July 30, 1946. J. D. TEAR 2,405,065

POWER DRIVEN GUN WITH AUTOMATICALLY POSITIONED SIGHT

Filed Nov. 18, 1940 2 Sheets-Sheet 1

Fig. 1

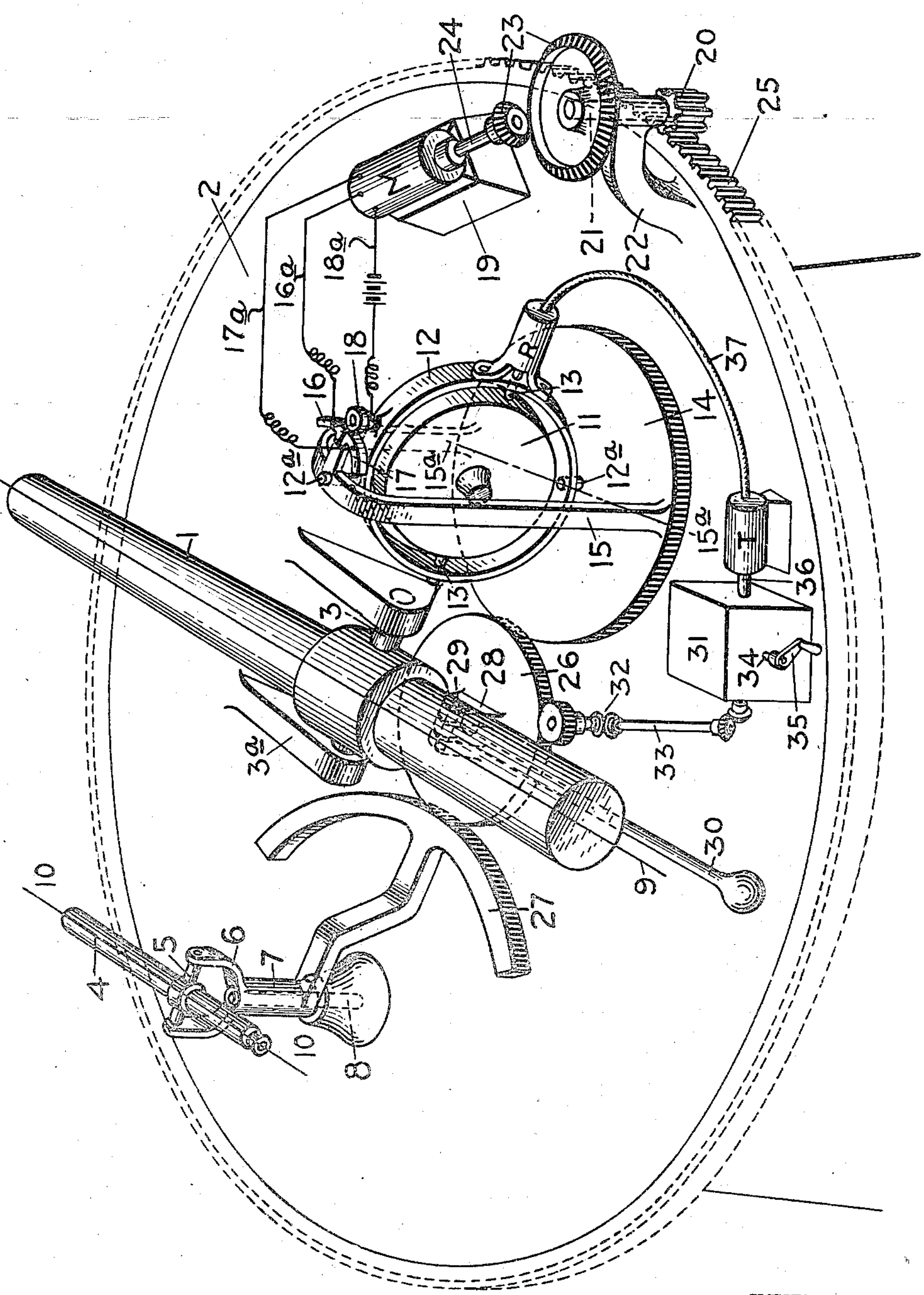

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Fig. 2

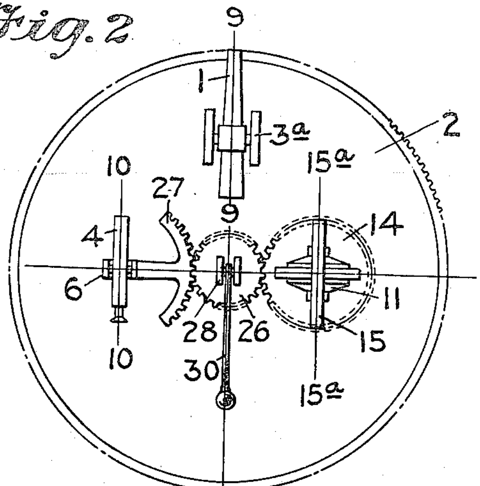


Fig. 3

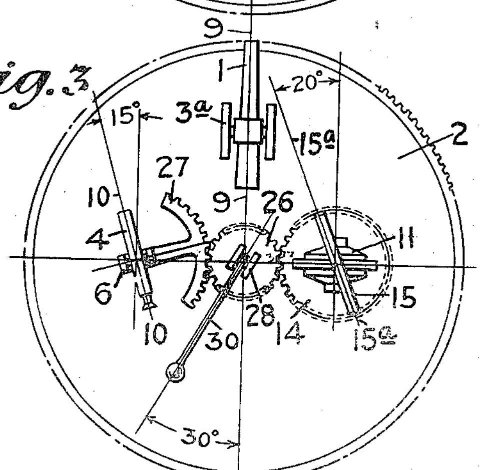
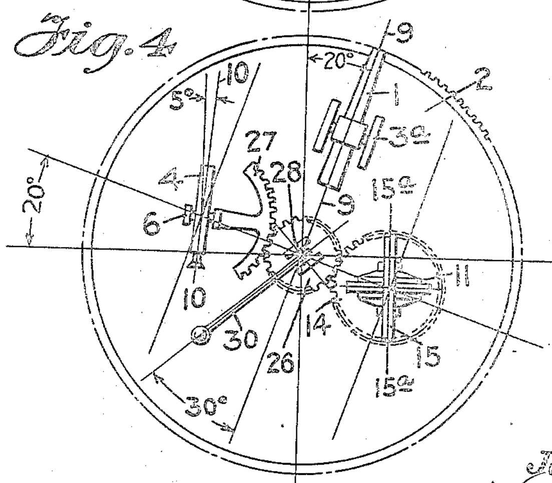


Fig. 4



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2,405,065

POWER-DRIVEN GUN WITH AUTOMATICALLY POSITIONED SIGHT

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8 Claims. (Cl. 89—41)

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This invention relates to sights for guns, especially of the type in which the gun is driven at an adjustable rate and the sight is automatically displaced from the gun in proportion to the rate so that the gun leads the sight to allow for the movement of the target during the time of flight of the projectile.

In sights of the prior art, such as is shown in United States Patent No. 1,067,859, it is customary to set the deflection (Ds) of the sight from the gun by simply angularly displacing the bore of the sight from the bore of the gun in proportion to the rate of train of the gun, or the rate of change in bearing (dB) of the target, and the time of flight (t) of the projectile, so that the gun leads the sight. This relation is expressed by the equation $Ds=t\cdot dB$. In the prior art, when the sight lagged behind the target due to an under set rate of train and an increased rate of train was set up, the sight was further displaced from the gun, as the displacement is proportional to the rate of train, and this increase in the displacement neutralizing for the moment the movement in train of the sight, caused operators in their efforts to keep up with and on the target to give further and greater changes in the rates of train than were required. When the sight thus over-corrected did come on the target and the rate of train was then decreased, the angular displacement, known as deflection, was also decreased thereby, causing the sight to be moved ahead of the target. This hunting action, especially when firing at high speed targets, made it extremely difficult to set the rate of train correctly and keep the sight on the target.

The principal object of this invention is to avoid this erratic action in adjusting the rate of train and the setting of the sight and the tendency to over-correct the sight for deflection by providing apparatus to mechanically train the gun and the sight support in a direction opposite to the direction of and during the application of the correction in deflection to the sight, an amount equal to the applied correction to the deflection and an additional amount in train to bring the sight on or slightly ahead of the target.

Another object of the invention is to provide in such apparatus a motor, controlled by contacts associated with a gyroscope, to train the gun and the sight support in a direction opposite to the direction of application of a correction of deflection an amount proportional to but exceeding the applied correction.

Another object of the invention is to apply in such apparatus a precessing force on the gyro

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to turn it in azimuth in a direction opposite to and in proportion to the set deflection.

Other objects will be apparent from a consideration of the specification and drawings in which:

Fig. 1 is a schematic perspective view of an embodiment of the invention;

Fig. 2 is a simplified plan view of an embodiment of the invention, showing the gun sight and gyro in their neutral or secured positions;

Fig. 3 is similar to Fig. 2, except that a deflection has been applied, without the training motor having functioned; and

Fig. 4 is similar to Fig. 3 except that the training motor has functioned in response to the set up deflection, but not in response to the precessing movement of the gyroscope.

Referring particularly to Fig. 1, the gun 1 is mounted on base 2 by the conventional elevation trunnions 3 rotating in brackets 3a. The sight 4 is mounted on elevation trunnions 5, yoke 6, and bushing 7, which is free to turn on stud 8 mounted on base 2. Lines 9—9 and 10—10, respectively, represent the bores of gun 1 and sight 4. The angle between lines 9—9 and 10—10 is a deflection, or the angular displacement of the sight from the gun.

A conventional gyroscope 11 is mounted in a vertical gimbal ring 12 on trunnions 13. The ring 12 is supported by trunnions 12a in gear disk 14 and the frame 15 supported on the disk 14. On gimbal ring 12 is mounted a receiver motor R, the rotor of which is connected to trunnion 13 of the gyroscope 11, whereby a precessing force may be applied to the gyro to cause it to precess in azimuth.

Gear disk 14 is mounted on base 2 and is free to turn about its own axis. Frame 15 mounted on disk 14 carries two contacts 16 and 17 insulated from the frame and from each other. These contacts cooperate with a roller 18 secured to ring 12, for making an electrical contact between roller 18 and either contact 16 or contact 17, according to the relative position of ring 12 with respect to the frame 15 or axis 15a—15a of disk 14 in the plane of frame 15.

A motor M secured to base 2 by lug 19 is connected to pinion 20 through shaft 21 journaled in bracket 22, gears 23 and shaft 24. Pinion 20 is in mesh with teeth 25 of a fixed ring gear surrounding base 2. Motor M is electrically connected to roller 18 by a conductor 18a which includes a suitable source of power. Contacts 16 and 17 are connected to the reversing leads of the motor M by conductors 16a and 17a respectively. Motor M angularly moves base 2 in a direction according to the relative position of roller 18 and contacts 16 and 17 and is of sufficient power to rotate base 2 as fast as sight 4 can be moved mechanically, as will be hereinafter described.

On base 2 is also mounted gear plate 26 which is free to turn about its own axis. Plate 26 is in mesh with gear disk 14 and with the teeth of arcuate arm 27 which is connected to bushing 7. In the center of plate 26 are mounted brackets 28 which support a conventional trunnion 29 to which is connected the operating handle 30.

Plate 26 is also connected to one input of a conventional dividing mechanism 31 by gears 32 and shaft 33. The other input of divider 31 is shaft 34, which is settable by crank 35 in accordance with the range or time of flight of the projectile. The output of divider 31, shaft 36, is connected to a transmitter T the output of which is connected to receiver motor R by cable 37. A suitable dividing mechanism is shown in Fig. 4 of Patent 1,450,585.

The ratios of the gearing between the gear plate 26 and gear disk 14 and between the plate 26 and arm 27 are determined by the characteristics of the gun to which the invention is to be applied and the general limits of range and initial velocity of the projectile to be fired. In one installation embodying this invention the ratio of gearing between plate 26 and arm 27 was two to one, and between plate 26 and 14 the ratio was three to two. The ratio of gearing between plate 26 and mechanism 31 was such that when the motion of shaft 33, which is proportional to deflection (Ds), was combined with the time of flight (t) as cranked in by shaft 34, the output of the divider

$$\left(\frac{Ds}{t}\right)$$

represented by the motion of shaft 36, was such that the force exerted by receiver motor R caused the gyro to precess at a rate (dB) proportional to the set deflection (Ds) of the sight and inversely proportional to time of flight (t) corresponding to the range of the target. This relation is expressed by the equation

$$dB=\frac{Ds}{t}$$

which is a transposed form of the well known equation $Ds=t\cdot dB$.

A conventional dash-pot mechanism (not shown) may be associated with handle 30 to restrict the quickness by which its position may be changed, so that the capacity of training motor M, controlled by contacts 16 and 17, and roller 18, is not exceeded.

Operation

The operation of the apparatus will be analyzed and described on the basis that the movements of the various parts of the mechanism are independent of each other. It will be realized of course that the movement of one part may simultaneously affect other parts, setting up other movements which may neutralize or overcome the movement set up in other parts of the apparatus.

As shown in Fig. 2, all the parts of the apparatus are in a neutral or secured position, with axes 9—9, 10—10 and 15a—15a, the spin axis of gyro 11 and the axis of handle 30 all parallel to each other. If it be desired to set up a deflection (Ds), of say "Right 15°," that is, the axis of the gun is to point 15° to the right of the axis of the sight, handle 30 is moved to point, say, 30° to the right. Gear plate 26 moves arm 27, displacing the sight 15° to the left of the gun. The 30° movement of handle 30 also displaces axis 15a—15a 20° to the left of the gun. These positions are shown in Fig. 3.

The movement of handle 30 also moves shaft 33 to a position representing the displacement of the sight (Ds) which movement is introduced into the mechanism 31, where it is divided by the time of flight factor (t) set up by shaft 34, causing transmitter T through receiver motor R to place a precessing force on gyro 11 of a sufficient value to cause gyro 11 to turn about its vertical axis at a rate (dB) proportional to the quotient of a deflection of 15° divided by the range of the target or time of flight of the projectile. Upon the movement of disk 14 with its frame 15, contact 17 comes into metallic contact with roller 18, which controls the power supplied to motor M to train the base 2 to the right so that the frame 15 remains aligned with the spin axis of the gyroscope 11.

In practice, the various parts do not assume the positions shown in Fig. 3 because the motor M drives the base 2 to the right as fast as or even faster than sight 4 is turned to the left relative to the base 2. Therefore, by the time handle 30 is pointed 30° to the right the relative positions of the gun, sight handle and disk 14 are as shown in Fig. 4, except that the movement of the gyro about its vertical axis due to applied precessing forces and the resultant movement of the gun has been disregarded. With no movement due to precession about the vertical axis of the gyro, the motor M would be stopped when the axis 15a—15a has passed through a theoretical movement of 20° to the left and a theoretical movement of 20° to the right, or in other words, remained aligned with the spin axis of the gyroscope 11, as roller 18 would then be in contact with the insulation between contacts 16 and 17. It will be noted, however, that the angular displacement of sight 4 from gun 1 is 15°, the deflection desired to be set up and the actual position of the base 2 with all of the parts secured thereto will be somewhat to the right rather than as shown in Fig. 4, due to the rotation of base 2 following the precession of the spin axis of gyro 11, which naturally takes place simultaneously with the movements of the sight 4, handle 30 and frame 15 relative to the base 2. The base 2 will continue to be rotated to the right at a rate of train determined by the deflection and range or time of flight values set up until handle 30 is pointed further to the right or to the left or the range or time of flight setting is changed when the rate of rotation will be determined by the new values set up.

If it be observed that the deflection of 15° and the corresponding rate of train is not great enough to keep the sight following on the target and the sight, say, lags behind the target requiring a greater deflection and rate of train, handle 30 is pointed more to the right and disk 14 is moved to the left and sight 4 is moved to the left relative to the base or gun. Motor M, controlled by disk 14 and gyroscope 11, moves base 2 farther to the right and a distance greater than sight 4 is moved to the left, so that the sight is actually moved to the right and brought up to the target. At the same time plate 26 operating through mechanism 31 sets up a higher rate of precession of the gyro 11.

It will thus be seen that this arrangement avoids the difficulties experienced in the prior art due to the required over-correcting of the deflection to bring a lagging sight on the target. In the present invention, increasing the rate of train of the base not only overcomes the rate of the lagging of the sight and gun but also advances the position of the gun and sight to move them through the actual lag of the sight behind the target at the time that a correction in deflection was observed to be required.

The invention is shown as applied to the training of a gun and the setting up of a deflection and the corresponding rate of train, but it is apparent and intended that the invention shall be applied to other movements of the gun relative to its base, such as elevation. It is also contemplated that various dials may be applied to the mechanism for indicating the instantaneous values represented by the different parts of the mechanism as described.

In the fire control art, it is well known that when a torque is applied about one axis of a gyro, the gyro will precess about the axis at right angles to the axis about which the torque is applied, and the gyro will precess at a rate proportional to the applied torque. A gyro acting under a precessing force integrates a movement proportional to the summation of the instantaneous values of the applied torques. A precessed gyro is therefore considered the equivalent of other types of integrators or variable speed devices.

It is evident that various changes may be made in the form, construction and arrangement of the various parts of the mechanism without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. In combination, a base mounted for angular movement, a gun mounted on the base, a sight mounted for angular movement on the base, a frame mounted for angular movement on the base, a gyro mounted for angular movement in the frame, all axes of movement being substantially parallel, power means responsive to relative angular movement between said gyro and said frame to angularly move said base, a control member for angularly displacing in respectively different amounts the sight and the frame relatively to the gun, and means settable by the control member for applying a precessing force to the gyro.

2. In combination, a base mounted for angular movement, a sight mounted on the base and adapted to angular movement relative thereto, a frame mounted on the base and adapted to angular movement relative thereto, a gyro mounted for angular movement in the frame, all axes of movement being substantially parallel, power means responsive to relative angular movement between said gyro and said frame to angularly move said base, a control member mounted on the base and adapted to angular movement relative thereto, means settable in accordance with a function of the range, and means settable by the control member and the settable means for applying a precessing force to the gyro.

3. In combination, a base mounted for angular movement, a gun mounted on the base, a sight mounted on the base and adapted to angular movement relative thereto, a frame mounted on the base and adapted to angular movement relative thereto, a gyro mounted for angular movement in the frame, all axes of movement being substantially parallel, a control member for angularly displacing the sight and the frame relatively to the gun, power means for rotating the base, and means positioned by relative angular movement between the gyro and the frame for controlling the power means.

4. In combination, a base mounted for angular movement, a gun mounted on the base, a sight mounted on the base and adapted to angular movement relative thereto, a frame mounted on the base and adapted to angular movement relative thereto, a gyro mounted for angular movement in the frame, all axes of movement being substantially parallel, control means for angularly displacing in respectively different amounts the sight and the frame relatively to the gun, means for rotating the base, and a pair of contacts on the frame and a cooperating contact on the gyro for controlling the rotating means.

5. In combination, a base mounted for angular movement, a gun mounted on the base, a sight mounted on the base and adapted to angular movement relative thereto, a frame mounted on the base and adapted to angular movement relative thereto, a gyro mounted for angular movement in the frame, all axes of movement being substantially parallel, a control member for angularly displacing in respectively different amounts the sight and the frame relatively to the gun, means settable in accordance with a function of the time of flight of the projectile, means settable by the control member and the settable means for applying a precessing force to the gyro, power means for rotating the base, and means connected to the frame and the gyro automatically operated by relative angular movement therebetween for controlling the power means, whereby the base is turned an amount proportional to but greater than the angular movement of the sight relative to the gun and also in angular movement at a rate proportional to the precessing force applied to the gyro.

6. In gun sighting apparatus, a gun mounted for angular movement, power means for moving said gun, a sight angularly movable relative to said gun, a frame angularly movable relative to said gun, all axes of movement being substantially parallel, control means for proportionately moving said sight and said frame relative to said gun, said sight and frame being connected to move in the same direction but said sight moving to a lesser angular amount than said frame, a gyro mounted for angular movement in said frame, means for applying a precessional force to the gyro proportional to movement of the control means and means actuated by relative movement between said frame and said gyro to cause said power means to move the gun.

7. In a gun sighting apparatus, a gun mounted for angular movement, a control member mounted for angular movement relative to said gun about an axis parallel to that of the gun, power means including a power output connected to effect angular movement of the gun, means including a rate input member for controlling the rate of movement of the power output in proportion to the displacement of the rate input member, means actuated by the control member to displace the rate input member an amount proportional to the displacement of the control member relative to the gun, and means actuated by the control member for additionally actuating the power output to effect angular displacement of the gun proportional to the displacement of the control member.

8. In a sighting apparatus, a gun mounted for

angular movement, a sight mounted for angular movement relative to the gun, a control member mounted for angular movement relative to the gun, all three axes of movement being parallel, power means including a power output connected to effect angular movement of the gun, means including a rate input member for controlling the rate of movement of the power output in proportion to the displacement of the rate input member, means actuated by the control member to displace the rate input member an amount

proportional to the displacement of the control member relative to the gun, means actuated by the control member for additionally actuating the power output to effect angular displacement of the gun proportional to the displacement of the control member, and means actuated by the control member to displace the sight reversely relative to the gun an amount proportional to the displacement of the control member.

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