No. 871,825. PATENTED NOV. 26, 1907.

L. SCHUPMANN.

PROJECTILE FOR RIFLED FIREARMS.

APPLICATION FILED SEPT. 7, 1906.

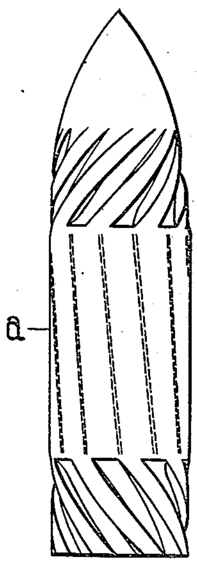

Fig-1.

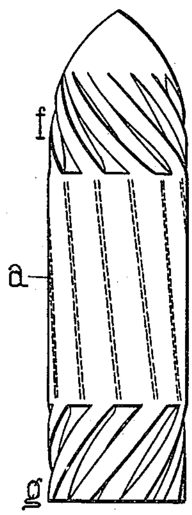

Fig-2.

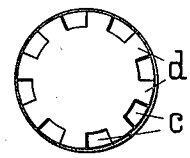

Fig. 3.

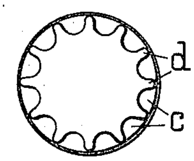

Fig. 4.

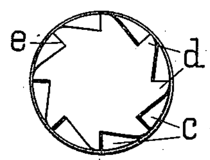

Fig. 5.

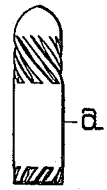

Fig-6.

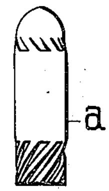

Fig-7.

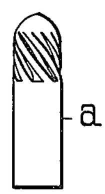

Fig-8.

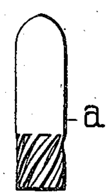

Fig-9.

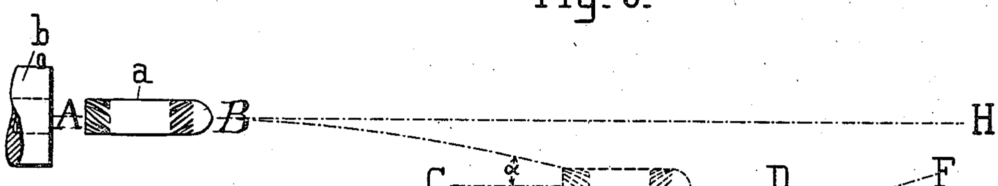

Fig-10.

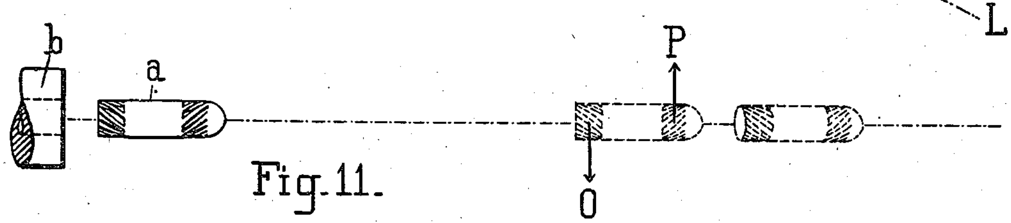

Fig-11.

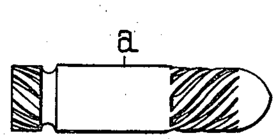

Fig-12.

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UNITED STATES PATENT OFFICE.

LUDWIG SCHUPMANN, OF AIX-LA-CHAPELLE, GERMANY.

PROJECTILE FOR RIFLED FIREARMS.

No. 871,825. Specification of Letters Patent. Patented Nov. 26, 1907.

Application filed September 7, 1906. Serial No. 333.592.

To all whom it may concern:

Be it known that I, LUDWIG SCHUPMANN, privy counselor and professor in the Royal Polytechnicum at Aix-la-Chapelle, a subject of the King of Prussia, residing at Aix-la-Chapelle, No. 18 Mariahilfstrasse, in the Kingdom of Prussia, Empire of Germany, have invented certain new and useful Improvements in Projectiles for Rifled Firearms; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My present invention relates to projectiles and particularly to that class thereof destined for rifled barrels, and it has for its object to provide the surface of the projectile with helical grooves and thus enable it, when fired from the rifled barrel, to penetrate the air in a less curved line than an ordinary projectile.

In the accompanying drawing:—Figure 1 is a side view of my projectile, in which the dotted lines indicate the impressions or the direction of the rifling of the barrel. In all the following figures the direction of the twist of rifling is supposed to be the same as shown in this figure. Fig. 2 is a side view of a similar projectile, in which the helical grooves are running in the opposite direction to that shown in Fig. 1. Fig. 3 is a rear view of the projectile shown in Fig. 2. Figs. 4 and 5 are similar rear views and represent modifications of the cross-section of the helical grooves. Figs. 6, 7, 8 and 9 show different arrangements of the helical grooves of my projectile. Fig. 10 is a side view diagram which specifically illustrates the effect of the helical grooves upon a fired projectile. Fig. 11 represents the diagram shown in Fig. 10 as seen from below. Fig. 12 shows an advantageous shape of an elongated small firearm projectile to which my invention applies.

If it were possible to transform the paraboloidal path of a fired projectile into a straight line, it would be far easier to hit the mark, as then the knowledge of the distance which lies between the rifleman and the target would be superfluous. My invention purposes to straighten this paraboloidal path as far as possible, so that the errors made in estimating said distance will be of considerably less importance than hitherto it has been the case. There might possibly be raised the objection that this purpose seems to involve a physical impossibility, but if considered that certain toys, for instance the boomerang, accomplish even more by progressing on a path curved in the opposite way, so that the ascent gradually increases, this objection is not maintainable. Moreover, the store of energy which an advancing projectile possesses is so great that a small portion of this energy amply suffices to hinder the dropping of said projectile during a given space of time, provided of course, that the means employed are suitable ones.

Generally speaking it must be conceded, that any inequalities or roughnesses on the exterior of the projectile merely tend to increase the inaccuracies of fire, but the grooves with which my projectile is provided run regularly in equal distances around the axis of the projectile and are provided with the same profile, so that the center of gravity of each cross-section of the projectile lies precisely in the longitudinal axis of the projectile. For these reasons the longitudinal axis possesses the quality of a so called "free axis", so that a continuous rotation without fluttering movements around this axis is assured and therefore a precise fire warranted. This same quality of a free axis a projectile possesses which is only provided with the impressions of the rifling, and experience has taught that these projectiles, in spite of their impressions or grooves, warrant a more accurate fire than projectiles fired from smooth-bore barrels. Consequently the application of grooves, if regularly arranged and if adapted and capable to serve an advantageous purpose, can produce great advantages.

In Fig. 10 the axis A—B of the projectile *a* which has just left the muzzle *b* coincides with the tangent A—H to the path of the projectile, which tangent may be supposed to be horizontal. While the projectile advances on its curved path the projectile retains, as is well known, the direction of its axis C—D unaltered, *i. e.* parallel to A—B, because it rapidly spins about its horizontal axis on account of the twist of the rifling. For this reason the axis C—D of the projectile and the tangent to the path of the projectile now forms an angle α, as shown in Fig. 10. If the projectile did always retain this horizontal direction of its axis, as it is nearly the case with ordinary projectiles, the pressure of the air upon the under-surface of the projectile, though greater than upon the upper-surface thereof, could never suffice to elevate the projectile to the horizontal line A—H, because only the dropping or sinking of the projectile produces this greater pressure of the air upon the under-surface. But my projectile is provided with said helical grooves. The forces which in consequence of these grooves act upon the flying projectile are the resisting forces of the air which act against these grooves or rather against their inclosures or the ribs which inclose them. The upper part of the two zones provided with grooves are free from resistance because they are sheltered by the body of the projectile against the air, which strikes the projectile from below and from in front according to the angle α, Fig. 10. The lateral parts of said zones are likewise almost free from resistance, because their plane nearly coincides with a line parallel to the celerity of the projectile. Of course, besides the friction there remain unquestionably some little forces, especially at the front set of grooves, which are directed upwards and downwards and equal to each other and merely tend to alter the rotatory celerity of the projectile, but by far the greatest effect is produced by the under parts of the grooved zones, because the resisting air strikes directly against their areas. This effect is proportional to the projection of the grooved area perpendicularly to the celerity of the projectile and in consequence, all other things being equal, proportional to the breadth of the zones, to the diameter of the projectile, and to the angle α.

Examining now the effect of the under parts of the grooved zones, it must be remembered, that the rotatory celerity of the circumference of the projectile is small in proportion to its advancing movement, because the rifling is not very inclined. Without committing a great error we can therefore assume, that the air will strike the ribs which separate the grooves, under an angle of about 45°, if said grooves are arranged under this inclination to a line running parallel with the longitudinal axis of the projectile. This error disappears if the grooves are arranged in such a manner, that their inclination forms an angle of 45° with the direction of the rifling. The angle α, Fig. 10, is hereby of no importance, because very small. Dissolving this pressure of the air against the under ribs in the well known manner into its components, we finally obtain at the front-set of grooves a force which opposes the advancing movement of the projectile, and another almost equal force P, Figs. 10 and 11. At the rear-set of grooves we likewise obtain a force which opposes the advancing movement and the force O, Figs. 10 and 11.

The two forces which act in opposition to the advancing movement retard the projectile in its course, but it must be remembered, that the pressure of the air against the point of the projectile is so great, that this retardation is of no importance in comparison with the retardation caused by the pressure of the air against the point of the projectile. The two remaining forces O and P, Figs. 10 and 11, form a force-couple which tends to alter the direction of the axis of the projectile horizontally. These forces are essential for my invention, because they greatly change the path of my projectile in comparison with an ordinary projectile. Such cause for deviating the direction of the axis of the projectile horizontally would also be produced if only the front-set of helical grooves, or for that matter the rear-set of such helical grooves, existed, because the force P as well as the force O does not intersect the center of gravity of the projectile, but then said cause would be only half as effective. From numerous treatises on physics, and also from experiments with the gyroscope it is known that a spinning body answers to such a force-couple in a remarkable way, in as much as its axis of rotation is not altered in the sense of the force-couple but perpendicularly thereto. Consequently in our case, according to Perry's rule (*Spinning Tops*, London 1890, page 42) the point of the projectile will be lifted, while the rear-end will be lowered, so that the axis of the projectile will attain the inclined position E—F shown in Fig. 10. This inclination against the primary tangent A—H, Fig 10, enables the pressure of the air which acts upon the now inclined under-surface of the projectile, to diminish the distance between the primary tangent and the pathway so that the projectile does not take the path A—L of ordinary projectiles, but will choose the straighter path A—K. Only by means of my invention can be obtained that during the course of the projectile this inclination of its axis to the direction of the primary tangent to the pathway is produced. Very small inclinations produce forces, especially at the beginning of the pathway where the celerity is still very great, which are directed upwards perpendicularly to the inclined under-surface of the projectile and which are great enough to alter the course of the projectile essentially.

We will assume that the inclination to the tangent A—H, Fig. 10, amounts for instance to 1° only. It may be assumed that the projectile under consideration is a small one, say 3 centimeters in length and 0.7 centimeters in diameter. The area of the under-surface which comes under consideration for the air-pressure is therefore $3 \times 0.7 = 2.1$ square centimeters; but taking the cylindrical curvature and the grooved zones into consideration this area may be assumed to contain only 1.2 square centimeters. The weight of such a projectile is about 13 grams. According to the well known formula we have the equation.

$$P = F(\sin\beta)^2 v^2 \frac{\zeta\gamma}{2g}$$

wherein in our case P signifies the force with which the air presses the projectile upwards perpendicularly to its inclination, F the area (1.2 square centimeters) under pressure; and β the angle of inclination to the direction of motion. The angle β is therefore equal to the angle $\alpha + 1°$. We will assume the angle β to be $= 1°$. In this manner we obtain only the increase of the force P, which acts upon my projectile in comparison with an ordinary projectile. In the above equation further signifies; v the celerity of the projectile (about 60,000 centimeters), ζ a coefficient (about 2), γ the weight of the cubic unit of air (0.0013 grams per cubic centimeter), and g the acceleration of gravity (981 centimeters). Inserting these numeral values into the above equation we obtain

$$P = 1.2\left(\frac{1}{57}\right) 2 \times 60{,}000^2 \times \frac{2 \times 0.0013}{2 \times 981} = 1.75 \text{ grams nearly}$$

If we had assumed that P is proportional to the sine and not to the square of the sine, an assumption frequently made, since science and experience have not yet decided this question, we would have obtained $P = 100$ grams approximately. These forces which we have obtained are therefore able to alter the course of this projectile essentially, whose weight is only 13 grams. Besides this we see that science has not yet far enough advanced to solve this problem by calculating.

To attain that the path thus traced by the projectile a does lie as precisely as possible in a vertical plane, or in other words, that the so called horizontal deviation is reduced, it can be advantageous for some forms of projectiles to make the surfaces occupied by the front set and the rear set of helical grooves, not of the same area, as shown in Figs. 6 and 7, or to apply only one of the two sets of helical grooves, as shown in Figs. 8 and 9. If for instance the rear set of helical grooves is omitted, only the force P, Fig. 11, will act upon the projectile, which tends not only to twist it, but also to deviate it horizontally, while the counter-balancing force O will be missed. This being so, the choice of one or the other of the arrangements shown in Figs. 2, 6, 7, 8 and 9 will form the means to modify the horizontal forces and thus reduce the horizontal deviation, which varies by the different shapes of projectiles as well in direction as in extent.

The inclination of the helical grooves against the direction of the twist of rifling is theoretically advantageous if chosen to be about 30° to 45°, while the profile of the helical grooves, if sufficiently deepened, is theoretically of less importance, but the greatest effect may be expected, when the ribs d are made as small as possible in comparison with the width of the helical grooves. Besides this the profile of the projectile may be adapted to suit the practical ends in view. Different profiles appear in the rear views given in the Figs. 3, 4 and 5. The profile shown in Fig. 4 possesses advantages for iron-mantled projectiles, whereas the profile shown in Fig. 5 promises good results, because the active small surface e, turned toward the point of the projectile, can be reached by the air with great facility.

Generally speaking, the projectile is least retarded on its path when the grooves are deepest at the circuits f and g indicated in Fig. 2.

Ordinary small projectiles are often provided with a small ring-shaped groove near their rear end, which groove can be adapted to my projectile, as thereby the air is enabled to enter easily into the rear-set of helical grooves, an arrangement illustrated in Fig. 12.

It now remains to demonstrate how the same purpose, *i. e.* the straightening of the path of the projectile, can be obtained, if the helical grooves run around the axis of the projectile in the opposite sense to that shown in Figs. 2, 10 and 11, which arrangement is represented in Fig. 1. In this case the force-couple O—P, Fig. 11, is inverted and now tends to depress the point of the projectile, so that the angle α, Fig. 10, is gradually diminished. A projectile of this class would consequently fly through the air like a feathered arrow, *i. e.* so that the long axis coincides with the direction of the projectile path, wherefore the tilting-over of the projectile is not to be feared, and it is a well-known fact, that this eventuality prohibits the making of the point of ordinary projectiles very sharp. We have now a means of sharpening the point of the projectile without any inconvenience, and thus of straightening the path of the projectile, which will become evident by the following statement:—A projectile which advances with its longitudinal axis coinciding with the direction of the pathway offers a minimum of resistance to the air, because the projection of its body in the direction of the movement is in this position of the smallest cogitable area. In this position the air pressure is on the under surface of the projectile equal to that of the upper surface thereof, because both surfaces lie in the direction of the movement, so that the resistance of the air acts exactly symmetrically against the point of the projectile and precisely opposite to the direction of the pathway. Diminishing the air-resistance on the one hand by sharpening the projectile, and on the other hand by this position of the projectile, we obtain advantages so great, that all other circumstances are of secondary nature. The total resistance against the pointed front-end of the above-named projectile of 13 grams weight is according to our formula about 500 grams. By sharpening the point this resistance can be easily reduced to about 250 grams. These great resisting forces gradually consume the energy of the projectile, *i. e.* diminish its velocity. As the curvature of the pathway is nearly inversely proportional to the velocity, we obtain by reducing the resistance to one half a much less curved pathway than usually. The projectiles of the latter class with inverted grooves offer moreover the advantages that the so called horizontal deviation is annulled, and that the influence of wind and rain upon the path of the projectile is lessened.

I claim:—

1. A pointed projectile having its forward cylindric part provided with a set of helical grooves, its body to the rear of such part not provided with said grooves and adapted to fit the rifled bore of the gun in which the projectile is to be used, to alter by the effect of said grooves the inclination of the longitudinal axis of the projectile to the horizontal plane during the course of the projectile.

2. A pointed projectile having its forward cylindric part provided with a set of helical grooves, its body to the rear of such part not provided with said grooves and adapted to fit the rifled bore of the gun in which the projectile is to be used, and at or near its rear end provided with a set of helical grooves, to alter by the effect of said grooves the inclination of the longitudinal axis of the projectile to the horizontal plane during the course of the projectile.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

LUDWIG SCHUPMANN.

Witnesses:

WILLIAM J. REUTERS,
HENRY QUADFLIEG.