This invention relates to a wad column for shotshells which tends to protect both the shotshell and the bore of the gun from abrasion or plastic deformation as the result of the passage of shot therethrough and is particularly applicable to use with ferrous metal shot. In its preferred embodiment the wad column comprises a gas sealing wad which acts as a piston to push a charge of shot out of the shell and through the barrel in combination with a shot enclosing sleeve formed from a section of material having physical characteristics such as those of biaxially oriented plastic tubing and which substantially resists penetration by shot pellets. This sleeve is so formed that it is capable of changing readily in its diameter to conform to diametral changes in the passageway from the shotshell and through the barrel but is designed to avoid opening a gap to permit the shot contained therein to contact the gun barrel. A refinement of the invention involves the use of a gas sealing wad which is so shaped that it functions to minimize the opportunity for shot pellets to arrange themselves in close packed, layered, and mechanically rigid conformations.

With all of the features of the invention combined, the column of shot pellets tends to conform generally to the changes in the dimensions of the passage from the shotshell through the bore of the gun in a relatively fluid-like manner, and tends to minimize both abrasion of the surface of the shotgun barrel and plastic deformation of the choked section of the shotgun barrel.

10 Claims, 12 Drawing Figures
WAD COLUMN FOR SHOTHELLS

RELATED APPLICATION

This application is a continuation-in-part of our application Ser. No. 168,681 filed Aug. 3, 1971, now abandoned.

BACKGROUND OF THE InVENTION

When waterfowl are hunted over marsh lands or shallow bodies of water, substantial quantities of lead shot may fall into the water where they sink to the bottom but may not be covered or disappear into the mud for some time. It has been estimated that nearly 6,000 tons of lead shot are so distributed across American wetlands every year. Several species of wild ducks are "bottom feeders" and either dive or dip their heads beneath the water to forage for food in the plankton, grasses or other material on the bottom. In so feeding, they are prone to pick up any available shot pellets which may be resting on the bottom. This problem is one which has been noted for some time, for the operation of the digestive system of the duck disintegrates the shot pellets and there have been losses of substantial numbers of ducks as a result of lead poisoning induced by this ground-up lead in their systems. Mallards are apparently the worst sufferers and it has been estimated that about four percent of the mallards in the Mississippi flyway suffer from lead poisoning each year.

Efforts have been made to solve this conservation problem by the use of lead alloys which decompose after exposure to water or by the application of protective coatings, but the disintegrating alloys tend to start this process while still in the shotgun, if stored under humid conditions, and the time required for complete disintegration in water is such that the problem is not substantially alleviated. The digestive system of the duck is so efficient in its disintegrating action that to our knowledge no coating material which can be practically applied to lead shot will resist the abrasion to which it is subjected in the duck's gizzard.

A more promising approach to this problem is to substitute some non-toxic metal for lead in the formation of the shot pellets. Unfortunately, there is no other material with density, hardness, and other physical characteristics approaching those of lead which is economically practicable to use. Iron or steel appears to offer the best compromise and these are, of course, in raw material form the least expensive of all the useful metals although much more difficult to process than lead shot. With a specific gravity only about two-thirds that of lead, a comparable charge weight of iron or steel shot occupies a much larger volume in the shotgun which requires substantial changes in shot shell and wad design. Further, the iron or steel shot pellets may be nearly as hard or harder than some of the steels used to form shotgun barrels. As a result, use of unprotected ferrous metal shot may scratch and abrade the normally polished barrel surface. Further, nearly all shotgun barrels are "choked" or formed with a constriction adjacent the muzzle to assist in controlling the dispersion of the shot charge. The passage of an unprotected compacted column of ferrous metal shot through the "choke" has been known to result in swaging the material to such an extent that the "choke" tends to disappear with a resultant swelling of the outside diameter of the barrel. This eventually adversely affects the pattern performance of the barrel.

Some efforts to resolve this problem have involved the production of the softest grades of iron shot as by the use of substantially pure iron and by decarburization thereof (e.g., U.S. Pat. No. 2,867,554 to L. P. Wilson et al., Jan. 6, 1959). Other efforts to resolve this problem have involved the use of protective capsules or cups intended to isolate the ferrous metal shot from contact with the barrel (e.g., U. S. Pat. Nos. 3,208,382 and 3,215,076 to D. S. Foote et al., respectively Sept. 28, 1965 and Nov. 2, 1965) which suggests that a minimum of 0.060 inches of injection molded plastic is required between the steel shot and the bore surface.

A further effort to resolve this problem has concerned the use of shot pellets individually coated with a thermoplastic polymeric coating as in U.S. Pat. No. 3,636,561 to C. R. Irons, Jan. 16, 1968.

None of these approaches were completely successful.

The softest iron shot may tend to abrade or distort at least some of the shotgun barrels in use unless the barrel is protected from contact therewith and all of the devices which have been proposed for such protection occupy space and further contribute to the already serious loading space problem resulting from the lower specific gravity of the ferrous metal shot. None of the prior art protective devices of which we are aware have contributed significantly to the solution of the problem of strain on the choke created by forcing a compacted column of shot to pass therethrough and which often produces permanent plastic deformation of the choked section of the barrel. Further, the softest grades of iron shot yet developed are all subject in some degree to work hardening so that handling in process, loading and the initial setback on firing in a gun all tend to increase the hardness of soft iron shot over at least a portion of its surface. This tends to mitigate to some degree many of the advantages which have been thought to be associated with very soft iron shot.

Although not specifically concerned with iron shot, the several patents to C. E. Miller et al., U.S. Pat. No. 2,953,990 — Sept. 27, 1960, U.S. Pat. No. 2,897,758 — Aug. 4, 1959, U.S. Pat. No. 3,055,301 — Sept. 25, 1962 and U.S. Pat. No. 3,162,124 — Dec. 22, 1964, may be noted since they are concerned with the use of thin unoriented plastic wrap-around sleeves to protect a shotgun body from the abrasion of a shot charge as well as to minimize the distortion of lead shot resulting from abrasion of the lead as it passes through the gun barrel in frictional engagement therewith.

SUMMARY OF THE InVENTION

Careful consideration of the various approaches to the use of ferrous metal shot leads to the conclusion that the use of protective wrappers or sleeves offers the best solution of the problem provided that a material can be found which offers adequate protection without requiring an excessive volume of protective material and if this material can be provided in a shape which maintains a barrier with no openings or gaps exposing the shot during the entire travel of the shot charge from its initial position within the shotgun shell to its emergence from the muzzle of the shotgun barrel.

Fortunately, such a material is available and is described in U.S. Pat. No. 3,103,170 to R. A. Covington,
3,786,753

Jr., et al., Sept. 10, 1963. This material is high density polyethylene which in tubular form has been subjected to working at temperatures below its crystalline melting point to a degree sufficient to impart preferential orientation to its molecular structure both longitudinally and circumferentially of the tube. Since the introduction of this material, virtually all domestic production of shotgun shells has come to utilize biaxially oriented plastic bodies produced by various techniques but all having essentially similar properties. This tubing is a already available in all commercial shotgun shell gauges and can be readily formed to other dimensions. As has been more than abundantly demonstrated in the use of this material as a body for plastic shotshells, it resists deformation by least load to such a degree and has such strength that it is not pulled down the barrel with the shot charge to produce the casualty known as "body cutoff" even when used without any protective sleeve or capsule.

Other polymeric materials which have physical characteristics which substantially resist penetration by shot pellets may be used provided these materials have enough strength and rigidity to resist penetration by the shot pellets.

As a shot charge is accelerated, the inertia forces acting thereon tend to expand the shot column radially, forcing the protective sleeve to expand and maintain engagement with the wall of the shotshell. As the protected charge moves from the shell into the barrel the shot charge is diametrically constricted by the forcing cone and then maintained at about the same diameter until it passes through the choke where it is again constricted. To avoid interference with the flight of the shot after it leaves the barrel, the protective sleeve must be slit or otherwise separated so that it will promptly open up or disengage itself from the shot column on emergence from the barrel and yet the structure must be such that at no point during passage through the barrel is an opening provided for shot to escape. A simple cylindrical sleeve or section of tubing cannot be used because it does not consistently disengage itself from the shot column without adversely affecting the pattern. One or more longitudinal slits in a tubular sleeve will assist in disengagement from the shot column but such an arrangement can let shot escape through the slits at some point in the passage of the shot from the shell through the barrel with consequent abrasion of the choke and/or forcing cone sections of the barrel.

If the protective sleeve is defined by a wrap-around band with square cut ends, the ends must be overlapped to a degree sufficient to avoid any opening as the band expands and contracts and there must be some overlapping with the gas sealing wad. This arrangement, however, requires that one of the ends of the band be notched to the extent of the overlap with the gas sealing wad to prevent trapping a double thickness of material at this point and the overlapping of the ends of the band detracts, even though to only a small degree, from the volume available to receive the shot charge. Further, the overlapped sleeve may interfere with the flow of shot into the tube during loading to the extent of requiring vibration of the shot during loading to achieve optimum filling.

A preferable arrangement is to take a smaller diameter oriented plastic tube such as a 16 gauge tube for use in a 12 gauge shotshell and to cut such tubing from end to end with the cut at a constant spiral angle with respect to the longitudinal axis of the tube. Such a tube does not require any overlap and has shown a remarkable and unexpected capacity to adapt itself to diametral changes by movement along the length of the spiral cut and without opening any gap at that cut.

Since the shot protective sleeve and the shot charge are pushed along by a gas sealing wad which engages and preferably has a protruding boss extending forwardly into the rear end of the sleeve it will be apparent that the gas sealing wad has some freedom to tip in the bore without disengaging itself from the sleeve and this action permits the pushing force of gas pressure to be applied to the shot charge and sleeve without opening any gap and without inhibiting the slipping of the preferred spirally cut edges upon each other as the sleeve conforms to the various diametral changes enforced upon it. Without the spiral cut it is necessary to overlap the cut edges to enable the sleeve to follow these diametral changes without opening a gap which would permit shot to reach exposed locations in which they could abrade the gun bore and choke. In general, an overlap is undesirable since it subtracts from the already limited volume available for shot and unless the material of the sleeve has at least the penetration resistance of biaxially oriented high density polyethylene it must be used in impractically great thickness and hence for this reason also subtracts from the volume available for containing shot.

A further advantage of using the biaxially oriented plastic material for the sleeve is that this oriented plastic material resists penetration of the shot pellets and provides a solid "lubricating" interface between the barrel and shot. Upon firing, the inertia of the shot column causes the shot pellets to "set back" and results in the radial movement of the shot pellets with adequate outward radial forces to indent the plastic sleeve. As the shot column and sleeve progress from the shell down the barrel, the constrictions in the barrel cause the shot pellets to shift and rearrange themselves and impart axial motion to the shot, including the outer layer of shot which has been previously indented into the plastic sleeve. The spiral slit in the plastic sleeve provides a "slip plane" along which relative motion occurs allowing the sleeve to undergo the reduction in diameter. Although after leaving the shell, the sleeve travels in a bore having different diameters, the diameters are always constricting to facilitate retaining the slit closed, thus minimizing shot contact with the barrel.

To insure the most uniform flight path for the shot, it is desirable that the shot pellets have a high degree of sphericity, smoothness and regularity of size.

Lastly, we have noted, that when a mass of shot pellets are deposited upon a flat surface surrounded by a cylindrical wall, they tend to position themselves in laminations parallel to the flat surface with each layer filled to the greatest possible degree in a close packed conformation. When such a configuration of pellets is subjected to a constricting force tending to diametrically contract the column, the pellets of each layer are in diameter to diameter opposition and tend to the highest degree to resist the constricting force. Similarly, if we consider any one of the several concentric circular patterns of shot in the close packed configuration, it will be apparent that circumferential constriction will be
resisted by substantially diametral opposition of the pellets in each of the concentric circular arrays. Thus, it is desirable to provide for an arrangement of the shot pellets which minimizes the possibility of diameter to diameter opposition of the shot pellets in any plane substantially normal to the axis of the barrel. The desired configuration can be approximated by designing the gas sealing wad with a shot engaging face which substantially conforms to the natural nesting angle of a pile of shot. For example, the face of the gas sealing wad against which the shot rests may be formed with about a 30° conical depression or with about a 30° conical protuberance and either of these configurations can be supplemented by providing around the outer periphery of the shot supporting surface a series of equally spaced, raised or depressed areas such that every other pellet in the outer circumferential row of pellets is displaced from the basal plane of that circumferential row by about one half pellet diameter.

When the shot column is built upon such a base, the rigidity producing diameter to diameter opposition of pellets is reduced to a minimum and the shot charge is less apt to form into a relatively inflexible plug which would tend to strain the choke or forcing cone.

Recapitulating, we believe that the optimum arrangement is provided by the use of shot pellets which are substantially spherical and smooth surfaced and which are hard enough that they substantially maintain this regularity of shape until released in free flight, these characteristics contributing primarily to pattern density. Secondly, we believe that optimum results are obtained when a shot protective sleeve is used which substantially resists penetration by the shot pellets and where the shot pellets are induced to move relative to each other so that the pellets can conform to the choke of the barrel in a fluid-like manner. Lastly, we believe that it is helpful to utilize a separate gas sealing wad which is provided on its shot engaging face with a configuration which minimizes the possibility of the more rigid arrays of shot pellets in close packed parallel laminations.

DESCRIPTION OF THE DRAWING

FIG. 1 is an isometric, partially cut away view of a shotshell loaded in accordance with this invention utilizing the preferred spirally cut shot protecting sleeve; FIG. 2 is a cross sectional view of a gas sealing wad which may be used in accordance with this invention; FIG. 3 is a pictorial view of a preferred spirally cut shot protecting sleeve for use in accordance with this invention;

FIG. 4 is a pictorial view of the shot protecting sleeve shown in FIG. 3 as it is recovered after shooting;

FIGS. 5, 6 and 7 are pictorial views of three different variations of shot protecting sleeves functionally similar to that shown in FIG. 3;

FIG. 8 is a view similar to FIG. 1 utilizing the overlapped longitudinally cut sleeve shown in FIG. 7; and

FIGS. 9, 10, 11 and 12 are isometric views partly in section of four different modifications of suitable gas sealing wads.

DETAILED DESCRIPTION

FIG. 1 is an exploded pictorial view of a loaded shotshell, partially broken away to show the interior components assembled in accordance with the preferred embodiment. Referring to this figure by characters of reference, the plastic body 1 of a shotshell is preferably of high density polyethylene which has been worked at temperatures below its crystalline melting point to impart preferential orientation to its molecular structure both longitudinally and circumferentially with respect to the axis of the tube. Such material and one process of producing it is shown in U.S. Pat. No. 3,103,170 to Covington et al., issued Sept. 10, 1963, and an alternative process of producing such material is described in U.S. Pat. No. 3,198,866 to Covington et al., issued Aug. 3, 1965. The shotshell may have the usual metallic head 2, basewad 3, and propellant charge 4. The shell may be closed with the usual folded crimp 5. The construction described thus far forms no part of the present invention and the exterior appearance of the shotshell is no different than that of any other conventional shotshell. Alternatively, the invention may be utilized in other forms of shotshells including those with paper bodies or those plastic bodied shells with the body and basewad formed integrally.

Within the shell we have provided an over powder wad 6 which may be of injection molded polyethylene or similar plastic material formed to define a gas sealing skirt 7 and a forwardly extending shouldered portion 8. Centrally disposed in the forwardly extending projection of this preferred embodiment is a conical recess 9 and a plurality of forwardly extending posts 10 are provided near the outer periphery of the portion 8. This wad rests upon the propellant charge 4 and has the function of acting as a gas sealing piston which applies the force of the exploding propellant to the propulsion of the shot charge 11.

The shot enclosing sleeve 12 is formed of a plastic tubing having properties substantially equivalent to those of plastic shotgun body tubing such as that described in the Covington et al. patents above referred to and is of a diameter which telescopes neatly within the shotshell body.

The two most widely used shotshell gauges are the 12 gauge and the 20 gauge. The nominal inside diameter of a 12 gauge plastic body tube is 0.729 inches. 16 gauge shotshell tubing has a nominal outside diameter of 0.720 inches. Thus, in the nominal situation, the 16 gauge tubing has a clearance of only 0.009 inches when telescoped into a 12 gauge tube and since it has a nominal wall thickness of only 0.032 inches occupies comparatively little space in the shotshell. Since the spirally slit tube which we prefer has considerable capacity for accommodating itself to variations in diameter, even at the extremes of permissible dimensions a 16 gauge tube is almost ideally adapted to be telescoped within a 12 gauge tube. Essentially, the same close fitting arrangement exists when the 28 gauge tube is telescoped within the 20 gauge tube. To provide the proper telescopic fit for other gauges, new sizes of tubes can readily be produced.

Such a tube 12 is preferably slit from one end to the other, preferably along a line 13 at about a 30° angle to the axis of the tubing and is preferably inserted into the shotshell with or following the insertion of the gas sealing wad 6 with the innermost end of the sleeve embracing the shouldered portion 8 of the gas sealing wad. The sleeve 12 is of such length as to extend the full length of that portion of the shotshell body between the gas sealing wad and the folded end closure 5 so that shot has no contact with any portion of the shotshell body except the cramped closure 5.
Handling of the sleeves 12 in machine loading equipment is facilitated by the fact that the sleeves may be hoppered and fed prior to sitting as short sections of tubing which do not tend to bridge or tangle in the hoppers and which may be spirally slit by suitable fixed or rotary knives as they pass through the feed tubes to the loading bushings. The rigidity of the sleeve section is such that even when spirally slit it has no tendency to uncurl but retains its sleeve conformation and can be inserted into the shotshell through the usual loading bushing with minimum likelihood of deformation or jamming.

The shot charge 11 is preferably of ferrous metal which has been selected for sphericity and smoothness and which may have been burnished as by tumbling, with or without added abrasive agents to improve the smoothness and rollability of the shot. Although hardness has been stated as one of the criteria, about all that is required is that the shot pellets be hard enough so that they do not substantially indent or deform each other as a function of the inertial loads imposed during acceleration. Considering the number of soft barrels available in some production lines and the thin barrels of some old double barrel guns still in use with the almost inevitable possibility that an occasional shot pellet may be loaded outside the protective sleeve, it seems preferable to use shot which is no harder than the steel of the softest barrels likely to be encountered in the field. A hardness range of about 60 DPH to about 100 DPH seems preferable.

Within the available space it is presently practicable to load, for example, in the 2 1/2 inches long, 12 gauge product a charge of 1-1/8 oz. of No. 4 (0.130 inch diameter) steel shot comprising about 217 pellets as contrasted to about 150 pellets included in a comparable charge weight of No. 4 lead shot. A greater weight of steel shot may also be practicable, depending on propellant and component volume considerations. Under same conditions 1/4 oz. of No. 4 lead shot comprising about 170 pellets or 1 oz. of No. 6 lead shot comprising about 275 pellets may be loaded in the available volume. Except at extreme ranges, the greater density of the lead shot does not offer a great advantage and at the normal moderate ranges the No. 4 steel pellets in a 1-1/8 oz. load are only slightly less effective against ducks than the No. 6 lead shot load commonly used for ducks.

When the shot is loaded into the shell, a column of shot is built upon the base provided by the gas sealing over powder wad 6. Although with very small shot the shot supporting the face of the over powder wad may well be flat as shown in FIG. 12, the configuration shown in FIG. 1, FIG. 2 and FIG. 9 has many advantages for use with relatively large shot such as No. 4 which would be used as a duck load.

By providing the conical recess 9 in the shot supporting the face of the wad (correlated with shot size), we can be reasonably certain that the successive layers of shot built upon that base will not nest together in mechanically rigid configurations with the pellets in close packed diameter to diameter opposition. The posts 10 supplement the conical recess by forcing every other pellet in the outer circumferential ring of pellets to assume a position displaced from the basal plane by about one half pellet diameter. Suitable post geometry and spacing may be selected to accommodate desired shot sizes to accomplish the same result. Since the column of shot pellets builds up from this base, it follows that the shot pellets in even the forward most layers are relatively free to move with respect to each other. FIG. 10 shows an alternative gas sealing wad which is the same as that shown in FIGS. 1, 2 and 9 except for the elimination of the supplemental posts 10.

The wad construction shown in FIG. 11 is a fairly obvious alternative of that shown in FIGS. 1, 2 and 9 in that the conical recess 9 is replaced by a conical protuberance 14 which has the same effect as the recess in breaking up the rigid laminar form characteristic of shot stacked upon a flat base. Although the gas sealing wads here illustrated are not arranged to provide any substantial degree of cushioning, it may be noted that interior ballistics may be improved if the wad column has a small degree of built-in compressibility. Thus, if a small reduction in the volume available for shot and powder may be tolerated, it may be desirable to mold the gas sealing wad with an intermediate cushioning section analogous to that provided in wad columns of the type illustrated in the patent to Foote et al. U.S. Pat. No. 3,217,648.

On firing, the gas sealing over powder wad 6 seals the propellant gases by expansion of the skirt 7 and applies forwardly moving pressure which forces open the crimped end closure 5 and tends to upset or diametrically enlarge the shot column. Through the shouldered portion 8 pressure is also applied to the rear end of the sleeve 12. As a result of the application of this force to the rear end of the sleeve 12 and the expanding force applied by the upsetting shot column, the sleeve tends to expand diametrically into close engagement with the wall of the shotshell. As has been demonstrated by high speed X-rays, the gas sealing wad 6 cocks slightly and its shouldered portion remains in engagement with the end of the sleeve. Obviously, the overlap provided by the reception of the shouldered portion 8 within the rearmost portion of the sleeve should be sufficient to insure that even though the abutting edges of the slit in the sleeve do move longitudinally with respect to each other, no gap will be opened up to permit shot at the rear end of the sleeve to contact the barrel. As the shot charge leaves the body of the shotshell and passes through the forcing cone into the cylindrical section of the bore, it is forced to contract and as it passes through the choked portion of the barrel it is forced to contract still further. To minimize the possibility that ferrous metal shot may contact or abrade the polished barrel surface, it is necessary that this accommodation in diameter take place without opening a gap. The spiral slit and the separate gas sealing wad which has an ability to cock and remain in engagement with the sleeve makes such accommodation a practical possibility.

Considerable accommodation is necessary for, as noted, the nominal inside diameter of a twelve gauge shotshell body is about 0.729 inches and the nominal outside diameter is about 0.790 inches when such a shell is fired in a normal 12 gauge chamber which has a diameter of about 0.798 inches in the location opposed to the chambered shot charge. The shell expands about 0.008 inches into a close fit with the chamber and for this purpose elastic expansion of the chamber per se may be disregarded. In passing from the shell into the bore of the gun, the shot charge and protective sleeve pass through a forcing cone defining the transition from chamber to bore and are brought back to
conformity with a bore diameter of about 0.730 inches which is normally maintained until the choked section of the barrel is reached where a full choke bore normally is constricted to about 0.690 inches. Thus, a shot protective sleeve which maintains contact with the shell wall and gun bore may start out at a nominal outside diameter of 0.729 inches, expand to about 0.737 inches while still in the shell, be constricted by the forcing cone to 0.730 inches, and further constricted by the choke to about 0.690 inches.

The action of the spiral slit in slipping of the two abutting edges of the slit with respect to each other permits diametral contraction without opening a gap in the protective wall. The hardness, smoothness, and sphericity of the shot and the hardness and penetration resistance of the protective sleeve all contribute to the fluid behaviour of the shot column.

One of the outstanding advantages of this invention becomes apparent when strain gauges are applied particularly at the choked section of the barrel to measure the circumferential strain of the barrel in micro inches per inch of circumference. It has been established that shotgun shells loaded with plastic sleeves in accordance with this invention and fired in a Remington M870 gun barrel did not produce maximum instantaneous strain values in the choke of the gun barrel much more than most lead shot loads and substantially less than some lead shot loads. The same Remington M870 gun barrel was used in the following tests.

A typical Skeet load using 1-½ oz. of No. 9 lead shot, relatively hard as a result of 6.5 percent antimony content, showed an average choke strain of 371 micro inches per inch and a load using 1⅛ oz. of No. 4 lead shot, relatively soft as a result of 1.2 percent antimony content, showed an average choke strain of 431 micro inches per inch. Certain Magnum and heavy duck loads with 1⅓ oz. of No. 4 lead shot showed an average choke strain of 509 micro inches per inch when loaded without granular fillers between pellets and nearly 700 micro inches per inch when loaded with granular filler between the pellets.

A load of burnished steel shot of 175 Diamond Pyramid Hardness, 1-½ oz., with a 45° spiral cut, biaxially oriented protective sleeve, showed an average choke strain of 481 micro inches per inch.

A load of burnished shot of 75 DPH, otherwise identical to that in the preceding paragraph, but fired later in a different barrel, showed an average choke strain of 501 micro inches per inch.

The use of a four slit shot container (a molded polyethylene cup with four longitudinal slits in its wall and with an integral gas sealing skirt) and either hard or soft steel shot increased choke strain to about 770 micro inches per inch.

When a section of oriented 16 gauge tubing with no slits was used with the gas sealing wad shown in FIGS. 1, 2, and 9, the average choke strain was near 800 micro inches per inch and when this protective sleeve was used with the flat faced gas sealing wad of FIG. 12 the average choke strain was about 880 micro inches per inch. Tests of this loading were also extremely unsatisfactory in other respects in that the sleeve failed to separate cleanly and consistently from the shot column with the result that pattern performance was extremely erratic and the sleeve with at least part of the charge still in it was frequently propelled as a dangerous slug-like missile for long distances down range.

In tests with no shot container, samples loaded with relatively soft ferrous shot (72 DPH) produced an average choke strain of a little over 1000 micro inches per inch. With such samples loaded with burnished hard steel shot (175 DPH) the average choke strain was just over 1100 micro inches per inch, and with unburnished hard steel shot (175 DPH) the average choke strain was just under 1300 micro inches per inch.

It should also be noted that the widest variation between maximum and minimum choke strain was noted in the use of the unburnished hard steel shot without a shot container with one round producing a strain of 1820 micro inches per inch and producing a bulged barrel, even though the test barrel was one of the strongest of modern heat treated steel shotgun barrels.

Although reference has been made hereinbefore to the desirability of using burnished shot as a means of improving the patterns and the relative fluidity and ability of the shot column to conform to diametral changes in the barrel, it should also be noted that the burnishing process also removes the sharp irregularities on shot pellets which, if accidentally exposed or caused to penetrate through the shot protective sleeve, might tend to cause scratching or erosion of the barrel surface.

Reference has been made to the desirability of using the spirally slit shot container. The ability of such a container to conform to diametral changes without opening a gap and by sliding movement of the abutting edges of the slit with respect to each other has been shown to exist over a range of slit angles ranging from about 15° to the axis of the tube as shown in FIG. 6 to about 60° to the axis of the tube as shown in FIG. 5. Angles less than 15° to the axis of the tube approach the situation of a straight longitudinal cut and unless an overlap is provided, a gap may be opened when the sleeve is expanded to allow at least some shot pellets to move through the gap into possibly damaging engagement with the barrel bore. Angles more than 60° to the axis of the tube may not always open without deflecting some shot and although we have had good performance with tubes slit at a 45° angle we prefer an angle of about 30° to the axis of the tube.

The overlapped, longitudinally cut protective sleeve 15 shown in FIGS. 7 and 8, is not the preferred embodiment for it is necessary to notch one corner as at 16 to avoid trapping a double thickness of material between the shouldered portion 8 of the gas sealing wad and the bore surface. Further, unless a similar notch is made at the other end, the protective sleeve must be oriented before feeding to the shell to insure that the notch is always adjacent to the gas sealing wad. If both ends are notched, the notch at the forward end may present a possibility of allowing shot to escape through the notch. Lastly, such a protective sleeve is preferably cut from a section of tubing of the same gauge as the shotshell body at such a circumferential dimension as to provide for an overlap of about 0.063 inch minimum when assembled within a 12 gauge shotshell body. Since such an arrangement involves a small waste strip as well as a cut out for the notch, it is obvious that it would be difficult to make the cut and dispose of the scrap while the sleeve is passing through the feed tube. If pre-cut, the cut sleeves tend to remain at 12 gauge diameter and may present a small gap at the cut which presents the possibility of entanglement in the hoppers and feed tubes.
In other respects, the overlapped straight cut sleeve illustrated in FIG. 7 and shown loaded in FIG. 8, performs in much the same way as the spirally cut sleeves. The overlap at the cut edge and with the shouldered end of the preferred gas sealing wad prevents the escape of shot during diametral changes and the sleeve conforms readily to such change. The overlapped section does subtract in some degree from the volume available to receive shot, but only to the extent of a few pellets. Pattern performance and choke strain are about equivalent to that realized with the spirally cut sleeves and the protection against barrel scratching appears to be about equally effective.

**SUMMARY OF OPERATION**

Upon firing, the gas sealing wad accelerates the shot charge and the protective sleeve tending to upset the shot column and hence to increase the effective diameter of the shot column and sleeve as the shotshell body is expanded into supporting relationship with the walls of the chamber in the barrel.

As the shot charge, sleeve and gas sealing wad make the transition from the chambered shotshell to the bore of the barrel they pass through the forcing cone which constricts them to the diameter required for passage through the cylindrical part of the bore of the barrel and a further constriction is enforced by the chocked section adjacent to the muzzle of the barrel.

The spirally slit or overlapped sleeves conform readily to these diametral changes and, as noted, do so without opening any gaps. As the changes are made, the relative movement of the abutting portions of the sleeve seems to promote movement and fluidity in the shot column which reduces choke strain.

As the shot pellets move through the bore, the inner surface of the oriented protective sleeve is indented to some extent and cold worked to such a degree that upon emergence from the bore the protective sleeve tends to spring open or uncurl from the smooth cylindrical form it had before loading and which it was constrained to maintain while in the shell and barrel bore. This springing open effects a very prompt release of the sleeve from the emerging shot column and insures that there will be substantially uniform patterns of a spread defined by the choke of the barrel. In fact, high speed photographs of emerging shot charges have shown that the oriented protective sleeve can turn itself almost inside out and then return part way to fall to the ground in about the shape shown in FIG. 4. In only a few instances does the sleeve travel as much as 20 yards from the point of firing and it offers minimal interference to the pattern of the shot.

What is claimed is:

1. A method of projecting ferrous metal shot from a gun barrel with minimum abrasion of the interior surface of the barrel and minimum plastic deformation of any choke or other portion of the barrel, which method comprises the steps of:
   a. Selecting ferrous metal shot pellets which are sufficiently smooth and regular in shape so that they can fly consistently and produce good patterns;
   b. Providing a shot protector sleeve about the selected pellets made of material having physical characteristics equivalent to those of biaxially oriented high density polyethylene and which substantially resists penetration by the shot pellets;
   c. Projecting the shot pellets and the shot protector sleeve through the barrel; and
   d. Inducing relative movement of the shot pellets while the pellets are in motion through the barrel so that the shot pellets can conform to the choke of the barrel in fluid-like manner without jamming together in a barrel deforming slug-like conformation.

2. A method as defined in claim 1 wherein said shot protector sleeve is provided with an angular slit means with the edges abutting throughout its length in order to maintain protection of the shot and to facilitate separation of the sleeve from the shot charge after being fired out of the gun barrel, said relative movement of the shot pellets cooperating with said angularly slit sleeve to permit the abutting edges of the angular slit to slip relative to each other and permit the circumference of the sleeve to be varied within the gun barrel without creating a gap at the slit means which would permit shot pellets to pass through a gap and come in contact with the gun bore.

3. A method as defined in claim 1 wherein said relative movement of the shot pellets is facilitated by the initial placement of the shot pellets in a configuration which minimizes the possibility of diameter to diameter opposition of the shot pellets in planes normal to the axis of the gun barrel.

4. For use in a shotshell loaded with a powder charge and with hard-metal shot, a wad column comprising in combination a tubular shot protector sleeve of plastic material having a forward end and a rear end, the sleeve containing the shot and having at least one slit extending from the forward end of the tubular sleeve to the rear end thereof so that the sleeve defines a discontinuous band, said sleeve having the edges of the slit in abutment with each other and with both edges of the slit being formed throughout its length at a constant angle with respect to the longitudinal axis of the sleeve so that, as the abutting edges of the sleeve slide with respect to each other the circumference of the sleeve can vary without creating any gap between the abutting edges and a gas sealing over powder wad comprising an expansible gas sealing skirt to be seated adjacent the powder charge, a forwardly facing shoulder which abuts the rear end of the protector sleeve and a forwardly extending projection which is received within the rear end of the protector sleeve.

5. A wad column as defined in claim 4, said sleeve being formed of a material having physical characteristics equivalent to those of biaxially oriented high density polyethylene to resist shot penetration.

6. A wad column as defined in claim 5, said gas sealing wad being formed to define on its forwardly facing surface in engagement with the shot charge a plurality of forwardly facing protuberances which displace about every other shot pellet in the outer circumferential ring of pellets forwardly by about one half pellet diameter to reduce the possibility of diameter to diameter opposition of the outer circumferential rings of shot pellets.

7. A wad column as defined in claim 4, said sleeve being formed of high density tubular polyethylene which has been subjected to working at temperatures below its crystalline melting point to a degree sufficient to impart preferential orientation to its molecular structure both longitudinally and circumferentially of the tubular form.
8. A wad column as defined in claim 4, the angle between the edges of the slit and the longitudinal axis of the sleeve being selected from those angles between about 15° and about 60°.

9. A wad column as defined in claim 4, said slit being formed throughout its length at an angle of about 30° with respect to the longitudinal axis of the sleeve.

10. A wad column as defined in claim 4, said gas sealing over powder wad being shaped to define a conical forwardly facing surface in engagement with the shot to minimize the placement of shot pellets in diameter to diameter opposition in planes normal to the longitudinal axis of the sleeve.