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DYNAMIC RECOIL BALANCER FOR CYCLIC FIRING GUNS

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Fig. 1.

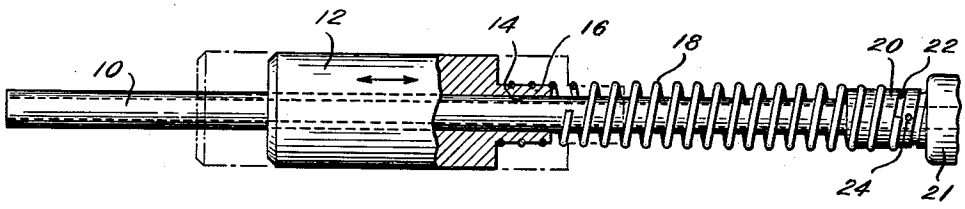
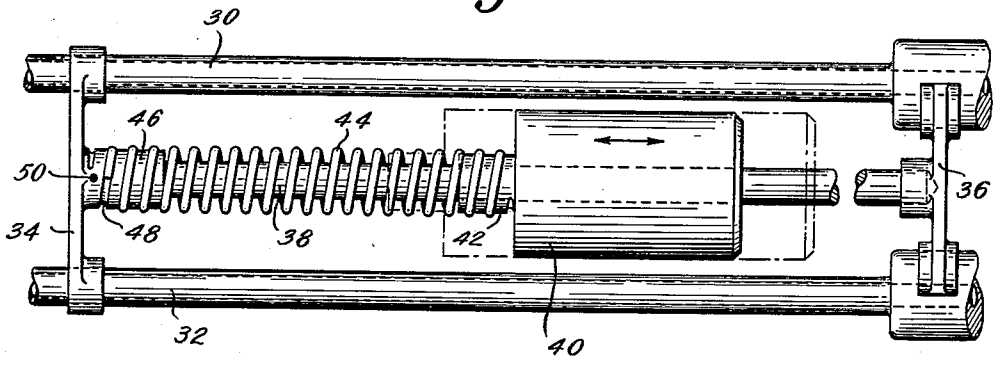


Fig. 2.



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DYNAMIC RECOIL BALANCER FOR CYCLIC FIRING GUNS

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16 Claims. (Cl. 89—44)

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This invention relates to automatic weapons and is more particularly concerned with new and improved mechanism for balancing the recoil of cyclic firing guns, whether they be of a single or a multiple barrel variety.

Heretofore many attempts have been made to provide means for eliminating or at least substantially reducing the vibration attendant upon the operation of automatic weapons, both large and small, including shoulder weapons of the submachine gun class as well as large caliber machine guns which must be held on various types of fixed mountings. So far as I am aware, most solutions which have been proposed operate upon the theory of snubbing the recoil from each shot, without regard to the cyclic nature of the weapon. Thus, the Cutts compensator tends to reduce the recoil attendant upon each shot. Similarly the mounting of the weapon upon a very massive basis tends to reduce the effect of vibrations by taking up the reaction to each shot in the inertia of a very heavy body.

While these various expedients have been effective in greater and lesser degrees, it has been evident for many years that there was ample room for further improvement. For example, in all automatic weapons presently in use which have come to my attention the muzzle tends to rise and whip during the firing of a fully automatic burst leading to inaccuracy and difficulties of control, particularly of shoulder weapons such as the standard .45 caliber Thompson machine gun. The accuracy of this particular gun is further impaired because the bolt moves forward and loads a cartridge into the chamber after the trigger is pulled, and this factor further adds to the loss of accuracy due to the tendency of the muzzle to rise during fully automatic fire. It is clear to all those experienced in the handling of this type of weapon that although the recoil against the shoulder of the user is relatively negligible, the recoil reducing means employed has done little if anything to increase accuracy.

Turning now from shoulder weapons, many of the same considerations are applicable to heavy machine guns. Thus, even when firmly anchored down with sand bags, the Browning caliber .30 machine gun will tend to rise quite markedly in firing of any burst particularly if the operator tries to hold the gun down by the pistol grip. Furthermore, with these weapons of higher power, including the .50 caliber machine gun and larger, the problem of providing suitable mountings to cushion the large vibratory forces created by the recoil became very important. In order

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to damp such forces, the mountings must be rugged and very heavy, thus not only increasing the cost but likewise reducing portability and hence the effectiveness of the weapon for military uses. Where problems of weight are concerned, as in military aircraft, the exceedingly heavy mountings reduce the range and payload of the airplane.

The principal object of the present invention is to provide a novel and simplified balancing attachment for cyclic firing guns for overcoming most, if not all, of the foregoing shortcomings.

Another object of the invention is to provide a dynamic balancer of the type described which makes obsolete the older snubbers and compensators, and which makes it possible greatly to reduce the weight of the carriage in which the gun is mounted.

Still another object of the invention is to provide a dynamic balancer of the type described which will tend to improve the accuracy of the automatic weapon to which it is applied to a very marked degree.

Yet another object of the invention is to provide a dynamic balancer which is applicable to multiple barrel cyclic firing guns as well as to those having a single barrel.

In accordance with the invention, I mount a weight on the automatic gun in such a manner that it is free to slide back and forth generally in the direction of the line of fire, and preferably symmetrically arranged with respect to the barrel or system of barrels of the gun. The weight is resiliently coupled to the gun by means of a spring. The gun for the purposes of the invention is considered as a single mass resiliently coupled through the spring to the weight, and hence the three together constitute a spring-mass vibratory system, energized by the recoil of the gun and capable of pre-adjustment or tuning in the field so as to have a natural period of vibration corresponding to the rate of fire. Under these conditions the weight, which represents only a small fraction of the weight of the gun, reciprocates at the same frequency but in opposition to the movement of the gun itself. Thus, when the gun is moving to the rear, the weight will be moving forwardly against the force of the spring and vice versa. By appropriately selecting the mass of the moving weight and the stiffness coefficient of the spring in relation to the mass of the gun, I am able to create a resonant system in which the weight moves back and forth with considerable amplitude while the amplitude of motion of the gun becomes negligible.

Conveniently, with single barrel guns, the weight, according to the invention, may consist of a ring mounted to slide back and forth on the barrel. A simple helical spring, surrounding the barrel, is attached to the weight at one end and to a portion of the barrel or receiver at the other. Preferably, I provide means for adjusting the length of the spring after installation so as to permit tuning in the field to the resonant frequency of the system.

Where multiple barrel weapons are involved, according to the invention, preferably I mount the balancing weight at a location at the center of symmetry of the vibrating system. In other words, generally speaking, the weight should always be disposed so as to vibrate in a line which is not only parallel to the axis of the gun barrel but symmetrically arranged with respect thereto and, in weapons having more than one barrel this line should be equidistant from all barrels so that there will be no torsional effect upon the same by reason of the movement of the balancing weight. Thus, where the gun has two barrels, the weight may conveniently be slidably mounted upon a shaft located midway between and parallel to the same.

Still further objects, advantages and features of the invention will become apparent from the following detailed description of preferred embodiments thereof taken in connection with the accompanying drawings in which

Fig. 1 is a side view, partially in section, of the barrel portion of a single barrel automatic weapon showing the novel recoil balancer of the invention mounted thereon; and

Fig. 2 is a plan view of a double barrel machine gun showing the mounting of the novel balancer between the two barrels.

Referring first to the embodiment of Fig. 1, the barrel of the weapon, which may be, for example, a shoulder type sub-machine gun or a .30 or .50 caliber machine gun, is indicated by the number **10**. Mounted to slide on the barrel is a generally cylindrical weight **12** having a central bore **14**. The outer surface of the barrel **10** is adapted to fit within the bore **14** to permit relatively undamped reciprocation of the weight **12** in the direction indicated by the arrow. At the rear end of the weight **12** there is a cylindrical extension **16** of reduced external diameter which is externally threaded, as shown, to hold the end coils of a helical spring **18** which also surrounds the barrel **10** and has its opposite end attached to a sleeve **20** which is located near the receiver end of the weapon. This sleeve **20** is provided with a helical groove **22**, also adapted to receive coils of the other end of the spring **18**. Preferably, the groove **22** is of greater length than is theoretically required by the construction to permit tuning adjustments in the field. Also preferably, the sleeve **20** is provided with a notch or marker **24** which may be used as a reference point in tuning.

Under ideal conditions of operation of the embodiment of Fig. 1 according to the invention, the natural period of vibration of the spring **18**, mass **12** and gun will correspond to the rate of fire of the gun. Under such conditions the weight **12** will move toward the muzzle of the gun while the barrel **10** is moving to the rear but with much greater amplitude, as indicated by the laws of motion. By Hooke's Law for one-dimensional motion we know that

$$F'=kx$$

where x is the change in length of the spring from its normal length by reason of the relative movement of the parts, k is its stiffness coefficient, and F' will be the force which the spring exerts at its ends. Further, we know that the force exerted by the smaller mass **12**, accelerating through a greater distance, will balance the corresponding force exerted by the heavier mass of the barrel and other members accelerating in the opposite direction but with less amplitude. If the mass **12** is sufficiently small with respect to the mass of the barrel **10** and associated parts, then the motion of the mass **12** will be relatively large and the motion of the gun will be virtually negligible. I have found that, generally speaking, the ratio of the mass **12** to that of the gun should be not greater than approximately 1:5. It is evident, for example, that if the masses were the same (a ratio of 1:1) the amplitude of motion of each would likewise be the same, thus defeating the purpose of the balancing system. On the other hand, if the ratio of mass of the balancing weight **12** to that of the gun is made too small, the necessary amplitude of motion of the balancing weight would be excessive for a practical device. Therefore, it is possible to give purely practical (but not theoretical) limits of this ratio as approximately from 1:5 to 1:20. A ratio of 1:10 yields good results.

From the foregoing principles, which have been only briefly outlined since they may be found in standard works on mechanics, it will be evident that the required mass of the weight **12** and the stiffness coefficient of the spring **18** may be calculated accurately by an appropriate mathematical treatment. However, in practice, I have found a simpler method yielding accurate results without involved computations. Knowing its normal rate of fire, the gun itself is attached to a suitable vibrator (a number of which are readily available on the market) and caused to reciprocate at this normal frequency linearly in the same direction it would have if firing. The amplitudes of vibration of the mass **12** and gun may then be observed by means of a stroboscope or other suitable instrument. The stiffness coefficient of the spring **18** is adjusted by turning it in the groove **22** until the amplitude of the mass **12** is at a maximum and the amplitude of the gun at a minimum. The position of the rearmost coils of the spring may then be marked with reference to the reference marker **24** and the spring may always thereafter be adjusted to that point without further experimentation. During the compression and tension of the spring, its diameter decreases and forms a very secure method of fastening upon the projection **16** and the sleeve **20**.

This experimental method of tuning obviates certain theoretical difficulties which might arise in calculating the values mathematically from the acceleration of the bolt and other working parts of the gun.

Turning now to Fig. 2, I have there shown a twin barrel machine gun having barrels **30** and **32** spaced from and parallel to each other. The balancer of the invention is mounted midway between the barrels **30** and **32** by means of a shaft **38** held on brackets **34** and **36** which span the distance between the two barrels, one near the muzzle and the other near the breech. Shaft **38** is held parallel to the barrels and the weight **40** is adapted to slide thereon. The weight **40** has a forward projection **42** which is spirally grooved (like the projection **16** in Fig. 1) to hold the end

coils of a helical spring 44 which surrounds the shaft 38 and whose front end is attached in like manner to a stud 46 extending rearwardly from the bracket 34. The stud 46 has a helical groove 48 corresponding to the groove 22 in the surface of the sleeve 20. This stud also is provided with a notch or marker 50 which is used as a reference point in the same manner as the reference point 24 for tuning in the other embodiment.

It will be observed that in Fig. 2 the dynamic balancer of the invention is located at the center of symmetry of the vibrating system so as to avoid the production of torsional forces which would tend to turn the barrels off the target.

While I have so far described the balancer of the invention attached directly to the barrel or barrels of the gun, it is evident that such specific attachment is not essential to the proper functioning of the device under some conditions. Thus some automatic weapons are recoil operated by movement of the barrel relative to the receiver and such movement, often of substantial amplitude, is essential to the proper functioning of the gun. In such cases the advantages of the invention may also be attained by coupling the reciprocating balancing weight not directly to the barrel but to some portion of the stationary receiver or carriage in which the barrel is mounted. In Fig. 1, if we consider the barrel 10 free to slide within the sleeve 20, the latter being attached directly to a forwardly projecting portion 21 of the receiver, these conditions may be considered to obtain. In such a construction the needed movement of the barrel 10 is unimpaired, but any sympathetic movement of the receiver carriage, etc. of the gun is balanced by the oscillating weight 12.

I have found that the novel dynamic balancer, according to the invention, may be adapted for use upon a variety of present day automatic weapons provided their rate of fire remains reasonably constant. Vibration, recoil and tendency of the barrel to whip or rise in shoulder weapons is enormously reduced and accuracy correspondingly improved. On the other hand with some types of heavier machine guns, such as those mounted in airplanes, savings of weight of the order of 500 to 1,000 pounds may be expected since the carriage need no longer absorb any intense vibrations.

While in the foregoing disclosure I have pointed out certain scientific theories of operation, such as treating the whole gun as a single mass in setting up my resonant system while ignoring factors of acceleration of parts within the same, I do not limit myself to any particular scientific explanation of the phenomena involved. In practice, I have found that the advantages of the invention may be readily attained by following the teachings which I have herein set out with the exercise of only the ordinary skill expected of competent engineers.

While I have herein also disclosed and described only a linear mode of vibration for the weights 12 and 40 parallel to the line of fire and symmetric with respect thereto, it is nevertheless clear that equivalent vibratory systems might be contrived employing masses oscillating at angles to the principal axis or in arcuate paths but whose resultant forces could be made to operate in the desired direction. Furthermore, it will be recognized that the invention is not limited to the specific helical spring shown and described and that other equivalent springs or resilient couplings may be found suitable for use in my dynamic balancer, the word "spring" being used in a generic sense, unless otherwise specifically limited, in this specification and the claims. Accordingly, I do not wish to be limited in the present application to the specific embodiments herein shown, since it is evident that various modifications and changes, some perhaps less efficient, may be made by those skilled in the art nevertheless employing the principles of the invention and within the spirit and scope of the appended claims.

I claim:

1. In combination with a cyclic firing gun, a dynamic recoil balancer comprising a weight of predetermined mass, said mass representing only a small fraction of the mass of said gun, mountings for mounting said weight on said gun for undamped reciprocatory motion relative thereto generally in the direction of the line of fire, and a spring connecting said weight to said gun, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun.

2. Apparatus in accordance with claim 1 including mechanism for adjusting the stiffness coefficient of said spring for tuning said system to resonance.

3. In combination with a cyclic firing gun, a dynamic recoil balancer comprising a weight slidably mounted on the barrel of said gun for relatively undamped longitudinal reciprocatory motion relative thereto, said weight having a predetermined mass representing only a small fraction of that of said gun, a spring having a predetermined stiffness coefficient connecting one end of said weight to said gun, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun, and a device for adjusting the length of said spring for tuning said system to resonance.

4. In combination with a multiple barrel, cyclic firing gun, a dynamic recoil balancer comprising a weight of predetermined mass representing only a small fraction of the mass of said gun, mountings for mounting said weight on said gun in a position symmetrically between its barrels for undamped reciprocatory motion relative thereto generally in the direction of the line of fire, and a spring connecting said weight to said gun, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun.

5. Apparatus in accordance with claim 4 including mechanism for adjusting the stiffness coefficient of said spring for tuning said system to resonance.

6. In combination with a cyclic firing gun, a

dynamic recoil balancer comprising a weight having a central bore, said weight being slidably mounted by means of said bore on the barrel of said gun for relatively undamped longitudinal reciprocatory motion relative thereto, said weight having a mass representing only a small fraction of that of said gun, a helical spring surrounding said barrel and having one end affixed to said weight and the other end affixed to a portion of said gun, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun, and mechanism for adjusting the stiffness coefficient of said spring for tuning said system to resonance.

7. In combination with a cyclic firing multiple barrel gun, a dynamic recoil balancer comprising a shaft mounted near the center of symmetry of said barrels and parallel thereto, a weight having a central bore slidably mounted by means of said bore on said shaft for relatively undamped longitudinal reciprocatory motion relative thereto, said weight having a mass representing only a small fraction of that of said gun, and a spring connecting said weight to a portion of said gun, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun.

8. Apparatus in accordance with claim 7 including mechanism for adjusting the stiffness coefficient of said spring for tuning said system to resonance.

9. In combination with a cyclic firing gun, a dynamic recoil balancer comprising a weight having a central bore slidably mounted by means of said bore on the barrel of said gun for relatively undamped longitudinal reciprocatory motion relative thereto, said weight having a mass representing only a small fraction of that of said gun, said weight also having a cylindrical projection at the rear end thereof and said barrel having a corresponding cylindrical sleeve thereon, said projection and said sleeve having external spiral grooves, and a helical spring surrounding said barrel with one end gripping said projection and the other end gripping said sleeve by means of said grooves, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun.

10. Apparatus in accordance with claim 9 in which said spring is arranged to be rotated in said grooves for adjusting the length thereof and thereby adjusting its stiffness coefficient for tuning said system to resonance.

11. In combination with a cyclic firing double barrel gun, a dynamic recoil balancer comprising a pair of longitudinally spaced brackets connecting said barrels to each other, a shaft mounted on said brackets midway between said barrels and parallel thereto, a weight having a central bore mounted by means of said bore on said shaft for relatively undamped longitudinal reciprocatory motion relative thereto, said weight having a mass representing only a small fraction of that of said gun, and a helical spring surrounding said shaft and connecting one end of said weight to one of said brackets, said weight, brackets, shaft, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said other members reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun.

12. Apparatus in accordance with claim 11 including mechanism for adjusting the stiffness coefficient of said spring for tuning said system to resonance.

13. Apparatus in accordance with claim 12 in which said mechanism comprises a sleeve on said shaft and a cylindrical projection on said weight, said projection and sleeve having helical grooves receiving some of the coils of said spring, said spring being adapted to be turned in said grooves for adjusting the length thereof.

14. In combination with a cyclic firing gun operated by relative motion of the barrel and the other parts of the gun, a dynamic recoil balancer comprising a weight attachable to said gun, said weight having a mass representing only a small fraction of that of said gun, mountings for mounting said weight on said gun for relatively undamped reciprocatory motion relative thereto generally in the direction of the line of fire, and a spring connecting said weight to one of said other parts of said gun, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said other parts of said gun and the relative motion between said barrel and said other parts being unimpaired.

15. Apparatus in accordance with claim 14 in which said weight is slidably mounted on said barrel and said gun is provided with a sleeve in which said barrel is free to reciprocate, said sleeve constituting the part of said gun to which said spring is connected.

16. In combination with a cyclic firing gun operated by relative motion of the barrel and other parts of said gun, a dynamic recoil balancer comprising a weight having a central bore, said weight being slidably mounted by means of said bore on the barrel of said gun for relatively undamped longitudinal reciprocatory motion relative thereto, said weight having a mass representing only a small fraction of that of said gun, said gun having a sleeve surrounding a rearward portion of said barrel and in which said barrel is free to reciprocate, a helical spring surrounding said barrel and having one end connected to said weight and the other end connected to said sleeve, said weight, gun and spring constituting a spring-mass vibratory system energized by the recoil of said gun and having a natural period of vibration corresponding to the rate of fire thereof with

said weight and said gun reciprocating at the same frequency but in opposition to each other, the amplitude of motion of said weight being substantially greater than the corresponding amplitude of said gun and the relative motion between said barrel and said other parts of said gun being unimpaired, and mechanism for adjusting the stiffness coefficient of said spring for tuning said system to resonance.

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