Jan. 28, 1947. R. J. WOODS 2,414,914

MULTIPLE GUN TRAINING MECHANISM

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FIG. 1.

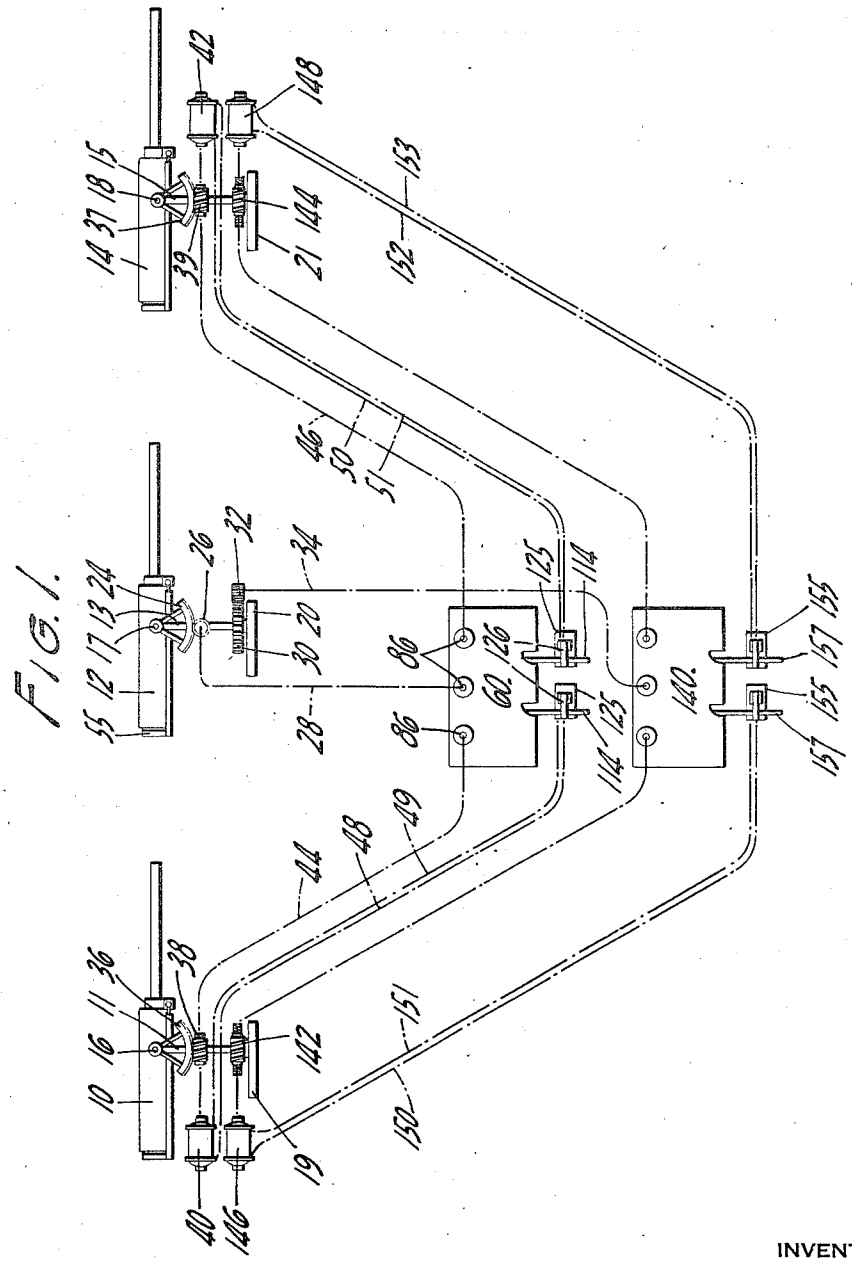

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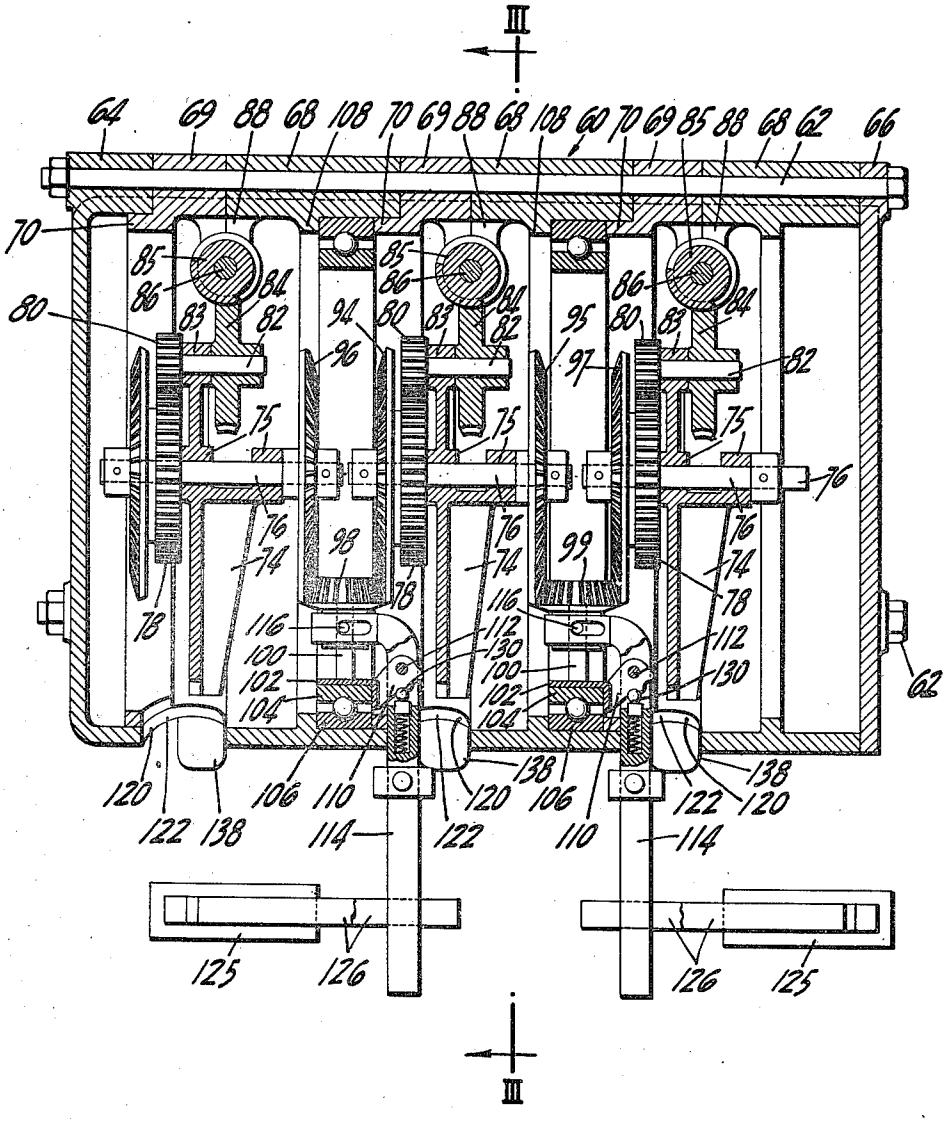
FIG. 2.



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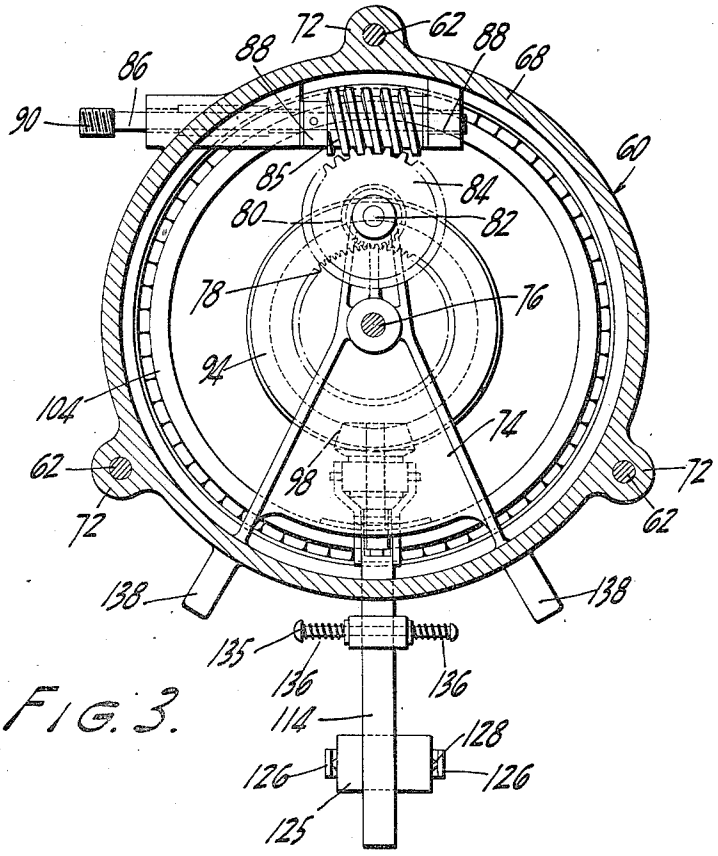

FIG. 3.

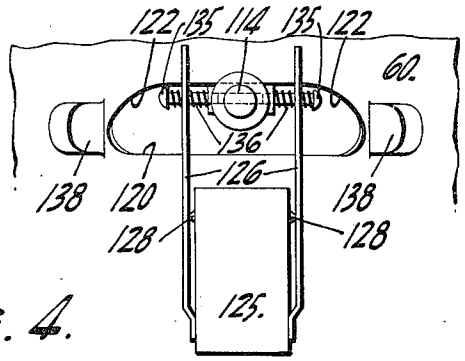

FIG. 4.

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MULTIPLE GUN TRAINING MECHANISM

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Application January 8, 1942, Serial No. 426,063

3 Claims. (Cl. 89—41)

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This invention relates to ordnance, and more particularly to improvements in devices for providing automatic aiming of flexibly mounted guns in synchronism with another gun or other master sighting device.

One of the objects of the invention is to provide a multiple gun battery including a plurality of flexibly mounted guns and improved aim synchronizing means in connection therewith, whereby the gun elements of the battery are adapted to be automatically trained accurately and in unison in an improved manner. Another object of the invention is to provide a design for a mechanism of the above stated features and advantages which is also of improved simplicity and structural form and wherein a plurality of identical parts are employed whereby advantages of parts standardization are attained and devices embodying the design may be manufactured in quantities by most economical shop production methods. Another object of the invention is to provide a mechanism of the above stated character which is adapted to be automatically disconnected in an improved manner to accommodate malfunctioning of the drive mechanisms of the follower gun units of the battery and to be manually reinstated in operation in an improved manner. Other objects and advantages of the invention will appear from the specification hereinafter.

In the drawings:

Fig. 1 is a diagrammatic illustration of a gun battery having three flexibly mounted gun units arranged for separate elevational and azimuth adjustments and equipped with aim synchronizing apparatus of the invention;

Fig. 2 is a longitudinal section through one of the synchronizing mechanisms of Fig. 1;

Fig. 3 is a transverse section, as along line III—III of Fig. 2; and

Fig. 4 is a fragmentary bottom plan of a drive motor control and disconnect device portion of the mechanism of Figs. 2 and 3.

In the drawings the invention is illustrated in connection with separately mounted machine guns indicated generally at 10—12—14, respectively; and it will be seen that the guns are pivotally mounted upon corresponding upright posts 11—13—15 by means of pivotal yoke connections as indicated at 16—17—18 respectively. The posts 11—13—15 are rotatably mounted upon corresponding base members 19—20—21 to extend vertically therefrom in freely rotatable relation about their vertical axes.

Toothed sector devices extend from the guns

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so as to be disposed radially of the corresponding pivotal yoke connection devices. In the case of the drawing the gun 12 is arranged to function as the master gun or lead sight device of the gun battery, and the sector 24 of the gun 12 is arranged to mesh with a spur gear 26 which is rotatably carried upon the central post 13. Thus, elevational adjustment movements of the gun 12 about the axis of the yoke connection 17 will be translated into corresponding rotation of the spur gear 26. A torque transmission cable 28 is operatively connected to the spur gear 26 so as to be driven thereby to provide an index drive device upon rotation of the gun 12 for controlling synchronizing actuation of the follower guns 10—14 in elevation, as will be explained more fully hereinafter. The mount post 13 of the gun 12 carries a spur gear 30 meshing with a pinion 32 which is operatively coupled to a second torque transmission device 34, whereby upon rotation of the central post 14 relative to the gun supporting base 20 the cable 34 is driven to control synchronizing actuation of the gun units 10—14 in azimuth, as will also be explained more fully hereinafter.

The sectors 36—37 of the guns 10—14 are toothed to mesh with corresponding worm gears 38—39 which are rotatably carried upon the corresponding gun mounting posts 11—15; and reversible direction electric motors 40—42 are operatively coupled with corresponding of the worm gears 38—39 for driving the latter to adjust the guns 10—14 in elevation in exact synchronism with elevational adjustments of the master gun 12. Torque transmission cables or like devices are arranged in operative connection with the corresponding worm gears 38—39, as indicated at 44—46; and the motors 40—42 are arranged to be energized through electrical circuits including ground connections and corresponding paired conductors 48—49 and 50—51. It will of course be understood that the electrical circuits referred to will include any suitable power supply source (not shown).

Arrangement is made for aiming the master gun 12 through use of any suitable manual control means. For example, the gun 12 may be arranged to be adjusted in elevation and azimuth simply through application of manually applied forces directed against the handle grip 55 pictured at the rear end of the gun 12. Or, any suitable power operated control device may be arranged in conjunction with the gun 12 whereby through manipulation of remotely disposed control devices suitable motor means will be ener-

gized to move the gun 12 about the vertical axis of the post 13 and about the horizontal axis of the yoke mounting 17 for azimuth and elevational adjustments of the gun, respectively. In any case, every elevational adjustment of the gun 12 will be accompanied by corresponding actuation of the index drive device 28, and every adjustment of the gun 12 in azimuth will be accompanied by actuation of the index drive device 34.

The elevational index drive devices 28—44—46 and the power supply conductors leading to the elevational control motors 40—42 are operably coupled to the elevational synchronizer mechanism which is contained within a housing 60. As illustrated in Figs. 2 and 3, the housing 60 is generally of cylindrical form and comprises a series of housing segments arranged in side-by-side relation and united in rigid assembly by means of tierods 62 spaced peripherally of the housing. Thus, the housing comprises a series of elements of which the opposite end members are in the form of end closure plates 64—66, and a series of alternately disposed ring members 68—69 arranged therebetween. Each ring member 69 is peripherally flanged as at 70 so as to be adapted to slide fit into abutting telescopic relation with respect to the adjacent ring member 68; and at the left hand end of the housing 60 the last ring member 69 fits against the end plate 64. The end plate and ring elements are all provided with radially extending eye portions 72 (Fig. 3) through which the tierods 62 are threaded, whereby upon assembly of the housing elements an accurately centered and rigid housing unit is provided.

Each ring member 69 is provided with an interiorly transverse bracket portion 74 extending from the lower portion thereof in A frame fashion so as to encompass the longitudinal center line of the housing structure. The brackets 74 are each formed with bearing block portions 75 which are aligned concentrically of the longitudinal axis of the housing 60 for rotatably supporting thereon corresponding shafts 76. In the case of the present drawings there are three of the ring elements 69, and three correspondingly mounted shafts 76. Each of the shafts 76 carries a spur gear 78 at an extending end portion thereof, and the gears 78 are arranged to mesh with corresponding pinions 80 which are carried by corresponding counter shafts 82.

Each counter shaft 82 is rotatably mounted upon another bearing block portion 83 of the corresponding bracket 74, and carries at its opposite end a worm wheel 84. A worm gear 85 is arranged to mesh with each corresponding worm wheel 84 and is carried by a stub shaft 86 which is in turn rotatably mounted upon split bearing portions 88 extending downwardly from the corresponding ring portions 68—69 as viewed in Figs. 2 and 3. Thus, the housing 60 is arranged to mount three similar gear units in parallel; each gear unit including a shaft 76, spur gears 78—80, and worm gears 84—85. The centrally disposed worm gear member is operatively coupled to the index drive device 28, as by means of a screw connection with the extending end portion of the worm shaft 86, as indicated at 90 (Fig. 3). Similarly, the worm gear shaft member of the gear unit at the left hand end portion of the housing 60 (Fig. 2) is operatively coupled to the index drive device 44 leading from the elevational adjustment control worm of the gun 10, and the worm drive shaft of the gear unit at the right hand end of the housing 60 is likewise coupled to the index drive cable leading from the elevational adjustment control worm of the gun 14.

The centrally disposed shaft 76 of the synchronizing mechanism is provided at its opposite end portions with oppositely disposed bevel gears 94—95, and the shaft members 76—76 disposed at opposite end portions of the housing are provided with similar bevel gears 96—97 so disposed as to face corresponding of the bevel gears 94—95 in opposed spaced relation to provide paired differential gear units. Differential pinion gears 98—99 are rotatably mounted upon corresponding shafts 100 so as to be normally disposed in mesh with the corresponding opposed bevel gear units 94—96 and 95—97. The shafts 100 are mounted rigidly upon corresponding mounting plates 102 so as to extend inwardly therefrom. The plates 102 are attached to the inner race portions 104 of corresponding ball bearing units 106 which are arranged peripherally of the housing 60 to fit against the interior wall thereof. As indicated at 108 (Fig. 2), the ring members 68 are shouldered to cooperate with adjacent flange portions 70 of the ring members 69 so as to provide therebetween annular recesses for accommodating the ball bearing devices 106—106 in clamped relation interiorly of the housing 60 so as to be positively fixed against movement longitudinally of the housing when in finally assembled form.

The spur gear device 26 of the elevational index drive control of the gun 12 and the worm gear devices 38—39 of the guns 10—14 are so arranged that in response to elevational adjustments of the guns in similar directions the bevel gear elements of each corresponding gear unit will be caused to rotate in counter directions and at proportionate speeds. Thus, for example, if the guns 10—12—14 are caused to move simultaneously in the same vertical direction and at the same speed of elevational adjustment the corresponding bevel gear members 94—96 and 95—97 are thereby caused to rotate counterclockwise and at identical speeds so that the corresponding pinions 98—99 are simply rotated about the axes of their mounting shafts 100—100. However, in the event that either of the guns 10—14 is not moving in elevational adjustment in the same direction and at an identical speed with respect to the master gun 12 the difference in gun adjusting movement will be translated into movement of the corresponding pinion gear or gears in either direction about the axis of the bevel gears, depending upon the character of the differential action. Thus, due to the mountings of the differential pinion gears upon the bearing races 104—104, the pinion gear reflecting differential movement of its corresponding differential gear unit will be caused to rotate peripherally of the housing 60.

Each of the mounting plates 102 is formed with a laterally extending bracket portion 110 which mounts, by means of a pivotal connection 112, a bell crank 114. The inner end of each bell crank 114 is yoke shaped to encompass the shank portion of the corresponding pinion gear 98—99, and to operatively connect therewith by means of a slot and pin connection as indicated at 116. The differential pinion gears 98—99 are slidably mounted upon their corresponding mounting shafts 100, and therefore any pivoting of the lever arm 114 in a counterclockwise direction as viewed in Fig. 2 about the axis of the pivotal connection 112, will cause the yoke end portion of the lever to draw the corresponding pinion gear away from

engagement between its corresponding bevel gear set.

Each ring portion 69 of the housing 60 is perforated as indicated at 120 to permit extension of the corresponding lever arm 114 therethrough; and the perforated wall portions of the casing structure are elongated peripherally of the housing and shaped as indicated at 122 (Fig. 4) at each end of the opening to provide a lateral cam surface at each side of the normal central position of the corresponding lever arm 114, as illustrated by Figs. 2 to 4. A snap action switch 125 of any suitable type such as for example is illustrated in U. S. Patent 2,379,305, is stationarily mounted adjacent each lever 114 at the extending end portion thereof; and each switch includes a pair of oppositely disposed spring finger elements 126 arranged to straddle the corresponding lever 114. The fingers 126—126 are arranged to actuate contact devices 128—128 of the switch (Fig. 4), and thus it will be understood that whenever the corresponding lever arm 114 is caused to bodily rotate about the axis of the housing 60 in view of differential operation of the corresponding bevel gear elements thereof, the lever arm 114 will move to displace either one of the finger members 126—126 away from its normal or unbiased position, depending upon the direction of movement of the lever arm 114 away from its normal centralized position. The micrometer switch 125 is so arranged as to be in open circuit condition when the actuating fingers 126—126 are in neutral position, as indicated in Fig. 4; and upon movement of the control lever 114 in one direction or the other one of the fingers 126—126 will be thereby caused to move the corresponding contact actuating device 128, whereby the switch will be actuated to close the circuit of the motor driving the corresponding gun elevation control worm so as to drive the gun in such manner as to match the aiming movement of the master gun 12. It will be understood that upon assumption of elevational adjustment operation by the motor device as explained hereinabove, the corresponding index drive device will be actuated to drive the corresponding differential bevel gear, whereby the movements of the master gun and the motor driven follower gun will be directly compared and any lead or lag of positional relation therebetween will be automatically compensated for by operation of the corresponding circuit controlling switches in such manner that all guns of the battery are immediately brought into positional conformity with respect to elevational adjustments of the sighting or lead gun.

Each of the levers 114 carries a spring-pressed detent device 130 adapted to slidably engage either of two suitably recessed portions arranged in an arc concentrically of the corresponding pivot pin 112 in a side wall portion of the corresponding bracket 110, whereby the lever 114 is adapted to be releasably held at either of two radially extending positions relative to the bracket pin 112 so that the lever 114 will be disposed either in pinion-engaged or pinion-disengaged position. Thus, in event that the gun elevational adjustment mechanism of either the gun 10 or the gun 14 becomes jammed or malfunctions for any other reason, the continued elevational adjustments of the master gun 12 will be thereupon translated into differential movements between the bevel gears 94—96 or 95—97, as the case may be, such as will be directly translated into rotation of the corresponding differential pinion in directions peripherally of the housing 60. Thus, the corresponding lever 114 will be carried by the pinion to move against its detent device 130 away from normal mid position and through the slotted portion 120 of the housing against either one of the camming surfaces 122 thereof. By reason of this action the lever 114 will be thereby pivoted upon its connection 112 in such manner as to disengage the corresponding differential pinion from meshed relation with the corresponding bevel gears, and the lever 114 will be held by its detent device 130 in pinion-unmeshed position until subsequently adjusted manually. Thus, it will be understood that damaging disruption of the synchronizing mechanism will be avoided, and that upon subsequent repair of the gun elevational control mechanism the synchronizer unit is ready to be operatively reinstated by simple manual return of the lever 114 against the action of the detent device into normal or pinion meshed position.

A pin 135 is slidably threaded through a suitably apertured portion of each of the levers 114—114 so as to extend at opposite sides thereof; and compression springs 136—136 are mounted under each headed end portion of the pins so that the pins are normally centered upon the corresponding lever arms but are adapted to be biased in either direction relative thereto. A pair of opposed stop abutments 138 are arranged to extend below each ring member 69 at opposite ends of the lever accommodating openings 120 of the housing structure and to register with the pins 135 upon rotation of the corresponding lever arms 114 into throw-out position. Thus, it will be understood that during throw-out operations as the levers 114—114 are cammed laterally of the housing apertures and the corresponding pinion is unmeshed the spring devices 136 kick the lever arms back toward normal centered positions relative to the housing 60, while the pinions remain in unmeshed condition. Thus, the lever arms return to switch-off positions, and are ready to be snapped sidewise manually into pinion-meshed position by a simple sidewise movement thereof.

As illustrated diagrammatically by Fig. 1, the azimuth training movements of the follower guns 10—14 are arranged to be accurately synchronized with azimuth adjustments of the master gun 12 through use of a second synchronizing mechanism which is designated generally at 140. The synchronizing device 140 may be manufactured as an exact duplicate of the device 60 illustrated and described in detail hereinabove for controlling elevational adjustments of the gun battery units. Consequently, in the interest of simplifying the description and drawings, the mechanism of the synchronizing device 140 is not illustrated or described in detail herein; but it will be understood that the azimuth index drive device 34 will be operatively coupled to the worm of the synchronizer device 140 corresponding to the centrally disposed worm 85 of the synchronizer unit 60 (Fig. 2). Other worms corresponding to the opposite end worms 85—85 of the synchronizer device 60 are operatively connected to corresponding azimuth control worm gear devices 142—144 arranged in connection with the azimuth control posts 11—15 of the follower guns 10—14.

Corresponding azimuth control motors 146—148 are operatively connected to the control worms 142—144 for driving the mounting posts 11—15 to adjust the guns 10—14 in azimuth

and in synchronism with azimuth adjustments of the gun 12. To this end the motors 146—148 are provided of reversible direction characteristics and are arranged to be energized by two-way circuits comprising suitable ground connections and opposed conductors 150—151 and 152—153, respectively. The circuits comprising the ground connections and the conductors aforesaid are arranged to be controlled by switches 155—155 which correspond to the switches 125—125 of the synchronizing mechanism 60; the switches 155—155 being arranged to be actuated by lever arms 157—157 extending from the interior of the synchronizer mechanism 140 which correspond to the lever arms 114—114 of the synchronizer mechanism 60.

Thus it will be understood that the synchronizer mechanism in connection with either elevational or azimuth control of the gun battery elements will operate as follows: When the lead gun, or other sighting member as designated at 12, is moved for aiming adjustment either in elevation or in azimuth the corresponding index drive cable will cause the corresponding differential bevel gears to rotate at a proportionate speed. This will cause the differential pinions to have planetary movements in the direction of rotation of the leading differential bevel gears, and thus the corresponding switches will be actuated so as to close the circuits of the follower gun adjustment motors. For example, when the lead gun 12 is actuated to move about its elevational aim adjustment axis the torque member 28 will be thereby driven to operate the worm 85 connected thereto. Through the gear system interiorly of the box 60, the bevel gears 94—95 will be thereby driven to rotate and because the companion gears 96—97 are relatively stationary the gears 98—99 will be thereby caused to bodily rotate about the axis of the shafts 76, whereby the switch control elements 114—114 will be pivoted as explained hereinabove. Hence, the motors are instantaneously energized to drive the follower guns toward positional conformity with the sighting member 12. Upon cessation of sighting member adjustment movements the corresponding adjustment movements of the follower gun members are terminated immediately upon arrival of the follower guns into positional conformity with the sighting member because of the corresponding release of the operating switch spring fingers due to retrograde operation of the differential gear systems. Obviously, if the follower gun driving mechanisms overrun corresponding positions of conformity with respect to the lead unit, the corresponding drive control switch mechanism will be actuated to reverse the driving operations for exact synchronization. Thus, each aiming adjustment movement of the sighting member is followed by movements of the follower guns of the battery into positions of mathematically accurate conformity with respect to the original positional relationships of the elements of the mechanism.

It will be appreciated that the invention provides an improved synchronizing mechanism in conjunction with a multiple gun unit battery wherein the aiming movements of a master gun or other sighting element as illustrated at 12 are accurately measured and compared in terms of mechanical motion transmitted to corresponding gear trains coupled to the follower gun units in such manner as to provide control of the follower gun units for exact synchronization thereof with the movements of the master sighting element. Corresponding aiming movements of the follower guns are initiated automatically through operation of power controlled mechanisms, and such movements of the follower guns are at all times directly compared to the motion of the master sighting element in such manner as to provide for constant correction of any differential operation, whereby exact synchronization is provided.

Improved means for causing automatic disconnection of the synchronizer gear train of an inoperative gun unit of the battery are provided, whereby damage to the synchronizing mechanism is avoided in the event of malfunctioning of the gun training mechanisms. Also, at any stage of operation the synchronizing mechanism corresponding to either one or all of the following guns may be readily disconnected by simple manual manipulation of the corresponding differential pinion control lever or levers, in event it is desired to control the following guns independently of the synchronizing mechanism. It will be understood, of course, that compensation to provide non-parallel aiming of the various gun units of the battery may be included in the synchronizing mechanism system, if desired, whereby convergence of fire from separated gun units upon a common target may be effected; and that in such case the respective gear trains providing control of the separate gun units will be arranged of such ratios as to provide automatically for the degree of such compensation desired.

It will be appreciated that a particular feature and advantage of the mechanism of the invention is that by reason of the novel construction of the synchronizer mechanism housing and mounting of the differential gear parts thereon, the housing structure segments and the differential gear elements of the mechanisms may be simply duplicated any number of times and arranged in series for unitary assembly by means of suitably extended tierods so as to provide synchronizing mechanisms adapted to actuate any number of units. For example, if it is required to operate more than two follower units as illustrated and described hereinabove, additional housing segments and differential gear units will be added longitudinally of the mechanism of the drawings at either or both ends thereof, and in such case adjacent of the differential gear mechanisms will interconnect to self-synchronize adjacent of such units and to relate the entire synchronizing operation back to the master control device. Thus, it will be understood that synchronizer mechanisms of the invention having various capacities may be manufactured in large quantity by simple part-duplicating processes, whereby important economies with respect to manufacturing cost and with respect to cost of repairs and servicing of such mechanisms may be realized.

It will be understood that in lieu of the electric motor and switch control mechanisms illustrated and described hereinabove, any other suitable power means may be employed for the purpose, such as hydraulic pressure mechanisms or the like; and that although only one form of the invention has been shown and described in detail, the invention is not so limited and that various changes may be made therein without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In ordnance, a flexibly mounted gun and a manually controllable target sighting member, each flexibly mounted for parallel elevational

and azimuth adjustment pivotal movements about two transverse axes, motor means operably coupled with said gun for causing the latter to be pivoted, and pivoting movement synchronizing means operably associated with said sighting member and said gun drive motor means for synchronizing pivotal movements of said gun and said sighting device, said synchronizing means including a base, a pair of differential gears rotatably mounted upon said base and operatively coupled respectively to said sighting member and to said gun for rotation commensurate with respective elevational and azimuth pivotal movements thereof, a carrier movably mounted upon said base, differential pinion means rotatably mounted upon said carrier and arranged to be normally maintained thereby in geared relation with said differential gears, whereby said carrier and said pinion means are adapted to be displaced circumferentially as a unit relative to said differential gears as a consequence of differential relative movement of said gears, adjustment means on said carrier for regulating the position thereon of said pinion means radially of said differential gears, motor control means positionally fixed relative to said carrier and arranged to be actuated in response to positional displacement of the latter to cause said motor means to be energized to pivot said gun toward positional conformity with respect to said sighting member and in synchronism therewith, and positionally fixed cam means adapted to act upon said pinion adjustment means to automatically withdraw said pinion radially of said gears from operative engagement therewith upon differential displacement of said carrier beyond positions of actuation of said motor control means.

2. In ordnance, a flexibly mounted gun and a manually controllable target sighting member, each flexibly mounted for parallel aim adjustment movements, motor means operably coupled with said gun for causing the latter to be moved, and a movement synchronizing means operably associated with said sighting member and said gun drive motor means for synchronizing movements of said gun and said sighting device, said synchronizing means including a base, a pair of differential gears rotatably mounted upon said base and operatively coupled respectively to said sighting member and to said gun for rotation commensurate with movements thereof, a carrier movably mounted upon said base, differential pinion means rotatably mounted upon said carrier and arranged to be normally maintained thereby in geared relation with said differential gears, whereby said carrier and said pinion means are adapted to be displaced circumferentially as a unit relative to said differential gears as a consequence of differential relative movement of

said gears, adjustment means on said carrier for regulating the position thereon of said pinion means radially of said differential gears, motor control means positionally fixed relative to said carrier and arranged to be actuated in response to positional displacement of the latter to cause said motor means to be energized to move said gun toward positional conformity with respect to said sighting member and in synchronism therewith, and positionally fixed cam means adapted to act upon said pinion adjustment means to automatically withdraw said pinion radially of said gears from operative engagement therewith upon differential displacement of said carrier beyond positions of actuation of said motor control means.

3. In ordnance, a gun battery comprising a plurality of flexibly mounted guns and a manually controllable target sighting member, each flexibly mounted for parallel aiming pivotal movements, motor means operably coupled with said guns for causing the latter to be pivoted, and pivoting movement synchronizing means operably associated with said sighting member and said gun drive motor means for synchronizing pivotal movements of said guns and said sighting device, said synchronizing means including a base, paired differential gears rotatably mounted upon said base and operatively coupled respectively to said sighting member and to corresponding of said guns for rotation commensurate with respective pivotal movements thereof, a carrier for each pair of guns movably mounted upon said base, differential pinion means rotatably mounted upon each of said carriers and arranged to be normally maintained thereby in geared relation with corresponding of said differential gears, whereby said carriers and said pinion means are adapted to be displaced circumferentially as units relative to said differential gears as a consequence of differential relative movement of said gears, adjustment means on said carriers for regulating the positions thereon of said pinion means radially of said differential gears, motor control means positionally fixed relative to said carriers and arranged to be actuated in response to positional displacement of the latter to cause said motor means to be energized to pivot said guns toward positional conformity with respect to said sighting member and in synchronism therewith, and positionally fixed cam means adapted to act upon said pinion adjustment means to automatically withdraw said pinions radially of said gears from operative engagement therewith upon differential displacement of said carriers beyond positions of actuation of said motor control means.

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