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UNDERWATER AMMUNITION

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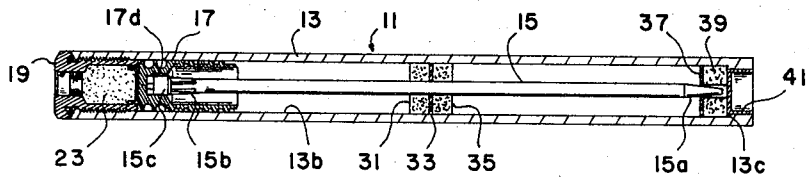

Fig. 1

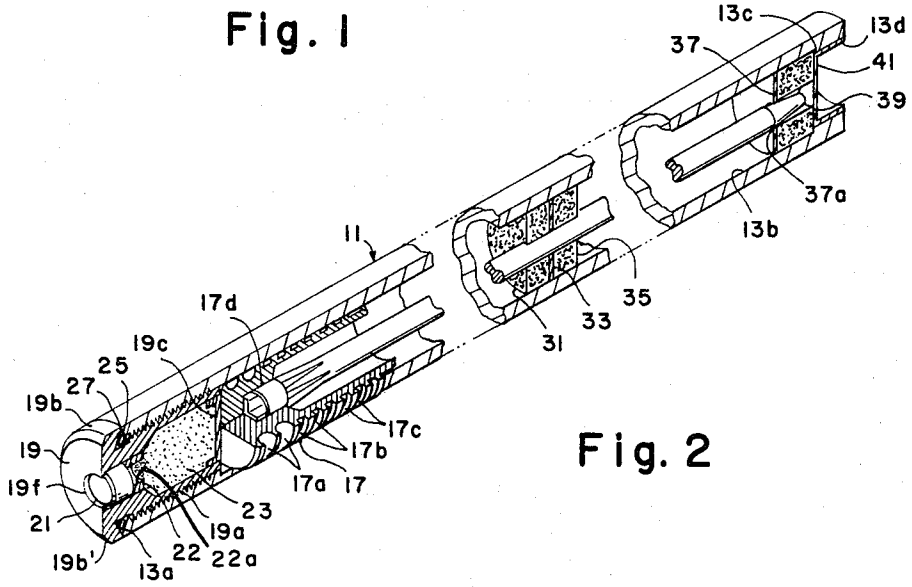

Fig. 2

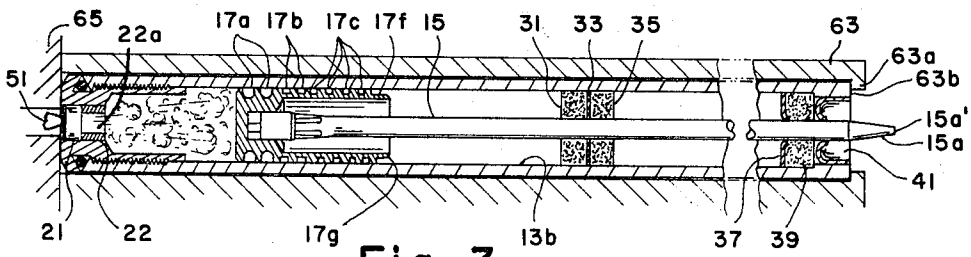

Fig. 3

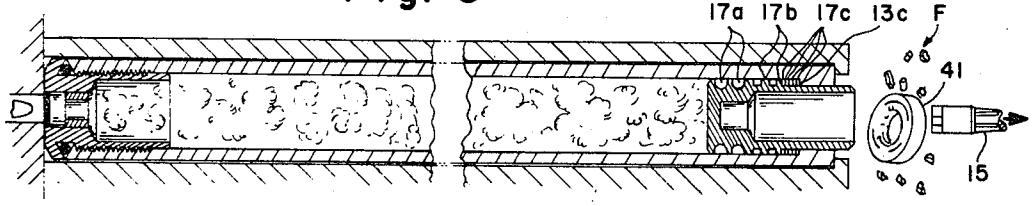

Fig. 4

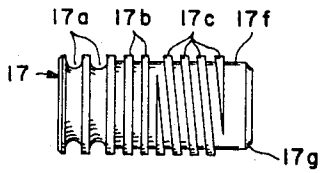

Fig. 5

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UNDERWATER AMMUNITION

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ABSTRACT OF THE DISCLOSURE

Underwater ammunition is disclosed, in which a flechette projectile is enclosed within the air-filled bore of a watertight sealed disposable barrell adapted to be removably inserted into a carrier cylinder or block for firing. The projectile is suspended by and between a rear-end-cradling pusher sabot, a frangible nose-guiding-and-supporting unit and a frangible mid-section-guiding-and-supporting unit. A propellant charge and percussion primer are disposed rearwardly of the pusher sabot, and the projectile is propelled forward by primer ignition of the propellant to impart forward motion to the pusher sabot, which in turn drives the projectile through a frangible and fully removable sealed front barrel cover. Forward motion of the sabot is stopped by successive incremental energy absorption through the shearing of an external helical shear thread on the forward section of the pusher sabot at the forward end of its travel, the shearing and compaction of which shear thread also seals in the propellant gases within the barrel bore at the end of the sabot forward travel. Pressure dropping annular expansion grooves on the rear section of the pusher sabot are employed to obviate blow-by of propellant gases during forward motion of the sabot.

Briefly, according to this invention underwater ammunition is provided in which the projectile is contained in a watertight sealed cartridge forming its own barrel, and in which the propellant blast is sealed in by a retained pusher sabot to prevent eardrum damage to an underwater operator, the projectile being mounted in the barrel-forming cartridge for efficient power utilization on firing and thereby yielding maximum initial muzzle velocity.

Details and various other objects, features and attendant advantages of the invention will be apparent to those skilled in the art from a reading of the following detailed description of a single preferred embodiment constructed in accordance with the invention, taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a longitudinal section view of a round of ammunition according to the invention.

FIG. 2 is an enlarged isometric view of the round of FIG. 1, with the round partially secured along its center line and broken for clarity of illustration.

FIG. 3 is a schematic representation of the round of FIGS. 1 and 2, illustrating the operation shortly after firing.

FIG. 4 is a schematic representation similar to FIG. 3, and illustrating the action of the pusher sabot at the terminal portion of its travel.

FIG. 5 is a longitudinal side view of a pusher sabot employed in the round of FIG. 1.

Referring now in detail to the figures of the drawings, a preferred embodiment of a round of underwater ammunition is illustrated in FIG. 1, and includes a tubular cartridge case forming a barrel **13**, which contains a subcaliber, drag or fin-stabilized projectile **15**, a front closure cup **41**, projectile-nose and mid-section guiding and supporting units **37**, **39**, and **31**, **33**, **35**, a dual purpose pusher

piston sabot **17**, and a threadedly secured head or end cap **19** containing a primer **21** and a primer anvil restrainer plug **22**, and a propellant charge **23**. The round is waterproofed for hydrostatic pressures in substantial excess of the desired useful depth range of for instance up to 30 feet by application of a waterproof compound, such as primer waterproofing lacquer, to the various exposed forward and rear joint lines, and the head-to-barrel joint is further sealed by an elastic annular O-ring seal **27**.

The head end cap **19** has a head flange **19***b* which is undercut at **19***b'*, and which in conjunction with the adjacent longitudinal reduced diameter surface of the end cap **19** and an interfacing undercut **13***a* on the adjacent end surface of the barrel forms a seal-receiving chamber in which is disposed a suitable elastic O-ring seal **27** of rubber or other suitable material, which is compressed into watertight sealing relation upon securing of the end cap with the flange **19***b* in metal-to-metal contact along the line **25** with the barrel **13**. The O-ring seal **27** may be suitably lubricated as by employment of silicon base lubricant to aid in providing a water-impermeable seal. The containment of the O-ring in this manner and configuration is particularly useful in containment and sealing of the propellant gases.

Head end cap **19** has along its forward reduced diameter section a threaded surface **19***a* which engages a complementary internal threaded surface in the barrel **13**, which threaded surfaces provide for ease of assembly and securing of the headed end cap **19** and O-ring seal **27** with the barrel **13**. End cap **19** houses at its forward end a charge of propellant **23** and at its rearward end a percussion primer **21**. Percussion primer **21** is secured in place by a press fit primer restrainer plug **22** having a central flash hole **22***a* communicating between the primer and the propellant charge **23**, and by an annular retaining lip **19***f* formed in the end cap and which serves as a shoulder against which the primer is seated to prevent rearward blowout of the printer upon firing. The propellant charge is preferably suitably enclosed at its forward end by a thin frangible propellant cover cap **19***c* press fit into the forward end of the head cap **19**, in order to provide for ease of sub-assembly and assembly, and is also particularly useful in preventing particles of the propellant charge from leaking into clearance spaces between the metal parts over the course of handling vibrations, and thereby avoiding possible accidental ignition of the propellant charge.

Temperature-reducing gas expansion grooves **17***a* are formed in spaced-apart annular relation at the rear end of the pusher piston sabot **17**, and serve, in conjunction with a light piston-to-bore lateral clearance of for instance .001–.002 inch, to provide a form of air-bearing friction-reducing sliding fit for the pusher piston **17** as well as enabling the adiabatic expansion and temperature reduction of the propellant gases during the movement of the piston primer forward by the pressure of these gases. The grooves may be formed of a suitable depth to insure that propellant gases will be sufficiently restricted in passage and reduced in pressure that substantially no propellant gas will be enabled to escape therepast during the time of travel of the pusher piston sabot **17** from its initial position to its final terminal position as seen in FIG. 4. For instance, with a standard propellant charge sufficient to propel a 155-grain projectile forward at a muzzle velocity of 700 feet per second it has been found that two pressure and temperaturer eduction grooves **17***a* of .070 inch width and .070 inch depth are adequate in a piston of .374 inch outer diameter, with a stroke length of approximately 4 inches for the piston **17**.

The forward section of the pusher sabot **17**, which is formed of metal such as steel, or other suitable material,

has an impact energy absorbing shallow external helical square shear thread **17***c* formed thereon with a plurality of turns, and forward of the threaded portion is a reduced diameter end section **17***f* which is camfered as at **17***g*. At the terminal zone of travel of the pusher sabot in the barrel bore **13***b*, the helical energy absorbing thread turns **17** are incrementally sheared by sequential incremental contact with a relatively thick inwardly extending annular shoulder stop **13***c* formed at the end of the barrel. Thus, the impact of the threaded turns against the shoulder stop **13***c* effects a desired energy absorption and stopping of the pusher sabot at the forward end of the barrel bore **13***b*, the upsetting and compacting of the sheared thread material serving to effect a further jam seal of the propellant gas against undesired escape into the water after completion of the firing action and expulsion of the projectile from the barrel. While in most instances the plural threaded turns **17***c* are in themselves sufficient to provide full energy absorption for effective stopping of the pusher sabot within the barrel **13**, it is desirable that in addition one or more additional spaced energy absorbing rings **17***b* be provided rearward of the threaded turns **17***c* to provide for any excess energy absorption which might be required due to variation in propellant charge or strength of materials. These excess energy-absorbing spaced circumferential rings **17***b* may be of one or two in number, as illustrated, and provide abrupt intermittent impact energy absorption as distinguished from the smooth continuous energy absorption provided by the forward thread turns **17***c*, and due to their relatively much larger resistive action area they require greater energy for shearing than is required at the incremental thread contact zones, thus effectively providing a full and sure stop medium for any small excess energy which may be involved.

The sabot **17***c* has a hollow open-ended cavity, the rear portion of which forms a pocket **17***d* which serves to cradle and support the rear tail section **15***b*, **15***c*, of the projectile **15**, the pocket fitting about the shroud **15***c* and fins **15***b* in a close slip fit, as for instance of the order of .003 inch clearance. In addition, the enlarged open-ended cavity formed in the forward end of the piston sabot **17***d* serves to reduce weight, thereby reducing the propellant charge requirement for propulsion and the energy absorption requirement for sabot travel termination.

The fangible mid-section guiding-and-supporting unit **31, 33, 35**, for the projectile serves to prevent undesired mid-section bowing of the projectile during pushing thereof by the sabot **17** while the projectile travels along the bore **13***b*, and to this end this frangible unit takes the form of a thin metal centering disc **33** formed of heat-treated aluminum for radial structural rigidity, which may suitably be of the order of .010–.012 inch thick. The centering disc **33** serves to resist and carry radial side loads from the projectile shank **15***d*, and has a central hole formed therein which forms a slip fit with the cylindrical projectile shank **15***d* and may be for instance of the order of .001 inch oversize for this purpose. Disposed in lateral supporting relation against the opposite end faces of the frangible centering disc **33** are two lightweight frangible supporting discs formed of lightweight foam plastic, such as Styrofoam, and which serve to provide limited lateral stability to the centering disc **33**. Each of the discs **31, 33, and 35** are slidably complementary to the barrel bore **13***b*, the thin centering disc **33** being of the order of .001 inch undersize and the thicker lateral supporting discs **31, 35** having a radial clearance of the order of .010 inch to insure adequate centering action, with ease of sliding freedom along the bore **13***b*. The lateral supporting Styrofoam discs **31, 35** are removably secured about the shank **15***d* of the projectile as by press fitting thereon, or by use of adhesive as may be desired.

At its nose end, the projectile is centered and supported through the medium of the frangible nose-guiding-and-supporting unit **37, 39**, which takes the form of a thin heat-treated aluminum centering disc **37** similar to the disc **33**, and a foam plastic face supported disc **39**. The centering disc **37** has a central aperture **37***a* of a diameter corresponding to a longitudinally intermediate zone of the projectile frusto-conical nose **15***a*, thereby serving to seat the conical nose surface of the projectile in the central aperture **37***a* of the disc **37** at this intermediate zone of the frusto-conical nose **15***a*. To accommodate small variations in tolerance of the parts during manufacture, the Styrofoam face-supporting disc **39**, which has a limited but adequate degree of elastic compressibility, is formed of a thickness sufficient to be under elastic compression in assembled condition, and thereby maintains the projectile under lengthwise compression against the sabot **17** at one end and the frangible forward centering disc **39** at its forward end, thus providing for general longitudinal rigidity of components in the assembled form.

The aluminum centering discs **33** and **37** are each relatively thin and easily frangible; however, it is desirable to increase the frangibility of these discs while maintaining their radial centering strength to a substantial degree, as by radial scoring of one or both lateral surfaces of each disc **33** and **37**. This is particularly useful in enabling ease of expulsion of the centering discs from the bore **13***b*, **13***d* of the barrel **13** and separation from the projectile **15**.

The forward end of the barrel **13** is closed by a closure cup **41** which engages in press fit relation with the annular shoulder bore surface **13***d*. As will be noted from FIGS. 1 and 2, the nose end **15***a* of the projectile **15** is spaced a short distance from this closure cup in the unfired ammunition assembly.

The ammunition may be used in lightweight cylinders or other carrier elements, such as a cylinder indicated schematically at **63** in FIGS. 3 and 4, the body of the cartridge forming its own pressure absorbing and retention barrel **13**. Thus, in operation, the cartridge assembly **11** may be removably inserted loosely into a bore chamber **63***b* formed in a cylinder **63**, and the cartridge **11** may be suitably removably retained in the cylinder bore through the medium of a conventional breech **65** and a retaining lip **63***a* at the forward end of the cylinder bore chamber **63***b*, the percussion primer being fired preferably through the medium of a spherical firing pin **51** to prevent rupture of the primer and escape of propellant gases. The flash from the primer flashes through the flash hole **22***a* and ignites the propellant charge **23**, which in turn burns and forms expanding propellant gas, the pressure from which is confined by the walls of the barrel **13** and the attached head end cap assembly **19**, thereby forcing the pusher piston sabot **17** forward to propel the projectile **15** toward and through the closure cup **41**, as schematically illustrated in FIG. 3. The pusher sabot prevents gas leakage therearound during its passage along the barrel bore **13***b*, through the medium of the labyrinth seal pressure and temperature reducing grooves **17***a*. The hot gases leaking around the sabot rear surface into the grooves **17***a* are retarded through sequential adiabatic expansion into the groove volumes, thereby reducing by adiabatic expansion the gas temperature and pressure, and locally resulting in a delay of forward gas motion therepast that is longer than the power stroke period of the round. In addition, the labyrinth groove arrangement and associated propellant gas flow thereabout enables the sabot **17** to utilize a floating air-bearing type clearance of for instance .001–.002 inch with the barrel bore **13***b* for friction reduction and increase in power utilization efficiency.

During the forward motion of the sabot **17** and projectile **15**, the projectile pierces the closure cup **41** and enlarges the central opening in the forward centering disc **37**, as illustrated in FIG. 3, and the mid-section guiding and support unit **31–35** is moved forward in the bore **13***b* with the projectile **15** to continue its guiding and centering action on the mid-section shank zone of the projectile. The foam plastic and aluminum centering disc units **31–35** and **37–39** thus keep the projectile **15** centered long enough during its acceleration and passage through the

bore 13*b* to establish an accurate launch, as once the projectile has attained a high velocity within the cartridge its inertial stability no longer requires alignment by the disc, the latter being the situation at the terminal zone of travel of the projectile through and from the barrel bore.

The extremely light construction ease of frangibility of the centering discs 31–37 is advantageous in their not being effective to materially perturbate the alignment of the rapidly moving projectile as the discs are longitudinally shifted and collapsed during their bore travel and final expulsion through the reduced diameter end bore 13*d* of the barrel 13.

The pusher sabot-projectile assembly 17, 15 continues to the end of the cartridge bore 13*b*, where the shoulder stop 13*c* is impacted by the shallow square thread 17*c* on the sabot 17, which thread matches the thickness of the shoulder stop 13*c*. The cartridge barrel shoulder stop 13*c* being much thicker than a single turn of the thread 17*c*, the impact of the shear thread 17*c* thus effects a continuous shearing of the sequential incremental sections of the thread. As each increment of thread 17*c* shears, it stacks against the shoulder stop 13*c*, while the sabot 17 continues forward through the bore 13*b*, 13*d*, and thus as each turn is incrementally sheared it stacks on itself and incrementally serves as a stop for shearing of the next turn of thread, smoothly and at a substantially constant energy absorbing rate due to the helical arrangement and continuous incremental sequential shearing action. This results in a maximum of damping energy with a minimum continuing restraining force being required by the cartridge barrel 11 and the cartridge-retaining shoulder 63*a* on the cylinder 63, during deceleration to prevent the sabot from exiting from the cartridge, and desirably a surplus quantity of thread 17*c* exists to insure stopping for a given propellant charge. However, as previously noted, in the event of excess energy imparted to the sabot 17 by the propellant 23, the intermittent impacted excess energy absorbing seaparated rings 17*b* will be effective to fully absorb the excess energy and effect stoppage of the sabot travel and retention of the sabot within the barrel 13, thereby also fully sealing and trapping the residual gases which may remain as illustrated in FIG. 4. The prevention of escape of propellant gases during and after termination of the travel of the sabot is important in preventing eardrum damage to the operator under water.

In the travel of the sabot 17 and projectile 15 along the length of the bore 13*b*, the travel of the sabot is unimpeded by any water mass, as the water is sealed out of the bore 13*b* by the closure cup 41 prior to firing. When the sabot begins to slow down upon impacting the shoulder 13*c* the projectile velocity is thus at its highest value, whereby momentum of the projectile 15 thus causes the projectile to separate from the sabot and continue on out of the cartridge barrel 13 and along its course of trajectory through the water.

The frangible guiding and centering discs 31–37 are shattered upon impacting at the forward end of the barrel bore 13*b* and by further impacting thereof by the forward end of the sabot 17. The residual components or fragments F of the discs 31–37 and the closure cup 41 expel from the bore 13*b*, 13*d* with the projectile, and the drag force of the water thereon easily strips these residual fragments F free of the projectile, as schematically illustrated in FIG. 4, such that the flight alignment of the projectile is undisturbed.

That which is claimed is:

1. Underwater ammunition comprising:
a disposable barrel having a longitudinal bore closed at both ends and having a primer and propellant disposed therein at one end and a frangible closure at its opposite end,
a projectile disposed in said bore between said propellant and said frangible closure, and
a pusher piston sabot disposed between said propellant and the rear end of said projectile,
said projectile being a flechette having a stabilizing finned rear section cradled in a forward recess formed in said pusher piston sabot, and
a further frangible projectile-guiding-and-supporting unit disposed in and engaging said bore and engaging and supporting a forward portion of said projectile.

2. Underwater ammunition according to claim 1,
said further projectile-guiding-and-supporting unit being elastic and disposed in longitudinally compressed relation about a portion of the nose end of said projectile and being in longitudinally compressed relation between the nose end of said projectile and the forward closed end of said barrel, and
a further mid-section frangible projectile-guiding-and-supporting unit disposed in said bore intermediate the ends of said projectile.

3. Underwater ammunition according to claim 2,
said projectile having a tapered nose section,
said projectile-nose-guiding-and-supporting unit including a frangible disc having an outer diameter substantially complementary to said bore and a central aperture corresponding to a diameter intermediate the length of said tapered nose section of said projectile and seated about an intermediate zone along the tapered length of said tapered nose section, and frangible elastic means disposed in compressed relation between said frangible disc and said closed end of said barrel.

4. Underwater ammunition according to claim 3,
said frangible apertured disc being a relatively thin disc of aluminum,
said elastic means being Styrofoam, and being disposed in compressed relation between said apertured aluminium disc and said closed end of said barrel.

5. Underwater ammunition according to claim 3,
said mid-section projectile-guiding-and-supporting unit including a thin frangible metal disc disposed in contiguous interfacing relation with and between two cylindrical sections of foam plastic,
said foam plastic sections being removably secured about said projectile, and
said frangible metal disc having a central aperture through which said projectile extends in a light slip fit.

6. Underwater ammunition according to claim 5,
said frangible metal disc having a radially scored face surface for increase of frangibility as a function of stress applied in the longitudinal direction of said barrel and projectile, while retaining radial centering strength to a substantial degree.

7. Underwater ammunition according to claim 1, further comprising:
a further mid-section frangible projectile-guiding-and-supporting unit disposed in said bore intermediate the ends of said projectile.
said mid-section projectile-guiding-and-supporting unit including a thin frangible metal disc disposed in contiguous interfacing relation with and between two cylindrical sections of foam plastic,
said foam plastic sections being removably secured about said projectile, and
said frangible metal disc having a central aperture through which said projectile extends in a light slip fit.

8. Underwater ammunition comprising:
a disposable barrel having a longitudinal bore closed at both ends and having a primer and propellant disposed therein at one end and a frangible closure at its opposite end,
a projectile disposed in said bore between said propellant and said frangible closure, and
a pusher piston sabot disposed between said propellant and the rear end of said projectile,
said barrel bore having a forward annular shoulder stop surrounding said frangible closure,
said pusher piston sabot having a helically threaded

energy-absorbing buffer section, the threads of which are engageable in impact-energy-absorbing relation with said shoulder stop during terminal travel of said sabot in launching said projectile from said barrel.

9. Underwater ammunition according to claim **8**,
said pusher piston sabot having a plurality of pressure- and - temperature - reducing annular gas-expansion grooves formed about the rear section thereof,
said piston having a light slip fit in said bore whereby propellant gas pressure and temperature is reduced by the gas expansion grooves while enabling low friction traveling of said piston along said bore, the shearing and crushing of the thread convolutions of said threaded energy-absorbing section aiding in effecting a terminal gas seal adjacent said shoulder.

10. Underwater ammunition according to claim **9**, and
at least one further spaced annular shear ring formed on the exterior of said pusher rearward of said forward threaded section to provide excess energy intermittent-impact-stopping action for said pusher sabot.

11. Underwater ammunition according to claim **10**,
said frangible closure being a cup removably press fit into a central aperture formed by said annular shoulder stop,
said propellant and primer being disposed in a cup-shaped end cap radially secured in said one end of said barrel,
said threadedly secured end cap having an undercut annular flange engageable with the outer annular edge of an adjacent facing undercut end surface of said barrel to form a metal-to-metal peripheral engagement and enclosing an annular seal-retainable

chamber formed by said facing undercut ends and an adjacent forwardly extending annular surface of said end cap,
an O-ring seal disposed in said annular chamber,
the annular line of contact between said annular shoulder stop and the annular line of contact between said primer and said one end of said barrel being hermetically sealed with primer lacquer,
said closure cup having its base end facing said projectile and having its open mouth facing outwardly away from said projectile.

12. Underwater ammunition according to claim **8**, and
at least one further spaced buffer shear ring formed on the exterior of said pusher sabot and spaced in rearward relation to said threaded buffer section to provide excess energy intermittent-impact-stopping action for said pusher sabot.

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