absence of stimulating liquors, and some returned members of a Toronto lodge of Good Templars testified strongly to the advantages of teetotalism in enabling the men to endure the rigors of the field work. Nominally, canteens have been abolished at the annual camps, but practically they still exist, for at most places where light drinks are permitted to be sold, alcohol is obtainable on the sly, and even when this is not the case there are always drinking places close to the camp limits. The most stringent measures should be adopted to reduce this annoyance to a minimum, for the proportion of training gained in camp will be in inverse ratio to the amount of whisky drunk, and especially does this hold good with the young farmers who form the greater proportion of the rural battalions. Perhaps a hint to the officers that the example of their mess would carry great weight with their subordinates, might not be considered out of place.

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Several correspondents have urged us to establish a column of queries in which puzzles in tactics or military law might be presented for discussion and solution, and we consequently gladly insert in this issue a letter containing some questions as to the treatment of a deserter, which we hope will induce many of our subscribers to hunt up the matter for themselves, for we are convinced that few officers could give prompt and correct answers without such hunting up. We hope this letter will be only the first of a regular system of "questions by correspondents," which will be far better submitted to our readers than answered directly by our editorial staff.

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## No. 3.—*RIFLES AND RIFLE SHOOTING.—XIII.*

BY CAPTAIN HENRY F. PERLEY, HEADQUARTERS STAFF.

Allusion has been made to the atmosphere pressing heavily upon the earth, and this pressure is one of its most important properties, and the action of a common pump fully illustrates it. In such a pump the top bucket is water tight, and as it is raised a vacuum is formed in the body of the pump, between it and the bottom bucket or valve, and as "nature abhors a vacuum" the water in the well is acted upon by the pressure—or weight of the air, and rises through the bottom valve until the empty space is filled, and the top bucket commences its downward motion. If the body of the pump be long enough the water will rise to a height of nearly 34 feet. From this it has been determined that the weight of a column of water 34 feet in height is equal to that of a column of air of the same horizontal section, and as high as the atmosphere extends, and from these data the pressure of the air or atmosphere at the surface of the earth has been determined thus:—

The weight of a cubic foot of water is........................ $62\frac{1}{2}$ lbs
A cubic foot contains........................ 1,728 cubic inches
A column of water, 1 inch square and 34 feet in height, contains........................ 408 cubic inches

Then, $\frac{62\frac{1}{2} \times 408}{1728} = 14.75$ lbs., or the pressure of the air per square inch.

This pressure of $14\frac{3}{4}$ lbs., commonly stated at 15 lbs., means the weight per square inch constantly being exerted on all things animate or inanimate at the level of the sea. The body of a well-proportioned man, 6 feet high, has to sustain a pressure of 20 tons, and though pressed by this great weight but little difficulty is experienced in moving from place to place, or in the exertion of breathing, the distension of the chest being the result of the elasticity of the muscles and ligaments which surround it.

The retardation, or effect of the resistance of the air varies with the surface, content, density, and velocity of a shot. Thus, spheroidal shot of the same diameter and density travelling with equal velocities, experience equal amounts of retardation; if travelling with unequal velocities their retardation is up to a certain speed, in proportion to the squares of those velocities, and beyond a certain speed equal to their cubes. If two shot of unequal diameters move at the same rate of speed, then they will be retarded in proportion to the squares of their respective diameters. The round or sharp ends of solids suffer less resistance than flat or plain ends of the same diameter: thus, the flat end of a cylinder and of a hemisphere suffer more resistance than the round or sharp ends of the same.

The path of a projectile through the air is called its trajectory. The force of projection if acting alone would carry it on in the same line and at the same rate forever, but the resistance of the air operates to retard its onward flight, whilst that of gravity acts continually during the whole duration of the flight, drawing it farther and farther from its original direction, and causing it to describe a curved path, which, if the body moved in vacuo, would be a perfect parabola. Trajectories are great bug-bears to some people, but yet they admit of an easy and simple explanation, The course taken by water issuing from the nozzle of a pipe attached to a fire-hose is the line of trajectory. If such be watched it may be seen that when the person holding the pipe wishes to throw the water a greater distance, he elevates the nozzle, and that there is an elevation to which it may be raised which will give the greatest distance to which the water can be thrown. If this curve be noticed it will be seen that it is not an even one, that from the nozzle, where the velocity is greatest and the resistance of the air the least, the curve is gradual until it reaches nearly the centre, then the water drops, and the latter part of the curve is more rounded than the first. This is exactly what happens to a rifle bullet, and it is only by the use of a properly graduated back sight that the exact elevation is given for the different ranges.

In gunnery, theory proves that the angle of elevation giving the greatest range is 45°, but that is obtained by assuming the passage of the ball to be in vacuo; in practice, however, it has been found that the greatest useful angle is about 32° or 33°, and this reduction from 45° is entirely due to the resistance of the air. Thus, a 56-lb. shot fired with a charge of 16 lbs. of powder, at an angle of 32°, ranged 3,720 yards or $3\frac{1}{4}$ miles; in vacuo at this angle the distance would have been 23,946 yards, or $13\frac{1}{5}$ miles, and at 45° 26,666 yards, or $15\frac{1}{10}$ miles. Elongated shot range much further than spherical balls, for instance, a shot weighing 175 lbs., fired from the Lynall-Thomas rifled gun at $37\frac{1}{2}$° elevation, ranged 10,075 yards, or $5\frac{3}{4}$ miles, and another weighing 250 lbs., fired with a charge of 50 lbs, at an angle of 33 degrees, from a Whitworth gun, ranged 11,243 yards, or $6\frac{1}{3}$ miles.

A projectile in its flight displaces the air, moving the particles aside in its passage, and this it cannot do without experiencing a retardation which varies with its velocity, the greater the velocity the greater the retardation. In viewing this resistance of the air it must be stated that no particle of air can be disturbed without moving others to a considerable distance from it, and these displaced particles take time to fall back into the positions they originally occupied; and where a projectile moves with great velocity the air in front becomes condensed, and highly rarified behind, and this displaced air does not return freely to fill the vacuum behind the bullet until its speed is reduced to about 1,340 feet per second. If a bullet moves through the air slowly and with a uniform velocity, it must drive before it certain particles of air, which are compressed and soon take a direction parallel to the lateral surface of the projectile, and ultimately close in its rear, thus filling up the temporary vacuum caused by the passage of the moving body. When the rate of motion is accelerated the air forms a series of vortices in the rear of the projectile, and they, rapidly succeeding each other, in some degree impel it forward.

Up to a certain velocity the resistance of the air is said to be in proportion to the square of the velocity: thus, a ball moving with a velocity of 500 yards, experiences a retarding force of 25, whilst if the velocity be increased to 600 yards the resistance wlll be equal to 36; or, for an increase of velocity of only 100 yards per second, the retardation is increased nearly 50 per cent. The resistance of the air to the flight of a Martini-Henry bullet may be judged from the following:—

| | | | |
|---|---|---|---|
| Velocity at | the muzzle | 1,362 | feet per second |
| " " | 100 yards | 1,207 | " " |
| " " | 200 yards | 1,084 | " " |
| " " | 300 yards | 984 | " " |
| " " | 400 yards | 900 | " " |
| " " | 500 yards | 830 | " " |
| " " | 600 yards | 770 | " " |
| " " | 700 yards | 718 | " " |
| " " | 800 yards | 672 | " " |
| " " | 900 yards | 632 | " " |
| " " | 1,000 yards | 597 | " " |

To fully comprehend the velocity of a rifle bullet a comparison may be made with the velocity of a railway train. Thus, a train moving at the rate of 30 miles per hour has a velocity of 44 feet per second, or only one-thirtieth part of the speed a Martini bullet has at the time it leaves the muzzle of the rifle, or one twentieth of its speed when it strikes a target at a distance of 500 yards, when it is travelling at the rate of 566 miles per hour.

*(To be continued.)*