

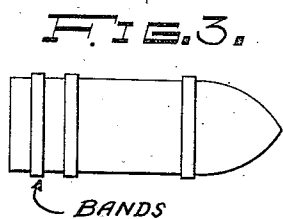
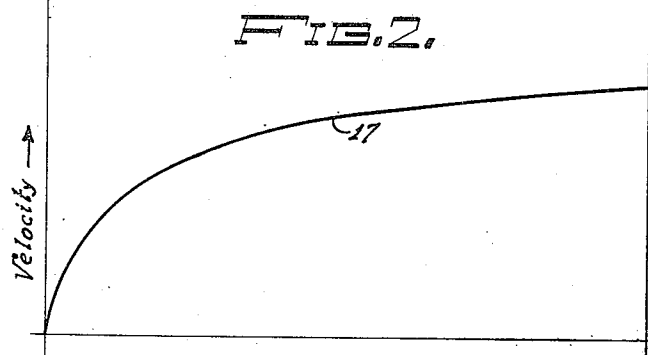
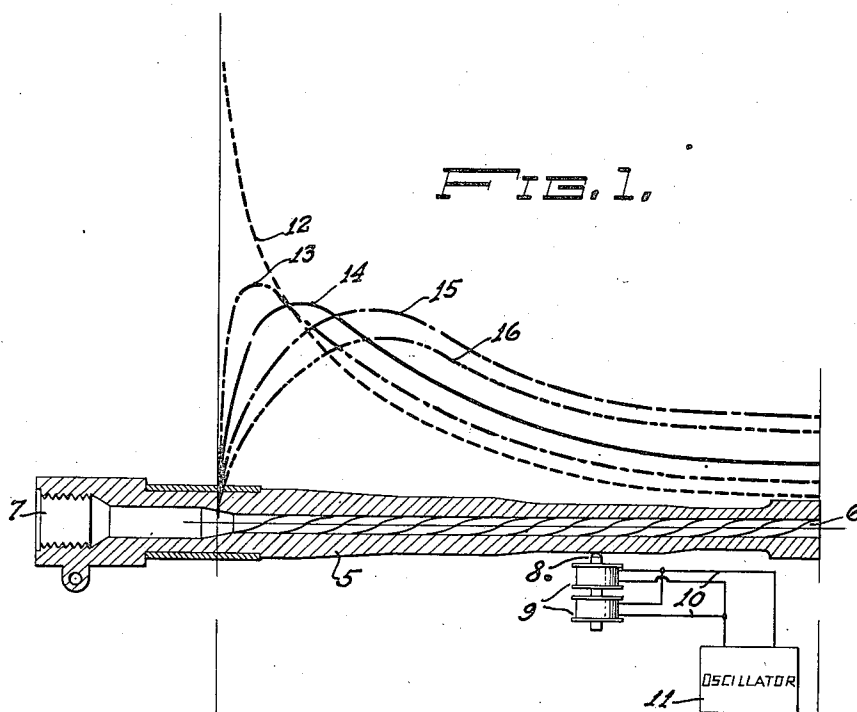
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A. VANG

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GUN

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UNITED STATES PATENT OFFICE

2,387,199

GUN

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Application September 23, 1942, Serial No. 459,366

2 Claims. (Cl. 89—1)

This invention relates to new and useful improvements in high velocity guns and more particularly it refers to a method and means for the reduction of friction between the projectile and the interior of the gun barrel by means of setting up forced vibrations in the latter.

It is well known in the science of ordnance that to obtain a high muzzle velocity of the projectile several important conditions have to be fulfilled. One of these is the relation between the time required for the burning of the charge and the time required for the projectile to traverse the length of the gun barrel. Other considerations are the maximum pressure and resulting strains which the gun barrel can stand, as well as the frictional resistance between the rifled gun barrel and the projectile. With higher and higher pressures being made possible by the use of new, improved steel alloys for gun barrels, one of the most serious limitations to the attainment of extremely high muzzle velocity has been the great amount of wear caused upon the interior of the gun barrel by the friction and resulting high temperature of the projectile. This wear is so great that on certain large naval guns it is only possible to fire about ninety projectiles before replacing the barrel.

It is also well known that the rifling of a gun barrel is necessary to obtain the desirable rotary motion of the projectile, which will produce the highest possible accuracy in hitting the target. The rifles are, therefore, necessary and cannot be dispensed with. There is also another reason for the necessity of rifles, namely, to obtain a sufficient friction to develop sufficiently high pressures from the charge and thereby to obtain the necessary muzzle velocity of the gun. In practice, therefore, it is necessary to strike a medium between excessive friction and the resulting excessive wear of the barrel and the desirable high muzzle velocity, which is necessary to obtain great range, great accuracy, and great penetration after hitting the target. According to the present day practices, the rifling may be either uniform or increased. The rifling usually consists of a number of helical grooves cut into the bore of a gun, beginning in front of the powder chamber and extending to the muzzle. The lands are the surfaces of the bore between the grooves. The chief purpose of rifling is to impart to elongated projectiles the rotation necessary to insure stability in flight. This is based upon the well known gyroscopic principle according to which a rotating body will try to keep its axis in a fixed position. The rifling must, there-

fore, of necessity have a definite relation to the muzzle velocity of the gun because if the projectile is caused to rotate with too great a speed its axis will remain in the same position it had in the gun barrel and it will not adapt its direction to the curved line of flight and a head-on impact will not be possible. This condition is called over-spin and is prevented by a careful consideration of the speed and weight of the projectile. Similarly under-spin will result in tumbling and instability in flight, which is just as undesirable as over-spin. The rate of rotation of the projectile, therefore, is an important design factor which must be carefully determined for any particular gun.

The problem of interior ballistics have been solved by many different investigators in various ways. One of the most commonly used solutions for the velocity and acceleration of the projectile is the famous Le Duc equation which may be written as follows:

$$v = \frac{au}{b+u} \quad (1)$$

where v is the velocity of the projectile, in feet per second, u is the travel of the projectile in the bore, in feet corresponding to v , and a and b are constants which must be determined for any particular gun.

The total force imparting velocity to the projectile is given by the relation:

$$\text{Force} = \text{mass} \times \text{acceleration}$$

Or if the unit force or unit pressure acting on the base of the projectile to produce velocity is designated with P , then:

$$P = \frac{w}{Ag} \frac{dv}{dt} \quad (2)$$

In Equation 2 A is the area of the base of the projectile in square inches, and g is the acceleration of gravitation, while dv/dt is the acceleration of the projectile. By differentiating Equation 1, one may obtain an expression for the acceleration of the projectile and which also gives a picture of the pressure curve because the powder pressure curve follows the acceleration curve of the projectile. The acceleration may, therefore, be expressed as follows:

$$\frac{dv}{dt} = \frac{a^2bu}{(b+u)^3} \quad (3)$$

Due to the above mentioned relation between the acceleration curve and powder pressure curve, one may determine the maximum pressure from

Equation 3 by differentiating same and equating to zero. By so doing it is found that when the pressure is a maximum:

$$u = \frac{b}{2} \quad (4)$$

therefore, the constant "b" is equal to twice the travel of the projectile to the point of maximum pressure.

From the pressure curves it is thus possible to calculate the muzzle velocity of guns and vice-versa if a given muzzle velocity is desired. One may determine the necessary pressure curve and thereby design the necessary strength of the gun barrel at its various sections. This is the basic consideration for the design of any type of gun, but in addition there are numerous other factors of considerable importance. One of these is the amount of friction developed by the rotating bands, which are usually located at one or two places of the projectile. The rotating bands are usually made from copper, brass, or other soft material, which will be engraved by the lands of the bore because the diameter of the rotating bands is always larger than that of the inside bore. The force of the pressure propelling the projectile, therefore, has to overcome the frictional resistance and provide the labor of formation required to engrave the rotating bands to fit the rifling of the barrel. In the case of guns with increasing twist this labor of formation is continuous because the grooves are constantly changing in angle to the axis of the bore. Due to the great weight of the projectile in guns of large caliber the rotating bands have to be of considerable thickness and width and therefore, the labor of formation required, as well as the amount of friction developed is very great. It is obvious, therefore, that a considerable amount of the energy developed by the charge will have to be expended in providing this labor of formation and overcoming the friction between the rotating bands and the lands and grooves of the bore. If a certain amount of this energy could be saved it is obvious that higher muzzle velocity could be obtained and greater range and penetration would result. It is to this particular end that my present invention is directed. I accomplish my purpose by means of vibrations set up in the gun barrel during the firing of the shot, thereby reducing the friction and labor of formation as will be hereinafter described.

In my application dated August 21, 1942, Ser. No. 455,642, for "Material drawing and forming by vibrations," I have described in detail how, by means of supersonic waves, I can temporarily reduce the tensile strength of a given material thereby making drawing and forming easier to accomplish and thus reducing the labor of formation and the friction developed during the operation. In the present invention I apply this principle to the projectile in a gun, and I have found that by the application of vibratory power of the proper frequency I can greatly decrease the labor of formation and the friction developed by the rotating bands in its path through the gun barrel. It is obvious that in this case I must apply vibrations which will only effect the tensile strength of the rotating bands because it would be undesirable to reduce the tensile strength of the gun barrel itself. This, however, can be practically accomplished because of the great difference in weight between the projectile and the gun barrel. For this reason vibratory power of a suitable frequency will set the pro-

jectile in violent vibrations without greatly affecting the gun barrel itself. This is so, because the natural frequency of the bands will be very much different from the natural frequency of that of the gun barrel. To obtain the natural frequency of the bands I apply variable frequency apparatus as described in the above identified co-pending application.

The object of my invention is, therefore, to provide a means of reducing the friction and labor of formation in the firing of a projectile.

Another object of my invention is to provide light and dependable sources of vibratory power whereby the projectile of a gun may be set into forced vibrations, thereby reducing the friction and increasing the muzzle velocity of the gun.

Other objects and advantages of my invention will be apparent during the course of the following description.

In the accompanying drawing, forming a part of this specification, and in which like numerals are employed to designate similar parts throughout the same,

Figure 1 is a section through a gun barrel embodying my invention,

Figure 2 is the velocity curve of the projectile in the gun barrel, and,

Figure 3 is an elevation of a conventional projectile provided with rotating bands.

In the drawing, wherein for the purpose of illustration, is shown a preferred embodiment of my invention, the numeral 5 designates the gun barrel proper with the rifled bore 6 and the breech 7. At a suitable point of the barrel 5 is applied the vibratory exciter 8, driven by coils 9, which are energized through wires 10 from oscillator 11.

In Figure 1 are shown various pressure curves 12, 13, 14, 15, and 16, which may be obtained by the use of various powders and charges. As mentioned supra, the shape of the pressure curves is influenced by the amount of friction and the labor of formation required to push the rotating bands through the grooves of the gun barrel. For a given gun and a given charge the pressure curve can be estimated as indicated supra. It is also, of course, possible for a given gun, to determine in advance the maximum pressure possible for a given section of the barrel. The curve 17 in Figure 2 illustrates the velocity of the projectile through the gun barrel. The muzzle velocity is the ordinate at the extreme right of Figure 2. As mentioned above, this velocity is dependent upon the pressure curves, the length of the barrel, the powder used and the friction developed, etc.

The operation of my invention is as follows:

In the application of my principle to any particular gun it is necessary, as mentioned supra, to predetermine the natural frequency of the bands and to make sure that the same is sufficiently far away from the natural frequency of the gun barrel itself. After the natural frequency of the bands has been carefully determined, an oscillator giving vibratory energy of this frequency is built and adjusted to give the proper amount of power at the correct frequency. The power furnished by the oscillator 11 is applied to the gun barrel 5 by means of the exciter coils 9 working upon the vibration exciter 8, which may be of various designs according to the frequency used and the amount of power to be transmitted. Means are also, of course, furnished for switching the vibratory energy off and on as desired.

After the proper frequency has been established and the vibratory power is available, the pressure curves of the gun can be determined for different charges for a given projectile. The charge is then selected, which will give the highest muzzle velocity inside of the limitations of the strength of the gun barrel. The gun is thus ready for use, and in the firing of the same it is only necessary to apply the vibratory energy either just before the charge is fired or simultaneously therewith. It is obvious that the application of the vibratory power to the gun barrel will cause the same to transmit these vibrations to the projectile and its bands and thereby the tensile strength of the bands will be reduced, and the friction will be reduced between the bands and the barrel, and the labor of formation required to engrave the rotating bands of the projectile will also be considerably cut down. It is also, of course, possible to use more tightly fitting rotating bands, if desired, thereby hanging the pressure curves so as to obtain other desirable qualities.

It is to be understood that the form of my invention, herewith shown and described, is to be

taken as a preferred example of the same and that various changes in the shape, size, and arrangement of the parts may well be resorted to without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described my invention I claim:

1. A method of reducing friction and labor of formation between a projectile having metal bands engaging the rifled gun barrel of a gun when said gun is fired to shoot said projectile, said method comprising vibrating said gun barrel during the firing period to produce vibration in said projectile to induce in the bands vibrations as near as possible to the natural frequency of vibration of said bands to increase the ability of the metal of said bands to flow under pressure.

2. A method for reducing the resistance to the passage of the engraveable portion of a projectile along the lands of a gun barrel, said method comprising vibrating said projectile at a frequency sufficient to substantially lower the tensile strength of the portion while the latter is in contact with the lands.

ALFRED VANG.

CERTIFICATE OF CORRECTION.

Patent No. 2,367,199.

October 16, 1945.

ALFRED VANG.

It is hereby certified that the name of the assignee of one-half interest in the above numbered patent was erroneously described and specified as "Stevens, Jordan & Harrison, Inc." whereas said name should have been described and specified as --Stevenson, Jordan & Harrison, Inc.--, as shown by the record of assignments in this office; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of January, A. D. 1946.

Leslie Frazer

(Seal)

First Assistant Commissioner of Patents.