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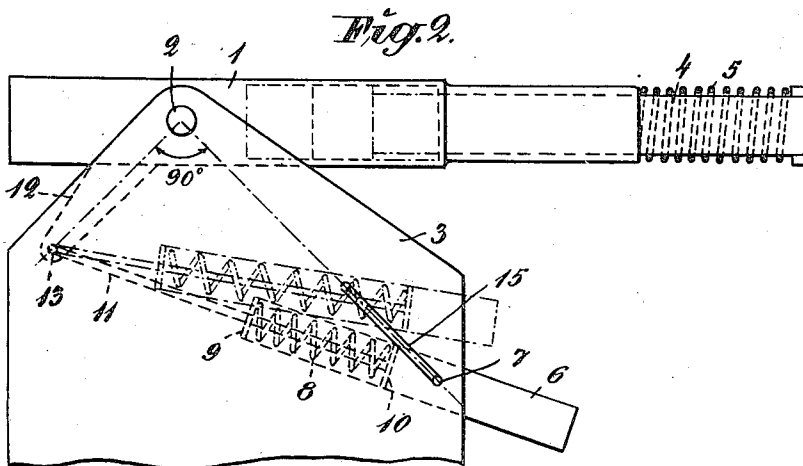
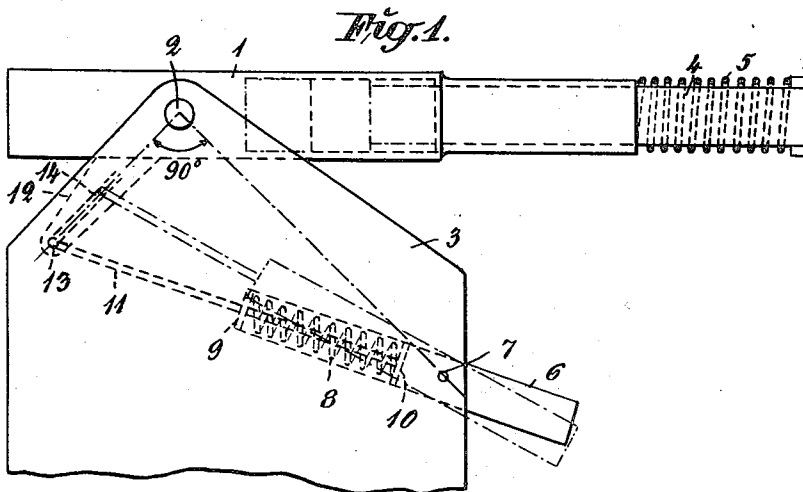
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2,564,360

BALANCING SYSTEM FOR GUN ELEVATING MECHANISM

Filed Nov. 5, 1945

2 Sheets-Sheet 1



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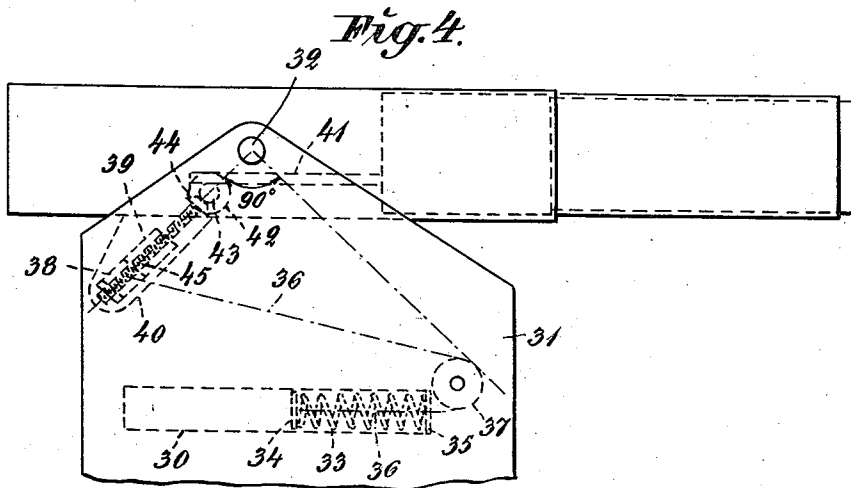
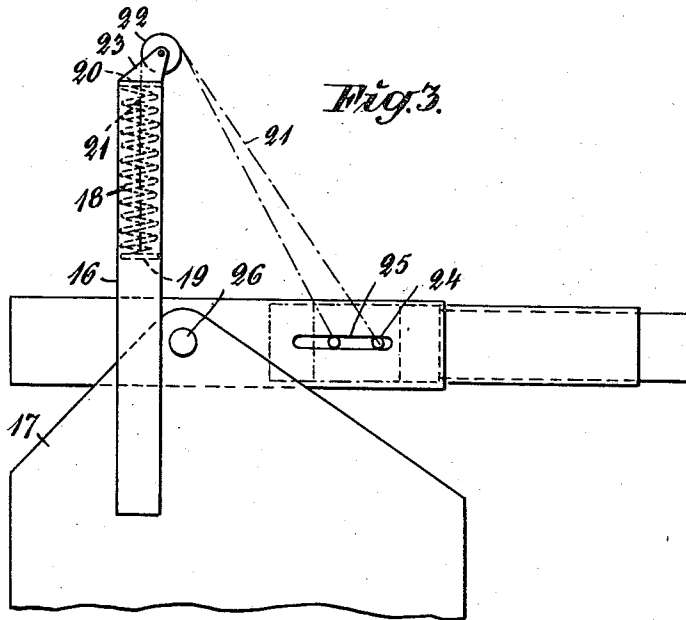
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UNITED STATES PATENT OFFICE

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BALANCING SYSTEM FOR GUN ELEVATING
MECHANISMVictor Hammar and Gustaf Dahlbäck,
Bofors, SwedenApplication November 5, 1945, Serial No. 626,642
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12 Claims. (Cl. 89—37)

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The present invention relates to an arrangement for balancing in elevation the tube of cannons, particularly automatic cannons, consisting of a spring arrangement, which is so connected partly to the gun carriage and partly to the elevation system of the tube that the spring arrangement exercises a turning moment on the elevation system which balances the tube in its position of rest.

However, hitherto known arrangements balance the tube in one position only of the centre of gravity of the elevation system in relation to the centre of trunnion, which position generally is the position of rest of the tube. As at the recoil the position of the centre of gravity is moved backwards, the balancing springs are not able to balance the tube, which becomes back-heavy, in such a manner that the tube has a tendency to become turned upwards during the recoil. This is a great disadvantage with artillery pieces, particularly automatic weapons, which must be able to be directed easily and steadily also during the recoil and readvancement of the tube.

The object of the present invention is to remove this inconvenience and to produce a balancing arrangement that will balance the elevation system of the tube not only at the position of rest but also at all positions of the tube during the recoil and readvancement and in all elevation positions so that the gunner undisturbed by the movements of the tube can continue to level the gun at all times during shooting.

According to the invention this is attained thereby that one or more members connected with the spring arrangement are so connected or coupled together with the recoiling system of the tube or with a part connected thereto that the tension of the spring arrangement or its turning moment lever acting on the elevation system of the tube or both these factors are continuously so changed during the recoil and readvancement of the tube that the turning moment exercised by the spring arrangement on the elevation system of the tube is continuously decreased during the recoil and continuously increased during the readvancement for the purpose of rendering possible balancing of the tube in all positions during said movements.

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Four different embodiments of the balancing arrangement according to the invention are shown schematically in Figures 1-4 respectively on the enclosed drawings.

In Fig. 1, 1 designates the elevation system, which by means of turning trunnions 2 is pivotally journaled in the crotch 3 of the carriage of the piece. 4 designates the tube or recoilable barrel which during the recoil compresses the recoil spring 5.

In the crotch 3 there is a cylinder 6 pivotally journaled by means of the pin 7. In the cylinder 6 there is arranged a balancing spring 8 between a flange 9 at one end of the cylinder and a movable piston 10 inserted into the cylinder, which piston by means of the rod 11 is connected with a lever 12 fixed on that part of the cannon which takes part in the elevation movement in such a manner that a pin 13 connected to the rod 11 enters a groove 14 provided in the lever 12 and directed towards the centre of trunnion 2.

The spring 8 is inserted with a certain initial compression so that the same is exercising a certain turning moment on the elevation system of the tube in the position of rest of the tube by pulling the rod 11 and the lever 12, which counteracts the fore weight of the tube. By suitable choice of spring, spring tension and journal points 7 and 13 the balancing of the tube in position of rest may be attained at any elevation.

The pin 13 or the rod 11 is connected with the tube 4 by means of a suitable transmission hereinafter described in such a manner that the pin 13 will be displaced in the groove 14 in the direction towards the centre of trunnion 2 during the recoil of the tube and back again during the readvancement. While doing this the cylinder 6 is turned continuously to new positions and the compression of the spring 8 is changed continuously. An intermediate position of the cylinder 6 is illustrated by dotted lines. From this it will be seen that the length of the spring 8 is increased and its compression force is decreased during the recoil in addition to which the lever of torque of the rod 11 is decreased. The turning moment of the spring 8 is thus decreased continuously during the recoil when the pin 13 moves towards the centre

of trunnion 2. However, at the same time the turning moment of the recoillable barrel is also decreased due to the fact that its centre of gravity is moved in direction towards the centre of trunnion 2. The whole thing can be so adapted that the spring 8 during the whole recoil movement at each moment balances the tube.

The position of the pin 13 required therefor in each moment can be calculated and the transmission between the pin 13 or the rod 11 and the tube is adapted accordingly so that the calculated positions of the pin 13 will be held. By the movement of the tube during the recoil the decrease of the turning moment of the spring 8 will thus take place synchronously with the decrease of the turning moment of the tube in opposite direction caused by the movement backwards of the tube.

The angle between the lines 2-13 and 2-7 is preferably made equal to or about 90°, which, however, is not necessary.

The embodiment according to Fig. 2 differs from what is described above thereby that the pin 13 is only pivotally, but not displaceably journaled in the lever 12 and that instead the pin 7 has to engage in a groove 15 provided in the crotch 3 and directed towards the centre of trunnion 2, in which groove the pin moves during the recoil and readvancement of the tube. With dotted lines an intermediate position of the cylinder 6 and the rod 11 is designated. Herefrom it appears that the working manner is the same as that according to Fig. 1, as the tension force of the spring 8 and its turning moment lever are decreased continuously during the recoil. A suitable transmission has to transmit the movement of the tube to the rod 11 or the pin 7.

The transmission referred to for connecting the resilient means or spring 8 to the gun-barrel 4 may consist of any mechanical connecting member or members suitable for imparting to the piston 10 and the tube 6 a relative displacement proportional to the displacement of the gun-barrel relatively to the elevating system. Such transmission does not form part of the present invention and is well within the reach of one skilled in the art.

In the embodiment according to Fig. 3 the balancing cylinder 16 is arranged vertically and rigidly connected to the crotch of carriage 17. The spring 18 enclosed in the cylinder 16 is abutting at the lower end against the piston 19 and at the upper end against a fixed flange 20 on the cylinder 16. To the piston 19 is attached a rope or chain 21 which at the top is led over a roller 22 rotatably journaled in a support 23 fixed to the cylinder 16. The other end of the rope 21 is secured to the recoillable barrel, for instance by means of a pin 24, freely passing through a groove 25 arranged on a non-recoillable part of the elevating system.

The tension force of the rope 21, which is determined by the initial compression of the spring 18, has to be so adapted that its moment with respect to the centre of trunnion 26 of the piece balances the tube in position of rest. On recoil the tube and thus the pin 24 are displaced backwards in the groove 25. An intermediate position of the rope is illustrated by dotted lines. During the recoil the piston 19 is displaced downwards correspondingly so that the compression force of the spring 18 as well as that of the torque lever of the rope 21 are decreased with respect to the centre of trunnion 26. By choice of a

suitable spring, of the distance between the centre of trunnion 26 and the pin 24 of the rope and of direction of the rope perfect balancing can be attained at all positions of elevation during the position of rest of the tube as well as during the recoil and the readvancement so that unobstructed leveling of the cannon may take place in course of shooting.

In the embodiment according to Fig. 4 the balancing cylinder 30 is fixed in horizontal or sloping position in the crotch of carriage 31 in which the centre of trunnion 32 of the piece is journaled. In the cylinder 30 the balancing spring 33 is placed between the movable piston 34 and a flange 35 at the end of the cylinder. To the piston 34 is fixed a rope 36, which is led over a roller 37 and at the other end fixed to a cross-piece 38 movably arranged in a groove 39 provided in a lever 40 arranged on the elevating system of the tube. The groove 39 is directed towards the centre of trunnion 32. The tension force of the spring 33 and of the torque lever of the rope 36 with respect to the centre of trunnion 32 are so chosen that the tube is balanced in position of rest.

To produce balancing also during the recoil and the readvancement, the following transmission means is provided:

41 designates a rack bar fixed to the recoiling system and engaging the gear wheel 42 rigidly connected to a conical gear wheel 44 in turn rigidly connected to a screw spindle 45 located in the groove 39 and threaded into the cross-piece 38.

At the recoil the rack bar 41 is brought backwards, thereby turning the gear wheels 42, 43, and the gear wheel 43 in turn rotates the gear wheel 44 and the screw spindle 45 so that the cross-piece 38 is displaced in the groove 39 in the direction towards the centre of trunnion 32.

Thereby the spring 33 is extended so that its tension force is decreased and at the same time also the torque lever of the rope 36 is decreased with respect to the centre of trunnion 32 so that the turning moment of the spring force is decreased more and more inasmuch as the tube is displaced backwards during the recoil. The contrary course will take place during the readvancement.

By suitable choice of spring, spring force, fixing point for the rope and rack gear, pitch of screw spindle etc. balancing can be attained in all elevation positions also during recoil and readvancement.

Having now particularly described the nature of our invention and the manner of its operation what we claim is:

1. In an ordnance piece including a carriage, elevating mechanism mounted thereon for rotation about a horizontal axis and a gun-barrel slidable relatively of said elevating mechanism to accommodate recoil, said gun-barrel and elevating mechanism being mounted on said carriage in overbalanced relation, said overbalance varying upon recoil of said gun-barrel, a device comprising resilient means operatively connected to said carriage and to said elevating mechanism to exert thereon a force in opposition to the overbalance exerted thereon by said gun-barrel and said elevating mechanism, and transmission means operatively connecting said gun-barrel to said resilient means to progressively vary the force exerted thereby in accordance with the movement of said gun-barrel during recoil and hence varying overbalance thereof and maintain-

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ing balance between said force and the overbalance.

2. A device as claimed in claim 1 wherein said resilient means is connected to a fixed point of said carriage and pivotally connected to a variable point of said elevating mechanism, the position of said variable point being determined by said transmission means in accordance with the position of said gun-barrel relative to said elevating mechanism.

3. A device as claimed in claim 1 wherein said resilient means is pivotally connected to a fixed point of said carriage.

4. A device as claimed in claim 1 wherein said resilient means is pivotally connected to a fixed point of said elevating mechanism and to a variable point of said carriage, the position of said variable point being determined by said transmission means in accordance with the position of said gun-barrel relative to said elevating mechanism.

5. A device as claimed in claim 1 wherein said resilient means comprises a cylindrical housing having an abutment at one end thereof, a compression coil spring in said housing one end of which engages said abutment, a piston slidable in said housing to abut against the other end of said spring and adapted to receive said force therefrom, and connecting means between said piston and said elevating mechanism and transmission means, whereby said force may be variably applied by said piston to said elevating mechanism in accordance with the movement of said gun-barrel relative to said elevating mechanism.

6. A device as claimed in claim 1 further including a rod connected to said resilient means and to said elevating mechanism, said force being varied by adjustment of said rod relative to said housing by said transmission means in accordance with the movement of said gun-barrel relatively to said elevating mechanism.

7. In an ordnance piece including a carriage, elevating mechanism mounted thereon for rotation about a horizontal axis and a gun-barrel slidable relative to said elevating mechanism to accommodate recoil, said gun-barrel and said elevating mechanism being mounted on said carriage in overbalance relation, said overbalance varying upon recoil of said gun-barrel, a device comprising resilient means operatively connected to said carriage and to said elevating mechanism to exert thereon a force in opposition to the overbalance exerted thereon by said gun-barrel and said elevating mechanism, and transmission means operatively connecting said gun-barrel to said resilient means to progressively vary the force exerted thereby in accordance with the movement of said barrel during recoil and hence varying the overbalance thereof and maintain balance between said force and overbalance, said resilient means comprising a cylindrical housing having an abutment at one end thereof, a compression coil spring in said housing one end of which engages said abutment, a piston slidable in said housing to abut against the other end of said spring and adapted to receive said force therefrom, connecting means between said piston and said elevating mechanism and transmission means, whereby said force may be variably applied by said piston to said elevating mechanism in accordance with the movement of said gun-barrel relative to said elevating mechanism, said housing being pivotally mounted on said carriage for rotation about an axis transverse to

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said housing and gun-barrel, said elevating mechanism being provided with a rigid arm extending therefrom and having a groove therein, and a pin slidable in said groove and journaled in said rod.

8. A device as claimed in claim 7 wherein said groove is so directed relative to said rod as to shift said rod and piston relative to said housing as said pin slides in said groove.

9. A device as claimed in claim 7 wherein said carriage is provided with a groove, said housing being mounted on a pivot slidable in said groove, said transmission means including a first pulley co-axial with said horizontal axis, a second pulley spaced therefrom, said pulleys being journaled on said carriage and said groove being intermediate said pulleys and substantially in line with the centers thereof, and a rope connecting said pivot to said gun-barrel and passing over said pulleys, whereby said pivot may be shifted along said groove in accordance with the recoil of said gun-barrel thereby varying the distance between said abutment and piston to vary the compression of said spring.

10. A device as claimed in claim 1 wherein said resilient means comprises a cylindrical housing having an abutment at one end thereof, a compression coil spring in said housing one end of which engages said abutment, a piston slidable in said housing to abut against the other end of said spring and adapted to receive said force therefrom, and connecting means between said piston and said elevating mechanism and transmission means, whereby said force may be variably applied by said piston to said elevating mechanism in accordance with the movement of said gun-barrel relative to said elevating mechanism, said housing being rigidly mounted on said carriage, said connecting means comprising a link tensioned by said spring and connected to said piston and to said elevating mechanism and transmission means, said force being varied by adjustment of said link relative to said housing by said transmission means in accordance with the movement of said gun-barrel relative to said elevating mechanism.

11. A device as claimed in claim 10 wherein said housing is substantially vertically mounted on said carriage and extending upwardly therefrom, said housing bearing a pulley journaled in the upper end thereof, said link being a rope passing over said pulley, said elevating mechanism being provided with a substantially longitudinal groove forward of said horizontal axis, said transmission means including a pin rigid with said gun-barrel and slidable in said groove, said rope being connected to said pin whereby the point of application of said force to said elevating mechanism may be displaced along said groove to vary the moment thereof.

12. A device as claimed in claim 10 wherein said housing is substantially horizontally mounted on said carriage, said elevating mechanism being provided with a rigid arm extending therefrom and having a groove therein, and a member slidable in said groove, said carriage having a pulley journaled thereon, said flexible link being a rope passing over said pulley and being connected to said member, said transmission means including a threaded spindle disposed longitudinally of said groove, said member being internally threaded to co-act with said spindle, and gear means including a rack connecting said spindle to said gun-barrel, whereby said spindle may be rotated to shift said member along said groove

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thereby displacing the point of application of
said force to said arm to vary the moment thereof.

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