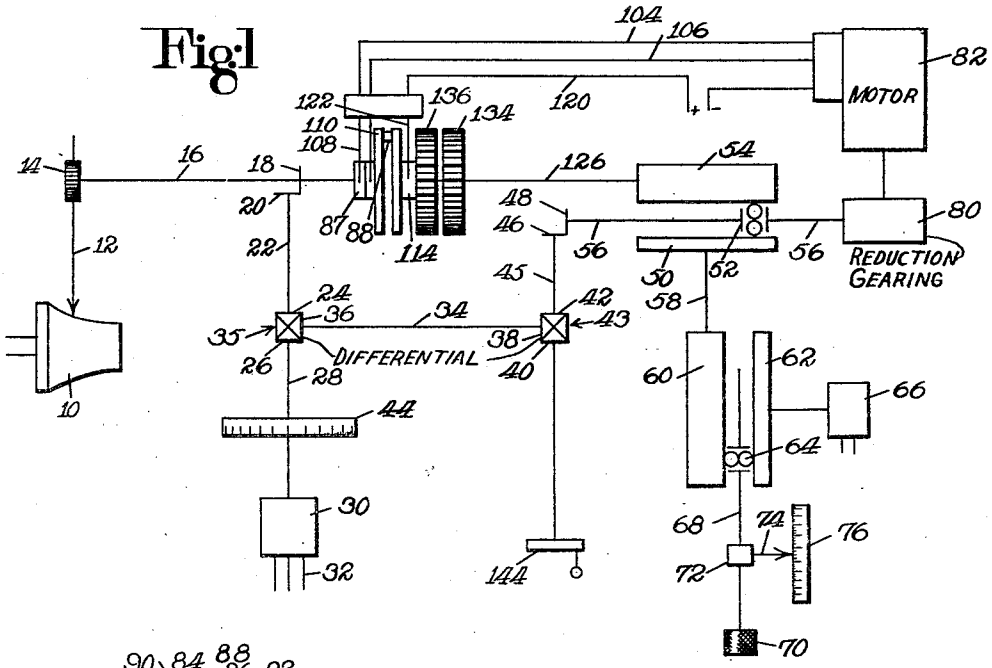
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Nov. 26, 1946. W. L. ABEL 2,411,511

ORDNANCE DATA CORRECTING APPARATUS

Filed April 9, 1943

Fig. 1



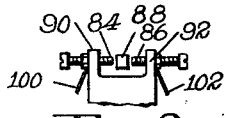


Fig. 3

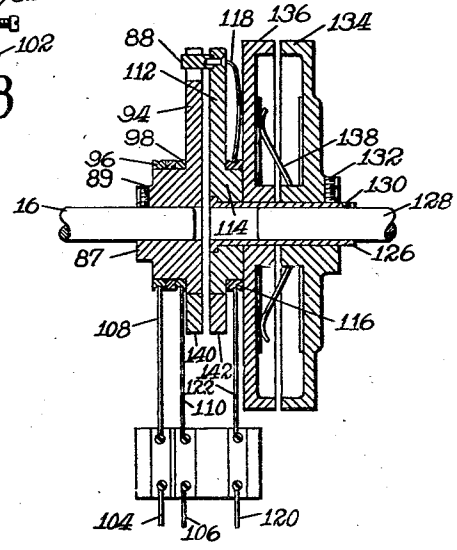


Fig. 2

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UNITED STATES PATENT OFFICE

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ORDNANCE DATA CORRECTING APPARATUS

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Application April 9, 1943, Serial No. 482,518

4 Claims. (Cl. 235—61.5)

1

This invention relates to apparatus for correcting ordnance data, for changes which may occur during the time interval between the determination of and the use of such data.

In the directing of gun fire toward moving targets, such as, for example, airplanes, it is the usual practice to employ a computing and predicting apparatus which is capable of providing data, such as, angle of train, angle of elevation and fuse value, for transmission to the gun or guns. When received, this data is used by the gun crew in aiming the gun and for setting the fuse on the shell. After the fuse has been set, in accordance with the received data, the shell is then placed in the gun and the gun is fired. Inasmuch as the fuse values are continuously changing, with the change in the computed time of flight of the shell to the predicted position of the target, it is necessary to introduce a correction for the so-called "dead time," i. e., the time it takes the gun crew to load and to fire the shell after the fuse has been set, in order that the shell will explode at the desired point in its trajectory.

It is an object of this invention to provide improved apparatus for continuously introducing dead time corrections into ordnance data, such as, for example, fuse values, as they are determined and before they are transmitted to the point of use. More particularly, this invention contemplates the provision of apparatus of such character that, by setting a manually adjustable member, in accordance with the particular dead time intervals for which correction is to be made, it may be conditioned for automatically and continuously making appropriate corrections to the data, being fed into the apparatus, before it is transmitted to the point where it is to be used. In this manner the correcting apparatus may be readily adapted to the different dead times of various gun crews.

Other objects and features of the invention will become apparent from the reading of the following detailed description of an illustrated embodiment of the invention, shown in the accompanying drawing, and will be pointed out in the claims.

In the drawing,

Fig. 1 is a schematic view of apparatus embodying the invention;

Fig. 2 is a view in section of mechanism forming a part of the apparatus shown in Fig. 1; and

Fig. 3 is a view in side elevation of parts of the mechanism shown in Fig. 2.

Referring to Fig. 1, for the purpose of describing the invention, the embodiment therein illustrated is shown associated with a ballistic cam 10 which forms a part of an ordnance computing and predicting mechanism, such as for example an anti-aircraft director, and similar to cam F, Fig. 1B of United States patent to Chaffee et al. No. 2,065,303. As will be understood by persons skilled in the art, the cam 10 is rotated and moved axially during the operation of the director to shift a follower 12 in accordance with the computed and predicted data, which, for the purpose of this description, will be considered as being fuse value. The bar 12 is provided with rack teeth which mesh with a gear 14, fast on a shaft 16, so that this shaft is rotated thereby. Accordingly, the shaft 16 will assume different angular positions corresponding to the different fuse values, as they are determined by the output of the cam 10, and will have an angular velocity which is proportional to the rate of change in these fuse values.

2

The shaft 16 drives, through bevel gears 18 and 20, a shaft 22 that is connected to one of the side gears 24 of a differential 35. The other side gear 26 of this differential is connected to a shaft 28 which drives a self-synchronous transmitting motor 30. The leads 32 from this motor are connected to a self-synchronous receiving motor, not shown, located at the gun. A correcting shaft 34 is connected at one end to the carrier 36 of the differential 35, and at its other end to the carrier 38 of a second differential 43, having side gears 40 and 42. A dial 44, carrying fuse value indicia, is also carried by the shaft 28. When the correcting shaft is not rotated, the fuse values, as determined by the cam 10, will be transmitted from the shaft 16 to the shaft 22 and thence, through the differential 35, to the shaft 28 and the transmitting motor 30. However, by rotating the shaft 34, these fuse values may be modified or corrected, inasmuch as the rotation of shaft 34 will be algebraically added to the rotation of shaft 22 in the differential 35. It will therefore be apparent, if the shaft 34 is rotated in accordance with the computed change in fuse value during a given dead time interval, that shaft 28 will be rotated in accordance with the predicted fuse value determined by the cam 10 and corrected for the computed change in the fuse value which will occur during that dead time interval.

For rotating the shaft 34 in accordance with the computed change in the fuse value during a given dead time interval, the following mechanism is provided. Extending from the side gear

42 of the differential 43 is a shaft 45 which carries a bevel gear 46. This bevel gear meshes with a bevel gear 48 which is secured to the ball carriage adjusting shaft 56 of a variable speed drive comprising a disk 50, a ball carriage 52 and a cylinder 54. The disk 50 is driven by a shaft 58 of a second variable speed drive comprising a cylinder 60, a disk 62 and a ball carriage 64. The disk 62 is driven by a constant speed electric motor 66. The ball carriage 64 is provided with an adjusting shaft 68, carrying a knurled knob 70, and is threaded through a block 72 from which a pointer 74 extends. This pointer travels past a scale 76 bearing indicia in terms of the dead time, and these indicia are so arranged with respect to the position of the ball carriage 64 that the cylinder 60 rotates at a speed proportional to the reciprocal of the dead time value on the scale which is opposite to the pointer 74.

In the variable speed drive including the disk 50, which is driven by the cylinder 60 just mentioned, the cylinder 54 will rotate at a speed which is proportional to the product of the speed of the disk 50 multiplied by the displacement of the ball carriage 52 from the center of said disk, i. e., V_c, the speed of the cylinder 54 is proportional to V_d, the speed of the disk 50, multiplied by d, the ball carriage displacement. This relationship may also be expressed, by transposing the term V_d, as follows: d is proportional to V_c divided by V_d. As before explained, V_d is proportional to the reciprocal of the dead time to which the pointer 74 has been set. Hence, d is proportional to the product of V_c multiplied by this dead time. It follows, therefore, that for any speed of the cylinder V_c, the rotation of shaft 56, which is a measure of the displacement of the ball carriage 52, d, will be proportional to the product of V_c multiplied by the dead time setting of the ball carriage 64, as indicated on the scale 76.

The dead time correction which is to be made, by the shaft 34, is the product of the dead time interval multiplied by the rate of change in the fuse values. A measure of this rate of change is present in the manner in which shaft 16 is rotated by the cam 10. That is to say, if the rate of change in the fuse values is uniform, this shaft will rotate at a uniform angular velocity, while, if the rate of change varies, the shaft 16 will be accelerated or decelerated, depending upon the direction in which the variation takes place. Hence, if the ball carriage 52 is continuously so adjusted that the speed of the cylinder 54, V_c, matches that of the shaft 16, the amount of rotation of the shaft 56 which was necessary to effect this matching, will be preportional to the product of the speed of rotation of the shaft 16, rate of change of fuse value, multiplied by the dead time, and will be a measure of the correction desired.

The matching of the speed of rotation of the cylinder 54 to that of the shaft 16 is effected in the following manner. The shaft 56, by means of which the ball carriage 52 is adjusted to vary the speed of the cylinder 54, is connected, by means of suitable reduction gearing 80, to a reversible electric motor 82. The operation of this motor is controlled by means of two contacts 84 and 86, carried by a hub 87, which is secured to the shaft 16 by means of set screw 89, Fig. 3, and a third contact 88. The contacts 84 and 86 comprise headed screws which are threaded through ears 90 and 92 formed on an arm 94 which is integral with the hub 87. The hub and arm are constructed of insulating material and two collector rings 96 and 98, mounted on the hub, are electrically connected to the contacts 84 and 86 by means of metallic strips 100 and 102, Fig. 3. Two lead wires 104 and 106 from the motor 82 are connected to these collector rings by means of brushes 108 and 110. The contact 88 is carried by an arm 112, formed integrally with a hub 114, and is electrically connected to a third collector ring 116, mounted on this hub, by means of a lead wire 118. Another lead wire 120 is connected to this ring by means of a brush 122. The last-mentioned lead wire is connected to one side of an electric circuit, the other side of which is connected to a third terminal on the motor, as shown in Fig. 1. The arrangement of these lead wires is such that when the contact 88 touches contact 90 the motor 82 runs in one direction, and when it touches the other contact 92, the motor runs in the reverse direction. The hubs 87 and 114 carry weights 140 and 142 for counterbalancing the arms 94 and 112.

The hub 114 is rotatably mounted on a shouldered bushing 126 which is secured to a shaft 128, extending from the cylinder 54, by means of a set screw 130. Secured to this bushing, by means of a set screw 132, is a dial wheel 134 and between this dial wheel and the hub 114 there is a second dial wheel 136 rotatably mounted on the bushing. This second dial wheel is held in frictional engagement with the hub 114 by means of a spring 138 which has sliding contact with the dial wheel 134. Thus, while the dial 134 is fixed with respect to the shaft 128 and must rotate with it, the dial 136 and the hub 114, together with its arm 112 and the contact 88, can move relatively thereto. Such relative rotation of the arm 112 and dial 136 with respect to shaft 128 and dial 134 will occur whenever the speeds of the shafts 16 and 128 are not the same, since the contact 88, which is secured to the arm 94, will then engage either one or the other of the two contacts 84, 86, which are secured to the shaft 16. Under these conditions, the motor 82 will be started and, through reduction gear 80, will turn the shaft 56 to effect a displacement of the ball carriage 52. The electrical connections to the motor and to the contacts are so arranged that this displacement takes place in a direction to bring the speed of rotation of the cylinder 54 and the shaft 128 up or down to the speed of rotation of the shaft 16. When this has been done, the contact 88 will move away from the contact 84 or 86 and the motor will come to a stop. Hence, should the speed of the shaft 16 vary, a corresponding change in the speed of the cylinder 54 will be effected, through the action of the motor 82 when contact is again made with either of the contacts 84 or 86. As before explained, the rotation of the shaft 56 is proportional to the product of dead time multiplied by the rate of change in the fuse values, i. e., the correction for dead time, and this correction is added algebraically in the differential 35 to the fuse values as they are determined by the cam 10. Corrections for observed errors may be made by means of a hand wheel 144, connected to the side gear 40 of the differential 43, these corrections being algebraically added to the dead time correction in this differential.

The operation of the correcting apparatus which has just been described should be apparent from what has been heretofore said and is briefly as follows: The knob 70 is turned to set the pointer 74 opposite to the appropriate dead time

235. REGISTERS.
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indicia on the scale **76** and the constant speed motor **66** is started. Now, as the target is tracked by the operators of the predicting and computing mechanism with which the cam **10** is associated, the fuse values are continuously determined by means of this cam and the shaft **16** is caused to rotate in accordance with the changes in these fuse values. These values are transmitted to the transmitting motor **30** through the shafts **22**, **28** and the differential **35**. Assuming that the ball carriage **52** was at the center of the disk **50** so that the cylinder **54** and its shaft **128** were stationary, the rotation of the shaft **16** would then bring one or the other of the two contacts **84** or **86** into engagement with the contact **88** and the arm **112**, together with the dial **136**, would be rotated relatively to the bushing **126** and the dial **134**. This difference in the speeds of the rotation of shafts **16** and **128** will be apparent by the relative movement of the dials **134** and **136**. Immediately, however, the motor **82** will be started and the ball carriage **52** moved in the proper direction to cause the cylinder **54** to rotate at the same speed as the shaft **16**. When this has been done, the shaft **56** will have been rotated an amount proportional to a correction in fuse value which corresponds to the dead time interval and the rate of change in fuse value at that particular instant. This correction is transmitted to the motor **30** by means of the shaft **44**, differential **43**, shaft **34**, differential **35** and shaft **28**. Accordingly, the fuse value which is transmitted to the guns from the motor **30** is the value determined by the cam **10** plus a correction for dead time. As the speed of the shaft **16** varies, with changes in the fuse value resulting from changes in the predicted position of the target, adjustment of the ball carriage **52** is automatically effected, by the motor **82**, so as to keep the speed of the cylinder **54** matched to that of the shaft **16**. As these adjustments are made, the resulting corrections are continuously computed, in the manner above described, and these corrections fed into the differential **35** by the shaft **34**.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for correcting ordnance data for changes occurring during dead time comprising a fuse value computing and predicting device, means driven by said device in accordance with predicted fuse values, a shaft, driving connections between said means and said shaft whereby the shaft is rotated in accordance with changes in predicted fuse values, a variable speed drive having a driving element, a driven element and a movable speed varying element, means for driving said driving element at a speed proportional to the reciprocal of the dead time interval for which correction is to be made, independently driven power-operated means, having control means sensitive to differences between the speeds of said shaft and said driven element, for automatically moving said speed varying element so as to cause said driven element to move in accordance with changes in the predicted fuse value, and means for combining the movements of the speed varying element with the rotation of said shaft.

2. Apparatus for correcting ordnance data for changes occurring during dead time comprising a fuse value computing and predicting device, means driven by said device in accordance with predicted fuse values, a shaft, driving connections between said means and said shaft whereby the shaft is rotated in accordance with changes in predicted fuse values, a variable speed drive having a driving disc, a driven cylinder, a ball carriage and a rotatable shaft for moving the carriage, means for driving the disc at a speed proportional to the reciprocal of the dead time interval of which correction is to be made, independently driven power-operated means, having control means sensitive to differences between the speeds of said shaft and said driven cylinder, for automatically rotating said second-named shaft to move the carriage so as to cause the cylinder to rotate at the same speed as said first-named shaft and hence in accordance with the changes in the predicted fuse values, and means for combining the rotation of the two shafts.

3. Apparatus for correcting ordnance data for changes occurring during dead time comprising a fuse value computing and predicting device, means driven by said device in accordance with predicted fuse values, a shaft, driving connections between said means and said shaft whereby the shaft is rotated in accordance with changes in predicted fuse values, a variable speed drive having a driving disc, a driven cylinder carrying a shaft, and a ball carriage, means for driving the disc at a speed proportional to the reciprocal of the dead time interval for which correction is to be made, a rotatable shaft for moving the ball carriage, means for rotating said shaft so as to cause the cylinder to rotate at the same speed as the first-named shaft and hence in accordance with the changes in the predicted fuse values, said shaft rotating means including a motor and means associated with the first-named shaft and the shaft carried by the cylinder for controlling the operation of the motor, and a differential for combining the rotations of the ball carriage moving shaft with the rotations of the first-named shaft.

4. Apparatus for correcting ordnance data for changes occurring during dead time comprising a fuse value computing and predicting device, means driven by said device in accordance with predicted fuse values, a shaft, driving connections between said means and said shaft whereby the shaft is rotated in accordance with changes in predicted fuse values, a variable speed drive having a driving disc, a driven cylinder carrying a shaft, and a movable ball carriage, means for driving the disc at a speed proportional to the reciprocal of the dead time interval for which correction is to be made, a rotatable shaft for moving the ball carriage, means for rotating said shaft so as to cause the cylinder to rotate at the same speed as the first-named shaft and hence in accordance with the changes in the predicted fuse values, said shaft rotating means including an electric motor and contacts on the first-named shaft and on the shaft carried by the cylinder for controlling the operation of the motor, and a differential for combining the rotations of the ball carriage moving shaft with the rotations of the first-named shaft.

WALTER L. ABEL.