

[54] **METHOD AND APPARATUS FOR
AUTOMATIC RANGING WITH VARIABLE
POWER TELESCOPIC GUN SIGHT**

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[51] Int. Cl. **G01c 3/20**

[58] Field of Search **356/20, 21; 350/10;
33/246**

[56] **References Cited**

UNITED STATES PATENTS

2,811,894	11/1957	Braker	33/246 X
3,684,376	8/1972	Lessard	356/21
3,492,733	2/1970	Leatherwood	350/10 X
3,213,539	10/1965	Burris	350/10 X
3,386,330	6/1968	Burris et al.	356/21
3,506,330	4/1970	Allen	356/21 X
2,734,273	2/1956	Blindenbacher et al.	356/21
3,431,652	3/1969	Leatherwood	356/21 UX

Primary Examiner—David Schonberg

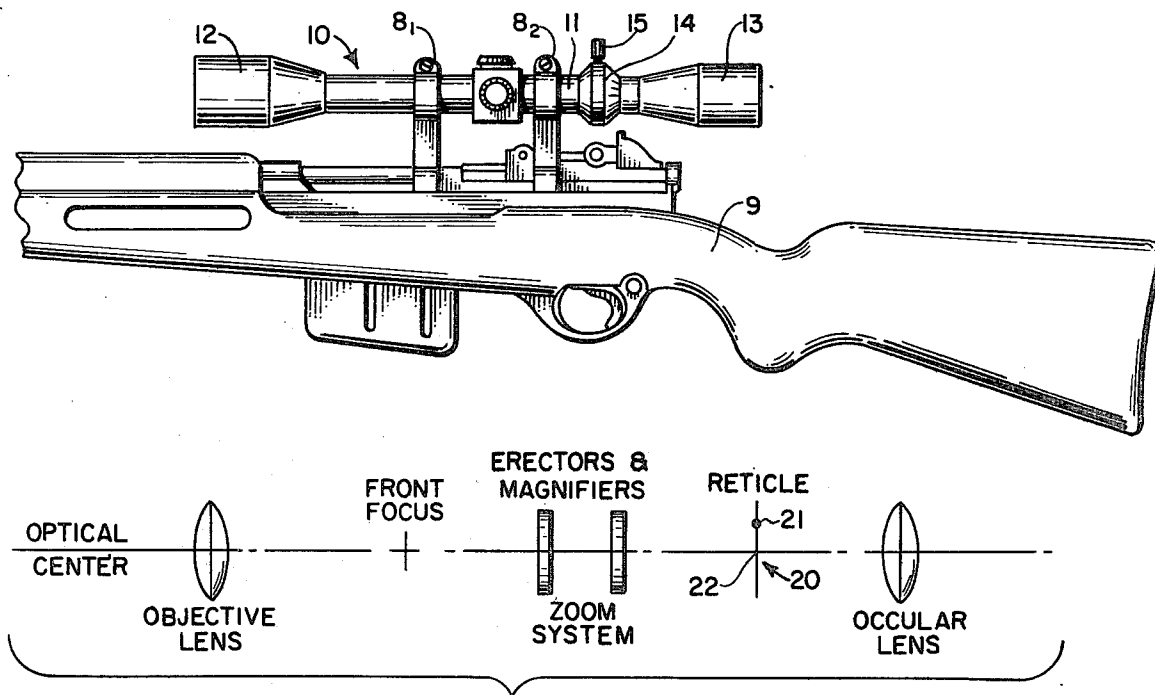
Assistant Examiner—Paul K. Godwin

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[57] **ABSTRACT**

In a variable power telescope gun sight, provided with stadia and aim point at the rear focus between the ocular lens and zoom system, an aim point is located above the optic center and correlated with bullet trajectory. The distance of off set of the aim point is such that, at minimum power, the aim point is zeroed relative to the stadia for impact at minimum range, this usually being the point blank range of the projectile, and at some higher power relative to an increase in range the projectile is again zeroed, in that the projectile impact and the aim point coincide. The novel telescopic sight and method of its use are based on the observations that (1) between approximately $\frac{1}{3}$ and $\frac{2}{3}$ maximum range and maximum range the trajectory of a high velocity bullet is substantially linear, (2) that as magnification is increased the aim point will appear to move downwardly toward optic center and (3) that the low power and some higher power of the telescope, respectively, can be correlated with a zero at the minimum and maximum range, respectively, with reference to the stadia. Correlated in such manner, changes in magnification, in the optic sense automatically set the aim point for firing without any necessity of the observer knowing the actual distance to the target.

7 Claims, 7 Drawing Figures



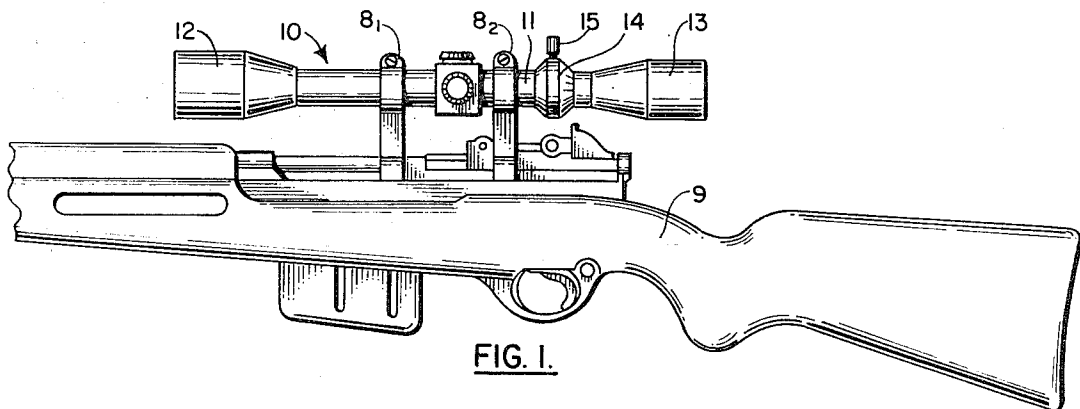


FIG. 1.

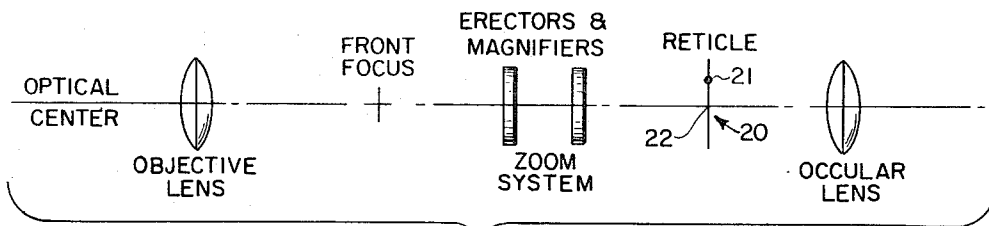


FIG. 2.

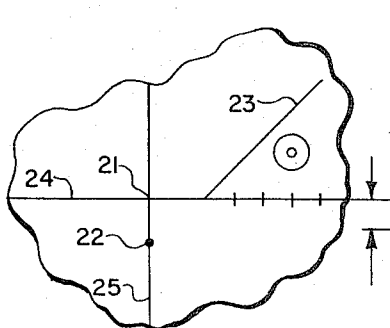


FIG. 3.

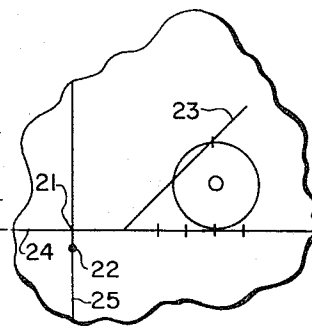


FIG. 4.

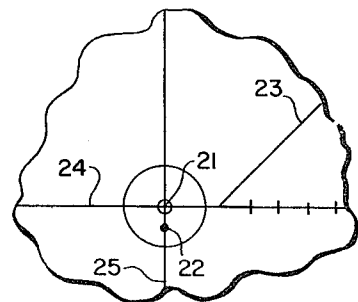


FIG. 5.

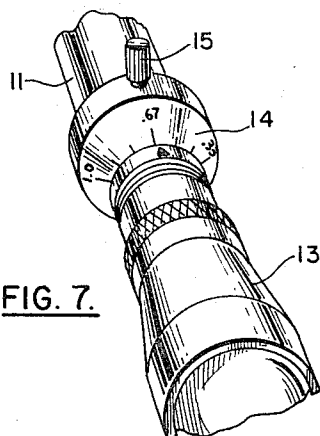


FIG. 7.

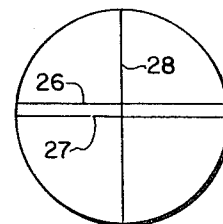


FIG. 6.

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METHOD AND APPARATUS FOR AUTOMATIC RANGING WITH VARIABLE POWER TELESCOPIC GUN SIGHT

Apparatus and method for automatic adjustment of the aim point of a variable power telescope with changes in magnification, with consequent changes in the bullet trajectory, without any necessity of the observer knowing the actual distance to the target. The aim point appears to move downwardly with increasing magnification, this allowing power increases as range increases, as is desirable for precision of aim.

Telescopic gun sights have been long known in the art, and it has become commonplace for sportsmen to mount such devices on small fire-arms, particularly rifles. In the standard telescopic gun sight there are two points of focus at which a reticle, or device which carries an aim point, e.g., cross hairs, can be located, viz., at the front focus or rear focus. In variable power telescopes it has now become most desirable to locate the reticle at the point of rear focus so that as power is increased, the apparent size or thickness of the reticle is not magnified, such as would tend to obscure the target.

Recently introduced telescopes which include a variable power or zoom element include the above described improvement in reticle location, and also built-in rangefinders of various types. In most telescopes now on the market, various indicia defining an aim point, e.g., the point where the vertical and horizontal lines of cross hairs intersect, is located within the telescope at the exact optical center (the point which does not move when power is changed). In most commercial variable power telescopes, once the range has been determined by use of the built-in rangefinder, the observer holds over the target to compensate for the difference between the range at which the telescope and rifle are zeroed and that estimated for the range of the target, and then fires.

A telescope with a built-in rangefinder of the above type, now in wide commercial use, is described in U.S. Pat. No. 3,386,330. In the telescope described therein, a target of known size is precisely circumscribed between stadia wires, and by change of power or magnification, the distance of the target from the observer can be read from a scale. Knowing the range, the observer can then select the magnification desired and then hold over the target to compensate for the difference between the range at which the telescope and rifle are zeroed and the distance to the target as determined by the known ballistics of the type of cartridge used, and then fire. The aim point is the optical center of the telescope sight which is held over the target by an amount estimated to compensate for the trajectory of the bullet, or bullet drop. The time required for adjustments of power, to estimate range, return to a desired magnification and mentally compute hold-over obviously have their limitations.

Devices are now described, e.g., in U.S. Pat. Nos. 3,340,614 and 3,492,733 which automatically adjust the trajectory of the bullet simultaneously with power changes, i.e., the steps of changing the power for framing a target between a pair of stadia automatically adjusts the trajectory for firing without any necessity of the observer knowing the actual distance to the target. Telescopic sights have thus been pivotally mounted in relation to a gun barrel so that power adjustments made

in framing a target between a pair of stadia raises or lowers the telescope with relationship to the barrel to align the optical center of the telescope upon the target after the adjustments are completed. Hold-over is unnecessary, and after the target is so framed, and the mechanical adjustment for trajectory thus made, a pair of stationary cross hairs, one horizontal and one vertical, which cross at the optical center of the telescope, is then sighted upon the target, and the gun fired.

U.S. Pat. No. 3,431,632 also described a telescopic gun sight wherein power adjustments automatically compensate for bullet trajectory without there being any necessity of the observer knowing the actual distance between himself and the target. In the device described, a scale ring is used to elevate and vertically space a pair of movable horizontal cross hairs to circumscribe a target of known size. The aim point defined by the lower horizontal cross hair and a fixed vertical cross hair is automatically set at the proper elevation to fix upon the circumscribed target. The above patents are technically superb, however, they require major modification to current design of telescopes or mounts and the non-stationary mounting gives rise to accidental displacement by rough service or the introduction of foreign particles between cam and stationary mount stud.

The telescopic gun sight embodied by the present invention obviates many of these disadvantages and provides further improvements over these and other known prior art telescopic sighting devices.

Among the objects of this invention are:

To provide a new and improved variable power telescopic gun sight which contains a rangefinder, or stadia, and means for changing magnification power while simultaneously automatically adjusting the reticle or aim point to compensate for the trajectory of the bullet, whether or not the actual distance to the target is known.

To provide a variable power telescope of the character described wherein the reticle or aim point is located in a vertical plane above the optic center of the telescope, and an exact relationship is provided between the eccentric reticle or aim point and an external ring which operates to produce magnification or power changes such that increases in magnification causes the reticle or aim point to move downwardly toward the optic center of the telescope thereby optically compensating for the bullet trajectory at increased ranges, whether or not the actual distance to the target is known.

To provide a telescopic gun sight of the character described wherein the relationship between the external ring which operates power magnification changes and the reticle can be easily adjusted to match the type of ammunition used.

To provide a more durable telescopic gun sight of simple structure, particularly one wherein there are no complicated mechanical adjustments to be made by changing the alignment between the telescope and the gun barrel during ranging and firing.

To provide a new and improved reticle with rangefinder of design particularly useful for fitting to targets of various known sizes (from small game to that of elk or moose size), adapted for rapid and efficient use by the observer, capable of both vertical and horizontal measurement.

These and other objects are achieved in accordance with the present invention which embodies improvements in telescopic gun sights, comprising the usual combination of a telescopic tube which contains objective lens, ocular lens, erectors and magnifiers for effecting change in magnification (i.e., a zoom system) and a power change mechanism or adjusting means for changing the magnification or power. In the improved combination, a reticle with aim point directly above the optic center, with respect to image, is located within the rear focus of the lens system, with stadia as used for estimating distance. The aim point is correlated, empirically or by calculation, with the trajectory of the gun on which the telescope is used, as determined by ballistics data, such that as magnification or power is increased relative to the stadia the aim point moves vertically downwardly to track the path of the bullet in flight as it falls due to the influence of gravity.

By locating the reticle within the rear focus between the ocular lens and the erectors and magnifiers of a variable power telescope, with an eccentric aim point directly above optic center, it is thus found that the aim point moves, in an optical sense, vertically downwardly with respect to the field as power is increased. By correlation between the paths defined by this optical change and bullet trajectory, which of course is also downward, with the combination of stadia, or rangefinder, a target can be ranged with the desirable quality of allowing power increases as range is increased. The degree of displacement of the aim point is such that as magnification is increased on a linear relationship with range, which can be read from the rangefinder, if desired, but whether or not the observer has any knowledge of the actual distance to the target, compensation is automatically made for the range and the aim point is centered directly on the target.

The invention, and its principle of operation, will be more fully understood by reference to the following detailed description of a specific embodiment, and to the attached drawings to which reference is made in the description. Subscripts are used to show a plurality of similar parts or components.

In the drawings:

FIG. 1 depicts a side elevation view of a variable power telescopic gun sight in accordance with this invention mounted on a rifle;

FIG. 2 depicts schematically the optical system of a standard variable power telescopic gun sight as embodied in this invention;

FIG. 3 depicts the essentials (the full field not being shown) of a preferred type of reticle cell or reticle disk which includes both aim point and stadia as embodied by the present invention;

FIGS. 4 and 5, taken together with the preceding figure, depict a series of views illustrating the method of enabling the observer to circumscribe and range a target using a preferred type of stadia while automatically setting the aiming indicia for firing, whether or not the observer is aware of the actual distance to the target; and

FIG. 6 depicts another preferred type of reticle for automatic range compensation, this design providing a pair of horizontal cross hairs which provide stadia, these intersecting with a vertical cross hair, one cross hair or aim point being at optic center and the other above optic center. The upper cross hairs provide an

eccentric aim point for automatic ranging and the other an aim point for conventional aiming.

FIG. 7 depicts a ring scale with indicia markings correlating the range to target as determined by stadia, which would allow the use of the reticle on arms having vastly different trajectories. In this case the ring scale is marked according to decrease from maximum range.

Referring to FIG. 1 there is shown a variable power telescopic gun sight or telescope 10 mounted via clamps 8₁, 8₂ on a rifle 9, the latter per se forming no part of the present invention. The telescope 10 includes the conventional barrel 11, an eyepiece 12, an objective 13 and an adjustment ring 14, provided with a handle 15 to facilitate adjustment and operation of internal linkage (not shown) which actuates a zoom element within the telescope so that the target image can be made to look larger or smaller in proportion to the field.

The optical system, which is depicted schematically by reference to FIG. 2, also includes the conventional objective lens, ocular lens and erectors and magnifiers which constitute a zoom system. In accordance with this invention the reticle, with its eccentric aim point, and the stadia or rangefinder are located within the rear focus of the optical system rather than within the front focus. Reticle 20 with its eccentric aim point 21 above optical center 22, with stadia or rangefinder, in combination with the conventional optic system described, constitutes the apparatus features of the present invention. The method and principles of circumscribing and ranging a target using a preferred type of stadia or rangefinder which in the optic sense automatically sets the aim point 21 for firing, whether or not the observer is actually aware of the distance to the target, is hereinafter described.

A preferred type of reticle, which can be illustrated by reference to FIG. 3, comprises a reticle cell, preferably a disk 20 constituted of any suitable transparent material such as plastic or glass, the disk being generally flat or of plano form. The transparent reticle disk 20 is scribed with a vertical line 25 and horizontal line 24, or indicia marks, which intersect to provide an eccentric aim point 21, or point which lies above the optic center 22 which is also generally the geometric center of the disk. A diagonal line or indicia mark 23 joins horizontal line 24 at a 45° angle, and the segment of horizontal line 24 lying below diagonal line 23 is scribed with numerals or other indicia representative of the vertical distances between lines 23, 24 at any given point on the horizontal scale. (Horizontal distances can also be measured between the point of intersection of lines 23, 24 and a point located on the horizontal scale.)

The vertical distances between lines 23, 24 define stadia and, at a preselected magnification, are a measure of distances between corresponding points within the field of view. When a target of known height, at such magnification, is framed between a pair of vertically aligned points lying on lines 23, 24 respectively, therefore, the distance to the target is known, and it has been conventional to provide means whereby such range could be read from a scale. In accordance with the present invention, however, it is unnecessary to actually know the distance to the target. Instead, the eccentric aim point is automatically moved downwardly, in the optic sense, in response to power increases, or conversely upwardly in response to power decreases

such that at the moment the target is framed the aim point is set for sighting and firing.

The technique of sighting and firing is best illustrated by reference to FIGS. 3 through 5, wherein it is assumed that both the telescope and rifle have been zeroed at maximum magnification to frame and strike a target at 400 yards distance, and that the scribed numerals along horizontal line 24, lying vertically below points on line 23, are read in inches. The observer sights in on a circle or bull's eye known by him to be 15 inches in diameter as shown in FIG. 3. The target does not fit between lines 23, 24 at the 15-inch scale, but is too small. Magnification is too low, e.g., 4 power. The observer knows, therefore, that the target is far away and that if a shot were fired that it would fall too low. The power is therefore increased, e.g., to 8 power, the full power of the telescope, until the target fits the 15-inch scale as shown by reference to FIG. 4. The range is known or can be easily determined, but this is immaterial, for the aim point 21 is, in the optic sense moved downwardly in the field, a distance shown by the difference between the arrows, compensating for bullet trajectory so that the muzzle of the rifle is raised when the shot is fired as shown by reference to FIG. 5.

A preferred type of reticle design is also described by reference to FIG. 6. A parallel pair of horizontal cross hairs 26,27 form stadia, the lower cross hair 27 being located at optical center. The point of intersection of vertical cross hair 28 forms an off-set aim point for automatic range compensation, the distance between the cross hairs 26,27 being used to span an object of known dimension. The compensation is generally from about 4 to 30 inches above optical center at 100 yards, and preferably from about 4 to 17 inches above optical center at 100 yards. For most sporting purposes, compensation of from about 6 to 12 inches above optical center at 100 yards on lowest available magnification is most preferred. The point of intersection of cross hairs 27,28 forms an aim point for conventional firing.

Referring to FIG. 7, there is shown a power selector ring scribed with an indicia scale representative of a range of values between a maximum compensated range at full magnification (M_H) and a minimum range at low magnification (M_L). For example, in utilizing a scope where maximum magnification is three times the power at minimum magnification, i.e., in a 3X-9X variable power telescope, M_H could be conveniently assigned a value of 1.0 and M_L a value of 0.33. The power is linear within this range and hence the witness mark could be used to clearly indicate the range of values representative of distances in terms of fractional units between minimum and maximum range, or fractional power units between 3X and 9X.

The present invention is based on the recognition that, in the optic sense, when the magnification of a variable power telescope with a non-magnifying reticle is changed, all points outside the optical center of the image will appear to shift inversely with power change in a one-to-one ratio, e.g., points 6 inches apart at 4 power become 2 inches apart at 12 power. The change in an aim point located above optic center, in conjunction with stadia which will also appear to move downwardly with increases in range, although linear with respect to range, can be correlated with a given segment of a curve representative of the trajectory of a bullet, the net change required being dependent on range, velocity, and the ballistic coefficient of the bullet. Thus, the reticle movement is selected such that at some low power relative to range and stadia it is zeroed for tra-

jectory and at some higher power relative to range increase it is also zeroed by the downward movement of the aim point. Thus, the low power magnification M_L is zeroed at M_L/M_H of the maximum range and the higher power, M_H , is zeroed at the maximum range, and between these two ranges bullet drop is approximated very closely by the off-set reticle. The best trajectory fit by the reticle is obtained with a high power to low power ratio of 1.5 to 3.0. The power ratio, however, is immaterial as all or only a portion of the full power can be selected to compensate between the two zero ranges. After a balance of maximum possible range to allowable error has been made, the excess power ratio may be used to extend the range finding capability and decrease hold-over normally required.

The degree of off-set may be found by trial and error or by calculation, and for most sporting purposes will be 2 to 8 minutes of angle above the optic center at the higher magnification. This off-set is fitted to the trajectory by the distance of off-set, or the trajectory may be fitted to the off-set by allowing the span value of the stadia and the maximum range to become variables. The movement of the reticle from minimum zeroed range (X_L) to maximum zeroed range (X_M) is linear and continuous with range changes. Therefore, the reticle describes a straight line between the two points at which zero occurs, the actual trajectory is a curve and at mid-ranges lies slightly above that line described by the reticle movement between the two zero points. The error introduced is greatest at the mid-point of minimum range and maximum range, e.g., at 300 yards if the X_L is 200 and X_M is 400 yards, this error being generally no more than 1 to 4 inches up to distances of 400 or more yards for high velocity arms having muzzle velocities ranging upward of about 2,700 feet per second which fire bullets having 0.30 or greater ballistic coefficient (Ingalls). The error is generally less than the precision of the rifle.

The following parameters are typical for a 0.30-06 caliber rifle when zeroed at 200 yards:

Range, in Yards	100	200	250	300	350	400
Actual Bullet Path, inches	+1.8	0	-3.3	-7.8	-13.4	-22.4
Reticle Movement, inches	0	0	-5.5	-11.1	-16.6	-22.4
Error in Aim, inches	+1.8	0	+2.2	+3.3	+3.2	0

In the above case the $M_H/M_L = 2.0$, the minimum range = 200 yards, maximum range = 400 yards. If the variable powers M_L and M_H were 4 and 8, then at 200 yards the shot would have been made at 4 power, at 400 yards on 8 power, at 300 yards at 300/400 times the M_H (or $\frac{3}{4}$ times 8X) on 6 power, etc.

It is apparent that various modifications and changes can be made without departing the spirit of the present invention. The exact amount of off-set of the aim point above optic center can thus be determined empirically or by actual calculation.

Thus, an approximate calculation of these parameters is had by the following formulas:

1. The desired distance to off-set the reticle, (Q), at highest desired magnification, in inches at 100 yards, is defined by the formula:

$$Q = M_L/M_H [B_4 X_M + B_3] X_M + B_2] X_M^2 (A)/X_M$$
 wherein: $A = 1.049$ where $M_H/M_L = 2$ and 0.960 where $M_H/M_L = 3$

$$B_2 = 17.6/V^2$$

V = muzzle velocity in thousands of feet per second

$$B_3 = 0.50 K (1 - 0.6/V) B_2$$

$$B_4 = 0.1815 K (1 - 1.2/V) B_3$$

$$K = 1/CV^{3/4}$$

M_H = highest magnification

M_L = lowest magnification

C = ballistic coefficient (Ingalls)

Q = off-set required at highest magnification, inches at one hundred yards

X_M = maximum desired range for automatic compensation in hundreds of yards

2. The point blank range, (X_L), the minimum range of automatic compensation and also the range at which the rangefinder span is calibrated at minimum magnification, in hundreds of yards, is given by the formula:

$$X_L = (M_L/M_H) \times X_M$$

3. Reticle movement, (T), in inches, from one range setting to another is described by the following equation, the limits of the range being defined as X_L to X_M .

$$T = X_2 \cdot X_M \cdot Q(1/X_2 - 1/X_0)$$

wherein:

X_0 = base or zero range in hundreds of yards

X_2 = range in hundreds of yards for which movement is desired from the base range

The reticle used to circumscribe the full field of view is preferably of circular design, though the horizontal length can also be greater than its vertical length (height). The reticle is preferably constructed as a unitary member, and includes both the aim point and the stadia, or rangefinder. The aim point can comprise essentially any kind of indicia, cross hairs, a dot, an open juncture between converging lines, and the like. The rangefinder can be any type of device normally used for measuring distance, but preferably the rangefinder is as described, though it can be located virtually anywhere within the field away from the optic center.

It is also feasible to grind ocular lens such that the optic center does not correspond with the geometric center, and thus the off-set or eccentric aim point may appear centered.

It is apparent that these and other various changes, such as in the absolute or relative dimension of the parts, materials used, use of constant off-set for manufacturing purposes with allowance of maximum range variance to fit ballistics data, and the like, can be made without departing the spirit and scope of the invention, as will be apparent to those skilled in the art.

Having described the invention, what is claimed is:

1. In a variable power telescopic gun sight for mounting on a gun wherein is included the combination of a barrel with enclosed objective lens, ocular lens, zoom system comprised of erectors and magnifiers, which

provide a front focus and rear focus, and means mounted on the barrel for changing the magnifying power of the telescope, the improvement comprising locating a reticle, with stadia and a fixed aim point physically located above the optic center of the telescope, at the rear focus between the ocular lens and the zoom system whereby power increases will cause the aim point to appear to move downwardly toward the optic center of the telescope and thereby automatically compensate for the trajectory of a bullet fired from the gun.

2. The apparatus of claim 1 wherein the aim point of the reticle is off-set above the optic center of the telescope by a distance sufficient to correlate a linear bullet trajectory, at high magnifying power, where the gun is zeroed, at maximum compensated range for the gun and, at lower magnifying power, where the gun is also zeroed, with a range defined by the formula M_L/M_H of maximum; wherein M_L equals the power of the telescope at low power and M_H equals the power of the telescope at high power magnification.

3. The apparatus of claim 2 wherein the telescope contains a reticle cell having a vertical cross hair and a pair of parallel horizontal cross hairs, one located above optic center and the other at optic center, the pair of horizontal cross hairs also defining stadia as well as an off-set aim point and a conventional aim point, respectively.

4. The apparatus of claim 1 wherein the stadia are comprised of a pair of lines which adjoin one to the other at an angle of 45°.

5. The apparatus of claim 4 wherein one of the lines is horizontal, and provided with indicia indicative of the height of a target within the field of the telescope.

6. In a variable power telescopic gun sight for mounting on a gun wherein is included the combination of a barrel with objective lens, ocular lens, zoom system comprised of erectors and magnifiers, which provide a front focus and rear focus, a reticle located at the rear focus between the ocular lens and the zoom system, stadia, and means for changing the power of the telescope, a method for correlating the trajectory of a bullet fired from the gun comprising physically locating a fixed aim point within the rear focus above the optic center at a distance such that, at high power, the aim point will be zeroed at the maximum range of impact of the bullet and at low power the aim point will be zeroed at a range defined by the formula M_L/M_H of maximum range; wherein M_L equals the power of the telescope at low power and M_H equals the power of the scope at high power magnification.

7. The method of claim 6 wherein at minimum power the telescope ranges from about one-fourth to about one-half of its maximum power.

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