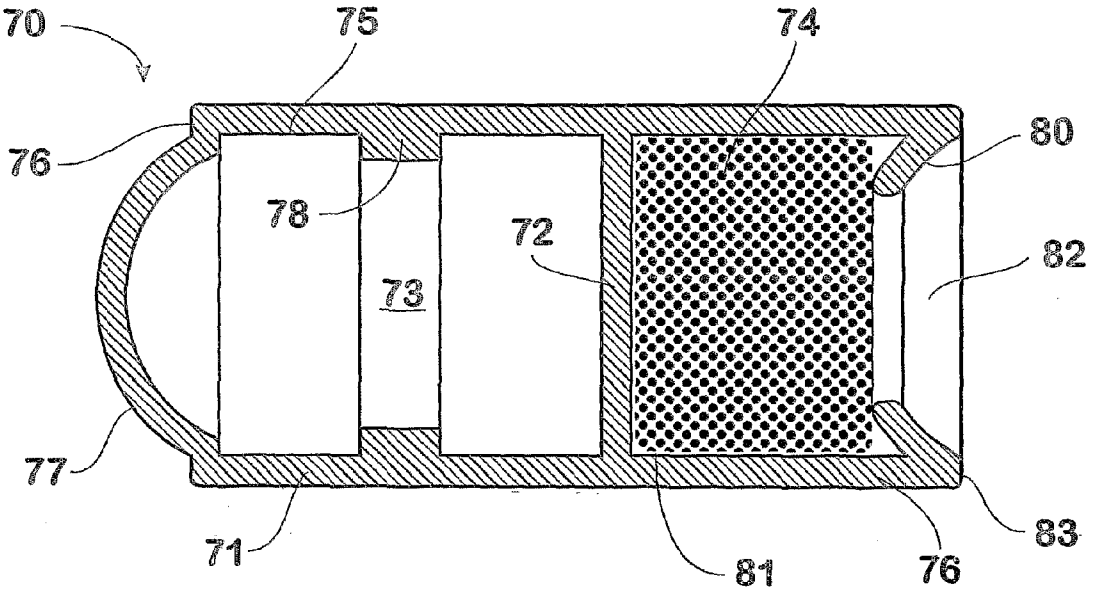

50a
62a
50b
62b
50c
62c
54a
54b
54c
57a
57b
65a-b
57c
65b-c

Fig. 7


70
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83

Fig. 8

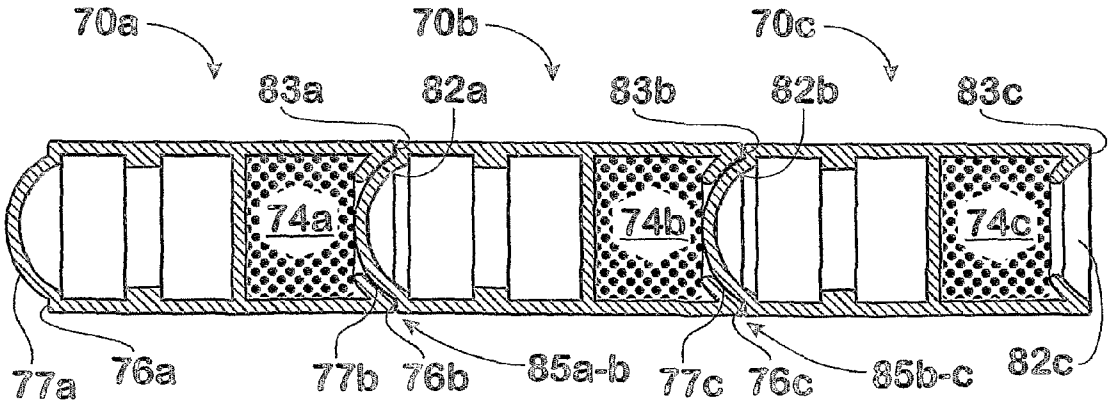
70a
70b
70c
83a
82a
83b
82b
83c
74a
74b
74c
77a
76a
77b
76b
85a-b
77c
76c
85b-c
82c

Fig. 9

PROJECTILE SEALING ARRANGEMENT

RELATED APPLICATIONS

[0001] This application is a divisional application of a co-pending U.S. patent application Ser. No. 10/512,003, filed Jul. 5, 2005, which is a national phase application of International Application No. PCT/AU03/00318, filed Mar. 17, 2003, which claims the priority from Australian Patent Application No. PS 1828, filed Apr. 19, 2002. The disclosures of the above-identified applications are incorporated by reference herein in their entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to projectiles. More particularly, this invention relates to projectile sealing arrangement.

BACKGROUND

[0003] The projectile sealing arrangements for barrel assemblies described in earlier International Patent Applications assigned to the present applicant, including PCT/AU94/00124, utilize operative sealing engagement between each projectile assembly and the bore of a barrel containing the projectile assemblies.

[0004] An important function of operative sealing engagement between projectile assemblies and the barrel bore is to prevent or at least minimize bum leakage of combustion products resulting from firing a leading projectile, which leakage might otherwise cause sympathetic ignition of propellant charges associated with trailing projectile assemblies within the barrel. These projectile assemblies include a variety of barrel seal configurations incorporated in sabots and wedging sleeves, rings or expandable portions—all arranged to seal against the bore of the barrel.

[0005] However the relative complexity and cost of manufacturing barrel assemblies utilizing operative sealing engagement with the barrel detracts from some applications of the applicant's barrel assemblies, especially where high volume, low cost manufacture is anticipated.

SUMMARY OF THE INVENTION

[0006] A projectile sealing arrangement for a barrel assembly of a weapon in which a plurality of projectile assemblies are axially disposed in abutting relationship within a barrel. Each projectile assembly is associated with a discrete propellant charge. The sealing arrangement includes a rearward opening communicating with a cavity provided in each projectile assembly for containing the discrete propellant charge, and a forward portion of an abutting projectile assembly arranged for operative sealing engagement with the rearward opening. During application of a compressive load to abutting projectile assemblies, the discrete propellant charge is sealed within the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In order that this invention may be more readily understood and put into practical effect, reference will now be made to the accompanying drawings that illustrate typical embodiments of the invention, wherein:

[0008] FIG. **1** is an isometric view of a projectile assembly of a first embodiment of the invention;

[0009] FIG. **2** is a partially fragmented isometric view of two projectile assemblies of the first embodiment in almost abutting relation within a barrel;

[0010] FIG. **3** is an isometric view of a projectile assembly of a second embodiment of the invention;

[0011] FIG. **4** is a partially fragmented isometric view of two projectile assemblies of the second embodiment;

[0012] FIG. **5** is an isometric view of projectile assemblies including a sealing arrangement of a third embodiment of the invention;

[0013] FIG. **6** is a sectional side elevational view of a projectile assembly of a fourth embodiment of the present invention;

[0014] FIG. **7** is a further section side elevational view of a projectile assembly of abutting projectiles of the fourth embodiment;

[0015] FIG. **8** is a sectional side elevational view of a projectile assembly of a fifth embodiment of the present invention; and

[0016] FIG. **9** is a further section side elevational view of a projectile assembly of abutting projectiles of the fifth embodiment.

DETAILED DESCRIPTION

[0017] The projectile assemblies **10** of the first embodiment illustrated in FIGS. **1** and **2** each include a body **11** having a head or forward portion **12** and a mouth or rearward opening **13** at a tail portion **19**, which opening communicates with a cavity **14** provided in the projectile body. The cavity **14** contains a discrete propellant charge **15** together with ignition means (not shown) for igniting the propellant charge. It will be appreciated that upon ignition of the propellant, suitably by electronic control means, combustion products including propellant gas will exit the projectile cavity **14** via the mouth **13** at the tail **19** of the projectile with considerable force.

[0018] In the first embodiment, a forward sealing surface **16** of the projectile head **12** is convex, having a simple hemispherical shape, whilst the mouth **13** has a peripheral sealing surface **17** that is provided or formed, at least in part, with a complementary concave shape to the hemispherical sealing surface **16** of head **12**. The precise configuration of the shapes are relatively unimportant, other than the requirement that they be complementary in order to satisfy the desired purpose of providing a substantially gas tight seal upon application of a compressive load to abutting projectile assemblies. Such a seal is intended to avoid inadvertent ignition of propellant associated with trailing projectiles, as discussed in relation to FIG. **2**. It is also desirable that the shapes utilized for the projectile provide sufficient strength to withstand the in-barrel forces that arise during firing of a weapon utilizing the projectile assemblies.

[0019] Whilst a simple hemispherical shape is employed in this embodiment, many variations to this are possible. For example, one simple variation is the projectile head and the receiving tail of the projectile have cooperating conical or wedge cross-sectional shapes for improved sealing engagement. In some embodiments, the surface shape of the head or forward portion **12** of the projectile body **11** will be determined in accordance with aerodynamic considerations.

[0020] FIG. **2** illustrates two (2) of a plurality of projectile assemblies **10** axially disposed in nearly abutting relation within a barrel **20**. The projectile assemblies are slightly separated and only a fragment of the barrel **20** is depicted for reasons of clarity. In normal operation, the forward surface **16**

of the head **12** of the leading or left-hand projectile **10***a* would be in contact with the rearward peripheral surface **17** of the mouth **13** of the trailing or right-hand projectile **10***b*, due to the compressive action of loading projectiles into the barrel **20**. The peripheral surface **17** extends inwardly of each projectile **10**, both from a rear end annular face **18** at the tail of the projectile and from an outer surface of the projectile body **11** toward the longitudinal axis **22** of the projectile.

[0021] Upon the application of compressive load L to the abutting projectiles **10**, the rearward peripheral surface **17** of the leading projectile **10***a* is operatively sealed against the forward surface **16** of the trailing projectile **10***b*, thereby sealing the propellant charge **15** within the cavity **14** in the projectile body **11**. Typically further compressive loading results from ignition of a forwardmost projectile (not shown in FIG. **2**) during the propulsion of the forwardmost projectile from the barrel **20**.

[0022] It should be noted that the interaction between the projectile assemblies **10** and the wall or bore **21** of the barrel **20** of the present embodiment, at least insofar as any requirement for sealing is concerned, is the same as that for conventional projectiles and barrel walls in known weapons. Thus only a level of sealing between the outer cylindrical surface of the projectile body **11** and the barrel bore **21** which inhibits propellant gases from escaping past the head **12** of the projectile body **11** during firing, such as provided by conventional rifling, is necessary for reliable operation.

[0023] A projectile **30** in accordance with the second embodiment of the invention is illustrated in FIG. **3**. The projectile **30** includes a body **31** having a reduced diameter head or forward portion **32** and a mouth or rearward opening **33** at a tail portion which mouth communicates with a cavity (not shown) provided in the projectile body. The projectile body **31** includes a frustro-concial tail portion **34** which terminates at an annular rear face **38** having a reduced diameter relative to the projectile body generally. The internal cavity contains a discrete propellant charge **35** together with ignition means (not shown) for igniting the propellant charge. The arrangements for igniting the propellant charge may suitably be similar to those described in the earlier International Patent Application PCT/AU94/00124, assigned to the present applicant.

[0024] A forward sealing surface **36** is provided on the projectile head, together with a complementary rearward sealing surface **37** at the periphery of the rearward opening **33**, which is arranged for operative sealing engagement with the sealing surface **36** of projectile head **32**.

[0025] FIG. **4** illustrates two (2) projectiles **30** of a second embodiment in substantially axial alignment, although they are spaced in the drawing apart for clarity. If required, a front face of the projectile body **31** may include an annular portion (not shown) transverse to a longitudinal axis **39** and arranged to abut the transverse, annular rear end face **38** of a leading projectile. This arrangement might be provided to limit the travel of the head **32** of a trailing projectile into the rearward mouth **33** of a leading projectile, thus minimizing the possibility of the respective sealing faces **36**, **37** becoming locked together through over-travel and/or deformation caused by repeated application of compressive forces to a chain or stack of projectile assemblies in a barrel.

[0026] Turning to FIG. **5**, there is shown projectile assemblies **40** of generally similar configuration to that described above in relation to FIGS. **1** and **2**. Each projectile assembly **40** includes a sealing means in the form of a gasket **41** retained on the rearward sealing surface **42** of an opening **43** adjacent the projectile tail portion **49**. This first gasket **41**, which may be composed of stainless steel or a suitably specified synthetic material, provides for enhanced sealing between the rearward sealing surface **42** and the forward sealing surface **44** of the projectile head. A double seal may be achieved, if required, by providing a second gasket (suitably spaced from the first gasket **41**) on the projectile head. However, sealing means disposed on the projectile head can detract from the aerodynamic performance of the projectile assembly **40**.

[0027] In other variations of the third embodiment, the sealing means may comprise an adhesive sealing material that forms a seal between abutting projectile assemblies in situ, and might also function to retain a plurality of projectiles in a chain for ease of loading into a barrel. A propellant charge **45** is retained with the body of the projectile assembly **40**, and may be formed as a solid block or as flowable material, such as powder or granules, as in the present embodiment.

[0028] This embodiment further includes a closure for the rearward opening **43**, in the form of a burstable disc **46**, for retaining the flowable propellant charge **45**. The closure, which may alternatively be formed of a combustible material rather than a burstable disc, includes retaining means that releasably engage with complementary retaining means on an adjacent projectile head. The retaining means in the present embodiment are formed by a spigot member **47** on the head, and by a socket member **48** provided in the burstable disc **46**, which members each include respective cooperating screw-threads allowing subsequent release as desired. In other embodiments using a solid block of propellant, retaining means may include a socket formed directly in the propellant block.

[0029] The spigot and socket members **47**, **48** of the retaining means may together comprise a frangible coupling. Rather than cooperating threads, the coupling may be released with the assistance of combustion, most desirably that present during firing. A plurality of projectile assemblies **40** can accordingly be coupled together to form a chain of projectiles for ease of handling and subsequent loading into a barrel.

[0030] FIGS. **6** and **7** illustrate, in cross-section, projectiles **50** of a fourth embodiment of the invention. The projectile **50** shown in FIG. **6** includes an outer wall **51** defining an internal cavity and a transverse inner wall **52** dividing the cavity into a cargo or payload cavity **53** and a propellant cavity **54**. The projectile body may be notionally divided into a head portion **55** and a tail portion **56** for ease of reference.

[0031] The forward external surface of the head portion **55** includes a flattened or truncated forward end **56** and a convex sealing surface **57**. An inner surface of the head portion includes an inwardly extending strengthening rib **58** for the cargo or payload cavity **53**. It will be appreciated that the rib **58** may, in one form, include a screw-thread arrangement for facilitating access to the payload cavity, as required.

[0032] The propellant cavity **54** can communicate externally of the projectile via a rearward mouth or opening **59** at the tail portion **56** of the projectile, which mouth is defined by an inwardly extending annular wall **60**. The opening **59** is covered by a closure, here in the form of a burstable disc **61**, adapted for rupture upon ignition of the flowable propellant (not shown) contained therein. A rearward sealing surface **62** of the annular wall **60** has a concave shape which is generally complementary to the convex sealing surface **57**.

[0033] Turning to FIG. **7** which shows a stack of three (3) projectiles **50***a*, **50***b*, **50***c* of the fourth embodiment, arranged in axially abutting relation as disposed in a barrel (not shown). Accordingly, the propellant cavity **54***a* of the first projectile **50***a* is sealed at interface **65***a-b* formed by cooperation of the rearward sealing surface **62***a* of the first projectile with the forward sealing surface **57***b* of the next adjacent (second) projectile **50***b*. In turn, the propellant cavity **54***b* of the second projectile **50***b* is sealed at interface **65***b-c* formed by cooperation of its rearward sealing surface **62***b* with the forward sealing surface **57***c* of the next adjacent (third) projectile **50***c*.

[0034] FIGS. **8** and **9** illustrate, in cross-section, projectiles **70** of a fifth embodiment of the invention. The projectile **70** shown in FIG. **8** includes an outer wall **71** defining an internal cavity and a transverse inner wall **72** dividing the internal cavity into a cargo or payload cavity **73** and a propellant cavity **74**. The projectile body may again be notionally divided into a head portion **75** and a tail portion **76** for ease of reference.

[0035] The forward outer surface of the head portion **75** includes a transverse annular surface **76**, located at the transition from a cylindrical side wall to a partially spherical front wall of the head portion **75**, said front wall having a forward convex sealing surface **77**. An inner surface of the head portion **75** of projectile **70** includes an inwardly extending strengthening rib **78** for the cargo or payload cavity **73**.

[0036] The propellant cavity **74** can communicate externally of the projectile via a rearward mouth or opening **79** at the tail portion **76** of the projectile, which mouth is defined by an inwardly extending annular wall **80**. A solidified block of propellant **81** (shown in phantom) may be contained in the propellant cavity **74**. A rearward sealing surface **82** of the annular wall **80** has a concave shape which is generally complementary to the convex, spherical, sealing surface **77**.

[0037] Turning to FIG. **9** which shows a stack of three (3) projectiles **70***a*, **70***b*, **70***c* of the fifth embodiment, arranged in axially abutting relation as stacked in a barrel (not shown). Accordingly, the propellant cavity **74***a* of the first projectile **70***a* is sealed at interface **85***a-b* formed by cooperation of the rearward sealing surface **82***a* of the first projectile **70***a* with the forward sealing surface **77***b* of the next adjacent (second) projectile **70***b*. It will also be seen that the abutment between a rearward corner **83***a* and the lateral annular face **76***b* of respective first and second projectiles resists over-travel and possible deformation of the projectiles **70***a*, **70***b* during axial compression of the projectile stack.

[0038] In turn, the propellant cavity **74***b* of the second projectile **70***b* is sealed at interface **85***b-c* formed by cooperation of its rearward sealing surface **82***b* with the forward sealing surface **77***c* of the next adjacent (third) projectile **70***c*. Similarly, over-travel is resisted by abutment of the rearward corner **83***b* of the second projectile **70***b* by the forward lateral face **76***c* of the third projectile **70***c*.

[0039] The present invention finds application in weapons for both military and law enforcement uses, although this invention is also applicable for other civilian uses. It has particular application to weapon systems in that it greatly reduces the stress requirements of the barrel and projectile, which also simplifies the manufacturing process. In particular, projectiles including the sealing arrangement of the invention may be utilized with barrels that employ standard construction techniques, including conventional rifling arrangements, as well as with more specialized barrels and weapons.

[0040] It is to be understood that the above embodiments have been provided only by way of illustration of this invention and that further modifications and improvements thereto, as would be apparent to persons skilled in the relevant art, are deemed to fall within the broad scope and ambit of the present invention described herein and defined in the claims that follow.

What is claimed is:

1. A projectile sealing arrangement for a barrel assembly of a weapon wherein a plurality of projectile assemblies are axially disposed in abutting relationship within a barrel, each projectile assembly associated with a discrete propellant charge; said sealing arrangement comprising:

a rearward opening communicating with a cavity provided in each projectile assembly for containing the discrete propellant charge; and

a forward portion of an abutting projectile assembly arranged for operative sealing engagement with the rearward opening; the arrangement being such that, during application of a compressive load to abutting projectile assemblies, the discrete propellant charge is sealed within the cavity.

2. The projectile sealing arrangement of claim **1** wherein the forward portion of each projectile assembly has a forward sealing surface of a predetermined shape, and the rearward opening has a rearward sealing surface of a complementary shape to the predetermined shape of the forward sealing surface.

3. The projectile sealing arrangement of claim **1** wherein either or both of the forward portion and the rearward opening include a sealing means to aid or enhance sealing.

4. The projectile sealing arrangement of claim **3** wherein the sealing means is preformed as a resilient body.

5. The projectile sealing arrangement of claim **3** wherein the sealing means is formed in-situ through the use of a suitable sealing material.

6. The projectile sealing arrangement of claim **4** wherein said sealing means has adhesive properties.

7. The projectile sealing arrangement of claim **1** wherein the sealing surfaces include planar surface portions.

8. The projectile sealing arrangement of claim **1** wherein the sealing surfaces include hemispherical shaped surface portions.

9. The projectile sealing arrangement of claim **1** wherein the sealing surfaces include conical shaped surface portions.

10. The projectile sealing arrangement of claim **7** wherein shapes of said sealing surfaces are dictated by aerodynamic considerations.

11. A barrel assembly for a weapon; said barrel assembly including:

a plurality of projectile assemblies axially disposed in abutting relationship within a barrel, each projectile assembly having a head portion and a tail portion and is associated with a discrete propellant charge;

ignition means for each propellant charge, whereby the discrete propellant charges may be selectively ignited to propel respective projectiles sequentially from the barrel; and

a sealing arrangement between abutting projectile assemblies, said sealing arrangement comprising:

a rearward opening communicating with a cavity provided in the body of each projectile assembly for receiving the discrete propellant charge; and

a forward portion of an abutting projectile arranged for operative sealing engagement with the rearward opening; the sealing arrangement being such that, during the application of a compressive load to the abutting projectile assemblies, the discrete propellant charges for trailing projectiles are sealed within their respective cavities.

12. The barrel assembly of claim **11** wherein the projectile body includes a transverse surface on at least one of the head and tail portions of the projectile assemblies, which transverse surface is arranged to prevent over-travel of a projectile relative to a trailing projectile upon application of an axial compressive load to said plurality of projectiles.

13. The barrel assembly of claim **11** wherein propellant charges are in solidified form.

14. The barrel assembly of claim **11** wherein propellant charges are in a flowable form.

15. The barrel assembly of claim **13** wherein the rearward opening includes a closure for retaining the propellant material within the cavity.

16. The barrel assembly of claim **15** wherein the closure comprises a burstable disc or a disc composed of combustible material.

17. The barrel assembly of claim **16** wherein said closure includes retaining means for releasable engagement with complementary retaining means on the head portion of an adjacent projectile assembly.

18. The barrel assembly of claim **17** wherein said complementary retaining means include a socket member and a spigot member.

19. The barrel assembly of claim **17** wherein said complementary retaining means include cooperating screw threads to facilitate release.

20. The barrel assembly of claim **17** wherein the retaining means is frangible.

21. A projectile assembly having a body with a head and a tail portion, said projectile assembly characterized in that:

the head includes a forward portion arranged for operative sealing engagement with the rearward opening of a leading projectile;

the tail portion includes a rearward opening communicating with a cavity provided in the projectile assembly for receiving the discrete propellant charge, which opening includes a rear portion arranged for operative sealing engagement with the forward portion of a trailing projectile; and

a sealing arrangement being such that, during the application of a compressive load to abutting projectile assemblies, the discrete propellant charge is sealed within the cavity.

* * * * *