

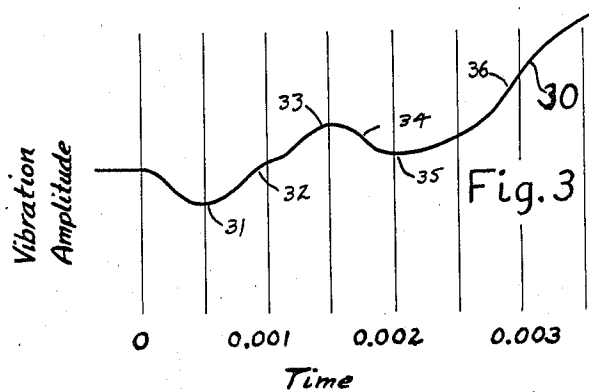
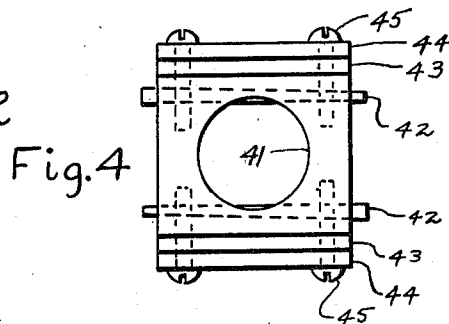
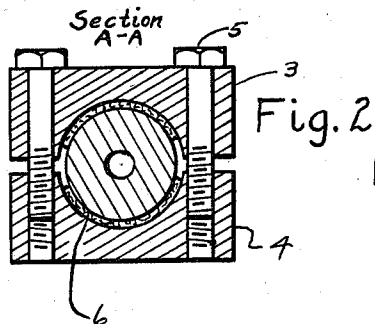
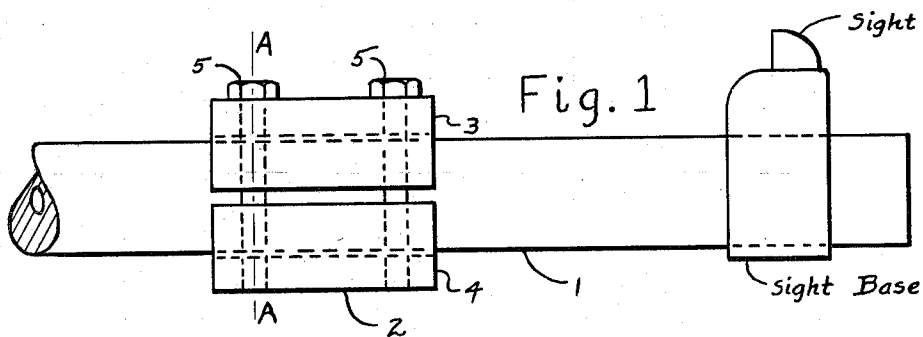
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FIREARM VIBRATION CONTROL

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FIREARM VIBRATION CONTROL

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8 Claims. (Cl. 42—1)

This invention relates to improving the accuracy of firearms, particularly rifles, and relates directly to control of vibrations set up in barrels whereby the projectile may be delivered from the bore at a time such that the muzzle is substantially stationary or such that the angle of the foremost part of the bore is not changing materially with respect to an arbitrary reference line.

An object of the invention is to control the periods of vibration of a gun tube so that a phase of small velocity during a vibration cycle may be made to coincide with the instant of delivery of the projectile.

An object is to control the vibration of a gun tube by fastening thereto pendulum weights of various sizes and/or locations whereby the natural vibration periods are modified so that the muzzle passes through a phase of minimum velocity at the instant of projectile delivery.

A further object of the invention is to enable a given arm to develop the greatest accuracy from a variety of different loads having different muzzle velocities, barrel times, weight of projectile and the like, the arm being adjustable for optimum accuracy for each given load.

These and other objects will be evident from the following description taken in connection with the illustrations in which:

Fig. 1 is an assembly of a gun tube and pendulum weight,

Fig. 2 is a section through Fig. 1, taken on line A—A,

Fig. 3 is a curve of muzzle displacement plotted against time showing how a barrel might vibrate under some arbitrary conditions, and,

Fig. 4 shows an alternative form for the pendulum weight.

It is well known that different projectiles will exhibit different barrel times due to minute differences in propellant charge, projectile weight, variations in ignition and other causes. If the muzzle is in rapid motion due to recoil and vibrations consequent thereto, projectiles having different barrel times will be delivered with the muzzle pointed in different directions, and the group formed by numerous shots will be enlarged. But if the motion of the barrel is small at the instant of delivery, the group size will be smaller.

Obviously, the barrel will be placed in motion due to the forces of recoil. But the motion will be a combination of oscillations of various frequencies (including zero frequency or transient displacement) whereby certain times after ignition are characterized by minimum or even zero

velocities. By considering the gun tube as a vibrating spring, it is apparent that the time after ignition at which the muzzle is momentarily at rest will be determined by the masses, compliances and damping factors of the various coupled vibratory systems including the tube, cradle or stock, mountings and the like. This system may be tuned by adding weights of various sizes or various locations on the gun tube or carriage.

This system of accuracy control is of great value in target rifles where such added weights are further advantageous in increasing the total weight of the rifle.

In the case of sporting rifles where minimum weight is sometimes a desirable feature, the idea is also applicable, for in this case the barrels need not be as stiff as ordinarily made, but may be made as light as desired consonant with the strength needed, and instead of stiffness to resist vibration, a small added weight may be adjustably mounted on the barrel to tune the vibration for greatest accuracy with any given load.

For guns of large caliber, including even coast defense artillery and the like, such vibration control can be utilized to reduce the cone of dispersion, and this end may be accomplished with or without the increase in total weight of the piece.

In Figs. 1 and 2 is shown a mass, which I choose to call a pendulum, as practically applied to a caliber .22 target rifle. The weight 2 is clamped around the tapered barrel 1. It is composed of two symmetrical halves 3 and 4 held together with screws 5 and clamping the barrel through pressure plates 6 which may be thin sheets of steel, fiber, leather or the like.

Such construction is convenient in the case of tapered barrels, but obviously may be modified in the case of cylindrical barrels. In the latter case a preferred structure would be a solid block, 40 in Fig. 4 having a bore 41 to fit the outside tube diameter, with indexing pins, drift keys or other well known devices 42 to hold the pendulum against rotational or longitudinal displacement.

Figure 3 shows how a barrel might vibrate after the ignition instant where time $t=0$. Curve 30 shows several periods of high velocity or rapid rates of displacement at 32, 34, and 36, and several periods of minimum velocity at 31, 33, 35. If the barrel time of a given lot of ammunition is 0.003 ± 0.0001 units of time, obviously the barrel would be in various positions in the region 36 at the various instants of delivery and the cone of dispersion would be expected to be large. But

if the barrel time is 0.002 ± 0.0001 , the barrel would be at rest as in region 35. The result would be large groups for the ammunition having a barrel time of 0.003 unit of time and small groups for the ammunition having 0.002 unit of barrel time.

A gun barrel, alone or coupled to a mount, carriage or stock is a vibratory system with distributed constants, and therefore has an infinite number of degrees of freedom. The added pendulum adds another degree of freedom, but being a concentrated mass this additional degree of freedom is made to predominate, and is the one which is controlled, or tuned, by selectively positioning the mass on the barrel. The barrel motion thus becomes more nearly simple harmonic, with smaller magnitudes of harmonics than would be the case if the mass is distributed. The control may be exerted either by using pendula of different masses to produce the different natural frequencies desired, or by moving a pendulum of given mass to different locations on the barrel. In either case the moment of the mass with respect to a point on the barrel, say the breech, or the receiver, is the quantity varied to produce the changes in natural period.

Accuracy has been controlled in the past by varying the propellant charge by trial and error until the best performance was obtained. The average shooter who has done his own hand loading is familiar with this art. But the present invention enables the greatest accuracy to be developed from existing loads, provided they do not vary excessively within a given lot. Thus, instead of attempting to vary the barrel time, the curve 30 may be compressed or expanded along the axis by adding weights to the vibrating gun tube, or sliding a weight or weights along the tube until the smallest cone of dispersion is obtained from a given lot of ammunition.

This adjustment of the period of vibration to fit a given lot of ammunition is best conducted by trial and error. Of course oscillographic means might be resorted to to find the actual barrel time and the actual shape of a curve such as 30 in Fig. 3, but practically the trial and error system is satisfactory. In the case of small arms, I prefer to fire the piece from a bench or muzzle-and-elbow rest, firing a group of 5 to 10 shots with each of several weight adjustments until the best group is obtained, and then firing additional groups with that optimum adjustment to prove that such adjustment is actually optimum. Obviously different lots of ammunition will be expected to require slightly different adjustment of weight size or location.

Instead of the device shown in Figs. 1 and 2, adapted to be located at the optimum point along a length of tube, a pendulum weight may be placed at a fixed location and the mass varied. In Fig. 4, block 40 has a bore 41 to fit closely the gun tube and is indexed on the tube by means of pins 42. Pairs of weight increments 43 and 44 are attachable to the block by means of screws 45 or other suitable fastenings such as dove-tail slots or the like.

Ordinarily the pendulum weight should be symmetrical with respect to the tube bore axis, otherwise the recoil would result in couple forces tending to bend the tube. In some cases, however, this effect can be used to offset some other asymmetrical effect such as the stock on a small arm. The added complexity, however, makes it desirable to maintain symmetry insofar as is convenient from a constructional standpoint.

For large guns where large recoil forces may be developed between the pendulum mass and the barrel, the pendulum can be adapted to slide along the barrel, being returned to proper position by recoil-counter-recoil mechanism well known in the artillery and ordnance arts.

Under some circumstances, such as certain types of military operations, it is desirable to increase the cone of dispersion rather than decreasing it in order to obtain greater areal coverage at some given range for a given piece. Obviously, by trial-and-error as previously explained, the adjustment can be so made as to produce large groups instead of small ones in accordance with this invention.

Another application of the invention is that of controllable compensation, whereby the barrel motion can be made to compensate for variable trajectory due to varying muzzle velocity. Thus different adjustments are usually optimum for different ranges. For example, the adjustment for 1000 yards differs from the adjustment found optimum for a range of 500 yards. This is due to the impossibility of creating a batch or lot of ammunition of perfect uniformity. Consider a fast and slow velocity projectile, aimed at a given point. The fast projectile drops less and normally strikes high. But if the delivery of the fast projectile occurs during a period when the barrel is pointed slightly downwards, and the slow projectile is delivered when the barrel is pointed slightly upwards, and the vibration is controlled so these two barrel positions are such as to just offset the changed trajectory shape, then at some given range the vertical dispersion will be small. Such adjustments of barrel vibration is conducted by testing the arm and a lot of ammunition at the given range, and determining the optimum moment of the pendulum mass for that particular combination of arm, ammunition and range.

By determining the interior ballistics of a given lot of ammunition and computing the possible vibration periods, it is possible to predetermine the pendulum moment instead of resorting to the trial-and-error method, though the latter is to be preferred.

I have found this means and method of control to be advantageous when used on a target rifle which had already been adjusted to optimum accuracy in accordance with the technique disclosed in a paper entitled "Tuning up small bore rifles" which was published in the American Rifleman, June, 1939. The accuracy improvement contributed by the pendulum amounted to roughly 30%. Without the pendulum, but with optimum adjustment otherwise, two groups of ten shots each, fired at a distance of 100 yards, measured respectively 1.3 and 1.5 inches in diameter. With the pendulum attached and adjusted, the same lot of ammunition averaged 1.01 inches for 5 groups of 10 shots each, and the largest of the five groups was only 1.1 inches in diameter measured on the circle which would contain all the bullet-hole centers. In arms of less inherent accuracy the percent improvement is even greater. In the case of another gun of lighter weight than that of the above example the improvement was from about 2.5 inches to about 1.3 inches average group size for the same ammunition lot.

I have found that the magnitude of the mass which proved satisfactory on one target rifle was about 1.5 pounds. The barrel of this particular gun was of the heavy type weighing roughly

seven pounds. The total weight of the complete arm with sights, sling, etc., was about 15 pounds. This pendulum required less than six inches latitude of position and adjustment within which range optimum values were found for two ammunition lots. These values are given for illustration only and are not intended to limit the scope of the invention which should be limited only by the appended claims.

Further details, advantages, and the results of tests may be found in the article, "Tuning up small bore rifles—Some further progress," published in the American Rifleman, December, 1939.

What is claimed is:

1. The method of improving the cone of dispersion of a firearm and a given lot of ammunition, comprising attaching a mass to the tube of such firearm, and adjusting the moment of such mass until a value of moment is found which results in a vibration period which is optimum for the given ammunition lot.

2. Means for increasing the accuracy of gunfire by controlling the vibration of the gun tube comprising in combination a gun tube, a pendulum mass secured thereto, and smaller increments of mass adapted to be secured to said pendulum, said pendulum being constructed and arranged to receive a variable number of said increments of mass so that its total mass and hence its moment may be varied until an optimum period of vibration of the tube-pendulum combination is found.

3. The method of improving the cone of dispersion of a firearm and a given lot of ammunition, comprising attaching a mass to the tube of such firearm, and adjusting the location of such mass upon such tube until a phase of small velocity during the vibration cycle coincides with the instant of delivery of the projectile from the tube.

4. The method of improving the cone of dispersion of a firearm and a given lot of ammunition, comprising attaching a mass to the tube of

such firearm, and adjusting the magnitude of such mass until the natural vibration period is modified so that the muzzle of the tube passes through a phase of minimum velocity at the instant of projectile delivery.

5. Means for improving the cone of dispersion of a firearm by controlling the vibration of the tube of said firearm comprising a pendulum mass, said mass consisting of two symmetrical halves adapted to be secured together with the gun tube secured therebetween, each half having a cut-away tube receiving space, and means to secure the two halves and the barrel in substantially unitary cooperation, and means for varying the moment of said mass.

6. Means for controlling the vibration of a gun tube comprising a pendulum mass having a tube receiving bore therein, means for fixing the mass to the tube, additional incremental masses adapted to be attached to said first mass to modify the natural period of vibration so that projectile delivery occurs at the time of minimum muzzle velocity, and means for attaching said incremental masses to said first mass.

7. The method of improving the cone of dispersion of a firearm and a given lot of ammunition, comprising attaching a mass to the tube of such firearm, and adjusting the moment of such mass until a value of vibration period is obtained such that the derivative of muzzle displacement is substantially zero at the instant of bullet delivery.

8. The method of improving the accuracy of a rifle and a given lot of ammunition, comprising rigidly attaching a mass to the tube of such rifle, adjusting the moment of such mass between successively fired test groups and noting the relative sizes of such groups, selecting the value of moment from which resulted the optimum group sizes, and adjusting the mass to such selected moment.

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