Aug. 17, 1965 G. N. VITT 3,200,751

AERODYNAMIC SHOTGUN SLUG

Filed Jan. 22, 1964 2 Sheets-Sheet 1

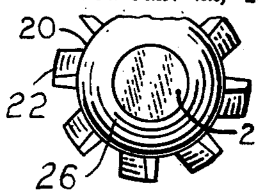

FIG. 2

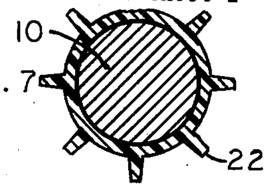

FIG. 7

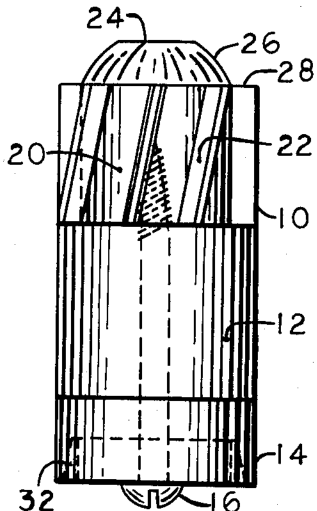

FIG. 1

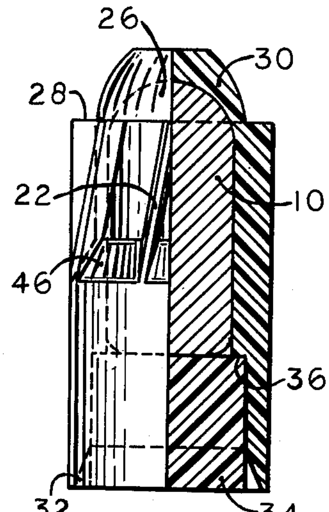

FIG. 3

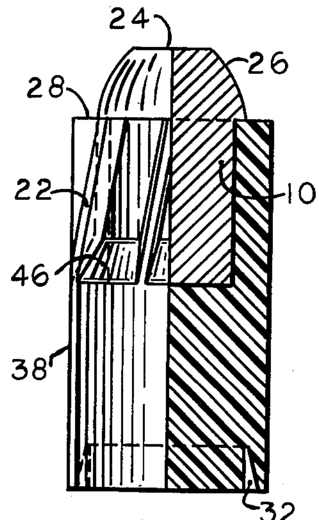

FIG. 4

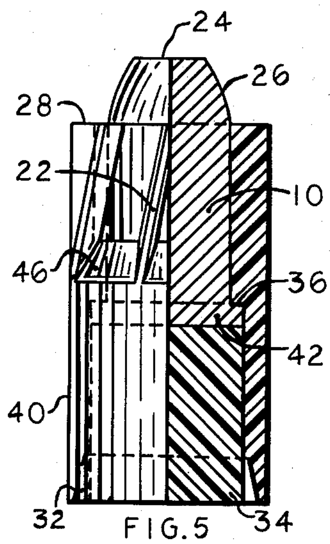

FIG. 5

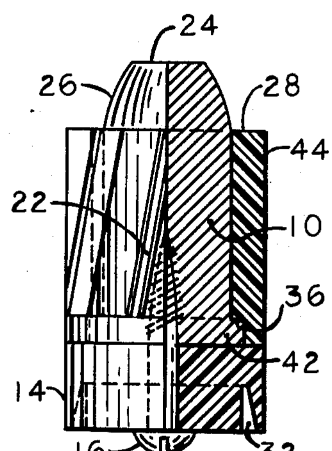

FIG. 6

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AERODYNAMIC SHOTGUN SLUG

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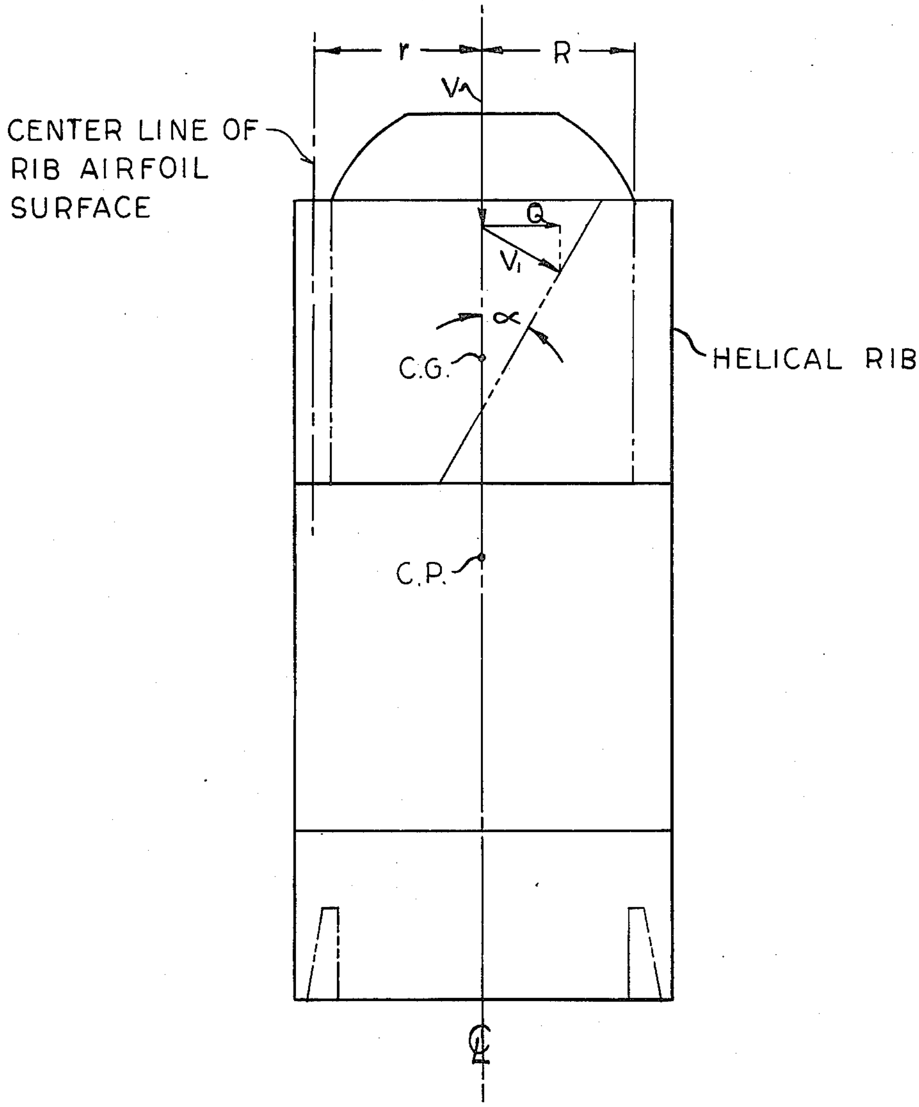

FIG. 8

SCHEMATIC

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3,200,751
AERODYNAMIC SHOTGUN SLUG

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10 Claims. (Cl. 102—92.5)

This invention relates particularly to projectiles for use in smooth bore guns, hereafter called shotgun slugs or slugs.

Shotgun slugs commonly used heretofore for any one given caliber were made in weights usually 25% to 40% lighter than the normal weight of birdshot substantially for one chief reason—difficulty in stabilizing a heavier and longer projectile for accurate head-on flight to the target when shot from a smooth bore gun. Such light slugs suffer from a number of deficiencies, such as low sectional density and ballistic coefficient, lower kinetic energy and penetration, and a consequent rapid loss of velocity, accuracy and kinetic energy at relatively short shooting ranges. Being of lighter weight and starting at a higher initial velocity, the existing slugs usually have a center of impact different from that of the standard birdshot pattern in the same gun. This causes a serious inconvenience in using standard shotguns for both purposes. It is therefore obvious that a heavier slug with a greater sectional density and substantially the same center of impact as obtained with standard birdshot loads at common birshot ranges would be preferred, provided it can be made to fly head-on with accuracy sufficient for hunting purposes over ranges of up to 100–150 yards.

The object of this invention is such a heavier and accurate shot gun slug of superior performance, made possible by advantageously combining into one whole entity several known and separate features and elements, and to add to them new and improved elements which together, and within certain interdependent and definable limits, are capable of effectively utilizing certain aerodynamic forces during the flight of the slug through air to produce sufficiently rapid rotation for true gyroscopic stabilization, to permit using such greater weight and resulting in superior accuracy of aimed fire up to and including ranges heretofore considered to be too great for standard shotguns, as well as greater kinetic energy and penetration and ability to shoot to the substantially same center of impact as when shooting with birdshot at birdshot ranges, to avoid the inconvenience of having to change sights or even barrels.

Further objects of this invention is to use the combination of said elements and features in accordance with certain engineering and scientific principles of aerodynamics, kinematics and exterior ballistics, and reduce it to practice to prove the object, the validity of my novel combinations and the superiority of the improved slug.

In the explanations to follow I shall endeavor to show that a number of basic factors of aerodynamic and ballistic engineering, and of practical design and construction, are interdependent, and thus must be inseparably combined and balanced for obtaining the above stated objects, and that all features of my design must be balanced within certain interdependent and definable limits, below and above which the improved qualities are difficult or impossible to obtain. Such explanations can be advantageously made by tracing these factors in their logical order, following the description of the drawings.

To attain the above objects certain basic design features were developed as will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIGS. 1, 3, 4, 5 and 6 are side veiws and partial cross sections of several configurations of the slug, and

FIG. 2 is the front view of FIG. 1, and FIG. 7 is a typical cross section of FIGS. 3, 4, 5 and 6.

FIG. 8 is a schematic view of the slug.

As seen from the drawings the configuration of the slug essentially consists of the following basic and typical elements: a heavy lead bullet **10** placed in the forward end of the slug; relatively high helical ribs **22** disposed around the outer forward periphery of the slug; an elongated body of light material, which can be made in several ways, as shown in the drawings and as described in detail later; and the fourth element is the tail skirt formed by an annular groove in the rear face of the elongated body.

In FIG. 1 this basic configuration is made up of the lead bullet **10**, a thick wad **12** made of compressed felt, plastic, cellulose fiber, or soft wood; and a plastic cap **14** with a tail skirt formed by the annular groove **32**, and these three elements are tightly fastened together by suitable means, such as a screw **16**. In this conventional configuration the helical ribs are integral with the cylindrical portion **20** of the bullet **10**; the shoulder of the slug **26** is rounded to form a projecting nose to improve its ballistic quality in the conventional manner, and the forward end of the slug is terminated in a flat **24** which facilitates seating the slug in the cartridge case with a suitable pressure ranging up to 100 lbs. exerted by the ram of the loading machine; the forward end of the helical rigs **22** are purposely made square with the central axis of the slug in order to abut squarely against the roll-crimped edge of the cartridge case to facilitate the neat and easy unfolding of the crimp particularly to avoid wedging of the slug over the crimp during firing, which mutilates or disfigures the ribs to partially spoil their aerodynamic functions, and to prolong the reloading life of the cartridge case.

Another and a new configuration of my slug is shown in FIGURE 3, in which the plain lead bullet **10** is inserted in a long plastic sleeve **30** with integral helical ribs **22** and a closed front end, having the same general effect of the design shown in FIG. 1, but with the addition of the light plastic rear plug **34** and a gently sloping shoulder **46** which blends the transition from the smaller diameter of the plastic sleeve between the ribs to the larger diameter of the tail portion of the slug.

The function of the plug **34** is manifold, to wit: to fill the space to prevent the slug from seating too deeply over the gun powder in the cartridge case, and, more importantly, to reduce the turbulent air drag during the flight of the slug through air, which significantly and undesirably increases the deceleration of the slug, as is well established by the theory and practice of aerodynamics as applied to external ballistics.

Another essential feature of the sleeve **30** is the inside annular shoulder **36**, which serves as a stop for plug **34** to help prevent the forward rupture of the sleeve **30** under the high pressure of the expanding gases of combustion of the gun powder acting upon the rear face with a force of up to 12,000 p.s.i. FIG. 4 shows a configuration of my slug functionally essentially the same as in FIG. 3, except that the lead bullet **10** is inserted into the hollow forward end of the plastic sleeve **38**, the rear portion of which is a solid integral member combining into one entity the features **12**, **14**, **16** and **32** in FIG. 1, and the features **30**, **36**, **34** and **32** in FIG. 3.

FIG. 5 shows a configuration of my slug essentially as before, except that the plastic sleeve **40** is a tube-like hollow cylinder with integral helical ribs, into which the lead bullet **10** is inserted from the rear and is retained in position against shoulder **36** by the integral rim **42** of the bullet **10**. As in FIG. 3, the rear space in the sleeve is filled with plug **34**.

FIG. 6 shows a configuration of my slug essentially as before, except that the hollow sleeve 44 does not have an integral elongated rear body, which, in this case is formed by the plastic cap 14 tightly fastened to the bullet by any suitable means, such as the screw 16.

As is seen from the above, and from explanation to follow, the three critical elements of the slug—the elongated helical ribs 22 in the forward portion, the elongated light weight rear portion of tail, and the annular groove 32 in the rear face of the slug, must be inseparably combined and joined by any one of the methods described above to the bullet 10 to form the slug; and such elements as the airfoil area and the angle of attack of the ribs (or the helix angle) and the height of the ribs 22, distribution of the mass along the central axis, the sectional density of the slug, and its ballistic coefficient, are all interdependent factors, all of which must be combined and maintained within certain limits of dimensions, relative positions and numerical relations, in order to fulfill the object of this invention.

Desirably greater kinetic energy and penetration at essentially equal velocities can only be obtained by increasing the weight of the slug for a given caliber, which results in a greater sectional density, which is expressed as the ratio of weight in lb. the slug divided by the square of its over-all diameter—W (lb.)/d^2 (inches). The factor of sectional density is universally accepted as a measure of a projectile's effectiveness, other things being equal. It follows that the greater the sectional density, the longer the slug must be for a given caliber, and therefore the heavier. This imposes certain limiting conditions, such as: (a) the greater the sectional density the greater must be the rotational speed to produce gyroscopic stabilization adequate for accurate head-on flight of the slug to the point of aim; in application to the shotgun slug, which solely depends upon aerodynamic action to produce such rotation, there are substantially narrow limits of utilizable sectional density in contrast to the rifled weapons, in which the rotation of the bullet is positively induced or enforced by the rifling in the gun barrel, and maximum rotational speed already exists at the instant when the bullet leaves the barrel and enters the air; (b) the length of the slug, however, cannot be greater than the longitudinal space available in the common shotgun cartridge case; (c) excessive weight would require increased powder charges and, therefore, pressures of expanding gases of combustion to propel the slug at a satisfactory velocity, which would be too great for the average shotgun designed for working pressures substantially limited to 11,000–12,000 p.s.i. maximum; and (d) the recoil factor.

Insofar as the weight of the slug is concerned for use in shotguns, 550 to 600 grains total weight is the optimum for 12 gauge guns, and proportionately less or more for other gauges, and it results in the same center of impact as birdshot ranges of up to 50–60 yards, as when using standard heavy birdshot loads. Consequently, the limits of satisfactory sectional density available for shotgun slugs

are from 0.130 to 0.175, with 0.1575 being preferred, and the lead portion of the slug must be solid to comply with space limitations, to minimize upsetting by the rapid acceleration caused by expanding powder gases, and to assure maximum penetration and correct expansion from the nose. Sectional densities below 0.125 are considered poor with respect to all elements of slug performance, at 0.15 they are considered as good, and above 2.0 as excellent.

Sectional densities in my preferred designs fall within the limits of 0.130 to 0.175, while the common commercial slugs have sectional densities below 0.120. Cooperating closely with the sectional density factor is the ballistic coefficient of projectiles, as may be determined from the well known Ingalls Tables of Ballistics. Within the limitations of shotgun usage and for adequate maintenance of velocity and energy, the limits of ballistic coefficient values are defined herein to be between 0.110 and 0.175, at which latter point the weight of the slug begins to be excessive. In my preferred configuration, as calculated from the Ingalls Ballistic Tables, the ballistic coefficient is substantially 0.125 to 0.135, while that of the previously available slugs is substantially 0.090 to 0.095.

Comparative advantages of my invention over the common so-called Foster slug are as follows, according to the Ingalls Ballistic Tables and actual field firing data:

	Range—50 yards		Range—100 yards	
	My slug	Commercial	My slug	Commercial
1. Weight, grains, av. d	575	400	575	400
2. Difference in wt., percent	+44		+44	
3. Sectional density	0.1575	0.117	0.1575	0.117
4. Difference, percent	+35		+35	
5. Ballistic coefficient	0.125	0.0932	0.125	0.0932
6. Difference, percent	+35		+34	
7. Initial velocity, ft./sec	1,400	1,400	1,400	1,400
8. Terminal velocity, ft./sec	1,183	1,110	977	831
9. Velocity loss, ft./sec	217	290	423	569
10. Velocity loss, percent	−15.5	−20.7	−30.2	−40.7
11. Initial energy, ft.-lb	2,500	1,740	2,500	1,740
12. Terminal energy, ft.-lb	1,785	1,090	1,216	613
13. Energy loss, ft.-lb	715	650	1,284	1,127
14. Energy loss, percent	−28.6	−37.4	−51.3	−64.8
15. Time of flight, seconds	0.12	0.13	0.2	0.35
16. Difference, percent		+8		+17.5

With the above in mind, long experience shows that the preferred sectional densities and ballistic coefficients result in well elongated projectiles, which cannot be accurately fired without rapid rotation about their central axis fast enough to produce adequate gyroscopic stabilization to prevent tumbling in flight. In rifles such rotation is positively enforced by rifling in the gun barrel to a satisfactory degree. In shotguns, however, the bore is smooth and the dimensional tolerances vary widely, imposing an additional handicap on accuracy of shooting. The principal part of my invention with particular application to common and standard shotguns as used for hunting, is therefore concerned with stabilizing the slug during its flight through air by rotation and establishing positive means for doing so by determining dimensional and non-dimensional limiting factors and relationships governing such stabilization on the basis of aerodynamics.

Prior claims in this respect are that rifled grooves around the periphery of a lead slug will cause it to start rotating as early as when it still is moving in the paper cartridge shell, and then as a result of friction while traveling through the smooth gun barrel, the friction being created by enlarging the sub-caliber diameter of the soft lead slug by upsetting due to rapid acceleration by the impact of the expanding powder gases. Contradicting the above, it was also claimed that the rifled grooves become obliterated in the process, which would nullify the claimed rotating effect by friction. However, such claims are ineffective for the basic reason that, once it is swaged to an initial tight fit in a smooth barrel, the amount of friction between the slug and the barrel becomes reduced nearly to zero, because lead lacks elasticity. Thus it cannot have any "bite" on the smooth barrel walls to induce rotation. More important, the inertia of the slug and the friction between the rough wads and the slug base during the period of acceleration in the barrel, virtually locks them together, which automatically prevents any rotation of the slug while in the barrel, and would be far in excess of any frictional rotating force, even if such a force could be created to any appreciable amount as claimed. Also, when fired, the common commercial slug wedges into the hard roll crimp of the stationary cartridge tube in the process of unrolling the crimp with a force great enough not only to arrest any claimed initial rotation within the cartridge tube, but also to shear or smooth the shallow rifled grooves on the slug's periphery, thus partially or totally destroying the alleged means for inducing further rotation by subsequent friction in the gun barrel. Finally, there is ample evidence to show that the common commercial slug does not upset enough to fill a standard gauge barrel, and shoots with consistent accuracy only out of such special barrels, whose inside diameter approximates the initial outside diameter of the common commercial slug, said special barrels marked with improper gauge designations.

The only feasible means of inducing rotation of the slug fired from a smooth bore gun is by the dynamic action of the air upon certain airfoil surfaces incorporated in the construction of the slug. To induce rotational speed adequate for gyroscopic stabilization of the slug having the preferred sectional density, ballistic coefficient and weight, as limited above, said air foils must have a certain minimum surface area, and they must be evenly disposed around the forward periphery of the slug at a certain minimum angle of helix to produce an adequate rotational force at common shotgun velocities of essentially 1200 to 1500 ft./sec. at the muzzle to cause the required rotational acceleration within a reasonable distance upon emergence of the non-rotating slug from the gun barrel. The primary function of the comparatively high helical ribs **22** as shown in FIGS. 2 through 7, is coupled with these additional automatic advantages: (*a*) tight fit in the cylinder bore of the shotgun barrel, which contributes to accuracy of shooting, and (*b*) permits safe shooting in barrels which may be tight or have muzzle constrictions known as "chokes," since the ribs are high, thin and soft, and therefore swage to smaller diameter without appreciably raising the powder gas pressures or creating dangerous moments of impact upon the constricted portions of the gun barrel muzzle, which can result in bulging or even bursting of the barrel with solid slugs or round balls, should these be used at full barrel dimensions for more accurate shooting. For reasons of safety common commercial "rifled" slugs and round balls are made glossy subcaliber at a known and variable sacrifice of effectiveness and accuracy of shooting.

Pertaining to my invention, the rotational force in ft.-lb. may be determined by the following formula for any of the desired configurations of my slug for 12 gauge guns, taken in conjunction with FIG. 8:

$$Q=\tfrac{1}{2}pV_1^2\times A\times \cos 'a'\times Cd\times r$$

in which the basic data for a preferred configuration of the 12 gauge slug within the limits herein set forth, is as follows:

p—density of standard air at sea level at 15° C.=0.00238 lb.

V_1—V sin $'a'$—velocity component perpendicular to helical ribs, where V is the average forward velocity of the slug=1200 sin 11°=210 ft./sec.

$'a'$—angle of rib helix or the angle of attack—11°

A—total area of airfoil surfaces of the ribs in square feet=0.00227

Cos $'a'$—factor to make the force normal to the axis of the slug.

Cd—coefficient of air drag for a flat plate=1.25

r—radius from central axis to middle line of airfoil surfaces of ribs=0.0273 ft.

The rotational speed is then calculated by using the following formulae:

Moment of inertia $I=\tfrac{1}{2}W/gR^2$ lb. ft./sec.^{2}

Rotary acceleration=Q/I radians/sec.^{2}

Rotational speed=$Q/I\times t_1$ radians/sec.

Revolutions per second=$(Q/I\times t_1)/2\int 1'1$

$=(Q/I\times t_1)2\times 3.1416$=r.p.s.

Revolutions per minute=r.p.s.×60=r.p.m.

in which formulae:

W—weight of the slug in lb.

g—acceleraiton due to gravity=32.2

R—radius of the solid slug body in feet—0.0242

t_1—time of flight in seconds.

Using the above formulae for a distance of substantially 50 yards with a time of flight of 0.12 second at an average speed of 1200 ft./sec., the rotational speed of the slug becomes about 6750 r.p.m. for a drag coefficient Cd=1.25, which will substantially cover air drag conditions to such altitudes at which hunting may be reasonably done. The slight decelerating effect of the rotational air drag is here disregarded in view of other unavoidable variables, such as the commonly encountered variation in muzzle velocity from shot to shot on the order of 5%. Since the air is elastic and gyroscopic stabilization by rotation does not occur instantly upon emergence of the non-rotating slug from the gun barrel, additional factors must be introduced to provide stability of the slug until the gyroscopic effect takes over as a result of rotational acceleration. With reference to FIG. 8, these factors are the location of the center of gravity CG and the relative location of the center of pressure CP. Actual reduction to practice, shows that the optimum distance along the central axis between the nose of the slug and CG in proportion to the total length of the slug must be a minimum of 0.25 and a maximum of 0.35 of said total length. Cooperating with such favorable location of CG, the center of pressure CP must lie on the central axis far enough behind the CG to assure head-on stability of the slug during the short interval of time before the gyroscopic effect takes over. This separation between CG and CP for the 12 gauge slug, for example, must be from 0.3 to 0.4 inch, and the ratio between the dimension of this separation and the total length of the slug must be between a minimum of 0.15 and a maximum of 0.22 for any gauge or caliber of shotgun slugs.

With the preferred examples of construction of the 12 gauge slug, as shown in FIG. 1 through FIG. 6, this ratio is substantially 0.345/1.625=0.212. Cooperating with the above contributing features and factors is the important element of my invention, and that is the numerical relation between the total area of the airfoil surfaces of the helical ribs and the sectional density of the slug. Expressing the airfoil area in square feet, this ratio must lie within the range of 0.013 minimum and 0.03 maximum. With the preferred examples of construction of the slug as shown in FIG. 1 through FIG. 7, the airfoil area of ribs is substantially 0.0023 square feet and the sectional density is substantially 0.1575, producing a ratio factor of 0.0143.

Coupled with the airfoil area is the angle of helix, or the angle of attack, of the ribs, which must lie substantially between the minimum of 10° and a maximum of 15° relative to the longitudinal axis in an unfolded flat pattern. It was found that with this angle smaller than 10° rotational speed is not great enough to stabilize the preferred long heavy slug, while with the angle over 15° excessive turbulent drag develops in the area of the relatively high ribs, which causes undesirably greater deceleration in flight.

According to the established facts of exterior ballistics, an accurate face of the rear of any projectile, and effective obturation or sealing of expanding gases of powder combustion, make an essential contribution respectively to the accuracy of flight and to a maximum velocity for a given charge of powder. Thus I made a novel contribution to the construction of particularly the shotgun slug by making the rear section of the slug of accurately molded suitable elastic and tough plastic material so as to form an annular skirt capable of expanding under gas pressure and thereby sealing the gases to prevent their blowing by and injuring the forward portions of the slug by melting or burning, as well as wasting energy causing variations in initial velocity and therefore accuracy. In FIGS. 3 through 5 this skirt is an integral part of the slug structure.

Tests prove that said obturating skirt performs its function in the barrel without wear or injury to itself due to the toughness and lubricity of certain plastics, and it assumes its unexpanded form upon leaving the barrel. During the flight through air the edges of the skirt form a geometrically accurate rear face, which significantly contributes to accuracy of aimed shooting, superior to using known felt or fiber wads.

While the above description repeatedly uses a certain configuration of the 12 gauge slug to exemplify the explanations, the combination of governing factors and features are not limited to said configuration and the 12 gauge size, but actually apply equally to 20, 16 and 10 gauges as well, and the same limits of dimensional and numerical ratios, ballistic and aerodynamic factors apply to these other gauges too.

I reduced the above to practice by experiments and prolonged firing tests with superior results. In addition, my invention was also tested in laboratory and field conditions by competent institutions and individuals. The combined results proved the validity of my reasoning and the significant improvement of performance in standard shotguns of modern construction and with standard interior barrel dimensions, thereby benefitting the many millions of users of such shotguns. Some of the features of construction are known, but the combination of all above features, with addition of my new elements of airfoil ribs' area and their relation to aerodynamic qualities, to sectional density, and some of the modes of construction described herein, are novel as particularly related to shotgun slugs.

Therefore I claim:

1. An elongated shotgun slug whose length is from 2.0 to 3.0 times greater than its greatest outside diameter with a series of longitudinal helical ribs whose airfoil area in square feet is in a ratio of 0.013 to 0.03 inclusive relative to the sectional density of said slug.

2. An elongated shotgun slug whose length is from 2.0 to 3.0 times greater than its greatest outside diameter with a series of longitudinal helical ribs whose airfoil area in square feet is in a ratio of 0.013 to 0.03 inclusive relative to the sectional density of said slug, and the angle of said helical ribs relative to the longitudinal axis of the slug is within the range of 10° to 15° when developed into a flat pattern.

3. An elongated shotgun slug whose length is from 2.0 to 3.0 times greater than its greatest outside diameter with a series of longitudinal helical ribs whose airfoil area in square feet is in a ratio of 0.013 to 0.03 inclusive to the sectional density of said slug, and the angle of said helical ribs relative to the longitudinal axis of the slug is within the range of 10° to 15° when developed into a flat pattern, and the sectional density of which is within the range of 0.130 to 0.175 inclusive.

4. An elongated shotgun slug whose length is from 2.0 to 3.0 times greater than its greatest outside diameter with a series of longitudinal helical ribs whose airfoil area in square feet is in a ratio of 0.013 to 0.03 inclusive relative to the sectional density of said slug, and the angle of said ribs relative to the longitudinal axis of the slug is within the range of 10° to 15° when developed into a flat pattern, with a sectional density from 0.130 to 0.175 inclusive, and whose center of gravity lies on the central longitudinal axis at a distance from the nose of the slug which is within the range of 0.25 to 0.35 of the total length of the slug.

5. An elongated shotgun slug whose length is from 2.0 to 3.0 times greater than its greatest outside diameter with a series of longitudinal helical ribs whose airfoil area in square feet is in a ratio of 0.013 to 0.03 inclusive relative to the sectional density of said slug, and the angle of said ribs relative to the longitudinal axis of the slug is within the range of 10° to 15° when developed into a flat pattern, with a sectional density from 0.130 to 0.175 inclusive, and whose center of gravity lies on the central longitudinal axis at a distance from the nose of the slug which is within the range of 0.25 to 0.35 of the total length of the slug, and in which the center of pressure lies along the central longitudinal axis behind the center of gravity at a distance of 0.15 to 0.225 of the total length of the slug.

6. An elongated shotgun slug in which the lead bullet is inserted in the forward closed portion of a light sleeve which has integral helical ribs in the forward section, an integral hollow rear section of a larger diameter than the lead bullet and with a shoulder serving as a stop for a rear filler plug, the rear portion of said rear section being tapered toward the rear to form a deep annular groove.

7. An elongated shotgun slug in which the lead bullet is inserted in the forward closed portion of a light sleeve which has integral helical ribs in the forward section, an integral hollow rear section of a larger diameter than the lead bullet and with a shoulder serving as a stop for a rear filler plug, the rear portion of said rear section forming a deep annular groove in cooperation with the said plug, said slug having a length from 2.0 to 3.0 times greater than its greatest outside diameter, and whose airfoil area of said ribs in square feet forms a ratio within the range of 0.013 to 0.03 inclusive relative to the sectional density of the slug, and the angle of said helical ribs relative to the longitudinal axis is within 10° and 15° range when developed into a flat pattern; said slug having a sectional density within the range of 0.130 to 0.175 inclusive, a center of gravity on the central axis within the range of 0.25 to 0.35 of the total length of the slug from its forward end, and the center of pressure on the central axis behind the center of gravity at a distance of 0.15 to 0.225 of the total length of the slug.

8. A shotgun slug in which the lead bullet is inserted in a forward recess with a closed bottom in a light body the integral part of which body is a series of peripheral helical ribs and the rear portion of same diameter as that of the circle formed by the outer edges of the ribs, and an annular groove in its rear face close to its periphery; said ribs having an angle of helix relative to the longitudinal axis within the range of 10° to 15° inclusive and whose airfoil area in square feet is in a ratio of 0.013 to 0.03 inclusive relative to the sectional density of said slug; whose center of gravity is on the central axis at a distance from the front end of 0.25 to 0.35 inclusive of the total length of the slug, and a center of pressure at a distance of 0.15 to 0.225 of the total length of the slug behind the center of gravity.

9. A shotgun slug consisting of an elongated lead bullet with a rear flange or rim inserted in a cylindrical sleeve of light material with an internal shoulder serving as a stop for said flange, said cylindrical sleeve having a series of integral helical ribs around its forward outside periphery, the rear portion tapered inside to a thin rear edge, and a separate rear plug of light material seated in the rear of the cylinder against the rear face of the lead bullet and forming an annular groove in cooperation with the rear edge of said sleeve; said ribs having a longitudinal angle of helix of 10° to 15° inclusive, and whose area of airfoil surface in square feet is in a ratio of 0.013 to 0.030 inclusive relative to the sectional density of the slug; said slug having a sectional density within the range of 0.130 to 0.175 inclusive, and a center of gravity on the central axis at a distance of 0.25 to 0.35 of the total length

of the slug from its forward end, and a center of pressure at a distance of 0.15 to 0.225 inclusive of the total length of the slug to the rear of the center of gravity.

10. A shotgun slug consisting of an elongated lead bullet with a rear flange or rim, inserted in a cylindrical sleeve of light material with an inside diameter equal to the outside body diameter of said bullet, and with a light rear cylindrical portion permanently fastened to the two forward components to form the slug; said rear cylindrical rear portion having a deep narrow annular groove in its rear face and close to its periphery; said cylindrical sleeve having a series of integral helical ribs around its outer periphery with an angle of helix from 10° to 15° inclusive relative to the central axis when laid out in flat

pattern; said ribs having square forward ends and an airfoil surface whose area in square feet relates to the sectional density of the slug within the range of 0.013 to 0.03 inclusive; said slug having a sectional density of from 0.125 to 0.175 inclusive, a center of gravity on the central axis at a distance from the front end within the range of 0.25 to 0.35 of the total length of the slug, and a center of pressure at a distance of 0.15 to 0.225 of the total length of the slug behind the center of gravity.

No references cited.

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