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(71) Applicant **The Marconi Company Limited, Marconi House, New Street, Chelmsford, Essex**
(72) Inventors **William Finn, George Duckworth**
(74) Agent **R. K. Tolfree, c/o The Patents Department, The Marconi Company Limited, Marconi House, New Street, Chelmsford, Essex**

(54) Improvements Relating to Gun Sights

(57) On the body 7 of a tank are mounted a gun 5 which pivots about axis 1 and a sight 8 which pivots about an axis 2.

To ensure that the sight 8 is aligned with the gun 5 for all angles of elevation the sight 8 and gun 5 are joined by a link 13. Adjustments must be made to ensure that the axes 1, 2, 3 and 4 lie at the corners of a parallelogram. This is done by setting the gun at midrange and adjusting turnbuckle 13A until the sight is aligned with it. The gun is then lowered to a given elevation and the error in the elevation of the sight is noted. The gun is then raised to another elevation and the error in the elevation of the sight again noted. From the two error values the adjustment required to the distance between axes 2 and 3 and the distance between axes 3 and 4 can be calculated. A special adjusting mechanism (Fig. 2: not shown) is used to carry out these adjustments, and moves the axis 3 in two orthogonal directions.

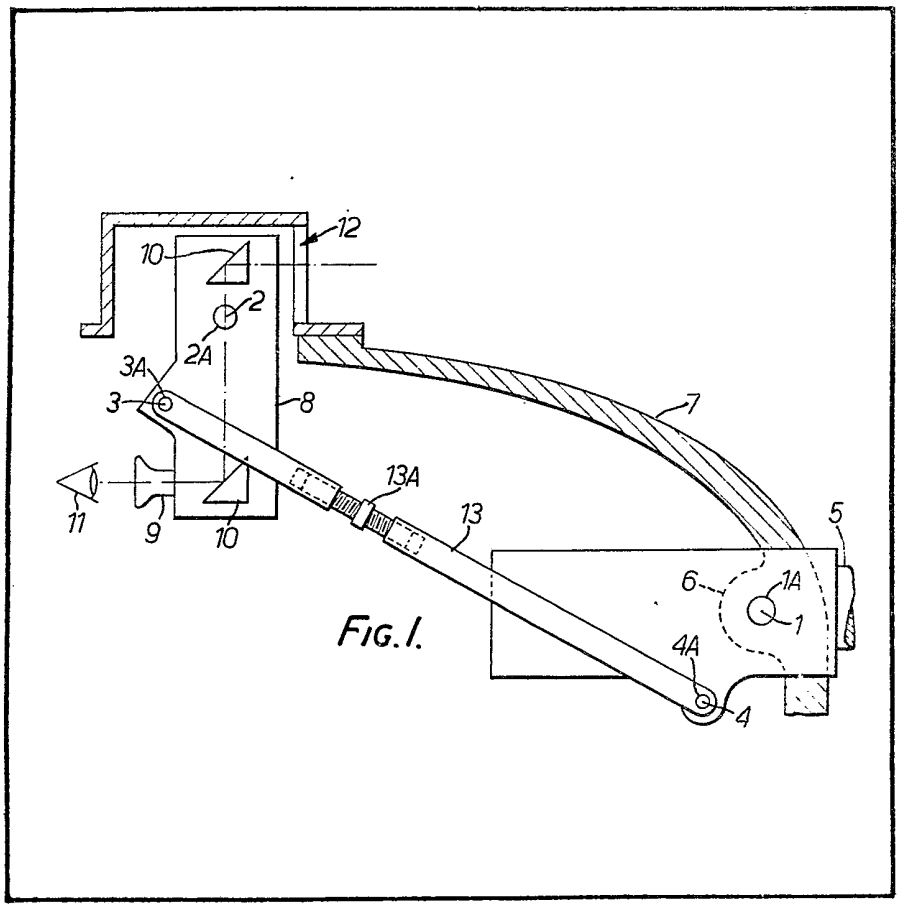

FIG. 1.

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The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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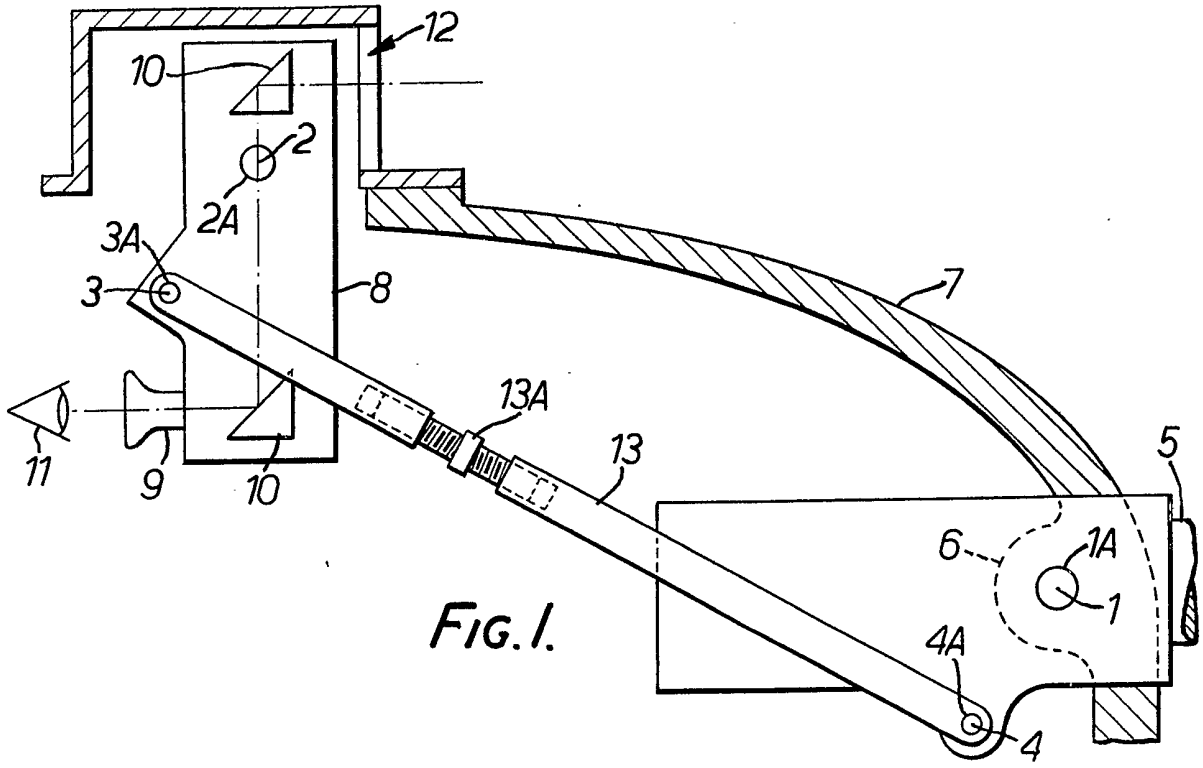

FIG. 1.

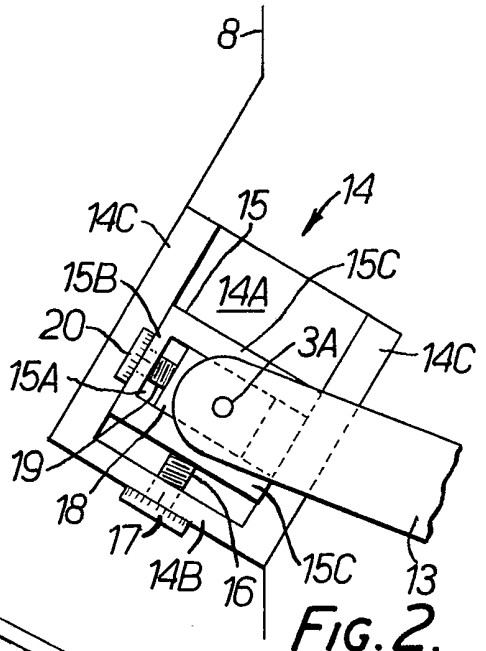

FIG. 2.

FIG. 3.

SPECIFICATION

Improvements Relating to Gun Sights

This invention relates to apparatus comprising a gun and a sight fitted or connected to the gun. It also relates to a method of adjusting the sight so that it is aligned with the gun at all elevation angles of the gun.

The invention arose through the need to fit a new sight to a gun belonging to an existing tank. Owing to the construction of the tank it was necessary for the sight to be located at a position spaced from the gun whilst ensuring that the movement of the sight accurately followed the movement of the gun. In the existing tank the position of the pivotal axis of the gun was not accurately known and this made it difficult to construct a satisfactory mechanical linkage to ensure that the elevation of the sight was the same as the elevation of the gun for all positions of adjustment.

According to the invention there is provided apparatus comprising a gun pivotted about a first axis on a support, a sight pivotted about a second axis on the support, a link pivotted about a third axis on the sight and about a fourth axis to the gun, first adjusting means for adjusting a first distance between the first and second or the third and fourth axes, second adjusting means for adjusting a second distance between the first and fourth or the second and third axes, and third adjusting means for adjusting the angle of the sight relative to a line between the second and third axes.

When employing the invention as defined in the immediately preceding paragraph it is necessary to ensure that the sight is aligned with the gun at one elevation angle and that the four axes are located at the corners of a parallelogram. This can be done by a trial and error process involving adjusting the first, second and third adjusting means until the sight is found to be aligned with the gun at all angles of elevation. This can be tested either by test firings of the gun or by using an instrument such as a clinometer for measuring angles of inclination.

During trials it was found to be very difficult, time consuming, and accordingly expensive to find the correct position of adjustment. The inventors devised a way of overcoming this difficulty involving the steps of:

a) setting the gun at a given elevation angle;

b) adjusting one of the said adjusting means until the sight is at the same elevation angle as the gun as indicated by an inclination sensing instrument;

c) lowering the gun to a lower elevation angle and noting the corresponding elevation of the sight as indicated by an inclination sensing instrument;

d) before or after step c) above, raising the gun at a higher elevation angle and noting the corresponding elevation of the sight as indicated by an inclination sensing instrument;

e) deriving from the noted values at least the approximate amounts by which the other adjusting means need be adjusted for the sight to be aligned with the gun at all angles of elevation of the gun; and

f) adjusting the said other adjusting means accordingly.

By employing these measures it has been found possible to adjust the apparatus of the invention in a small fraction of the time which would otherwise be necessary.

It will be noted that, under step e) above it is only necessary to use a relatively easily derived approximation of the adjustments required. Further accuracy can be achieved simply by repeating steps c) to f).

One way in which the invention may be performed will now be described with reference to the accompanying drawings in which:—

Figure 1 is a schematic diagram depicting part of a turret of a tank in which the invention is employed, an outer body of the tank being shown in cross-section,

Figure 2 is a detail, again very schematic, of an adjusting device employed in the apparatus of Figure 1, and

Figure 3 is an even more diagrammatic form of Figure 1.

Referring to Figure 1 the four axes of the invention are shown respectively at 1, 2, 3 and 4. These axes are all parallel to each other and at right angles to the plane of the drawing. The axis 1 is the axis of rotation of a gun 5 which is attached to pivot pins one of which is shown at 1A. The pins 1A fit in journals defined by lugs (one of which is shown at 6 forming part of an armoured body 7 of the tank.

A telescopic sight 8 comprises an eye-piece 9 and reflectors 10 enabling an observer, depicted schematically at 11, to view a target through a window 12 in the body 7. The sight 8 is pivotted on a shaft 2A about the axis 2, the shaft 2A rotating in a bearing fixed in relation to the body 7.

A link 13 fits on and pivots relative to shafts 3A and 4A which are associated with the axes 3 and 4 and are fixed relative to the sight and gun respectively. This link 13 is formed in two parts joined by first adjusting means in the form of a turnbuckle 13A having opposite threads as shown so that the length of the link can be increased or decreased by turning the turnbuckle in the appropriate direction.

The connection between the link 13 and the sight 8 is an adjustable pivot connection allowing adjustment of the axis 3 relative to the sight in two orthogonal directions. It is shown in greater detail in Figure 2. Referring to Figure 2, attached, e.g. by welding, to the outer casing of the sight 8 is a guide 14 having a groove 14A machined along it, this groove being parallel to the illustrated line joining axes

2 and 3. The groove 14A terminates short of one end of the guide 14 to leave an end wall 14B. Reference 14C depicts side rails which define the parallel edges of the groove.

The groove 14A receives a slide 15. This slide has a threaded bore (not shown) receiving a threaded shaft 16 which bears in the end wall 14B and can be turned by maniputaling second adjusting means constituted by an adjusting member 17. Such turning drives the slide 15 along the groove 14A thereby adjusting the distance between axes 2 and 3, the distance of movement being indicated by graduations on the member 17 and an index mark on the wall 14B. The groove 14 is slightly undercut and the slide 15 is correspondingly dovetailed to hold the slide in the groove.

The slide 15 is similar in construction to the guide 14 having an undercut groove 15A, and end wall 15B and side walls 15C. The groove 15A is perpendicular to the groove 14A and receives a second slide 18 fixed to the pivot pin 3 to which the link 13 is attached. The second slide 18 is driven by a threaded shaft 19 and third adjusting means constituted by an adjusting member 20 so as to adjust the angle of the sight relative to the line between axes 2 and 3. The member 20 has graduations which co-operate with an associated index mark on the wall 14C.

The sight is adjusted as follows. First the gun 5 is elevated to a reference angle of 120 mils, i.e. 0.12 radians relative to the horizontal as measured by a clinometer. This angle is chosen because it is the middle of the elevational range of this particular gun. It will be understood that different angles would be chosen for different guns. The turnbuckle 13A is then adjusted until the elevation of the sight is also 120 mils, again as measured by a clinometer.

The gun is now lowered until the angle of the sight reaches a chosen value S_1 close to the lower limit of the range. Let us say, for example, that S_1 is minus 40 mils (the negative sign indicating that the angle is below the horizontal). The angle G_1 of the gun is then noted and suppose that this is minus 38 mils. An error value E_1 is then calculated according to the equation $E_1=G_1-S_1$ i.e. plus 2 mils.

The gun is now elevated until the sight achieves an angle S_2 which is above the reference angle of 120 mils then calculated according to the equation $E_2=G_2-S_2$ i.e., 1.5 mils.

For the angles S_1 and S_2 given by way of example in the foregoing it will be shown that the location of axis 3 on the sight must be changed by the amounts X and Y by manipulating the members 17 and 20 respectively, these amounts being given by the equations:

$$X \simeq 0.2\,E_1 + E_2 \qquad \text{equation I}$$

$$Y \simeq -6.9\,E_1 - 7.1\,E_2 \qquad \text{equation II}$$

Therefore, for the figures of E_1 and E_2 given in the foregoing

$$X = 1.9 \text{ mm}$$
$$Y = 24.45 \text{ mm}$$

The adjustors 17 and 20 are turned by the appropriate amounts to alter x and y by the above values X and Y. The sight should then be approximately in the correct position of adjustment. However, to eliminate inaccuracy due to the approximations made in deriving equations I and II the gun 5 may be lowered again until S_1 equals −40 mils and the process of adjustment from (a) to (b) repeated as necessary.

Equations I and II above are calculated as follows, with reference to Figure 3, where points 1, 2, 3 and 4 correspond to the axes 1, 2, 3 and 4 of Figure 1 and the dimensions x and y are Cartesian co-ordinates of the point 3 relative to the point 2, these co-ordinates being those which can be adjusted using members 17 and 20 respectively. Point 3^1 is the position to which point 3 must be adjusted to make the linkage a parallelogram.

The requirement for correct tracking is:

$$S = G \text{ for all } \theta \text{ when } -40 \text{ mils} \leq G \leq 280 \text{ mils}$$

The parallelogram condition is

$$z = a; \text{ and } x^2 + y^2 = b^2.$$

We shall write

$$x = b + X$$
$$y = b \sin(\phi - \theta) + Y$$
$$z = a + Z$$

where X, Y, Z are the required *shortenings* of the 3 lengths x, y and z.

By applying Pythagoras' Theorem to a triangle with hypotenuse z:

$$\begin{aligned} z^2 &= (a - b\cos A + x\cos D + y\sin D)^2 \\ &\quad + (-b\sin A + x\sin D - y\cos D)^2 \\ &= a^2 + b^2 + x^2 + y^2 \\ &\quad - 2ab\cos A + 2ax\cos D + 2ay\sin D \\ &\quad - 2bx\cos(A-D) + 2by\sin(A-D) \end{aligned}$$

Now transform from x, y, z to X, Y, Z, and linearise by neglecting squares and products of X, Y, Z, A−D, $\phi-\theta$.

$$\begin{aligned} a^2 + 2aZ &\simeq a^2 + b^2 + b^2 + 2bX \\ &\quad - 2ab\cos D + 2ab\sin D\sin(A-D) \\ &\quad + 2ab\cos D + 2aX\cos D \\ &\quad + 2ab\sin(\phi-\theta)\sin D + 2aY\sin D \\ &\quad - 2b^2 - 2bX. \end{aligned}$$

This simplifies to

$$\begin{aligned} Z &\simeq X\cos D + Y\sin D \\ &\quad + b\sin D\{\sin(A-D) + \sin(\phi-\theta)\} \end{aligned}$$

But $A-D+\phi-\theta = G-S = E$
So the correction equation is

$$-X\cos D - Y\sin D + Z = b\sin D\sin E$$

The alignment procedure:
i) adjusts z to make

$$E = 0 \text{ when } G = G_0 = 120 \text{ mils},$$
$$\text{so } D = D_0 = 1444.2 \text{ mils}.$$

ii) measures $E = E_1$ when $G = G_1 = -40$ mils,
so $D = D_1 = 1284.2$ mils.
iii) measures $E = E_2$, when $G = G_2 = 280$ mils,
so $D = D_2 = 1604.2$ mils.
iv) solve for X and Y the simultaneous linear equations

$$\begin{aligned} -X\cos D_0 - Y\sin D_0 + Z &= 0 \\ -X\cos D_1 - Y\sin D_1 + Z &= b\sin D_1\sin E_1 \\ -X\cos D_2 - Y\sin D_2 + Z &= b\sin D_2\sin E_2 \end{aligned}$$

v) *shortens* x and y by X and Y,
vi) repeats (i) to (v) as necessary.
Elimination of Z gives the pair of equations

$$\begin{aligned} X(\cos D_0 - \cos D_1) \div Y(\sin D_0 - \sin D_1) &= b\sin D_1\sin E_1 \\ X(\cos D_0 - \cos D_2) - Y(\sin D_0 - \sin D_2) &= b\sin D_2\sin E_2 \end{aligned}$$

The particular numerical values quoted previously lead to the equations:

$$\begin{aligned} -0.1657\,X - 0.0237\,Y &= 0.1355\,E_1 \\ 0.1673\,X + 0.0042\,Y &= 0.1401\,E_2 \end{aligned}$$

working in mm and mils.
By Gaussian elimination:

$$\begin{aligned} X + 0.1432\,Y &= -0.8181\,E_1 \\ X + 0.0253\,Y &= \quad 0.8375\,E_2 \\ 0.1178\,Y &= -0.8181\,E_1 - 0.8375\,E_2 \\ Y &= -6.94\,E_1 - 7.11\,E_2 \\ X &= \quad 0.18\,E_1 + 1.02\,E_2 \end{aligned}$$

again working in mm and mils.

More approximately:

$$X=0.2\ E_1+E_2$$
$$Y=6.9\ E_1-7.1\ E_2$$

Claims

1. Apparatus comprising a gun pivotted about a first axis on a support, a sight pivotted about a second axis on the support, a link pivotted above a third axis on the sight and about a fourth axis to the gun, first adjusting means for adjusting a first distance between the first and second or the third and fourth axes, second adjusting means for adjusting a second distance between the first and fourth or the second and third axes and third adjusting means for adjusting the angle of the sight relative to a line between the second and third axes.

2. Apparatus according to claim 1 in which the first means for adjusting includes a length adjusting device for adjusting the effective length of the link.

3. Apparatus according to claim 2 in which the actual length of the link is adjustable.

4. Apparatus according to claim 1, 2 or 3 including an adjustable pivot connection by which one of the members, namely the gun, the support structure, the sight, or the link is connected to another of the said members, the second and third adjusting means being operable to adjust the position of the pivot independently in two orthogonal directions.

5. Apparatus according to claim 4 in which the adjustable pivot connection includes a bearing rigidly attached to one of said members, a shaft which rotates in the bearing and is attached to another of the said members, a first slide by which the shaft and bearing can be slideably adjusted in one of said orthogonal directions, and a second slide by which the shaft and bearing can be slideably adjusted in another of said orthogonal directions.

6. Apparatus according to claim 5 in which the first slide runs in a track formed in the second slide, which second slide runs in a second track formed in a body which is fixed relative to one of said members.

7. Apparatus according to claim 5 or 6 including screw adjusting mechanisms for adjusting said slides.

8. Apparatus according to any preceding claim including gauges for indicating the amount of adjustment of the said first and second distances.

9. Apparatus according to claim 1 substantially as described with reference to the accompanying drawings and substantially as illustrated therein.

10. A method of adjusting a gun sight in an apparatus constructed in accordance with claim 1 comprising:

a) setting the gun at a given elevation angle;

b) adjusting one of the said adjusting means until the sight is at the same elevation angle as the gun as indicated by an inclination sensing instrument;

c) lowering the gun to a lower elevation angle and noting the corresponding elevation of the sight as indicated by an inclination sensing instrument;

d) before or after step c) above, raising the gun to a higher elevation angle and noting the corresponding elevation of the sight as indicated by an inclination sensing instrument;

e) deriving from the noted values at least the approximate amounts by which the other adjusting means need to be adjusted for the sight to be aligned with the gun at all angles of elevation; and

f) adjusting the said other adjusting means accordingly.

11. A method according to claim 8 in which steps c), d), e) and f) are repeated.

12. A method according to claim 10 or 11 in which the step b) is effected using a relatively course adjusting mechanism and step f) is effected using relatively find adjusting mechanisms.

13. A method according to claim 12 in which step b) is effected by adjusting the actual length of the said link.

14. A method according to claim 10 and substantially as described with reference to the accompanying drawings.

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