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Kendy

CROSS REFERENCE

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- [54] WEAPON FIRING COMPUTER
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- [73] Assignee: Hughes Aircraft Company, Culver City, Calif.
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- [51] Int. Cl. G06g 7/80
- [58] Field of Search 235/61.5 R, 61.5 B, 235/61.5 E, 61.5 DF, 186, 189, 190, 191, 192

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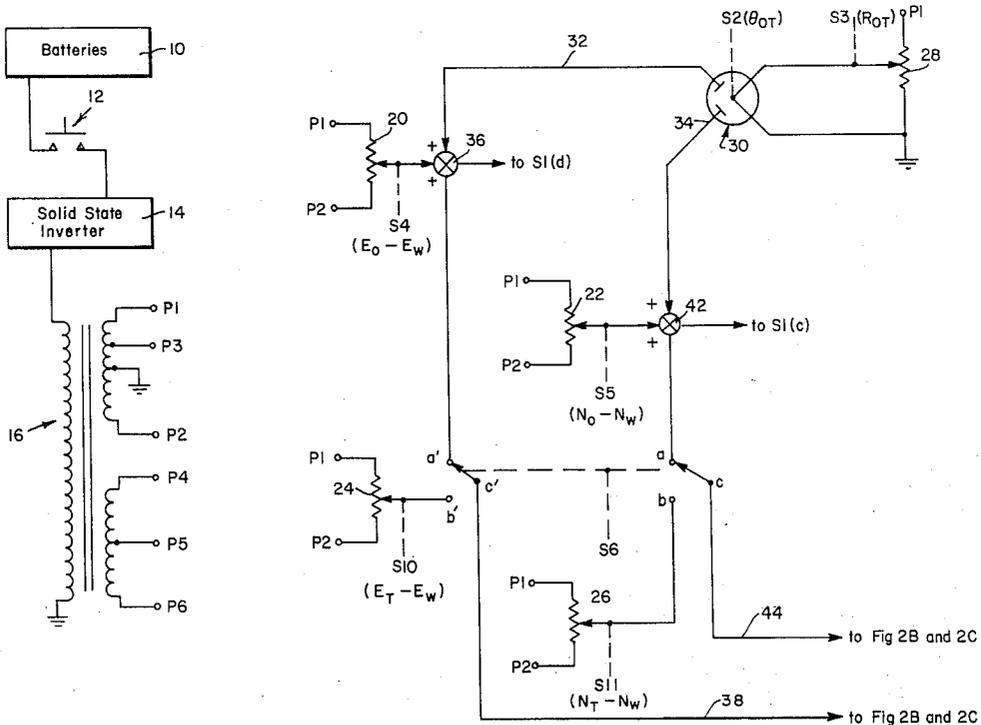
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[57] **ABSTRACT**

The present invention is a fire control computer which computes weapon firing data from known information set into the computer by handset controls in a predetermined sequence of operations. The fire control computer is analog in nature and uses handset knobs and switches coupled to dials to input known information to potentiometers and resolvers. Other knobs and switches are used to null electrical signals to resolvers and potentiometers to provide the desired information on dials which may be read by the operator.

9 Claims, 5 Drawing Figures



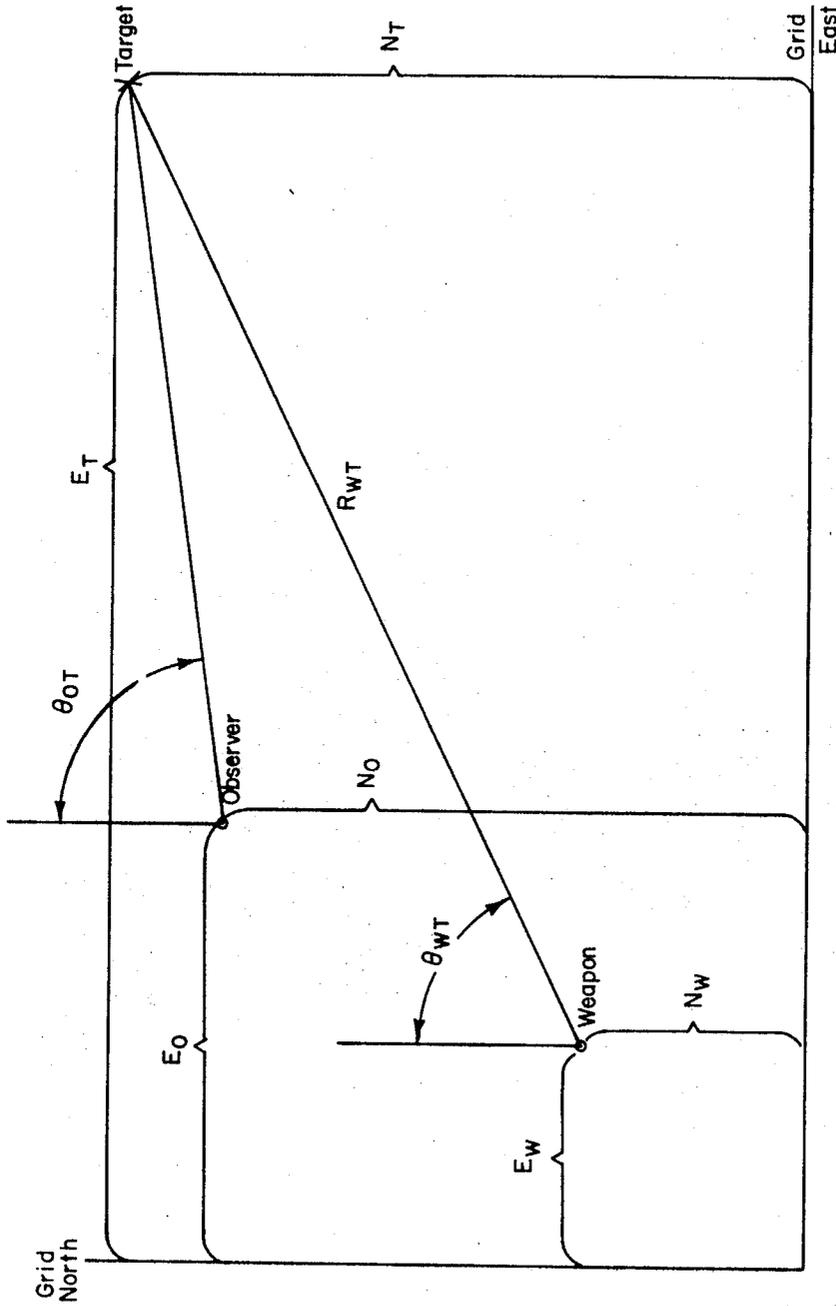


Fig.1.

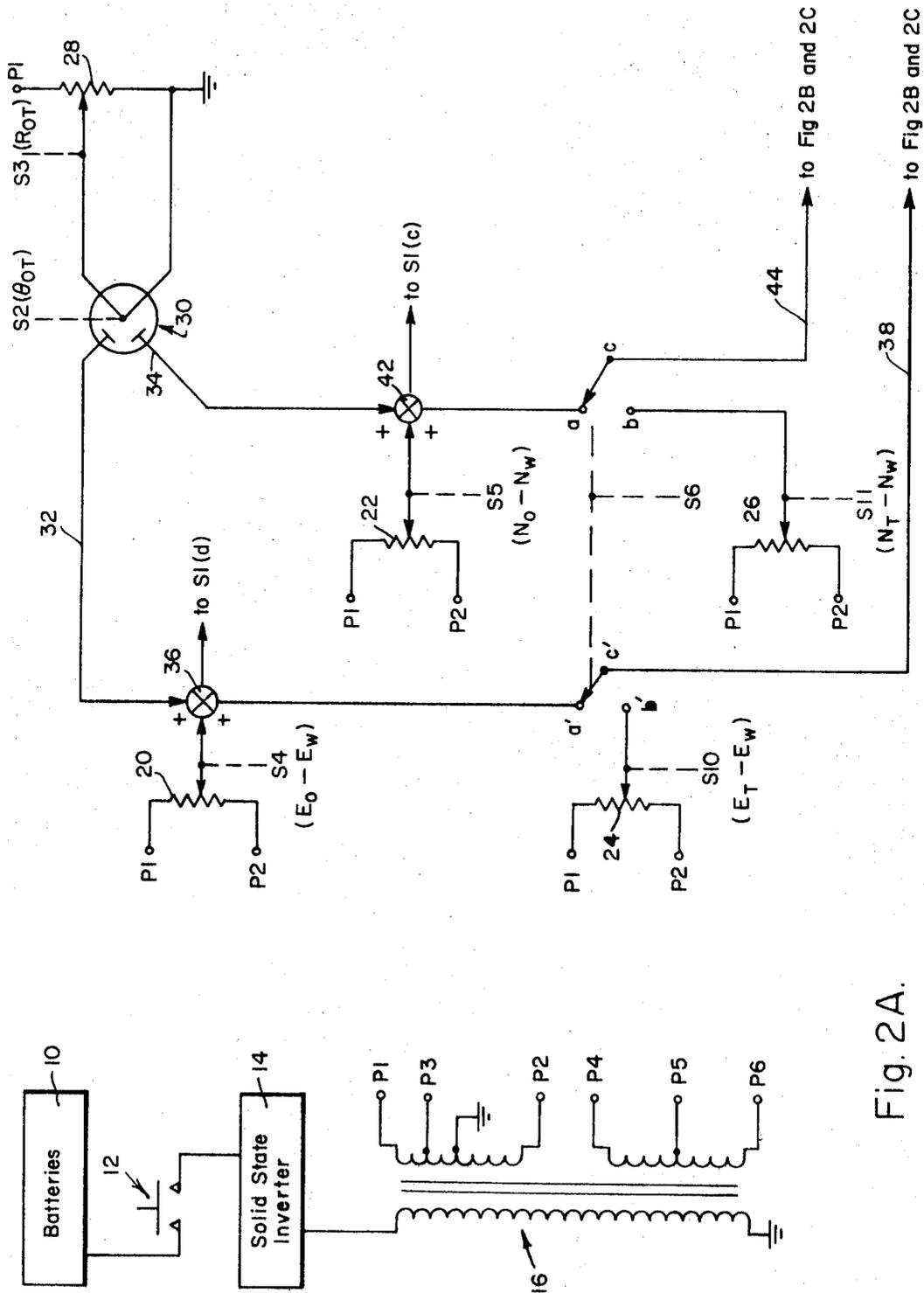


Fig. 2A.

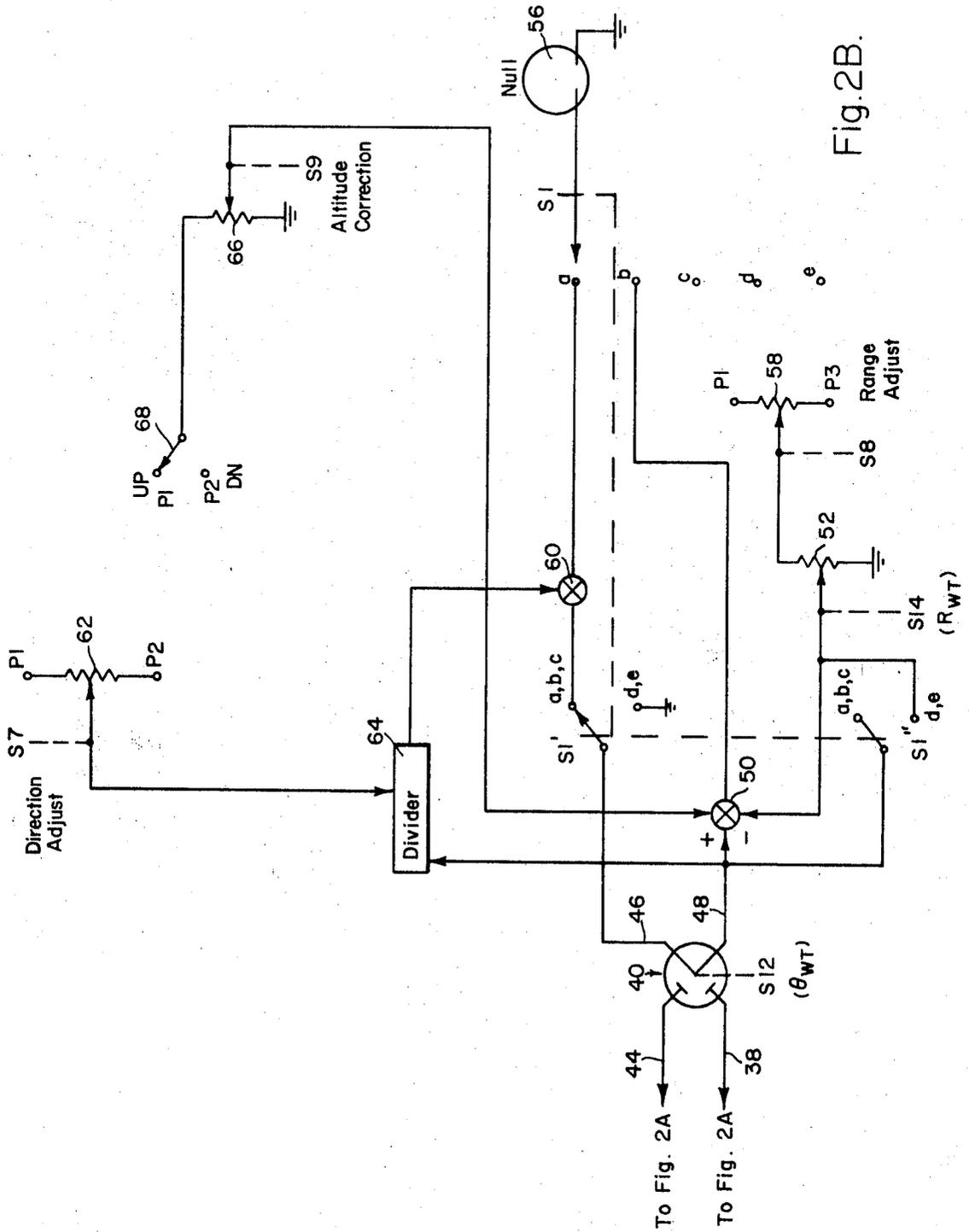


Fig. 2B.

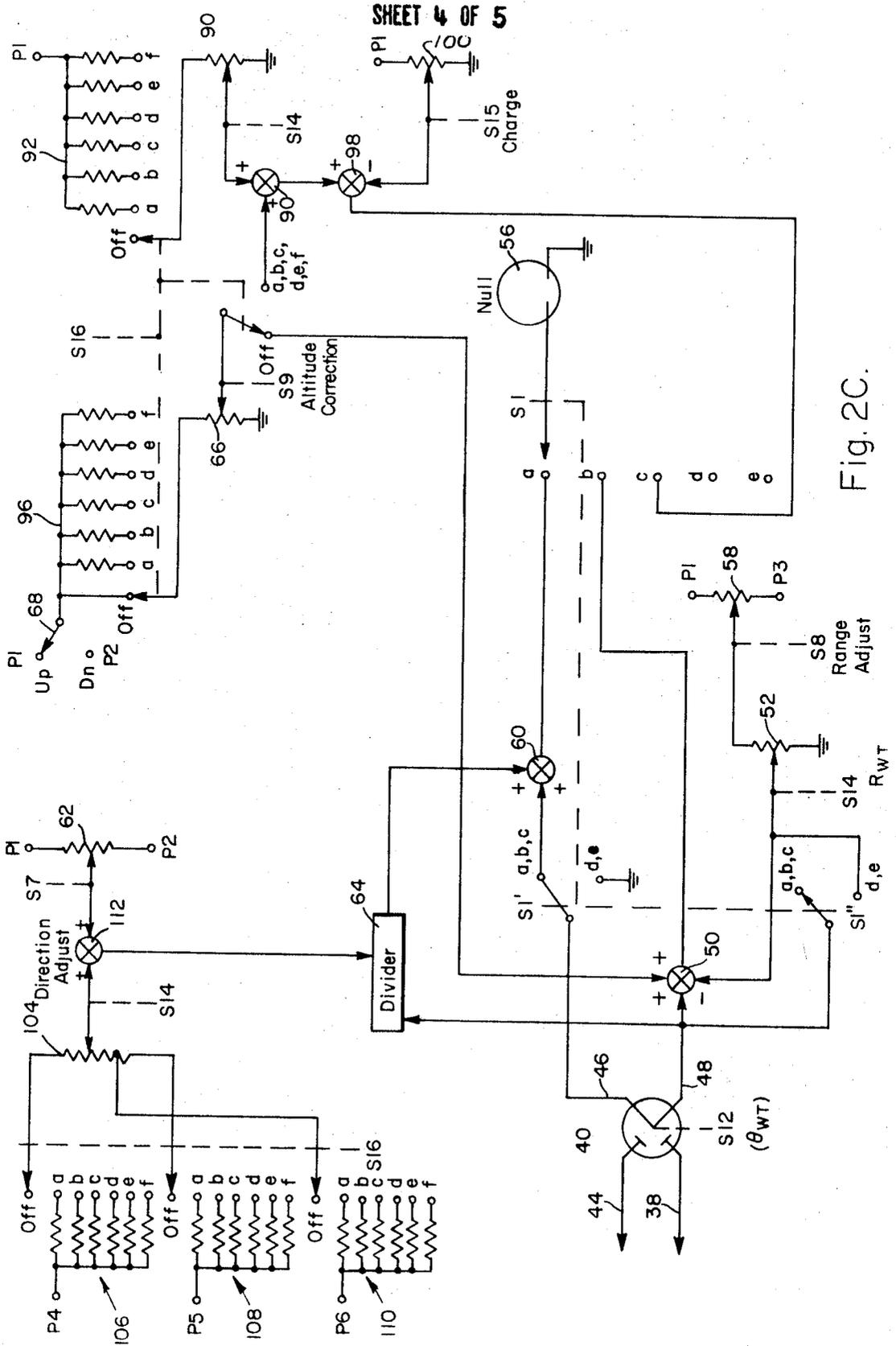


Fig. 2C.

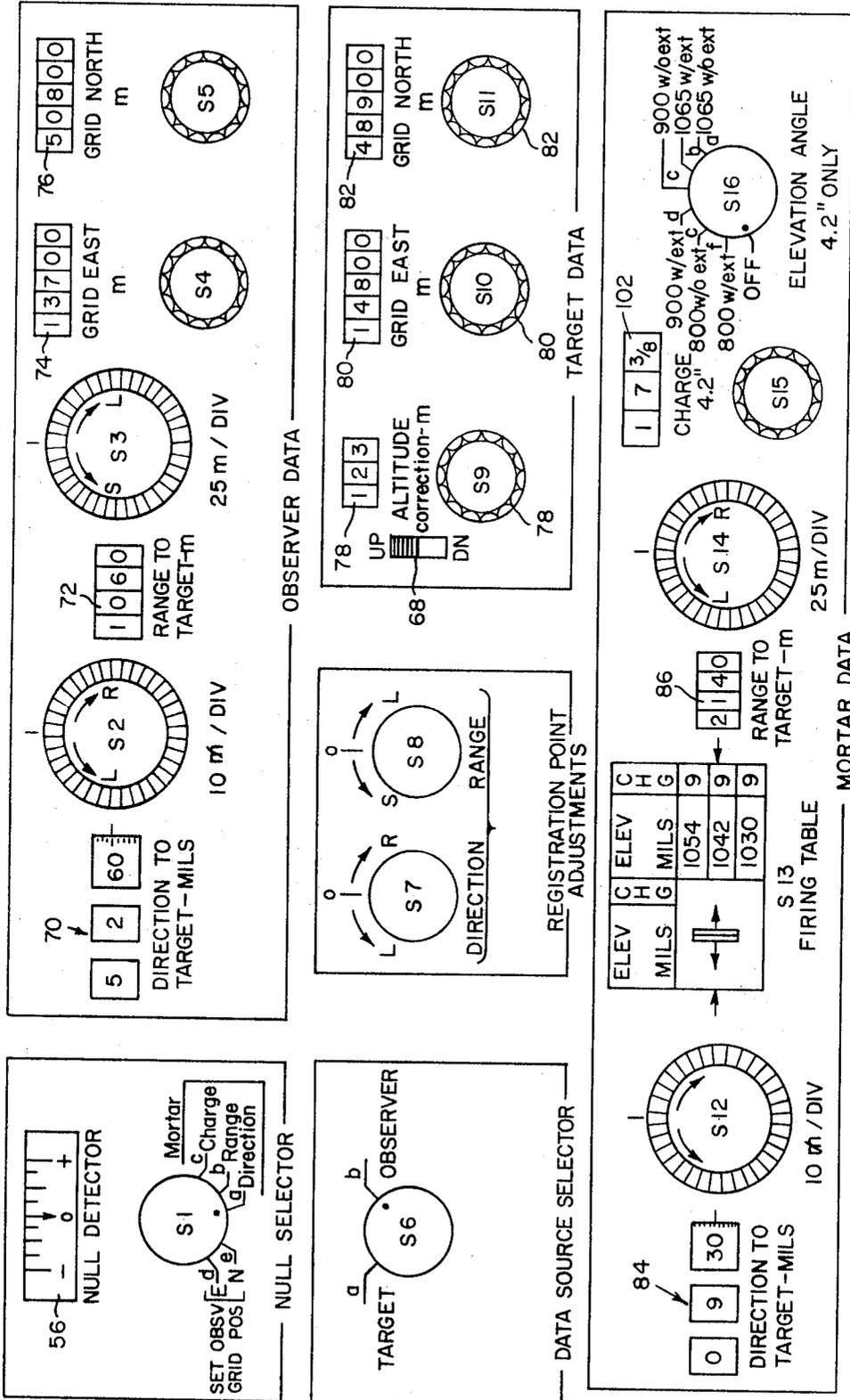


Fig. 3.

WEAPON FIRING COMPUTER

BACKGROUND OF THE INVENTION

Weapons such as cannons and mortars normally are emplaced in defilade to conceal them from the enemy. For the vast majority of targets, placing pieces in defilade precludes sighting the weapon directly at the target (direct fire). Consequently, indirect fire must be employed to attack the targets. The gunnery problem is primarily the problem of indirect fire. The solution of this problem requires weapon and ammunition settings which, when applied to the piece and the ammunition, will cause the projectile to burst on, or at a proper height above, the target. The steps in the solution of the gunnery problem are

- a. Location of the target and battery,
- b. Determination of chart data (direction, range, and vertical interval from weapons to target),
- c. Conversion of chart data to firing data,
- d. Application of firing data to the weapons.

Weapon firing is accomplished by a team effort. The elements of the gunnery team are

- a. *Observers.* The observers (to include all target acquisition devices) detect and report to the fire direction center the location of suitable targets, initiate calls for fire, and conduct an adjustment if necessary.
- b. *Fire Direction Center.* The fire direction center (FDC) evaluates the information received from the observers, determines firing data, and furnishes these data in the form of fire commands to the firing battery.
- c. *Firing Battery.* The firing battery applies the firing data to the weapons and fires the weapons.

The prior art methods of computing the firing data vary depending on the type of weapon. For example, for field artillery the computation is usually provided by a digital computer. On the other hand, when mortars are being fired, the computations are made by graphical techniques and hand computations using a plotting board, special scales, slide rules, nomographs, charts and tables. In the event of a failure in a field artillery digital computer, the backup computations are performed in the same manner as for the mortars. Hand computations are subject to human error, especially because many different scales and tables must be read and geometric constructions must be made. In addition, considerable training time and skilled personnel are required. The invention provides a primary means of computing mortar firing data in a manner suitable for use by personnel having a minimum of training, and a backup means of computing field artillery firing data.

SUMMARY OF THE INVENTION

The present invention is a fire control computer which computes weapon firing data from known information set into the computer by handset controls in a predetermined sequence of operations. The fire control computer is analog in nature and uses handset knobs and switches coupled to dials to input known information to potentiometers and resolvers. Other knobs and switches are used to null electrical signals to resolvers and potentiometers to provide the desired information on dials which may be read by the operator.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of a typical grid coordinate system used for weapon firing.

FIG. 2A is a portion of the circuit diagram common to both of the alternate preferred embodiments of the present invention shown in FIGS. 2B and 2C.

FIG. 2B is a portion of the circuit diagram for one preferred embodiment of the present invention.

FIG. 2C is a portion of the circuit diagram for a second preferred embodiment of the present invention.

FIG. 3 is a diagram of an operators panel for the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 there is shown a typical grid coordinate system used for weapon firing. Under actual field conditions the grid coordinates will be on a map of the area. The weapon will be in a position on the grid coordinate system identified by the distance in meters along the grid east coordinate E_w and the distance in meters along the grid north coordinate N_w . Similarly, the observer will be at a position identified by the distance in meters along the grid east coordinate E_o and the distance in meters along the grid north coordinate N_o . Similarly, the target will be at a position identified by the distance in meters along the grid east coordinate E_T and the distance in meters along the grid north coordinate N_T .

The information required for firing the weapon is the direction from the weapon to the target measured as an angle from the grid north coordinate to the straight line drawn between the weapon and the target. This is identified in FIG. 1 as the angle θ_{WT} . The angles for weapon firing are measured in mils. An angle of 1 mil will subtend an arc of 1 meter at a distance of 1,000 meters. In addition to the direction from the weapon to the target θ_{WT} , it is required to know the angle of elevation from the horizontal of the weapon and the amount of charge to be used in firing the weapon. The angle of elevation and the charge is a function of the range R_{WT} from the weapon to the target. If the grid positions of the weapon and the target are known, the direction angle θ_{WT} and the range R_{WT} may be obtained in a fairly straightforward manner by solving the following equations:

$$E_T - E_w = R_{WT} \sin \theta_{WT} \quad (1)$$

$$N_T - N_w = R_{WT} \cos \theta_{WT} \quad (2)$$

It should be apparent that even in this ideal situation, the determination of the range and the direction angle requires a fairly complex computation or table lookup procedure.

In the less than ideal situation, of course, the computations become increasingly difficult. For example, many times the grid coordinate position of the target is unknown. Furthermore, the weapon firing personnel may not be able to see the target and thus would not have any way of determining the range or the direction angle from the weapon to the target. Thus, in many types of weapon firing, an observer located at a point distant from the weapon position may make estimates

of the direction angle θ_{OT} from the observer to the target and the range R_{OT} from the observer to the target. This information is transmitted to the weapons firing personnel. Then, if the grid position E_o and N_o of the observer is known, the direction angle θ_{WT} and the range R_{WT} from the weapon to the target may be determined by trigonometric relationships. It should be apparent that the trigonometric computation would be fairly complex. Additional complications are brought in by the fact that many times the grid position of the observer is not known. In any case, if a certain minimum amount of information is known, it may be possible to compute by actual computation or geometric constructions or table lookup procedures the weapon firing information needed.

FIGS. 2A and 2B show a circuit diagram for one embodiment of the weapon fire control computer of the present invention. As shown in FIG. 2A, power for the circuitry is supplied by batteries 10. The direct current from the batteries 10 is coupled through a push-to-close power switch 12 to a solid state inverter 14 which provides an alternating current output when the switch 12 is closed. The output of the solid state inverter 14 is coupled to the primary coil of a transformer 16. The transformer 16 will have secondary coils to provide the required voltages for the operation of the circuitry. The terminals P1, P2, P3, P4, P5 and P6 correspond to similarly labelled terminals in the remainder of the circuit diagrams where the voltage on the transformer terminal is applied.

The circuitry shown in FIG. 2A further includes a potentiometer 20 which represents the algebraic difference between the observer's grid east coordinate and the weapon grid east coordinate ($E_o - E_w$). The potentiometer 20 is positioned by handset knob S4. A potentiometer 22 is provided to represent the algebraic difference between the observer's grid north coordinate and the weapon grid north coordinate ($N_o - N_w$). The potentiometer 22 is positioned by handset knob S5. A potentiometer 24 represents the algebraic difference between the target grid east coordinate and the weapon grid east coordinate ($E_T - E_w$). The potentiometer 24 is positioned by handset knob S10. A potentiometer 26 represents the algebraic difference between the target grid north coordinate and the weapon grid north coordinate ($N_T - N_w$). The potentiometer 26 is positioned by handset knob S11. A potentiometer 28 is provided to represent the range from the observer to the target R_{OT} . The potentiometer 28 is positioned by handset knob S3. The output of the potentiometer 28 is applied to one of the rotor windings of a resolver 30. The second rotor winding of the resolver 30 is coupled to ground potential. The rotor of the resolver 30 is positioned by handset knob S2. The angular displacement of the knob S2 is representative of the direction angle from the observer to the target θ_{OT} . A first stator winding 32 of the resolver 30 provides an output which is representative of the function $R_{OT} \sin \theta_{OT}$. A second stator winding 34 provides an output which is representative of the function $R_{OT} \cos \theta_{OT}$.

The first stator winding 32 of the resolver 30 is coupled to one input of a summing junction 36. The output of the potentiometer 20 is coupled to a second input of the summing junction 36. One output of the summing junction 36 is coupled to a contact for position (d) of a first pole of a multipole-multiposition selector switch S1. A second output of the summing junction 36 is cou-

pled to a contact (a') of a double pole/double throw switch S6. The output of the potentiometer 24 is coupled to a contact (b') of the switch S6. A pole terminal (c') of the switch S6 is coupled to a first stator winding 38 of a resolver 40 shown in FIG. 2B.

The second stator winding 34 of the resolver 30 is coupled to a first input of a summing junction 42. The output of the potentiometer 22 is coupled to a second input to the summing junction 42. One output of the summing junction is coupled to a contact for position (e) of the selector switch S1. A second output of the summing junction 42 is coupled to a contact (a) of the double pole/double throw switch S6. The output of the potentiometer 26 is coupled to a contact (b) of the switch S6. A pole contact (c) of the switch S6 is coupled to a second stator winding 44 of the resolver 40.

Referring now to FIG. 2B, the rotor of the resolver 40 is positioned by handset knob S12. The angular position of the knob S12 is representative of the direction angle from the weapon to the target θ_{WT} . A first rotor winding 46 of the resolver 40 is coupled to a second pole of the switch S1 identified as S1'. A second rotor winding 48 of the resolver 40 is coupled to one input of a summing junction 50, to a third pole of the switch S1 identified as S1'' and to one input of a divider circuit 64. The output of a potentiometer 52 is coupled to an input of the summing junction 50. The potentiometer 52 is positioned by handset knob S14. The output of the potentiometer 52 is representative of the range from the weapon to the target R_{WT} . The output of the potentiometer 52 is also coupled to the contacts representative of positions (d) and (e) of the third pole S1'' of switch S1. The output of the summing junction 50 is coupled to a contact representative of position (b) of switch S1.

The basic functional operation of the circuits shown in FIGS. 2A and 2B will now be described. The first condition to be described is that where the target grid coordinates are known and the weapon grid coordinates are known. Switch S6 is put into position (b). The potentiometer 24 is set by knob S10 to the algebraic difference between the target grid east coordinate and the weapon grid east coordinate ($E_T - E_w$). Similarly, the potentiometer 26 is set by knob S11 to the algebraic difference between the known target grid coordinate and the weapon grid north coordinate ($N_T - N_w$). Now, with switch S6 in position (b), the voltage representative of $E_T - E_w$ is applied to stator winding 38 of the resolver 40. Similarly, the voltage representative of $N_T - N_w$ is applied to the stator winding 44 of the resolver 40. Switch S1 is placed in position (a). The second set of contacts S1' for the switch S1 will couple the first rotor winding 46 of the resolver 40 through a summing junction 60, which will be ignored for the present, to contact (a) of the first set of contacts for switch S1. The pole of switch S1 is coupled to a voltmeter 56 adapted to act as a null meter. With power switch 12 held in the closed position, the knob S12 is rotated until the voltage output on the first rotor winding 46 goes to zero as shown by the voltmeter 56. The position of the knob S12 then represents the direction angle from the weapon to the target θ_{WT} . This angle θ_{WT} may then be read from a counter coupled to the knob S12 and calibrated to read in military mils.

To determine the range from the weapon to the target, R_{WT} , the switch S1 is placed in position (b). The switches indicated as S1' and S1'' will not electrically

change from the position shown in FIG. 2B. The second rotor winding 48 will have an output voltage as a result of the prior setting of the resolver by knob S12. This output voltage is coupled to the summing junction 50. The third input to the summing junction 50 will be ignored for the present. The output of the summing junction 50 is coupled to position (b) of switch S1. Voltage is then applied to the voltmeter 56. As the power switch 12 is held closed, knob S14 is rotated until the output voltage from the potentiometer 52 applied to the summing junction 50 balances the voltage from the second rotor winding 48 from the resolver 40 as shown by the voltmeter 56. When the voltages are balanced, the knob S14 position will indicate the range from the weapon to the target R_{WT} . This range may then be read from an indicator which may be calibrated in meters.

In many situations the weapon grid coordinates may be known but the target grid coordinates will not be known and the target cannot be seen by the weapon firing personnel. In this case, an observer located at some position distant from the target and the weapon is used to provide weapon firing information. Assume now that the weapon grid coordinates are known and the observer grid coordinates are known. Referring again to FIG. 2A the algebraic difference between the observer grid east coordinate and the weapon grid east coordinate ($E_o - E_w$) is set on potentiometer 20 by knob S4. Similarly, the algebraic difference between the observer grid north coordinate and the weapon grid north coordinate ($N_o - N_w$) is set on potentiometer 22 by knob S5. Switch S6 is placed in position (a).

Now, the observer will sight on the target to provide an estimate of the direction angle from the observer to the target θ_{OT} and an estimate of the range from the observer to the target R_{OT} . The direction angle θ_{OT} is set on knob S2 which rotates the rotor of the resolver 30. The range R_{OT} is set on knob S3 which sets potentiometer 28 to give a signal representative of the value of the range R_{OT} . The first stator winding 32 of the resolver 30 will provide an output signal representative of $R_{OT} \sin \theta_{OT}$. This signal is applied to the summing junction 36 where it is summed with the signal from the potentiometer 20 which is representative of $E_o - E_w$. The output of the summing junction 36 will then provide a signal which is representative of $E_T - E_w$ in accordance with the following equation:

$$(E_T - E_w) - (E_o - E_w) = R_{OT} \sin \theta_{OT}$$

(3)

In a similar manner the second stator winding 34 of the resolver 30 will provide an output which is representative of $R_{OT} \cos \theta_{OT}$. This signal is applied to the summing junction 42 and is summed with the output of the potentiometer 22 which is representative of $N_o - N_w$. The output of the summing junction 42 provides a signal representative of $N_T - N_w$ in accordance with the following equation:

$$(N_T - N_w) - (N_o - N_w) = R_{OT} \cos \theta_{OT}$$

60

Thus, contact (c') of switch S6 will provide a signal representative of the target grid east coordinate with the offset for the weapon grid east coordinate. Similarly, contact (c) of switch S6 will provide a signal representative of the target grid north coordinate with an offset for the weapon grid north coordinate. These signals are applied to the stator windings of the resolver

40. The remainder of the circuitry for finding the firing information R_{WT} and θ_{WT} will operate in the same manner as described previously.

In many situations the weapon grid coordinates may be known but the target grid coordinates are not known and the observer grid coordinates are not known. Before the observer can provide meaningful data regarding the position of the target, the observer's grid coordinates must be known. The circuitry of the present invention provides a means for providing this information. Assuming now that the observer can see the weapon position, one method of locating the observer's grid coordinates is to have the observer sight on the weapon and provide information regarding the direction angle from the observer to the weapon and the range from the observer to the weapon. This information is set on knob S2 and knob S3. Knobs S12 and S14 are set to zero. Switch S1 is set to position (d) or position (e). With switch S1 in position (d) or (e), the set of contacts labeled S1' will provide a ground signal to the first rotor winding 46 of the resolver 40. In a similar manner, since knob S14 is set to zero (ground), the switch contact labeled S1'' will provide a ground signal to the second rotor winding 48 of the resolver 40. Further, since knob S12 is at zero, the stator windings 38 and 44 of the resolver 40 will be at ground. Switch S6 is set to position (a) and ground will be applied to summing junctions 36 and 42. Now, with switch S1 in position (d), and switch 12 depressed, the output of the summing junction 36 is applied to the voltmeter 56. In this condition knob S4 is rotated until the voltmeter is nulled with the signal from the stator winding 32 of resolver 30. The potentiometer 20 will then be set to the observer grid east coordinate with the offset for the weapon grid east coordinate in accordance with the following equation:

$$E_o - E_w = R_{OW} \sin \theta_{OW}$$

(5)

In a similar manner, when switch S1 is set to position (e), the signal from the second stator winding 34 of the resolver 30 is nulled with the output of the potentiometer 22. When a null position is reached, the signal from the potentiometer 22 will be representative of the observer grid north coordinate with the offset for the weapon grid north coordinate, in accordance with the following equation:

$$N_o - N_w = R_{OW} \cos \theta_{OW}$$

(6)

Now that the observer grid position has been determined, the observer may then provide information concerning target location and firing information may be determined as previously described.

Another method of determining the observer grid position is to set in target grid position east and north on knobs S10 and S11. Then with switch S6 in position (b), weapon firing information θ_{WT} and R_{WT} is determined with knobs S12 and S14 following the procedure described previously. Now, the observer may sight on the known target and give the direction angle and range from the observer to the target θ_{OT} and R_{OT} . If there is no known target, the weapon firing personnel may fire a marking round with the firing information previously determined. The observer then sights on the burst of

the marking round and gives his direction angle and range information. This information is set on knobs S2 and S3. Switch S6 is then placed in position (a) and switch S1 is placed in position (d) or (e). Knobs S4 and S5 are then used to null the signals. The potentiometers 20 and 22 will then provide signals representative of the observer grid east coordinate offset for the weapon grid east coordinate and the observer grid north coordinate offset for the weapon grid north coordinate respectively.

After the observer has been located and the initial firing data to a particular target has been determined, actual weapon firing may commence. If the first round misses, the observer will report the observed errors in θ_{OT} and R_{OT} . These values are set in on knobs S2 and S3. The nulling procedure previously described is used to determine new values of θ_{WT} and R_{WT} . This procedure is continued until actual target hits are obtained.

If all conditions of materiel and weather are standard, firing a weapon at a particular range and deflection angle would cause the projectile to strike the target. However, standard conditions of materiel and weather seldom exist. For example, there may be crosswinds or headwinds or tailwinds which may affect the trajectories of the ammunition being fired. Other errors may be introduced due to particular characteristics of the ammunition being used. The usual way of compensating for these non-standard errors is to conduct a registration. The operational procedure requires that a known target be fired upon until hits are scored. The differences between the initial and final values of direction and range to target are the registration errors. An error in direction is treated as a bias and is to be added to all other target direction coordinates. An error in range is treated as a proportional error. For example, an error of +300 meters when firing at a target with a 3000 meter range gives an error of +10 percent. All other target ranges are thereafter to be decreased by 10 percent. The circuits shown in FIG. 2B adds appropriate circuitry to the circuitry previously described to provide for these error corrections, without requiring any calculations by the operator.

Under normal conditions without a direction adjustment, knob S12 would be rotated until the signal on rotor winding 46 of the resolver 40 is zero. For the direction adjustment, we would like to sum a fixed voltage representative of the fixed direction angle bias with the signal on rotor winding 46. For this purpose, a summing junction 60 is provided to accept the signal from switch contact S1' for positions (a), (b) and (c). The output of summing junction 60 is coupled to position (a) of switch S1. A potentiometer 62 is provided to give a positive or negative direction adjust signal. The potentiometer 62 is operated by knob S7. The output of the potentiometer 62 is applied to a divider circuit 64. Ignoring the operation of the divider 64 for a moment, it would be desirable to couple the direction adjust signal from the potentiometer 62 directly into the summing junction 60 and thereby provide for the direction angle bias. Then when knob S12 is rotated to achieve a voltage null at the output of summing junction 60, the signal on rotor winding 46 will be not quite at zero. However, because the direction angle bias is small, the signal on rotor winding 48 will still be essentially the same. However, with a resolver the scale factor depends upon the amplitude of the excitation to it. Thus the amount of adjustment to provide for a fixed angle

bias, depends upon the signal on the stator windings 38 and 44 which would depend upon the range from the weapon to the target. To compensate for this, the signal on rotor winding 48 is coupled to one input to the divider 64. The fixed voltage from the potentiometer 62 is coupled to the other input to the divider 64. The signal from the potentiometer 62 is then scaled to be proportional to the resolver excitation. The divider output is coupled to the summing junction 60 to provide the adjustment for the fixed angle bias.

After conducting the registration, to store the direction bias in the computer, switch S6 is set to position (b). Knobs S10 and S11 are set to the known target grid coordinates used for the registration. Knobs S12 and S14 are left at the positions finally determined by the registration. Switch S1 is set to position (a) and the input to voltmeter 56 is nulled by adjusting potentiometer 62 with knob S7.

As noted, the range adjustment for the registration firing is proportional to the error for the registration round. This adjustment can be accomplished by changing the scale factor of the potentiometer 52 which represents the range from the weapon to the target. The scale factor adjustment is made by using an additional potentiometer 58 which is operated by knob S8. The output of the potentiometer 58 provides the voltage excitation for the potentiometer 52. After conducting the registration, any error in range is compensated for by setting switch S6 to position (b). Knobs S10 and S11 are set to the known target grid coordinates used for the registration. Knobs S12 and S14 are left at the positions finally determined by the registration. Switch S1 is set to position (b) and the input to voltmeter 56 is nulled by adjusting potentiometer 58 with knob S8. This will provide the same percentage adjustment for all subsequent settings of potentiometer 52 and the reading from knob S14 of the range from the weapon to the target will be that used to fire the weapon because the correction has been automatically introduced by the circuitry.

Another adjustment which may have to be made is the adjustment based on the difference in altitude between the weapon and the target. If the altitude of the target is either higher or lower than the altitude of the weapon, the weapon must be fired at an apparent range which is different from the actual geometric range from the weapon to the target. For example, if the target is at an altitude higher than the weapon, the weapon must be fired at an apparent range which is greater than the actual geometric range to be able to hit the target. When the weapon is an 81 mm mortar the change in the range used to account for the difference in altitude is equal to one-half of the difference between the altitude of the weapon and the altitude of the target. Of course, the change in the range will be either added to or subtracted from the geometric range depending upon whether the target is higher or lower than the weapon. The circuitry shown in FIG. 2B provides means for giving this altitude adjustment. A potentiometer 66 is provided. The potentiometer 66 is operated by knob S9. A two-position switch 68 provides either positive or negative voltage to the potentiometer 66 depending upon whether the altitude of the target is higher or lower than the altitude of the weapon. When an altitude adjustment is to be made the knob S9 is turned to a position representing the difference in altitude. Switch 68 is then turned to either positive or neg-

ative. The voltage excitation to potentiometer 66 is scaled so that its voltage output represents one-half of the altitude difference set in. This output is coupled to the summing junction 50 to be added to or subtracted from the range signal from the resolver 40. Then when knob S14 is rotated to null the output of summing junction 50, the dial coupled to knob S14 will give the apparent firing range and not the actual geometric range. This apparent range will reflect both the registration and the altitude corrections.

As previously noted, the fire control computer of the present invention may be used for many types of weapon firing. For example, the fire control computer may be used advantageously for the firing of mortars. FIG. 3 shows an operator's panel for a fire control computer used for mortar firing. The switches, knobs and dials are identified with reference numbers which correspond to the reference numbers used in the circuit diagrams of FIGS. 2A and 2B.

Knob S1 in the upper lefthand corner of FIG. 3 operates all sets of contact for the switch S1. Further, when knob S1 is pushed, it operates the push-to-close power switch 12. The dial of the null detector 56 is displayed above the knob S1. Knob S2 operates the resolver 30 which represents the direction angle from the observer to the target θ_{OT} . A mechanical counter 70 is geared directly to knob S2 to provide a visual reading of the direction angle in mils. Knob S3 operates potentiometer 28 which represents the range from the observer to the target R_{OT} . A mechanical counter 72 is geared directly to the knob S3 to provide a visual reading of the range from the observer to the target in meters. Knob S4 operates potentiometer 20 which represents the grid east coordinate of the observer. Knob S4 is geared directly to a mechanical counter 74 which visually displays the grid east coordinate. Recall that the output of potentiometer 20 is representative of the algebraic difference between the observer grid east coordinate and the weapon grid east coordinate. One method of setting the potentiometer to the algebraic difference between the two coordinates while having the counter 74 read directly in the observer grid east coordinate is to have the knob S4 connected to the potentiometer 20 through a spring loaded mechanical clutch mechanism. By pulling out the knob against the spring pressure, the clutch is disengaged. The operating procedure would be that the potentiometer 20 would first be set to electrical zero. Then the clutch is disengaged and the mechanical counter 74 is set to the weapon grid coordinate. Next, the clutch is engaged and the counter 74 is set to the observer grid coordinate. The net effect is that the mechanical counter 74 reads in the observer grid coordinates directly while the output of the potentiometer 20 represents the algebraic difference between the observer grid east coordinate and the weapon grid east coordinate.

Knob S5 operates potentiometer 22 which represents the observer grid north coordinate. Knob S5 will be geared directly to a mechanical counter 76 to provide visual indication of the observer grid north coordinate. Knob S5 will be identical in operation to knob S4. Knob S6 operates switch S6 which selects either the observer input information in position (a) or the target coordinate information in position (b).

Knob S7 operates potentiometer 62 which represents the registration point adjustment for the direction angle from the weapon to the target. Knob S8 operates po-

tentiometer 58 which represents the registration point adjustment for the range from the weapon to the target. Knob S9 operates potentiometer 66 and is coupled to mechanical counter 78 to give a visual reading of the altitude correction in meters. Two-position switch 68 provides the proper polarity for the altitude correction.

Knob S10 operates potentiometer 24 and is geared to mechanical counter 80 to provide a representation of the target grid east coordinate. Knob S11 operates potentiometer 26 and is coupled to mechanical counter 82 to provide a representation of the target grid north coordinate. Knobs S10 and S11 operate in a manner identical to knob S4 with the clutch mechanism to provide the difference between the target coordinates and the weapon coordinates.

Knob S12 operates resolver 40 and is coupled to mechanical counter 84 to provide a representation of the direction from the weapon, in this case a mortar, to the target. Knob S14 operates potentiometer 52 and is coupled to mechanical counter 86 to provide a representation of the range from the weapon, in this case the mortar, to the target. The function of knobs S15 and S16 will be explained later.

As was noted previously, the information required for firing of a weapon is the direction angle from the grid north coordinate and the elevation of the weapon and the charge to be used in firing the weapon. The elevation and charge are functions of the range from the weapon to the target. Once the range has been determined, the weapon firing personnel consult a chart for the particular ammunition being used which gives values for the elevation and charge which correspond to the particular range. There is usually some overlap in the chart for various levels of charge. For example, for a particular range, a certain charge and elevation may be provided by the table. Also, for the same range, a greater charge and a greater elevation may be provided. This gives some flexibility to the weapon firing personnel to control the trajectory of the ammunition. In any case, once the range from the weapon to the target has been determined, the remaining firing information may be obtained. In FIG. 3 the firing Table 13 is shown as a plug-in cassette. There would be a particular firing Table for the type of ammunition being used. The plug-in cassette may be geared directly to the range knob S14. In this way, when the range is set on knob S14, the weapon firing personnel may read the elevation and charge directly from the firing table cassette. By sliding the cover to either the right or the left, two sets of elevation and charge can be read for the input range setting. It should be understood that the firing table cassette, while being a convenience to the weapon firing personnel, is not critical for the operation of the present invention. The weapon firing personnel may read the range figure from the mechanical counter 86 and then look up the appropriate elevation and charge from a firing table which may be separate from weapon firing computer.

The weapon firing computer described in FIGS. 2A, 2B and 3 will provide all necessary weapon firing information for the firing of an 81 millimeter mortar. The 81 millimeter mortar has a continuously variable elevation and uses ammunition with up to nine increments of charge variation.

When the weapon is a 4.2 inch mortar, additional firing data must be generated. With a small addition of circuitry, the weapon firing computer may accommo-

date a 4.2 inch mortar. The 4.2 inch mortar differs somewhat from the 81 millimeter mortar in that the 4.2 inch mortar is normally fired from one of three fixed elevation angles. A round of ammunition comes with or without extension. The extension is a tubular piece added on the rear of the ammunition round, containing additional charges. Range is adjusted by changing the amount of propelling charge, in one-eighth charge increments.

FIG. 2C shows the same circuitry as shown in FIG. 2B with the additional circuitry necessary to accommodate the 4.2 inch mortar. A selector switch S16 is provided with an off position that disconnects the circuitry for the 4.2 inch mortar. The selector switch S16 also has six additional positions to select one of the three elevation angles with or without ammunition extension.

The range from the weapon to the target R_{WT} is determined following the procedures previously described. The range R_{WT} will be set on knob S14. The range must be converted to the amount of charge required. This is accomplished by providing a potentiometer 90 which is also set by knob S14. Potentiometer 90 represents the relationship between charge and range which is a linear function. However, the slope of the linear relationship is different for each of the ammunition/elevation choices. A set of six resistors 92 is used to change the scale factor for potentiometer 90 in accordance with the setting of selector switch S16. The output of potentiometer 90 is coupled to one input of a summing junction 94.

The altitude correction is set on potentiometer 66 by knob S9 as previously described. The only alteration required for the 4.2 inch mortar is to adjust the scale factor for the ammunition/elevation choices. A set of six resistors 96 is used to change the scale factor for potentiometer 66 in accordance with the setting of selector switch S16. The output of potentiometer 66 is switched to a second input to summing junction 94 when selector switch S16 is in any position except OFF.

The output of summing junction 94 is representative of the charge required for the range set on knob S14 for the particular ammunition/elevation combination selected. In order to provide a charge readout, the output of summing junction 94 is coupled to one input of a summing junction 98. A potentiometer 100 is provided to represent the total charge required. Potentiometer 100 is operated by handset knob S15 and its output is coupled to a second input of summing junction 98. The output of summing junction 98 is coupled to contact (c) of switch S1.

To determine the total charge, switch S1 is set to position (c). With power switch 12 depressed, knob S15 is rotated until a null is reached on meter 56. The rotation of knob S15 is then representative of the total charge. Knob S15 may be coupled to a mechanical counter 102 shown in FIG. 3 to provide a visual readout of the charge.

There is one additional correction required for the 4.2 inch mortar. The 4.2 inch mortar round is spin stabilized and will drift in flight due to the spin. This requires a direction angle correction as a function of range. The amount of the drift correction is a non-linear function of range. However, the relationship may be approximated by two linear functions. The drift correction starts at some fairly high value for short range distances. The correction decreases as range increases

up to some point after which the correction increases as range increases.

The direction angle drift correction is provided by a potentiometer 104 which is operated by knob S14. The potentiometer 104 has three voltage inputs which are scaled by sets of resistors 106, 108 and 110 for the possible elevations. The lowest voltage is applied to a point along the potentiometer winding representative of the point on the drift correction vs. range curve where the slope of the curve changes from negative to positive. The output of potentiometer 104 is coupled to a summing junction 112. The direction adjustment for potentiometer 62 is coupled to a second input of summing junction 112. The output of summing junction 112 is then representative of the total direction angle correction and is coupled to divider 64.

In the operating procedure for the 4.2 inch mortar it is initially necessary to null θ_{WT} and R_{WT} twice. The reason for this is that the first time, θ_{WT} is set before R_{WT} is set in and therefore the drift correction is not yet set. After the first nulling of R_{WT} , it is necessary to renull θ_{WT} to account for the drift correction. It is not necessary to repeat the iteration because of the small magnitude of the drift correction.

It should be apparent that the weapon firing computer may be operated by relatively non-skilled operators simply by turning knobs and switches following a fixed step by step procedure. In practice a procedure chart would be provided to minimize the chance for operator error.

While the detailed circuitry for mortar firing has been described, it should be apparent that the circuitry may be modified to account for the special requirements of other types of weapon firing such as artillery.

What is claimed is:

1. A weapon site gunner operated computer for determining the range and direction angle from a weapon positioned at known grid coordinates to a target, said computer comprising:

handset data means for converting gunner handset data into computer instrumented representations thereof;

first circuit means responsive to a first portion of said representations of said handset data which are a measure of known factors in the trigonometric relation between an observer's position, the target position, and the weapon position for providing signals representative of the target grid coordinates in relation to the weapon grid coordinates;

second circuit means responsive to a second portion of said representations of said handset data which are a measure of unknown factors in said trigonometric relation and to the signals of said first circuit means, for providing a null balance signal when said second portion of said representations comprises a correct representation of the range from the weapon to the target and the direction angle from the weapon to the target.

2. A computer as claimed in claim 1 wherein said first circuit means includes means for converting the range and direction angle from an observer at known grid coordinates relative to the weapon, to signals representative of the target grid coordinates in relation to the weapon grid coordinates.

3. A computer as claimed in claim 1 wherein said second circuit means includes

- a circuit coupled to receive the signals of said first circuit means for providing a first signal representative of the direction angle from the weapon to the target and a second signal representative of the range from the weapon to the target,
- signal detecting means for detecting when one of the second portion of said representations of said handset data is a correct representation of the direction angle represented by the first signal of said circuit; and
- signal detecting means for detecting when another one of the second portion of said representations of said handset data is a correct representation of the range represented by the second signal of said circuit.
4. A computer as claimed in claim 3 which further comprises:
- means for providing a fixed offset of the first signal of said circuit in response to one of the first portion of said representations of said handset data; and
- means for providing a proportional offset for the second signal of said circuit in response to another one of the first portion of said representations of said handset data.
5. A computer as claimed in claim 1 wherein said first circuit means comprises:
- a first potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the range from an observer position to the target;
- a first resolver having the angular position of its shaft provided by said handset data means, the angular position of the resolver shaft being representative of the direction angle from the observer to the target;
- said first resolver being coupled to receive the analog signal of said first potentiometer for providing a first signal representative of the range from the observer position to the target times the cosine of the direction angle from the observer to the target, and a second signal representative of the range from the observer position to the target times the sine of the direction angle from the observer to the target;
- a second potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the difference between the observer grid north coordinate and the weapon grid north coordinate;
- a third potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the difference between the observer grid east coordinate and the weapon grid east coordinate;
- a first summing means coupled to receive the first signal of said resolver and the analog signal of said second potentiometer for providing an output signal representative of the difference between the target grid north coordinate and the weapon grid north coordinate;
- a second summing means coupled to receive the second signal of said resolver and the analog signal of said third potentiometer for providing an output signal representative of the difference between the target grid east coordinate and the weapon grid east coordinate;
- a fourth potentiometer having its shaft position provided by said handset data means for providing an

- analog signal representative of the difference between the target grid north coordinate and the weapon grid north coordinate;
- a fifth potentiometer having shaft position provided by said handset data means for providing an analog signal representative of the difference between the target grid east coordinate and the weapon grid east coordinate; and
- manual switching means coupled to provide a first output and a second output, said first output being the output signal of said first summing means when said manual switching means is in a first position and said first output being the analog signal of said fourth potentiometer when said manual switching means is in a second position; said second output being the output signal of said second summing means when said manual switching means is in a first position and said second output being the analog signal of said fifth potentiometer when said manual switching means is in a second position.
6. A computer as claimed in claim 5 wherein said second circuit means comprises:
- a second resolver having the angular position of its shaft provided by said handset data means, and being coupled to receive the first and second outputs of said manual switching means for providing a first signal equal to zero when the angular position of the shaft of said second resolver represents the direction angle from the weapon to the target, and a second signal representative of the range from the weapon to the target; and
- signal detecting means coupled to receive the first signal of said second resolver for detecting when the signal is essentially equal to zero.
7. A computer as claimed in claim 6 which further comprises:
- a sixth potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the range from the weapon position to the target;
- a third summing means coupled to receive the analog signal of said sixth potentiometer and the second signal of said second resolver for providing an output signal which is the difference between the two input signals; and
- signal detecting means coupled to receive the output signal of said third summing means for detecting when the signal is essentially equal to zero.
8. A gunner operated weapon firing computer for determining the range and direction angle from a weapon positioned at known grid coordinates to a target, said weapon firing computer comprising:
- handset data means for converting gunner handset data into shaft position;
- a first potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the range from an observer position to the target;
- a first resolver having the angular position of its shaft provided by said handset data means, the angular position of the resolver shaft being representative of the direction angle from the observer to the target;
- said first resolver being coupled to receive the analog signal of said first potentiometer for providing a first signal representative of the range from the observer position to the target times the cosine of the

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direction angle from the observer to the target, and a second signal representative of the range from the observer position to the target times the sine of the direction angle from the observer to the target;

a second potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the difference between the observer grid north coordinate and the weapon grid north coordinate;

a third potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the difference between the observer grid east coordinate and the weapon grid east coordinate;

a first summing junction coupled to receive the first signal of said resolver and the analog signal of said second potentiometer for providing an output signal representative of the difference between the target grid north coordinate and the weapon grid north coordinate;

a second summing junction coupled to receive the second signal of said resolver and the analog signal of said third potentiometer for providing an output signal representative of the difference between the target grid east coordinate and the weapon grid east coordinate;

a fourth potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the difference between the target grid north coordinate and the weapon grid north coordinate;

a fifth potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the difference between the target grid east coordinate and the weapon grid east coordinate;

manual switching means coupled to provide a first output and a second output, said first output being

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the output signal of said first summing junction when said manual switching means is in a first position and said first output being the analog signal of said fourth potentiometer when said manual switching means is in a second position; said second output being the output signal of said second summing junction when said manual switching means is in a first position and said second output being the analog signal of said fifth potentiometer when said manual switching means is in a second position;

a second resolver having the angular position of its shaft provided by said handset data means and coupled to receive the first and second outputs of said manual switching means for providing a first signal equal to zero when the angular position of the resolver shaft represents the direction angle from the weapon to the target, and a second signal representative of the range from the weapon to the target; and

signal detecting means coupled to receive the first signal of said second resolver for detecting when the signal is essentially equal to zero.

9. A weapon firing computer as claimed in claim 8 which further comprises:

a sixth potentiometer having its shaft position provided by said handset data means for providing an analog signal representative of the range from the weapon position to the target;

a third summing junction coupled to receive the analog signal of said sixth potentiometer and the second signal of said second resolver for providing an output signal which is the difference between the two input signals; and

signal detecting means coupled to receive the output signal of said third summing junction for detecting when the signal is essentially equal to zero.

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