APPENDIX

The Appendix contains the following two chapters:

LIMITS OF ACCURATE COMPUTATION

If the Computer Mark 1 had been designed to produce uniformly accurate outputs for the whole range of values of every input, and for all possible combinations of input values, it would have been several times its present size. In order to keep its size within practical limits, and for other design reasons, a number of approximate solutions were accepted.

The acceptance of the approximate solution instead of the true solution results in various errors. These errors are called "Class B" errors.

In general, approximate solutions are chosen to keep the Class B errors very small throughout the usual range of the input values, rather than to maintain a nearly uniform degree of accuracy for all input values. As a result, Class B errors are quite large in a few instances when certain inputs reach unusual values. The Trunnion Tilt Section of the Computer Mark 1, for example, computes highly accurate corrections when L and Zd are less than 10° and $E2 + L$ is less than 70°, but when L and Zd reach the unusual value of 20°, the Trunnion Tilt Corrections may contain errors as high as several degrees.

The Class B errors in a Computer are the result of deliberate decisions. These decisions are based on many considerations resulting from conditions at the time the instrument was designed or modified. The size of the instrument and the usual range of the input values have already been mentioned. The degree of accuracy of the inputs is another consideration. For example, there is no point in putting enough mechanisms into a Computer to handle *I.V.* corrections with a maximum error of only one part in a hundred, if the *I.V.* input, itself, represents an estimate which is probably in error by at least ten parts in a hundred.

The design characteristics of the equipment which uses the Computer outputs are other important considerations in the choice of Class B errors. For example, the 5"/38 cal. gun mounts can move in train at a maximum rate of 30° per second and in elevation at a maximum rate of 15° per second. The mounts will fall behind any gun order signals which change faster than this.

The limitations of the equipment using the Computer outputs were considered particularly in designing the Trunnion Tilt Section of the Computer Mark 1.

The effect of trunnion tilt on the Line of Fire is removed by corrections to Gun Train and Elevation. When the guns are at a high elevation, such as 80°, the amount of movement in train required to counteract the effect of 15° of Cross-level is about ± 56 degrees. On a destroyer the mounts would have to train 224° every nine seconds and reach a maximum rate of approximately 60° per second. It is clear that accurate Trunnion Tilt Corrections for Gun Elevation greater than 70° would be largely wasted. Partly for this reason, the Computer Mark 1 Trunnion Tilt Section computes accurately for values of Gun Elevation only up to 70 degrees.

The same consideration entered into the decision to compute accurate Trunnion Tilt Corrections only when Level and Cross-level were less than 15 degrees. Accurate stabilization of the guns for values of Level and Cross-level greater than 15° would often require higher maximum rates of Train and Elevation than can be provided by the hydraulic drives on the mounts.

Most of the Class B errors in the Computer Mark 1 are so small that for all practical purposes they can be ignored by the Computer and Director Operators. However, a few Class B errors can become large enough to be important considerations in deciding when the Computer Gun Orders are reliable enough to justify firing the guns. Computer Operators should know under what conditions these Class B errors will become large enough to affect the accuracy of the Computer outputs.

This chapter first describes the Class B errors which may *seriously* affect the accuracy of the Gun Orders. It then discusses a number of other Class B errors which cannot by themselves jeopardize the Gun Orders, but which may, under certain circumstances, become large enough to be taken into account by the Director and Computer Operators.

NOTE:
An accurate picture of the Class B errors of the Computer Mark 1 cannot be obtained from an inspection of the Class B errors in the fifteen A Test Problems. These A Test Problems are a mechanical check of the Computer, and not a representative set of operating problems. They show neither the largest possible Class B errors nor the average Class B errors.

THE LARGER CLASS B ERRORS

In general, the accuracy of the Computer Mark 1 outputs will begin to decline very sharply:

1. When Target Elevation exceeds 70°
2. When Level and Cross-level exceed 20°
3. If Rate Control is continued when Present Range is less than 1500 yards

Errors caused by Target Elevation values greater than 70°

There are cams in the Computer Mark 1 which compute the secant of *E* and *E2*. The secant curve rises so steeply as the angle nears 90° that it was considered impractical to cut cams for values of *E* above 70 degrees.

One of the secant cams is in the Integrator Group, where it is used to convert the measurement of Generated Angular Deflection from a slant plane into the horizontal plane.

When *E* goes above 70°, Generated True Bearing, $\triangle cB$, and Generated Relative Target Bearing, $\triangle cBr$, will be in error. If erroneous values of $\triangle cBr$ are used for Rate Control, they will result in false values of *Sh*, *dH*, and *A*.

The *jDd* Computer of the Trunnion Tilt Section computes the secant of $E2 + L$ up to 70 degrees. Generally speaking, the *jDd* Computer converts the measurement of *Ds* from a slant plane to the deck plane. When the value of $E2 + L$ exceeds 70°, the accuracy of the *jDd* computations will decline rapidly.

If the guns are fired as Target Elevation increases above 70°, the errors in the Gun Orders cannot be corrected by spotting, because the errors will increase at a rapidly increasing rate as Target Elevation increases. If spots are put in on the basis of bursts which were fired when *E* was 75°, and *E* has meanwhile increased to 80°, the errors in Gun Position and Fuze Time will have increased so much that the spots will be almost useless.

If firing is attempted with Target Elevation greater than 70°, it should be controlled so that the guns will fire at the midpoint of the roll. At this point, *L* and *Zd* will usually be at low values and error from the Trunnion Tilt Corrections will be at a minimum.

Errors caused by large values of Eb and Zd

The Trunnion Tilt Section is designed to compute accurately as long as Cross-level is less than 15°, Deflection is less than 20°, and Elevation plus Level is less than 70°. For greater values of these quantities, the Trunnion Tilt computations are partially in error.

The Deck Tilt Computer also has a limited accuracy, but the maximum errors here are smaller and are therefore discussed on the next page under the smaller Class B errors.

Errors caused by rate-controlling with Range less than 1500 yards

The Integrator Group in the Computer Mark 1 generates accurate changes of Target Position only when Range is between the values of 1500 yards and 22,500 yards. The errors introduced by rate-controlling with Range above 22,500 yards may be ignored, since they are small and do not affect the firing of the guns.

If Rate Control is continued when Range decreases to less than 1500 yards, serious errors in *Sh, dH*, and *A* will result.

When Range decreases to less than 1500 yards, the follower in the *1/cR* cam passes into the cam's outer constant radius. This cam follower positions the carriage of the *1/cR* Integrator. The speed of the output roller of the *1/cR* Integrator will therefore remain constant for all ranges below 1500 yards.

The output of the *1/cR* Integrator affects both Generated Bearing and Generated Elevation. If Rate Control is continued at ranges below 1500 yards, the Observed Elevation and Bearing Rates will be synchronized with false rates of Generated Elevation and Bearing, which can be speeded up only by fictitious increases in Target Speed and Rate of Climb.

THE SMALLER CLASS B ERRORS

Deck Tilt

During the sharp turns required for evasive maneuvers, the roll of the ship can be as great as 20° due to the combination of heeling over and roll and pitch. The *jB'r* output of the Deck Tilt Computer under these conditions can be in error up to approximately one degree.

Rate Control

In order to save mechanisms, the Rate Control Group gives a completely accurate solution for a constant Range and constant Elevation.

The correction inputs to the Rate Control Group are angular corrections *jE* and *jBr*. The conversion of these angular corrections into the linear corrections required by the Rate Control Computing Mechanism would necessitate the use of a secant cam multiplier, a reciprocal range cam, and several other mechanisms. Instead, the angular corrections are converted into *approximate* linear corrections by means of gear ratios. As a result of these and other approximations, the Rate Control Computing Mechanism corrects the Target Motion setup by a series of successive approximations.

Well-informed operators can speed up this process of approximation without running into danger of over-rate-controlling.

Prediction

The Prediction Section contains a great number of approximations, most of which have been discussed already in the chapter on the Prediction Section.

Parallax

The *1/R2* cam in the Parallax Component Solver computes the reciprocal of *R2* for values of *R2* down to 1500 yards. When *R2* is less than 1500 yards, the Parallax Corrections will be partially in error.

MODIFICATION DIFFERENCES IN THE COMPUTER MARK 1

There are two groups of differences in the various Computers Mark 1: *Mod Differences* and *Design Differences.* A *Mod Difference* is a difference involving a major change in design or operation, or any change in design or operation which adapts the Computer to a different use. A *Design Difference* is a difference in design or operation which affects all mods, or any difference of a minor nature.

Originally the Computer Mark 1 was designed for the 5"/38 cal. dual-purpose guns only. The mod differences in the early mods are those which adapt the Computer to the different mounts and different parallax needs of different installations. At the same time various other improvements were made, such as increasing the limits of various quantities, installing additional transmission units, etc. In later mods the Star Shell Computer was added, and in still later mods the Computer was adapted for the 5"/54 cal. guns, the 6"/47 cal. guns, and the 8"/55 cal. guns.

Each instrument has a *mod number* and a *serial number*. The *mod numbers* are assigned at the time the design work is done, and the *serial numbers* are assigned at the time of production. Because of this there is no relation between the mod number and the serial number of an instrument. An instrument with a higher mod number may reach production before one with a lower mod number. As a result, an instrument with a higher mod number may have a lower serial number than one with a low mod number. For example, Mod 13 was in production before Mod 8; therefore some Mod 13 instruments have serial numbers lower than some Mod 8 instruments.

This chapter describes the major differences characterizing each mod and lists the serial numbers of the first instruments which incorporate each of these and other differences. It also contains lists of pertinent FORDALT's, ORDALT's, and OD's.

MAJOR MODIFICATION DIFFERENCES

MOD 0

The Computer Mark 1 Mod O (blank space on the name plate) was designed for DD's with single mounts and was assigned to DD409 to 428 inclusive. Mod O had single-speed transmitters for *Vs* and *Ds,* computed Train Parallax Corrections based on *B′gr,* and had IN values of *Rj* limited to 1800 yards.

MOD 2

like Mod O, was designed for DD's with single mounts. It was similar to the Mod O, but differed from it in three ways: (1) An *So* Receiver was added and the upper limit of *So* was increased to 45 knots. (2) Bearing and Elevation Correction Indicating Transmitters were added. Previously a single pair had been used for both Auto and Indicating. (3) The quantity $L + Zd/30$ was added to the Elevation Correction output.

MOD 1

was designed for cruisers and battleships with twin mounts. It differed from Mod O and Mod 2 mainly in that: (1) It computed Train Parallax Corrections based on *B′r* instead of *B′gr.* (2) Double-speed transmitters were used for *Vs* and *Ds* instead of single-speed transmitters.

MOD 9

A spare Mod 1 became Mod 9 by ORDALT 1182, which added single-speed transmitters for *Vs* and *Ds.*

MOD 3

like Mod 1, was designed for cruisers and battleships. It was similar to the Mod 1 with the following major differences: (1) The upper limit of Generated Present Range was increased from 22,500 to 35,000 yards. (2) Provision was made for control of main-battery A.A. projectiles. (3) The *Vs, Ds, F,* and *Ph* transmitters were increased in size from 6 G's to 7G's.

The changed limits of other quantities are shown on the chart of Principal Differences, Ordnance Drawing No. 210535.

MOD 10

A spare Mod 3, Ser. No. 100, became Mod 10, also by ORDALT 1182.

MOD 4

was essentially the Mod 3 with the addition of a Star Shell Computer.

MOD 5

was the Mod 2 with the addition of a Star Shell Computer and the equipment for the computation of Elevation Parallax for a horizontal base. Only two Mod 5's were made. They were Ser. Nos. 58 and 59, and both were assigned to the USS Hornet (CV8).

MOD 6

was essentially the Mod 2 with the addition of a Star Shell Computer.

MOD 7

was designed for the Essex Class carriers having both single and twin mounts. The Mod 7 differed from the Mod 5 in that it had both single-speed and double-speed transmitters for *Vs* and *Ds*.

"UNIVERSAL" MOD 7

To speed production of Computers Mark 1, the limits and features of Mods 4, 6, and 7 were incorporated into one instrument. This instrument was designated Mod 7, but is called the "Universal" Mod 7. The first "Universal" Mod 7 instrument had Ser. No. 216. It differed from the "old" Mod 7 in that it had the larger limits of *Rj* and *F* as in Mod 4 and also had a shift gear with which to select either *B′r* or *B′gr* for use in the Parallax computations.

A series of alterations were then made to the "Universal" Mod 7 without changing the Mod number.

ORDALT 2116A later ordered all existing "Universal" Mod 7's changed to become Mod 13's.

MOD 13

is like the "Universal" Mod 7 except that the Range Receiver has been changed from values of 36,000 and 2000 yards to 72,000 and 2000 yards, and the Radar Range Receiver has been eliminated. Both these changes were made by ORDALT 2116A.

MOD 11

was like the Mod 7 except that Elevation Parallax was computed for a zero vertical base. All Mod 11's were ordered changed to Mod 13's.

MODS 8 and 12

are for the 5″/54 cal. dual-purpose gun. Mod 12 has a zero vertical base.

MODS 14 and 16

are for the 6″/47 cal. gun.

MOD 15

is for the 8″/55 cal. gun.

MODIFICATION DIFFERENCES IN THE STAR SHELL COMPUTER MARK 1

Star Shell Computer Mark 1 Mods O and 1 are used with Computer Mark 1 Mods 4, 5, 6, 7, 11, and 13.

The Mod 1 supersedes the Mod O. In the Mod 1, Elevation and Deflection Handcranks and Elevation and Deflection Spot Dials were added. The Gun Order Dials and the Fuze Counter are on the front where they can be observed through a large window. The Range Spot limit is changed to IN 2857 – OUT 1500. The first Star Shell Computer Mark 1 Mod 1 had Ser. No. 621.

Star Shell Computer Mark 1 Mod 2 is like the Mod 1 except that it was designed for the 5"/54 cal. guns. The Match Star Shell Range Dials are calibrated differently and the Range Spot limit is IN 2700 – OUT 1500. The Mod 2 is used with Computers Mark 1, Mods 8 and 12.

PERTINENT SERIAL NUMBERS

Computer Mark 1 Serial Numbers

58 Star Shell Computer Mark 1, Ser. No. 1, was installed with Computer Mark 1 Mod 5, Ser. No. 58.

101 First instrument originally equipped with a Bearing Filter and a modified Ship Course Receiver. ORDALT 1172 equipped Mods 1 through 6 below Ser. No. 101 with the Bearing Filter and modified Ship Course Receiver (OD 4178).

101 First instrument equipped with AUTO Range Rate Control. Alteration of Rate Control on instruments below Ser. No. 101 is given on OD 4185.

101 First instrument originally equipped with a Radar Range Receiver in place of the Battle and Shell Order Annunciators. ORDALT 1080 made this change on instruments below Ser. No. 101. The Radar Range Receiver was later removed by ORDALTS 2116 and 2116A.

216 First "Universal" Mod 7 instrument.

234 First instrument originally equipped with a Target Course Follow-up instead of a Target Angle Follow-up. Instructions for making this change on all instruments below Ser. No. 234 are contained in OD 4239.

371 Instruments with Ser. Nos. 371, 373 and above are not equipped with Powder Fuze Ballistic Cams.

390 First instrument originally equipped with an *I.V.* lower limit of 2350 f.s. instead of 2450 f.s. Instructions for making this change on all instruments below Ser. No. 390 are contained in OD 5106.

390 First instrument to have Target Elevation, *E*, lower limit of −25 degrees. First instrument to have an intermittent drive added in the *E* line to the sec *E* cam. Instruments below Ser. No. 390 were not altered.

421 First instrument originally equipped with a Target Course Transmitter instead of a Target Angle Transmitter. A-232 was replaced by A-258. Instructions for making these changes in instruments below Ser. No. 421 are contained in ORDALT 1995 and OD 5108.

Ser. No. 421 was also the first instrument supplied with a Target Course Indicator instead of a Target Angle Repeater. Instructions for changing the Target Angle Repeater to a Target Course Indicator are contained in ORDALT 1994 and OD 5107.

435 First instrument with larger shaft verniers on the $1/cR$ and sec E lines. A-148 and A-150 were eliminated. Instructions for changing to the new sec E shaft in Ser. Nos. 1-434 and new $1/cR$ shaft in Ser. Nos. 220-434 are contained in FORDALT 18.

435 Target Control signal lamp, resistor, and relay were omitted from Ser. No. 435 and up.

435 First instrument equipped with two indicating E Counters, one located in the Computer Section and one in the Corrector Section. A-259 and A-260 were added.

501 First instrument with the original relocation of the Eb Receiver resistor. ORDALT 2123 ordered the relocation of the resistor in instruments with Ser. Nos. 500 and below.

518 Last instrument supplied with Solution Indicator Generators.

568 First instrument originally designated Mod 13. Previous Mod 7 instruments were modified by ORDALT 2116A to change them to Mod 13.

781 First instrument designed for more accurate Fuze computation.

811 First instrument with *I.V.* Correction going into the $Tf/R2$ Ballistic Computer.

List of FORDALT's

5 Frame No. 66 Damper. Redesign using 2 bearings to prevent wobble.

6 Frame No. 50 Damper. Redesign using 2 bearings to prevent wobble.

8
- a Change *A* Transmitter to *Ct* Transmitter.
- b Design Target Course Indicator to be mounted on Star Shell Computer.
- c Connected by local cable.

Began with Ser. No. 420.

10 Spot Transmitter Mark 1. Change for red light illumination.

11 Star Shell Spot Transmitter Mark 1. Change for red light illumination.

12 Range Spot Transmitter Mark 2. Change for red light illumination.

18 Redesign vernier adjustments on shafts 44-S42 and 44-S44 to prevent breaking of shaft. Began with Ser. No. 435.

26 Photographic type dials. Began with Star Shell Computer Ser. No. 521. Began with Computer Mark 1, Ser. No. 751.

30 Change in value of Range Receiver and removal of Radar Range Receiver. Mod 7 to become Mod 13.

32 Removal of Solution Indicator Generators. Began with Ser. No. 519.

35 Redesign Time Motor Regulator.

36 Relocation of *Eb* Receiver Resistor. Ser. No. 501.

42 Redesign 5-inch integrator to provide a more rigid mounting for disk bearing.

44 Star Shell Computer Mark 1 Mod 1 to incorporate function of Star Shell Spot Transmitter. Began with Ser. No. 621.

79 Change of Range Receiver Mark 1. Add 4 Mfd Capacitor to increase torque of output.

96 Oldham Couplings. Shaft extensions longer to prevent disengaging from shock.

106 Star Shell Computer Mark 1 Mod 1 to receive spots from Star Shell Spot Transmitter.

108 New Fuze computation. Ser. No. 781 up of Mod 13, as in Mods 8 and 12.

126 Guard to protect *jB'r* and *Vz* Follow-up contacts.

129 Improve performance of Servo Motor Control by increasing spring pressure and designating specific oiling points. Change wire diameter from 0.020 to 0.026.

156 Improve Class B errors by correcting *Tf/R2* for effect of variation of *I.V.*

161 Add Range Spot Dial to *Vj* Dial IN 180 – OUT 342.5 (= 24,600 yards).

176 Relocate *B'r* Resistor to prevent overheating of *Dd* Friction.

List of ORDALT's

1080 Radar Range Receiver replaces Battle and Shell Order Annunciators. Later removed by ORDALT 2116A.

1172 Bearing Filter and modified Ship Course Receiver added below Ser. No. 101, except Mod 0.

1182 Add *Vs* and *Ds* single-speed transmission to spare Mod 1 then designated Mod 9, and to spare Mod 3 then designated Mod 10, for CV3.

1224 Addition of Selector Drive Mark 1 replacing Cross-level shaft.

2116 Change all Mods to receive Range at 2000 and 72,000 yards per revolution.

2116A Change Mod 7 to Mod 13.
Remove Radar Range Receiver.
Add ORDALT record plate.

2117 Star Shell Computer. Increase lower limit of *Rjn* to accommodate control of smoke projectiles.

2123 Relocate *Eb* Receiver Resistor to prevent overheating of gearing.

2125 Replace Synchronize Elevation brake springs with springs giving approximately twice the pressure.

2126 Change *So* Receiver to 30 knots per revolution on Ser. No. 627.

2127 Add Deflection scale to Generated Bearing Crank.

2266 Change Bearing Correction Transmitter from 5G to 6G and Elevation Correction Transmitter from 5G to 6DG on Mod 0 machines.

2283 For CL55 type. Instructions for 6"/47 A.A. fire incorporating use of Computer Mark 28. FICO Drg. No. B-4147.

2321 Relocation of *B'r* Resistor to prevent damage to *Dd* friction by overheating.

5224 Change Mod 11 to receive Range at 72,000 and 2000 yards per revolution.

List of OD's

4178 Computer Mark 1 Mods 1 through 6. Installation Instructions for Modified Ship Course Receiver and Bearing Filter.

4185 Computer Mark 1 Mods 0 through 6, below Ser. No. 101. Alteration of Rate Control System.

4233 Computer Mark 1, Ser. Nos. 1 through 100. Instructions for changing Target Angle Follow-up shaft.

4236 Selector Drive Mark 1. Instructions for Installation and Operation.

4239 Computer Mark 1. Instructions for converting Target Angle Follow-up to Target Course Follow-up.

5106 Computer Mark 1 and Modifications. Instructions for altering *I.V.* limits from 2600 and 2450 to 2600 and 2350 f.s.

5107 Target Course Indicator Mark 1. Conversion from Target Angle Repeater Mark 1.

5108 Computers Mark 1 Mod 4, 5, 6, and 7. Below Ser. No. 421. Alteration to provide for mounting of, and operating with, Target Course Indicator Mark 1.

5116 Computer Mark 1 Mod 3 and 10. Alteration to provide for mounting of, and operating with, Target Course Indicator Mark 1.

5117 Computer Mark 1 Mod 0, 1, 2, and 9. Alteration to provide for mounting of, and operating with, Target Angle Control Switch.

5127 Instructions for providing red illumination on Ford instruments.

5146 Computer Mark 1 Mod 4, 5, 6, and 7. Below Ser. No. 519. Instructions for removal of Solution Indicator Generators and connecting material.

5158 Computer Mark 1 Mod 7. Instructions for converting to Mod 13.

DETAILS OF MODIFICATION DIFFERENCES

$Vf + Pe$ Ballistic Computers

In Computers Mark 1, Mods 0 through 10, 13, and 15, Pe is computed for a vertical base of 30 feet.

In Computer Mark 1, Mod 14 the vertical base is 40 feet. In Mod 16 the base is 15 feet.

Computers Mark 1 Mods 11 and 12 were designed for ships on which the Directors were located at approximately the same height as the guns. There was no need for a computation of Elevation Parallax, Pe. In these Mods, therefore, Vf Ballistic Computers replace the $Vf + Pe$ Ballistic Computers. The output of the Vf Ballistic Computer is simply Superelevation, Vf.

Fuze Computation

On Computers with Ser. No. 781 and up, more accurate computation of Fuze Setting Order was incorporated.

The Fuze Setting Order is actually a value computed in advance for the value of Time of Flight at the instant of firing.

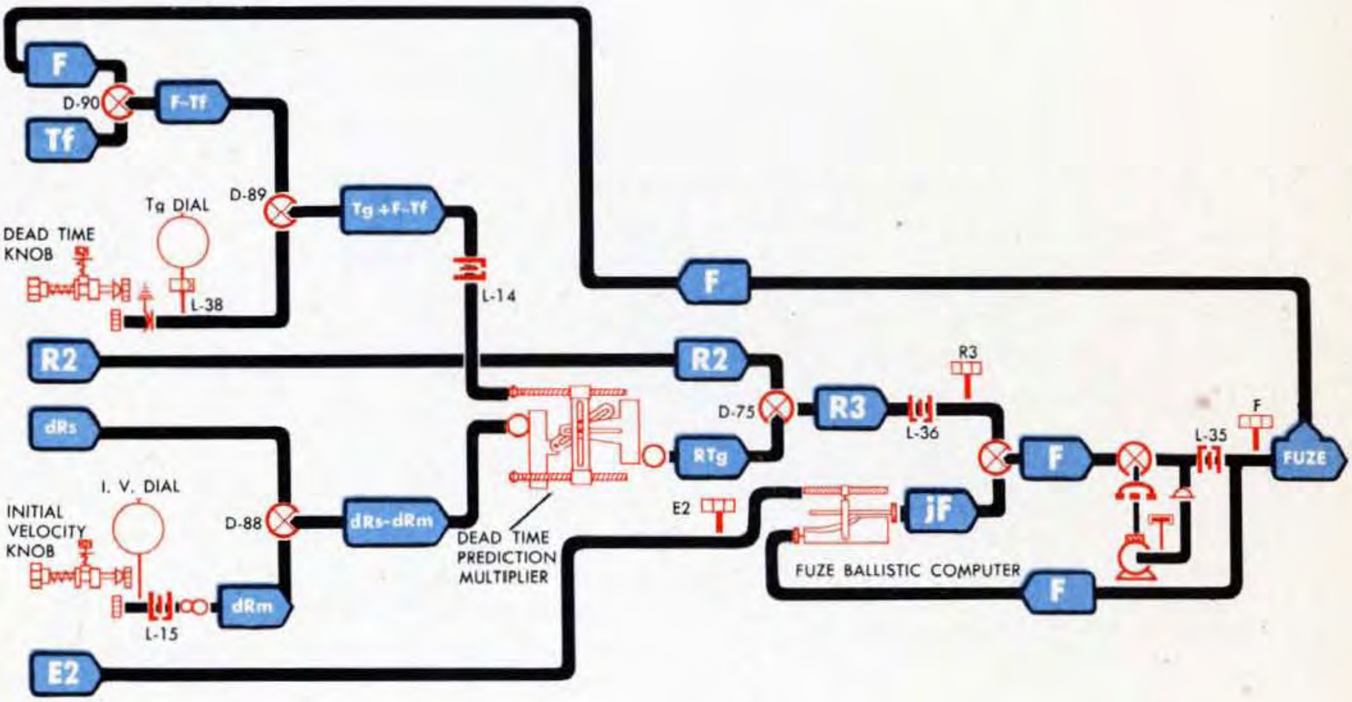
The output of the Dead Time Prediction Multiplier is RTg. The old equation was $RTg = K \times dR \times Tg$. The new equation is $RTg = K\ (dR + dRxe)\ (Tg + F - Tf)$. For convenience of design, the factor $(dR + dRxe)$ is computed as $(dRs - dRm)$.

The time elapsed between the instant the projectile is removed from the shell hoist and the instant of firing is known as Dead Time, Tg. Added to Dead Time is the difference between Time of Flight when the projectile is removed from the shell hoist and Time of Flight at the instant of firing. This difference is expressed by $(F - Tf)$. Thus the total time correction is $(Tg + F - Tf)$. The correction to Time of Flight is then the product of Total Range Rate and this total time correction.

The subtraction of Initial Velocity Correction, *dRm,* from Prediction Range Rate, *dRs,* produces Total Range Rate for the computation of RTg.

The value RTg is added to $R2$ to form $R3$ which is the Fuze Range.

Further accuracy of computation is accomplished by turning the Fuze Ballistic Cam by F rather than $R3$. The cam output, *jF,* is added to $R3$ to form F.



Rate Control on Computers Mark 1 with Serial Numbers below 101

On Computers below Ser. No. 101, the Rate Control System was altered for the purpose of improving the action and increasing the speed of solution of the Rate Control System. The instructions for making this alteration are given in OD 4185.

The wiring connecting the Range Rate Control Time Clutch was disconnected so that the Range Rate Correction Integrator carriage remains at the 5-second offset.

Originally, with the Change of Range Switch at ON RANGE FINDER, the Range Motor was energized only when the Range Operator in the Director closed the signal circuit. When altered, the power supply to the Range Motor was disconnected from the signal circuit and connected to the Range Switch. With this arrangement the Range Motor drives whenever the switch is at ON RANGE FINDER.

With the Time Clutch to the Range Rate Correction Integrator disconnected, it becomes possible to match Generated Range to Observed Range continuously. When the signal to commence tracking is received, the Computer Operator should turn the Change of Range Switch from ON RANGE FINDER to OFF. If the Observed Range Dials and the Range Finder Signal indicate that the correct Range is being received continuously, the Computer Operator should turn the Generated Range Handcrank in its IN position and continuously match Generated Range with Observed Range.

If the received values of Range are intermittent, it may become necessary to over- or under-rate-control. The Generated Range Dials should be matched to the Observed Range Dials only when the Range Finder Signal is on. When the rate of divergence between Generated and Observed Range is large, that is, when the Dials move relatively far out of synchronism in a relatively short time, the Operator should over-correct.

To over-correct he should do the following:

1. With the Generated Range Crank IN, turn until the index of the fine ring dial passes and overtakes the arrow on the inner dial.
2. Turn the ring dial back until the index matches the arrow on the inner dial *without putting in any rate correction.* This can be done either by shifting the Range Switch to ON RANGE FINDER until the dials are matched and then shifting it back to OFF, or by pulling the Generated Range Crank OUT against spring pressure, and turning it in the OUT position.

If the rate of divergence between the Generated and Observed Dials is small, the Operator should under-correct in a similar manner.

The wiring was further changed to enable the Computer Operator to cut out Bearing and Elevation Rate Corrections by means of the Target Speed Handcrank while the Control Switch was at AUTO. The new connections are such that the *jE* and *jBr* clutches will open when the Target Speed Handcrank is put in HAND.

If the Operator desires to discontinue rate control from the Director while in Automatic Control, he shifts the Target Speed Handcrank to HAND. Shifting the handcrank back to AUTO restores Director rate control.

If the Control Switch is at SEMI-AUTO and the Operator desires to change to AUTO control, he should do the following:

1. Shift the Target Speed Handcrank to HAND.
2. Turn the Control Switch to AUTO until the Generated Dials are synchronized.
3. Shift the Target Speed Handcrank to AUTO.

If the Control Switch is at SEMI-AUTO and the Operator wishes to shift to LOCAL, he should do the following:

1. Shift the Target Speed Handcrank to HAND.
2. Turn the Control Switch to AUTO, until the Generated Dials are synchronized.
3. Turn the Control Switch to LOCAL.

Remote control of Target Angle

Starting with Mod 4, the Computer Mark 1 was equipped with a set of relays to effect remote-control slewing of Target Angle. The system was completed with an auxiliary unit called the Target Angle Repeater Mark 1 which was mounted at the Control Officer's Station in the Director Mark 37, and a Target Angle Transmitter within the Computer. The purpose of the system was to permit a quick setup of estimated Target Angle when shifting to a close target.

Soon the need for a Target Course Indicator developed. Starting with Ser. No. 421, the Target Course Indicator replaced the Target Angle Repeater and a change in gearing changed the Target Angle Transmitter to a Target Course Transmitter. ORDALT 1995 (OD 5108) altered the transmitters on Computers Mark 1 below Ser. No. 421. The Target Angle Repeaters were changed to Target Course Indicators by ORDALT 1994 (OD 5107).

Mod 3 instruments were modified by OD 5116 for Target Course control.

OD 5117 installed a Target Angle Control Switch to slew Target Angle on Mods 0, 1, 2 and 9.

Lower Limit of *I. V.*

The Computers below Ser. No. 390 had a lower limit of 2450 f.s. for *I.V*. It was found that old rifles at cold temperatures called for a lower *I.V*. The present limit is 2350 f.s. Computers below Ser. No. 390 were to be altered, as per OD 5106. On the Computers not altered, it is necessary to introduce Range Spots whenever the *I.V*. is below 2450 f.s.

Control of Star Shell Fire without a Star Shell Computer

On installations not equipped with the Star Shell Computer, a Star Shell Data Plate supplies the necessary information. The Star Shell Data Plate gives Sight Angle and Fuze Setting Orders for firing Star Shells at various values of Advance Range.

Firing a Search Spread

When firing a search spread, all guns are used to fire star shells. With the Sight Angle and Fuze Handcranks in the IN position, set the counters at the values given opposite the value of Advance Range to transmit gun orders from the Computer to the guns. Approximations are necessary for uneven values of Advance Range. A plotted curve may be employed to obtain these approximations.

Firing Star Shells from only part of a battery

When firing star shells from one or more guns and firing regular service projectiles from the remainder of the battery, another method is employed. Sight Angle and Sight Deflection must be left undisturbed in the Computer so that regular gun orders are transmitted to the guns firing service projectiles. The Searchlight Corrector may be used to transmit gun orders to the star shell gun. The Searchlight Corrector normally transmits Director position plus Level and Cross-level corrections. Spots introduced into the Searchlight Corrector would make its output correspond to the proper values for firing star shells. The Elevation Spot would be Sight Angle given on the Star Shell Data Plate opposite the Computer value of Advance Range, minus 2000 minutes. The Deflection Spot would be the value of Sight Deflection as read on the Computer *Ds* Counter, minus 500 mils and converted into degrees and minutes. A chart may be laid out to speed this computation. These spots are telephoned to the Director for introduction into the Searchlight Corrector. Additional spots may be added to the Searchlight Corrector to correct for wind and other errors if necessary. Fuze Setting Order from the Star Shell Data Plate may be telephoned to the gun mount firing the star shells.

Elevation Lower Limit of – 5 Degrees

On Computers below Ser. No. 390 the lower limit of L-12 is −5 degrees. Extra precaution must be exercised in the operation of these Computers to avoid slamming into the Elevation limit stops while slewing the Director. On these instruments, the Director Slew Sight is secured at a minimum value around −20 degrees. Since the Computer lower limit is −5°, there is considerable danger of slewing into the lower limit in the Computer if the slew key is closed after all the circuits have been energized but the Slew Control has not been brought up to the horizontal position.

Another precaution must be exercised. The Computer should not be set up to receive Director Elevation if either the Computer is in LOCAL or if Level is not feeding into the Computer. In either case there is danger of slewing into the ends of the limit stops.

Suppose that Level is not feeding into the Computer and that the Level angle is 15° at the instant that the Control Officer slews the Director down to an angle of 5 degrees. The resultant angle would then be −10 degrees. The Computer Elevation line would slam into the −5° lower limit with the possibility of damage to the gearing, or, as usually happens, of causing A-59 to slip. A-59 is an inaccessible assembly clamp which was redesigned in later instruments to prevent slippage.

Again suppose that Level is feeding into the Computer but that Director Train is not being received either because the Computer is in LOCAL or because *B′r* is shut off at the switchboard. Further suppose that the Director is trained 180° from the *B′r* input to the Stable Element. In such a setup, Level of the opposite sign would be measured and the situation would be doubly as dangerous as not having Level feed in at all.

The following precautionary measures are recommended:

1. Loosen the Synchronize Elevation Knob holding friction until there is just enough friction to hold the Synchronize Elevation Dials matched. Then *E* will back out of the synchronizing differential D-12 whenever either limit of L-12 is hit.

2. Leave Director DC turned OFF until the Control Officer has the Slew Sight released from the secure position and is ready to slew to the Target.

3. Do not receive Director Elevation unless Director Train and Level are also being received

TABLE OF MODIFICATION DIFFERENCES

Miscellaneous

Mod No.	Ser. Nos.	Gun	Ship	Pe Base	Dip Base	Parallax driven by	Star Shell Computer
0	1-20	5"/38 single	DD's Aux.	30 feet	17.83 yards	B'gr	None
2							
1	21-28 45-56	5"/38 twin	BB's CL's			B'r	
9	29	5"/38 both	CV3				
3		5"/38 twin	BB's 58-60				
10	100	5"/38 both	CV3				
4	Below 101 Above 100	5"/38 twin	CL's CA's BB's				Star Shell Computer supplied except on some early Mods 4 and 6 Mk 1 Mod 0 Ser. No. 1-620 Mk 1 Mod 1 Ser. No. 621-up
6		5"/38 single	DD's			B'gr	
5	58-59		CV8				
"Old" 7	187-188 193-200	5"/38 both	CV's DD's				
"Univ" 7	216-389 390-518 519-567		All			Either B'gr or B'r selected by A-242	
11	*			0			
13	568-780 781-810 811-			30 feet			
8	*	5"/54	CVB		22 yards		Star Shell Computer Mk 1 Mod 2
12	*			0	13 yards		
15	*	8"/55	*	30 feet	59 feet		
14	*	6"/47		40 feet	70 feet		

Limits

Mod No.	Present Range	Advance Range	Target Height	Range Spot	Mech. Fuze	Time of Flight	Own Speed	I.V.	Elevation Spot	Elevation
0	0 22,500	1500 18,000	0 25,000	IN 1800 OUT 1800	0.60 45.05	1.80 61.80	0 40	Originally 2450-2600; changed to 2350-2600 by OD 5106	UP 180 DOWN 180	−5 +85
2							0 45			
1										
9										
3	0 35,000	500 18,000	0 50,000	IN 12,000 OUT 1800	0.60 55.00	0.60 60.60				
10										
4										
6				IN 1800 OUT 1800	0.60 45.00					
5										
"Old" 7										
"Univ" 7				IN 12,000 OUT 1800	0.60 55.00			2350 2600		
11										
13										
8		500 20,000			0.60 49.00	0.60 50.60		2400 2650	UP 342.5 DOWN 180	−25 +85
12										
15		*			0.60 45.60			2400 2700	UP 180 DOWN [illegible]	
14					0.60 49.00					

Intermittent Drives

Mod No.	Ds	Vs	cR	E	R2
0	320 680	2000 3800	None	None	None
2					
1	None	None			
9					
3			750 22,500		
10					
4					
6	320 680	2000 3800			
5					
"Old" 7					
"Univ" 7					
11					
13					
8	None	None		−2 +85	1500 18900
12					
15	390 590	2000 4460			
14					

Receivers

Mod No.	So	Radar Range	Range	$L + \frac{Zd}{30}$ Shaft
0	None	108,000-yard Receiver in Mods 2-7 Ser. Nos. 101 and up Installed in Ser. Nos. 1-100 by ORDALT 1080 All removed by ORDALT 2116A	Originally 2000 and 36,000 yards Altered to 2000 and 72,000 yards by ORDALT 2116A Ser. Nos. 216-567 become Mod 13	None
2	21.8 34.5 40.0			Provided
1	30.0 34.5			
9				
3	30.0 34.5			
10				
4	40.0			
6	25.0 40.0			
5	34.5			
"Old" 7	40.0			
"Univ" 7				
11				
13				
8		None	2000 and 72000 yards	
12				
15				
14				

Transmitters

Mod No.	Train Parallax	Elevation Parallax	Parallax Range	Sight Angle minutes	Sight Deflection mils	Fuze seconds	Elevation and Bearing Correction	B'gr Information	Solution Indicator	Mod No.
0	6 G's @ 30°	None	None	6 G's @ 2400	6 G's @ 442.24	6 G's @ 2 and 100	ORDALT 2266	None	None	0
2							6 G's @ 5° Auto. and 5 G's @ 10° Ind.			2
1				6 G's @ 200 & 7200	6 G's @ 100 & 4000					1
9				ORDALT 1182	ORDALT 1182					9
3	7 G's @ 30°			7 G's @ 200 and 7200	7 G's @ 100 and 4000	7 G's @ 2 and 100				3
10				ORDALT 1182	ORDALT 1182					10
4				7 G's @ 200 and 7200	7 G's @ 100 and 4000				Originally provided; removed by OD 5146	4
6				7 G's @ 2400	7 G's @ 442.24					6
5		7 G's @ 10°								5
"Old" 7				Both 6 G's @ 2400 and 6 G's @ 200 and 7200	Both 6 G's @ 442.24 and 6 G's @ 100 and 4000					"Old" 7
"Univ" 7										"Univ" 7
11									None	11
13										13
8				7 G's @ 200 and 7200	7 G's @ 100 and 4000					8
12										12
15		None	7 G's @ 0.001	7 G's @ 100 and 3600	7 G's @ 210.48	7 G's @ 20/7 and 360/7		7 G's @ 10°		15
14		7 G's @ 10°	*	7 G's @ 200 and 7200	7 G's @ 100 and 4000	7 G's @ 2 and 100				14

*Information not available at time of printing.

GLOSSARY of QUANTITIES and SYMBOLS

In the Mark 37 System, those quantities which can be rigidly defined have fire control symbols.

A quantity may be broken down into a basic quantity and modifying quantities. For example, the quantity "Own Ship Speed" consists of the basic quantity "Speed" and the modifying quantity "of Own Ship."

The fire control symbols may be broken down in the same way: into basic symbols for the basic quantities and modifying symbols for modifying quantities.

Capital letters are used for the basic symbols, small letters for the modifying symbols. For example, the symbol for "Own Ship Speed" is *So*; capital "*S*" is the symbol for the basic quantity "Speed", and small "*o*" is the symbol for the modifying quantity "of Own Ship."

This chapter lists separately the basic symbols and the modifying symbols used in building the symbols for the Gun Director Mark 37 System. Familiarity with the meaning of these individual letters will make the memorizing of the symbols much easier.

In the definitions given here, the following terms are understood:

a The term "Line of Sight" is used to designate the Line of Sight from the Director to the Target.

b The term "deck plane" means the standard reference plane of Own Ship.

c The term "horizontal plane" refers to the horizontal plane through the Director sights. The solution given by the Computer is based upon this plane.

d The term "plane through the Line of Sight (or Fire)" refers to the plane *containing* the Line of Sight (or Fire).

BASIC SYMBOLS

A Target Angle

B Bearing (of Target, unless modified), measured in the horizontal plane

B′ Same as *B*, but measured in the deck plane

C Course, measured in the horizontal plane

D Lateral Deflection (angular measure)

E Elevation (of Target, unless modified), measured in the vertical plane

E′ Same as *E*, but measured in a plane perpendicular to the deck

F Fuze Setting

H Height of Target (normally in feet)

K K_1, K_2, etc. Constants

L Level Angle, measured in the vertical plane

P Parallax

R Range

S Speed

T Time

V Elevation Prediction (angular measure)

X Horizontal deflection component of velocity perpendicular to the vertical plane through the Line of Sight

Y Horizontal range component of velocity in the vertical plane through the Line of Sight

Z Cross-level Angle

NOTE: In general, a *prime* after a basic symbol indicates the quantity is measured in the plane of the deck of Own Ship, or in a plane perpendicular to the deck of Own Ship.

MODIFYING SYMBOLS

b Of Director

c Before a quantity means the value of that quantity as generated by the mechanism, as opposed to the *observed* value of the same quantity. After a quantity means relative to rate control.

d Before a quantity means a time rate of change of that quantity. After a quantity means in or relative to the deck plane or plane perpendicular to the deck.

e Elevation

f Due to standard trajectory

g Of Gun

h Horizontal projection of

j Before a quantity means a correction or partial correction to that quantity, usually generated by the mechanism. After a quantity means arbitrary correction (spot) to that quantity.

m Loss of Initial Velocity

o Of or due to Own Ship

r Relative to Own Ship

s Relative to the Line of Sight, or in a slant plane. (Since several slant planes may be used, each definition should specify the plane used.)

t Of or due to Target

v Vertical projection of

w Of or due to Wind

z Of or due to Cross-level

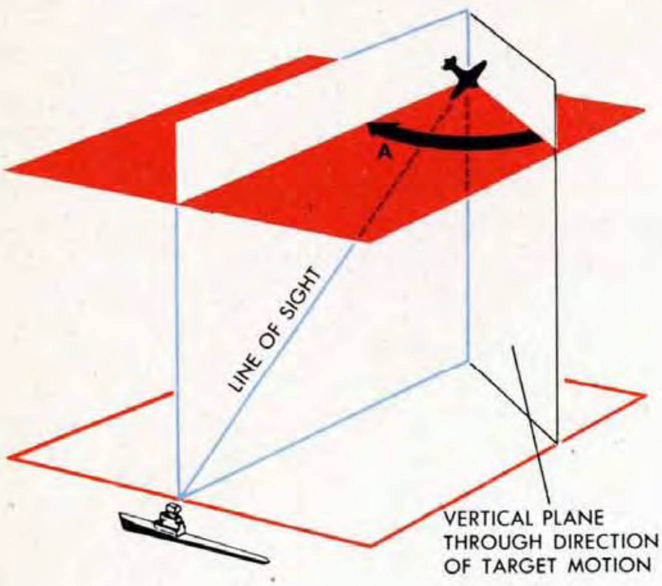
f( ) Function of the quantity in parentheses

Δ Before a quantity means change in that quantity during some specific time. Increment of a quantity.

$\int$ Before a quantity means the integral of that quantity

2 After a quantity indicates that it is the predicted value of that quantity for advance position; i.e., for the instant a projectile, which is fired at the present time, hits (bursts for anti-aircraft fire).

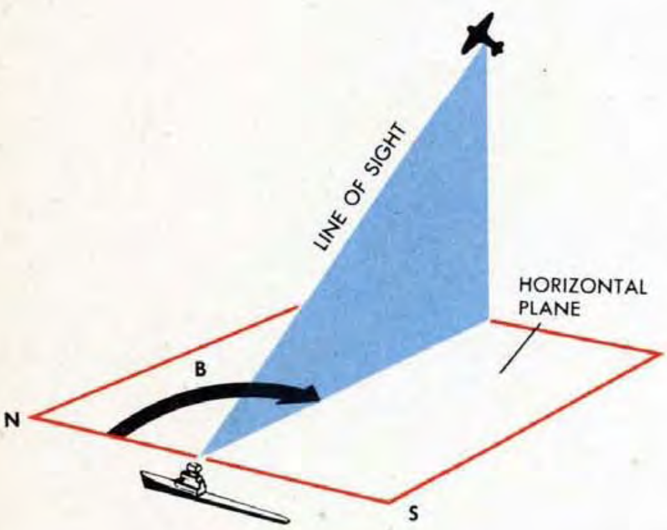
3 After a quantity indicates that it is the predicted value of that quantity for fuze position; i.e., for the instant a projectile, fired dead time seconds from the present time, hits (bursts for anti-aircraft fire).



A TARGET ANGLE

The angle between the vertical plane through the direction of Target Motion and the vertical plane through the Line of Sight, measured in the horizontal plane, clockwise from the direction of Target Motion.

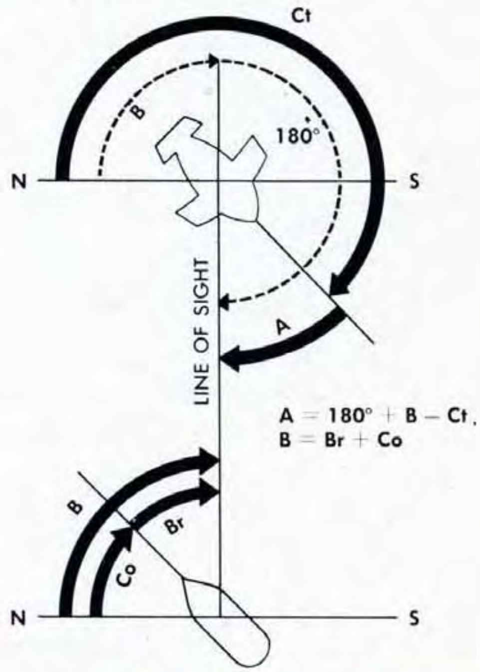
$$A = 180^\circ + B - Ct$$



B TRUE TARGET BEARING

Compass direction of the Line of Sight.

$$B = Br + Co$$



ΔcB INCREMENT OF GENERATED TRUE BEARING

Change in True Bearing computed by the instrument.

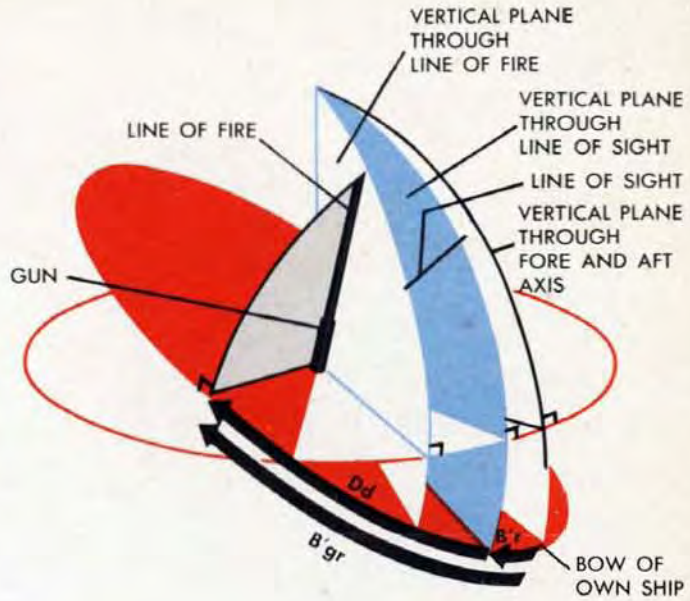
jBc LINEAR DEFLECTION RATE CORRECTION

Rate Control Correction affecting Linear Deflection Rate.

B'gr GUN TRAIN ORDER

The ordered angle between the fore and aft axis of Own Ship and a plane through the Line of Fire at right angles to the deck, measured in the deck plane clockwise from the bow, without correction for horizontal parallax.

$$B'gr = B'r + Dd$$



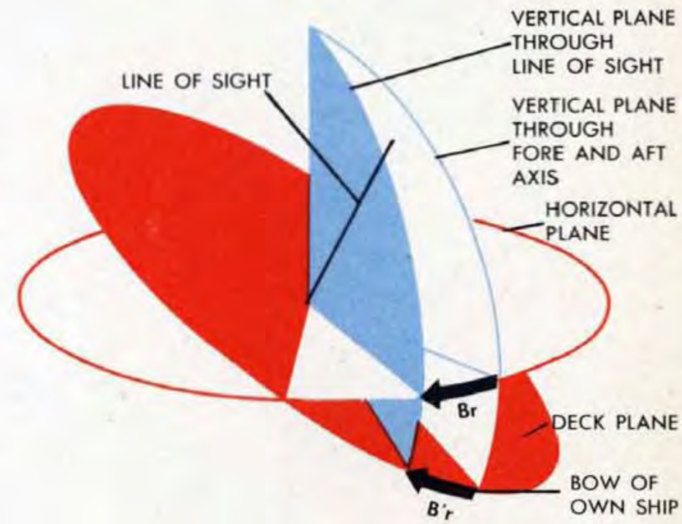
Br RELATIVE TARGET BEARING

The angle between the vertical plane through the fore and aft axis of Own Ship and the vertical plane through the Line of Sight, measured in the horizontal plane clockwise from the bow of Own Ship.

$$Br = B'r + jB'r$$

B'r DIRECTOR TRAIN

The angle between the vertical plane through the fore and aft axis of Own Ship and the vertical plane through the Line of Sight, measured in the deck plane clockwise from the bow of Own Ship.



cBr GENERATED RELATIVE TARGET BEARING

Relative Target Bearing computed by the instrument.

$$cBr = jBr + \triangle cBr$$

cB'r GENERATED DIRECTOR TRAIN

Director Train computed by the instrument.

$$cB'r = cBr - jB'r$$

ΔcBr INCREMENT OF GENERATED RELATIVE TARGET BEARING

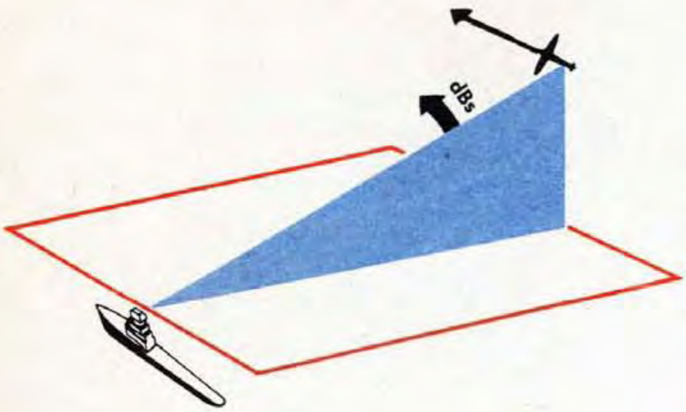
Changes of Relative Target Bearing computed by the instrument.

$$\triangle cBr = \triangle cB - Co$$

ΔcB'r INCREMENT OF GENERATED DIRECTOR TRAIN

Changes of Director Train computed by the instrument. (Bearing Correction.)

$$\triangle cB'r = \triangle cBr - jB'$$



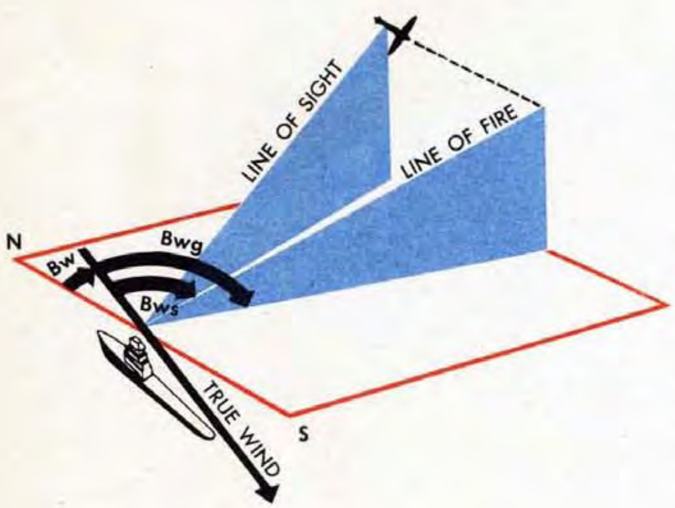
jBr INITIAL OR CORRECTIVE SETTING OF GENERATED RELATIVE TARGET BEARING

jB'r DECK TILT CORRECTION

Correction to Director Train, *B'r,* for the effect of Deck Tilt, used to refer Director Train to the horizontal plane.

dBs BEARING RATE IN SLANT PLANE

Bearing Rate measured in the slant plane through the Line of Sight and at right angles to the vertical plane through the Line of Sight. (Does not exist separately in the mechanism.)



Bw WIND DIRECTION

The compass direction *from* which the Wind is blowing.

Bwg PREDICTED WIND ANGLE

The angle between the direction *from* which the Wind is blowing and the vertical plane through the Line of Fire, measured in the horizontal plane clockwise from the direction *from* which the Wind is blowing.

Bws WIND ANGLE

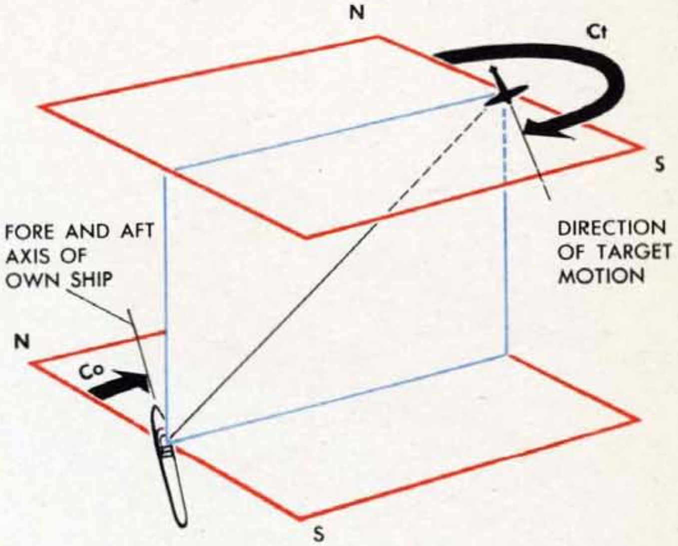
The angle between the direction *from* which the Wind is blowing and the vertical plane through the Line of Sight, measured in the horizontal plane clockwise from the direction from which the Wind is blowing.

Co SHIP COURSE

Compass heading of Own Ship.

Ct TARGET COURSE

Compass Direction toward which the Target is moving.



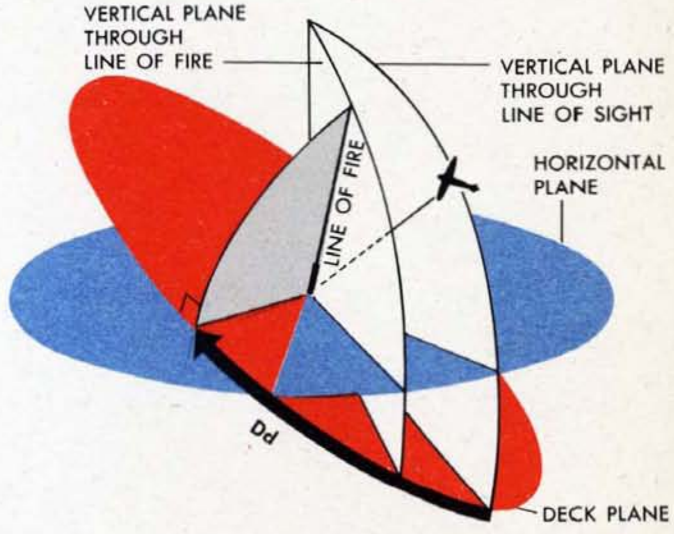
Dd DECK DEFLECTION

The angle representing total Deflection in the deck plane; it is added to Director Train to obtain Gun Train Order, $B'gr$.

$$Dd + B'r = B'gr \quad \text{and}$$
$$Dd = jDd + Dz$$

jDd PARTIAL DECK DEFLECTION

One term of a mechanism equation used in computing total Deck Deflection, *Dd*.

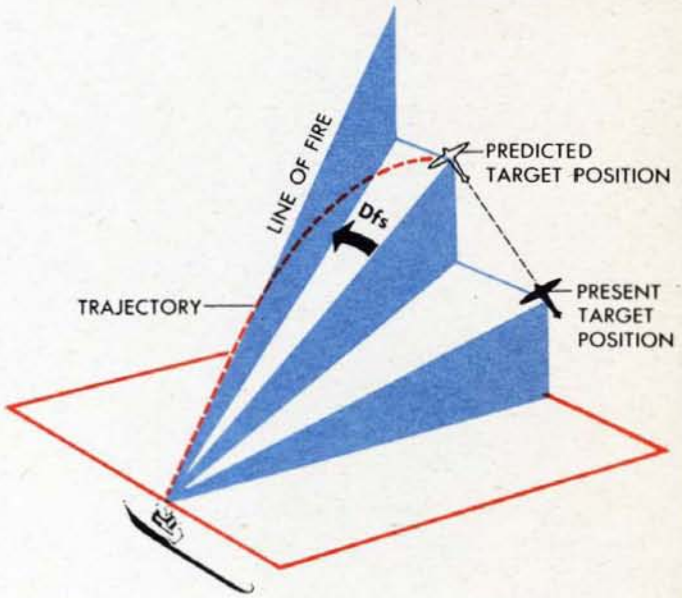


Dfs DRIFT CORRECTION

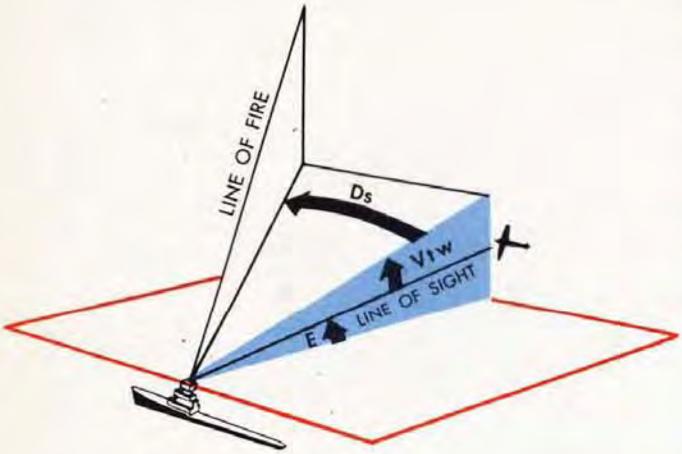
The lateral Deflection angle to compensate for drift of a projectile, measured in the slant plane through the Predicted Target Position.

$$Dfs = K\,(Vf + Pe + Vfm - K_1)$$

Dj DEFLECTION SPOT



NOTE:
The term "deck plane" does not mean the plane through the deck, but a plane at the level of the Director Sights parallel to the Director roller path.

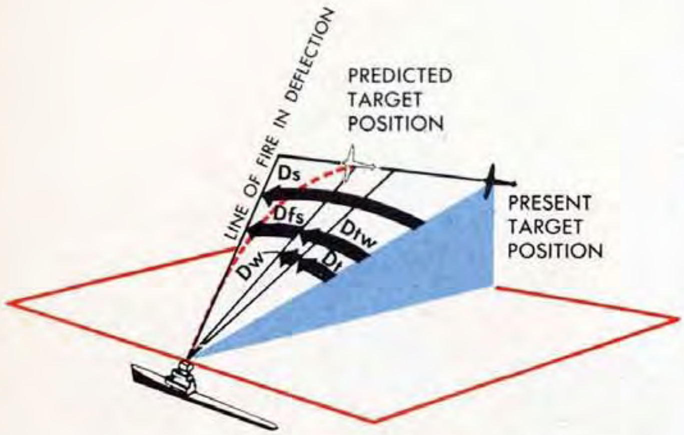


Ds SIGHT DEFLECTION

The angle between the vertical plane containing the Line of Sight and the vertical plane through the Line of Fire, measured in the plane at right angles to the vertical plane containing the Line of Sight, at angle *Vtw* above the Line of Sight. *Ds* is positive when the gun is trained to the right of the Line of Sight.

(This is an approximation of *Ds* as defined in OD 3447.)

$$Ds = Dtwj - Dfs$$



HERE Dt, Dw, Dtw, AND Ds ARE NEGATIVE

Dt RELATIVE MOTION DEFLECTION PREDICTION

Deflection Prediction to compensate for Relative Motion of Own Ship and Target during Time of Flight. (Does not exist separately in the mechanism.)

Dw WIND DEFLECTION PREDICTION

Deflection Prediction to compensate for the effect of Apparent Wind on the projectile. (Does not exist separately in the mechanism.)

Dtw RELATIVE MOTION AND WIND DEFLECTION PREDICTION

$$Dtw = Dt + Dw$$

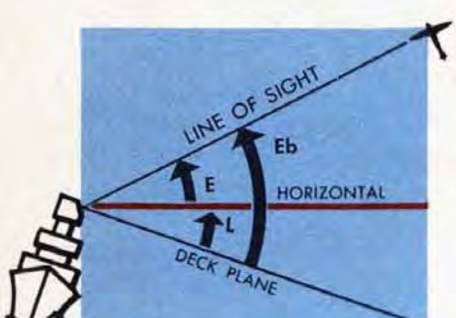
Dtwj TOTAL DEFLECTION PREDICTION

$$Dtwj = Dtw + Dj$$

Dz

One term of a mechanism equation used in computing *Dd;* it represents approximately the Trunnion Tilt Train Correction to compensate for Cross-level.

$$Dz + jDd = Dd$$



E TARGET ELEVATION

The angle between the horizontal plane and the Line of Sight, measured in the vertical plane through the Line of Sight.

$$E = Eb - L$$

Eb DIRECTOR ELEVATION

The angle between the deck plane and the Line of Sight, measured in the vertical plane through the Line of Sight.

cE GENERATED TARGET ELEVATION

Target Elevation computed by the instrument.

△cE INCREMENT OF GENERATED TARGET ELEVATION

Changes of Target Elevation computed by the instrument.

△cEb INCREMENT OF GENERATED DIRECTOR ELEVATION

Changes of Director Elevation computed by the instrument.

$$\triangle cEb = \triangle cE + L$$

△cEb + Zd/30 ELEVATION CORRECTION

Computed Changes of Director Elevation compensated for the roll of the Director Sights in Cross-level.

dE ANGULAR ELEVATION RATE

(Does not exist separately in the mechanism.)

jE INITIAL OR CORRECTIVE SETTING OF GENERATED TARGET ELEVATION

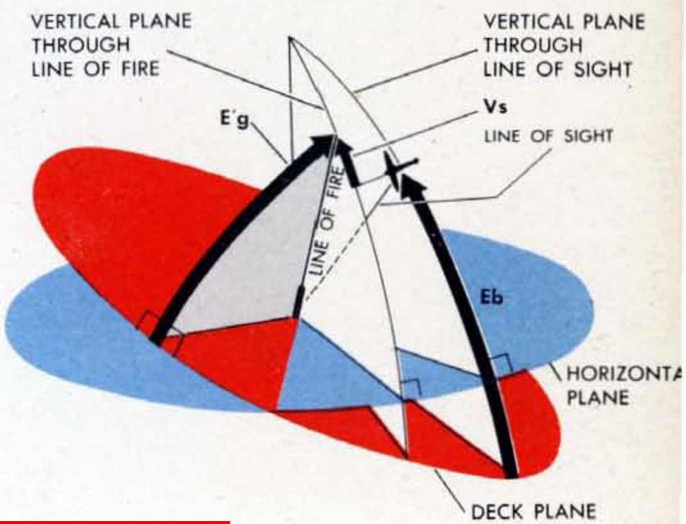
jEc LINEAR ELEVATION RATE CORRECTION

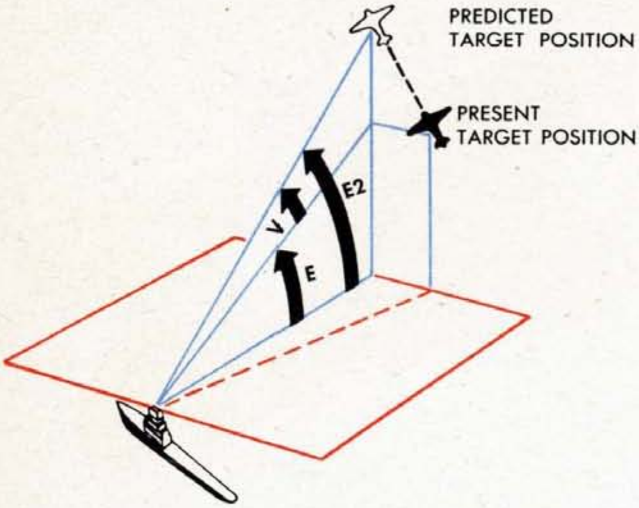
Rate Control Correction primarily affecting Linear Elevation Rate.

E'g GUN ELEVATION ORDER

Ordered Elevation of gun above the deck plane, measured in a plane through the Line of Fire and at right angles to the deck plane. Includes Parallax Correction for a vertical base, but not for a horizontal base.

$$E'g = Eb + Vs - Vz$$



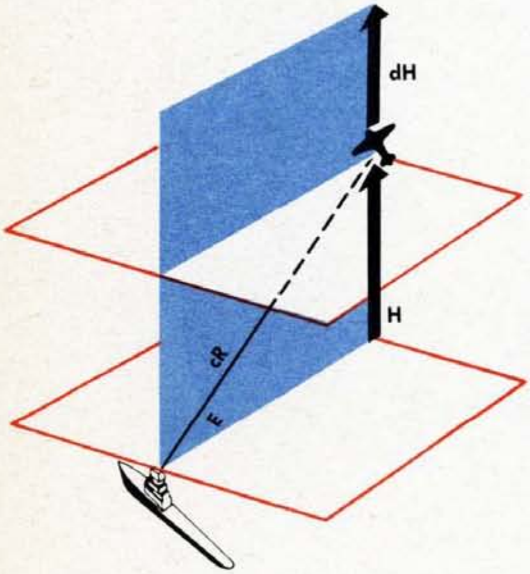


E2 PREDICTED TARGET ELEVATION

Approximate Elevation of the Target at the end of the Time of Flight.

$$E2 = E + V$$

F FUZE SETTING ORDER



H TARGET HEIGHT

Vertical distance between the Target and the horizontal plane through the Director sights.

$$H = cR \sin E$$

dH RATE OF CLIMB

Vertical component of Target Velocity.

jHc RATE OF CLIMB CORRECTION

Rate Control Correction primarily affecting Rate of Climb.

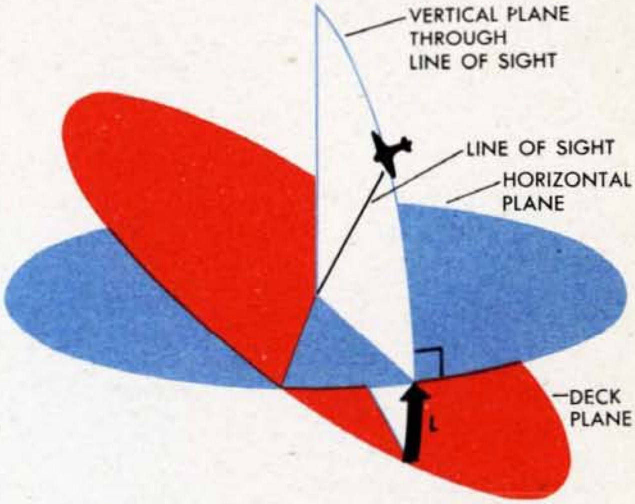
I. V. INITIAL VELOCITY OF PROJECTILE

K, K_1, K_2, etc. CONSTANTS

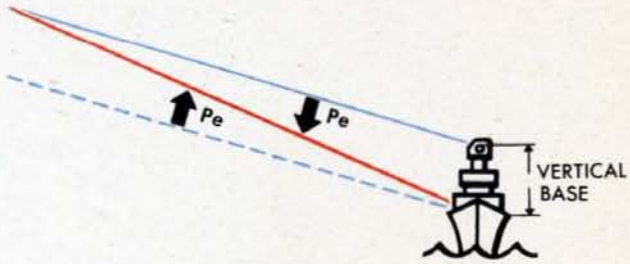
Two or more constants in the same expression are distinguished by numbers.

L LEVEL ANGLE

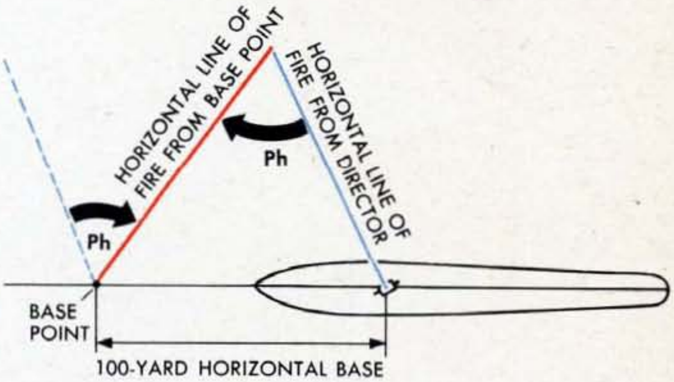
The angle between the horizontal plane and the deck plane, measured in the vertical plane through the Line of Sight. *L* is positive when the deck toward the Target is tilted down.



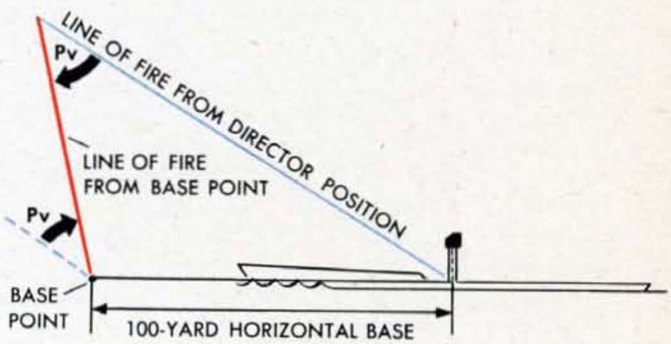
Pe ELEVATION PARALLAX CORRECTION FOR VERTICAL BASE



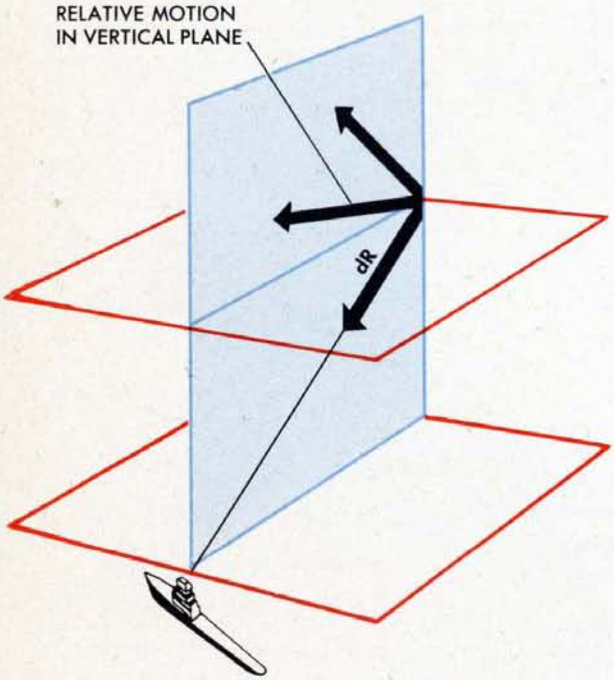
Ph TRAIN PARALLAX CORRECTION FOR HORIZONTAL BASE

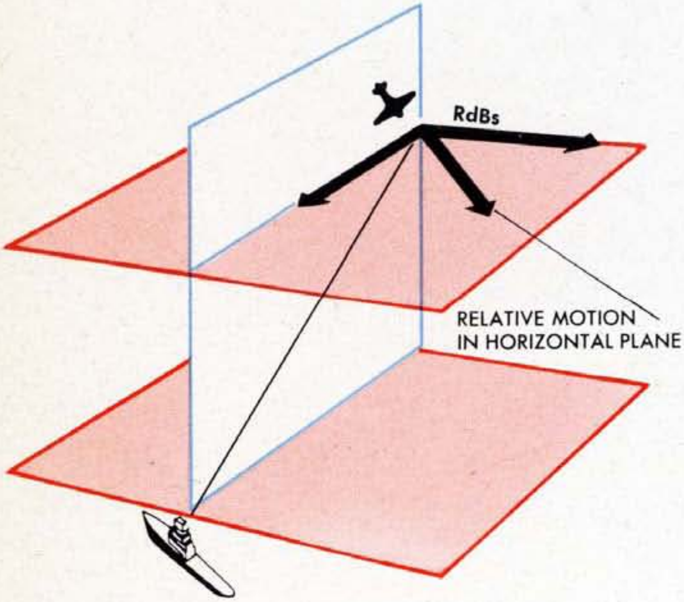


Pv ELEVATION PARALLAX CORRECTION FOR HORIZONTAL BASE



R OBSERVED PRESENT RANGE





cR GENERATED PRESENT RANGE

Present Range computed by the instrument.

1/cR RECIPROCAL OF GENERATED PRESENT RANGE

△cR INCREMENT OF GENERATED PRESENT RANGE

Changes of Range computed by the instrument. (Range Correction.)

dR DIRECT RANGE RATE

The Line of Sight component of relative motion between Target and Own Ship.

jdR DIRECT RANGE RATE CORRECTION

The Rate Control Correction primarily affecting Range Rate.

jR INITIAL OR CORRECTIVE SETTING OF GENERATED RANGE

jRc LINEAR RANGE CORRECTION

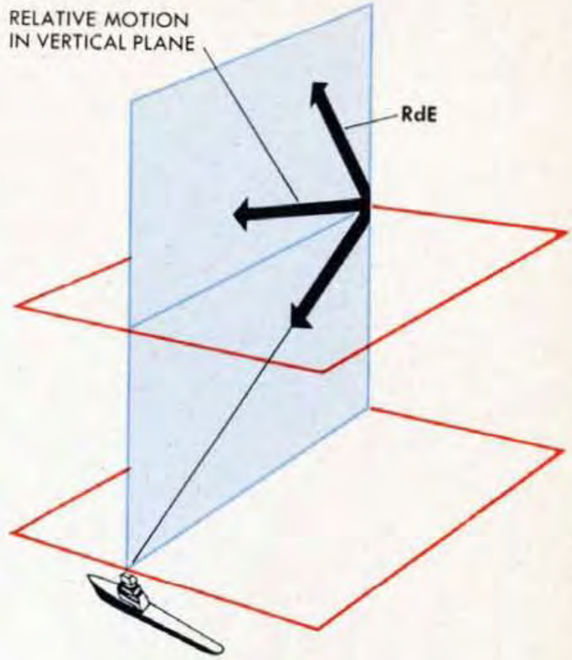
Applied to Generated Range.

RdBs LINEAR DEFLECTION RATE

The horizontal component of relative motion between Target and Own Ship, at right angles to the vertical plane through the Line of Sight.

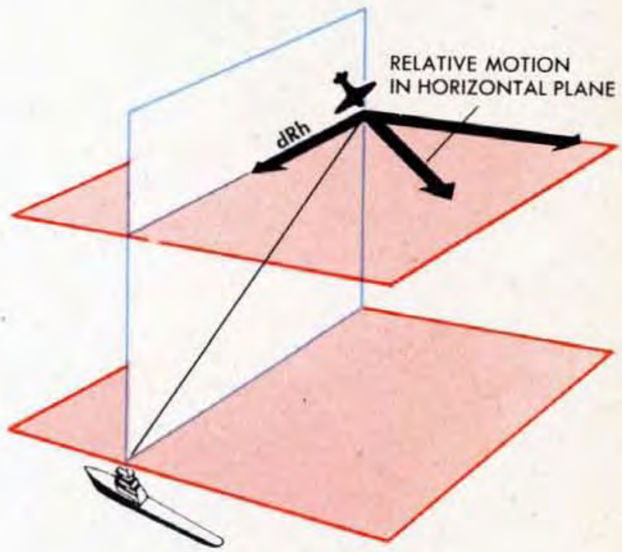
RdE LINEAR ELEVATION RATE

The component of relative motion between Target and Own Ship, at right angles to the Line of Sight and in the vertical plane through the Line of Sight.



dRh HORIZONTAL RANGE RATE

The horizontal component of relative motion between Target and Own Ship, in the vertical plane through the Line of Sight.



jdRh HORIZONTAL RANGE RATE CORRECTION

Rate Control Correction primarily affecting Horizontal Range Rate.

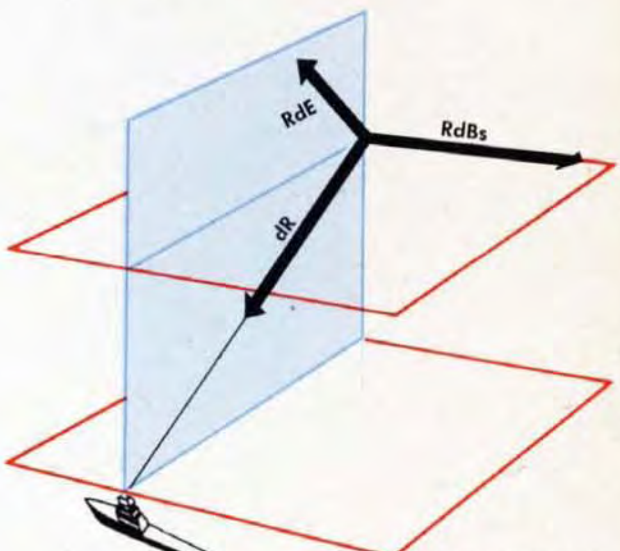
Rj RANGE SPOT

Rm

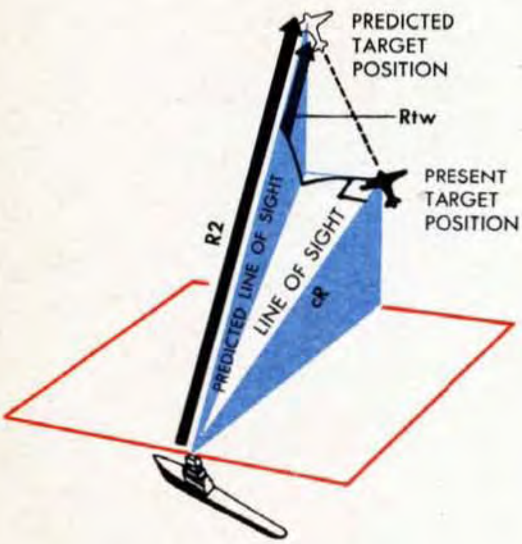
Correction to Range Prediction for a change in *I.V.* from 2550 f.s.

dRm

Alteration to Prediction Range Rate for a change in *I.V.* from 2550 f.s.



THE THREE RELATIVE MOTION RATES ARE USUALLY SHOWN LIKE THIS



dRs PREDICTION RANGE RATE

Direct Range Rate corrected for the effect of Deflection and Elevation Rates, and for a change in *I.V.* from 2550 f.s.

$$dRs = dR + dRxe + dRm$$

Rt RELATIVE MOTION RANGE PREDICTION

Compensates for the Relative Motion of Own Ship and Target during the Time of Flight. (Does not exist separately in the mechanism.)

Rw WIND RANGE PREDICTION

Compensates for the effect of Apparent Wind on the projectile. (Does not exist separately in the mechanism.)

Rtw RELATIVE MOTION AND WIND RANGE PREDICTION

(Does not exist separately in the mechanism.)

$$Rtw = Rt + Rw$$

Rtwm TOTAL RANGE PREDICTION

$$Rtwm = Rtw + Rm$$

dRxe RANGE RATE CORRECTION

Correction to Prediction Range Rate for the effect of the Deflection and Elevation Rates.

RTg

Correction in Fuze Range for Dead Time.

R2 ADVANCE RANGE (OR PREDICTED RANGE)

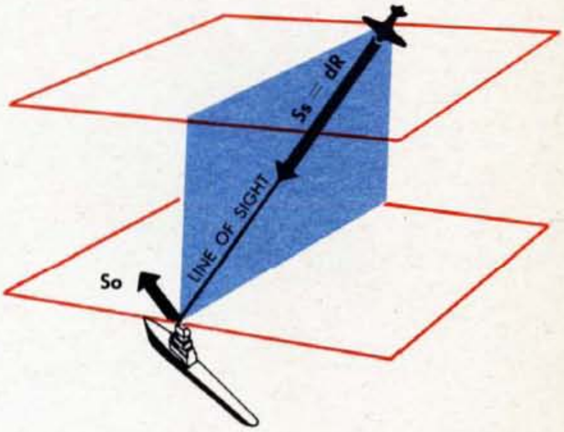
$$R2 = cR + Rtwm + Rj$$

R3 FUZE RANGE

$$R3 = R2 + RTg$$

Sh TARGET SPEED
Horizontal ground speed of Target.

So OWN SHIP SPEED



Ss DIVING SPEED OF TARGET
Speed along the Line of Sight, or Direct Range Rate.

Sw TRUE WIND SPEED

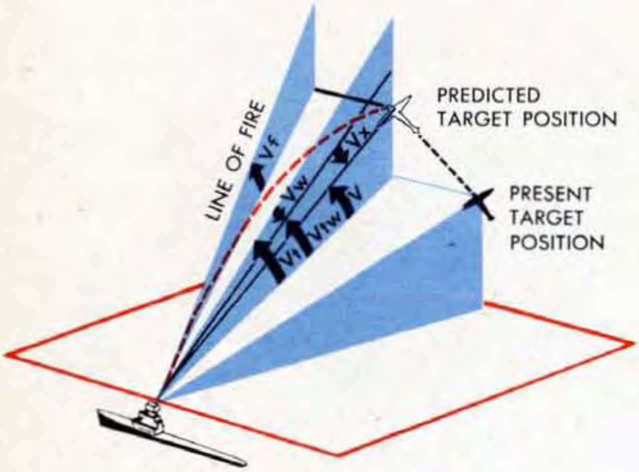
T TIME
Generated by the regulated Time Motor.

T/cR TIME DIVIDED BY GENERATED PRESENT RANGE

Tf TIME OF FLIGHT

Tf/R2 TIME OF FLIGHT DIVIDED BY ADVANCE RANGE

Tg DEAD TIME
Time in seconds between the setting of the fuze and the firing of the projectile.



V TOTAL ELEVATION PREDICTION

The approximate amount that Target Elevation changes during the Time of Flight.

$$V = Vtw - Vx + Vj$$

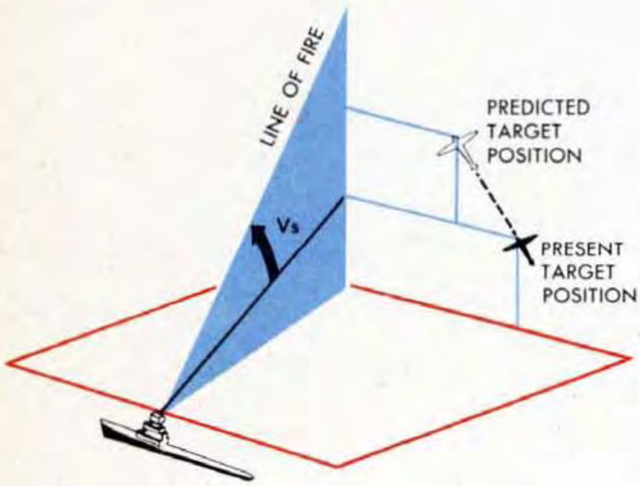
Vf SUPERELEVATION

The angle the gun must be elevated above the Predicted Line of Sight to compensate for the curvature of trajectory in the vertical plane.

Vfm

Correction to Superelevation for a change in *I.V.* from 2550 f.s.

Vj ELEVATION SPOT



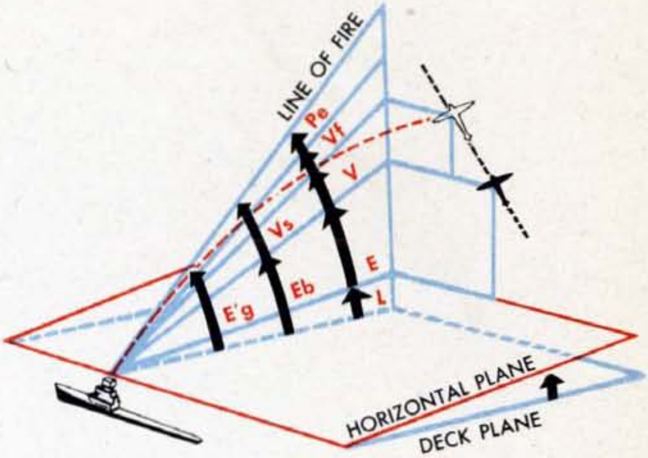
Vs SIGHT ANGLE

The difference between the elevation of the Line of Fire above the horizontal plane and the elevation of the Line of Sight above the horizontal plane, measured in the vertical plane through the Line of Fire. (Positive when the Line of Fire is above the Line of Sight.) (This is an approximation of Sight Angle as defined in OD 3447.)

$$Vs = V + (Vf + Pe) + Vfm$$

Vt RELATIVE MOTION ELEVATION PREDICTION

Compensates for the Relative Motion of Own Ship and Target during the Time of Flight. (Does not exist separately in the mechanism.)



A SUMMARY OF ELEVATION QUANTITIES

Vw WIND ELEVATION PREDICTION

Compensates for the effect of Apparent Wind on the projectile. (Does not exist separately in the mechanism.)

Vtw RELATIVE MOTION AND WIND ELEVATION PREDICTION

$$Vtw = Vt + Vw$$

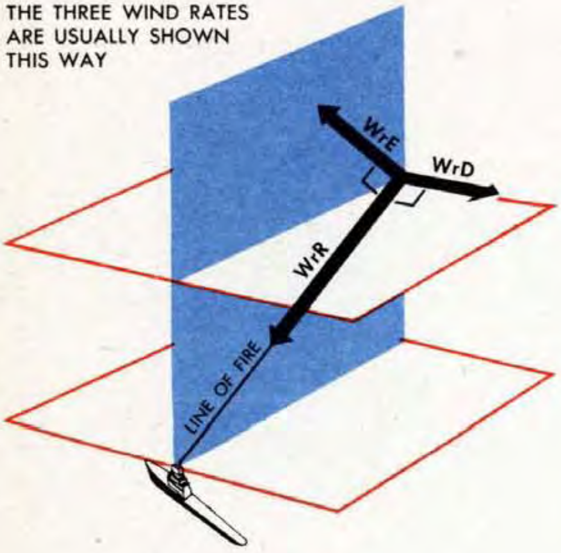
Vx COMPLEMENTARY ERROR CORRECTION

Correction to Elevation Prediction to compensate for Deflection Prediction.

Vz TRUNNION TILT ELEVATION CORRECTION

Correction to Gun Elevation to compensate for the effect of Cross-level.

THE THREE WIND RATES ARE USUALLY SHOWN THIS WAY



WrD DEFLECTION WIND RATE

The component of Apparent Wind Velocity affecting Deflection Prediction.

WrE ELEVATION WIND RATE

The component of Apparent Wind Velocity affecting Elevation Prediction.

$$WrE = Ywgr \sin K{\bullet}E2$$

WrR RANGE WIND RATE

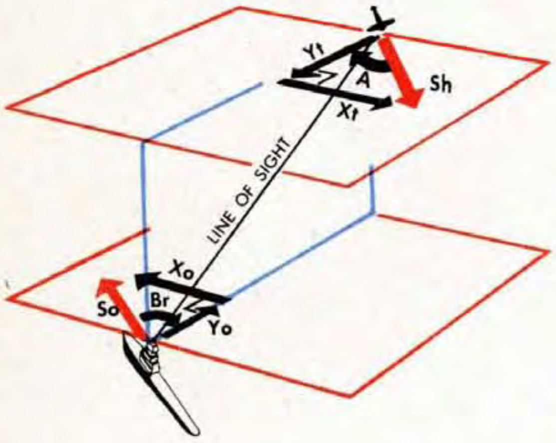
The component of Apparent Wind Velocity affecting Range Prediction.

$$WrR = Ywgr \cos K{\bullet}E2$$

Xo

Horizontal component of Own Ship Velocity at right angles to the vertical plane through the Line of Sight. (Deflection component.)

$$Xo = So \sin Br$$



Xt

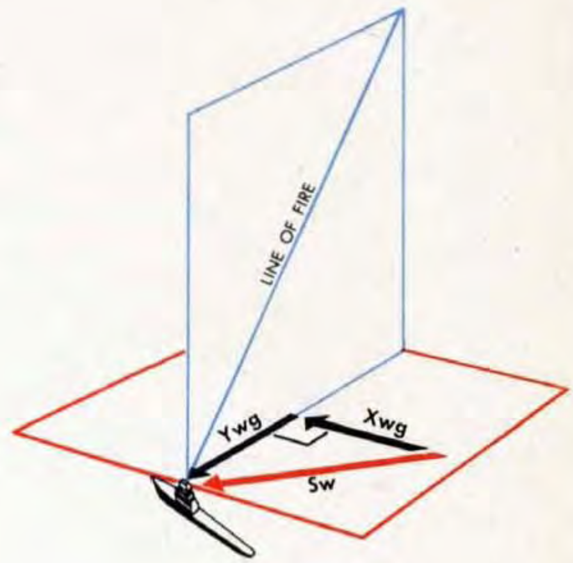
Horizontal component of Target Velocity at right angles to the vertical plane through the Line of Sight. (Deflection component.)

$$Xt = Sh \sin A$$

Xwg

Horizontal component of True Wind Velocity, at right angles to the vertical plane through the Line of Fire. (Deflection component.)

$$Xwg = Sw \sin Bwg$$



Yo

Horizontal component of Own Ship Velocity in the vertical plane through the Line of Sight. (Horizontal range component.)

$$Yo = So \cos Br$$

Yt

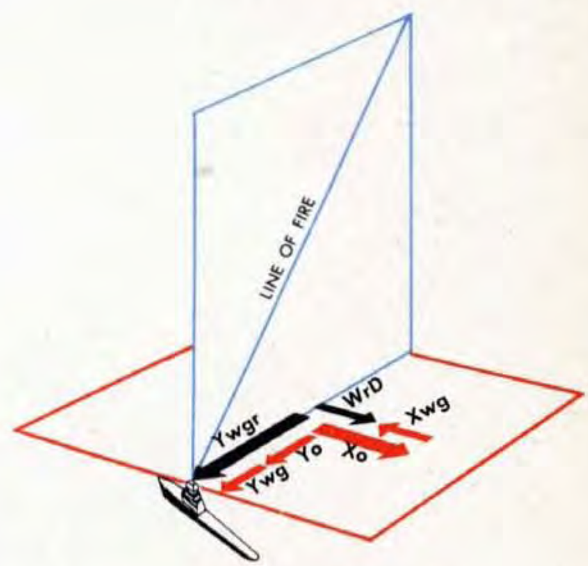
Horizontal component of Target Velocity in the vertical plane through the Line of Sight. (Horizontal range component.)

$$Yt = Sh \cos A$$

Ywg

Horizontal component of True Wind Velocity, in the vertical plane through the Line of Fire. (Horizontal range component.)

$$Ywg = Sw \cos Bwg$$



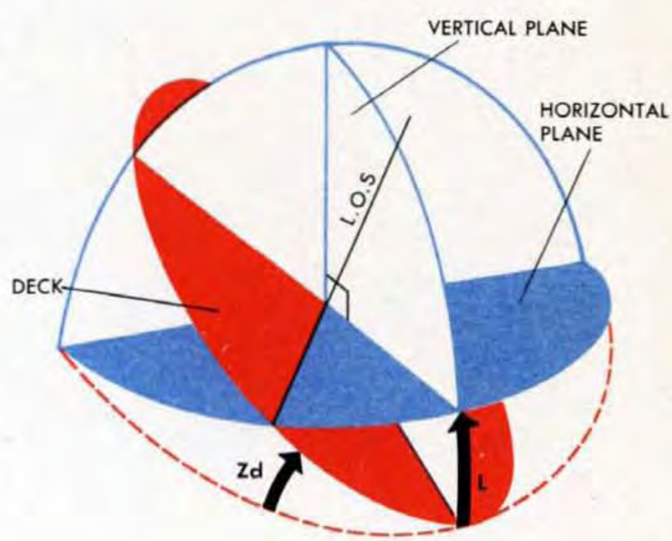
Ywgr

Horizontal component of Apparent Wind Velocity, in the vertical plane through the Line of Fire. (Horizontal range component.)

$$Ywgr = Yo + Ywg$$

Zd CROSS-LEVEL

The angle of roll of the deck about a line which is the intersection of the deck plane with the vertical plane through the Line of Sight. The correction for Zd is positive if, when one faces the Target, the deck at the left is tilted down.



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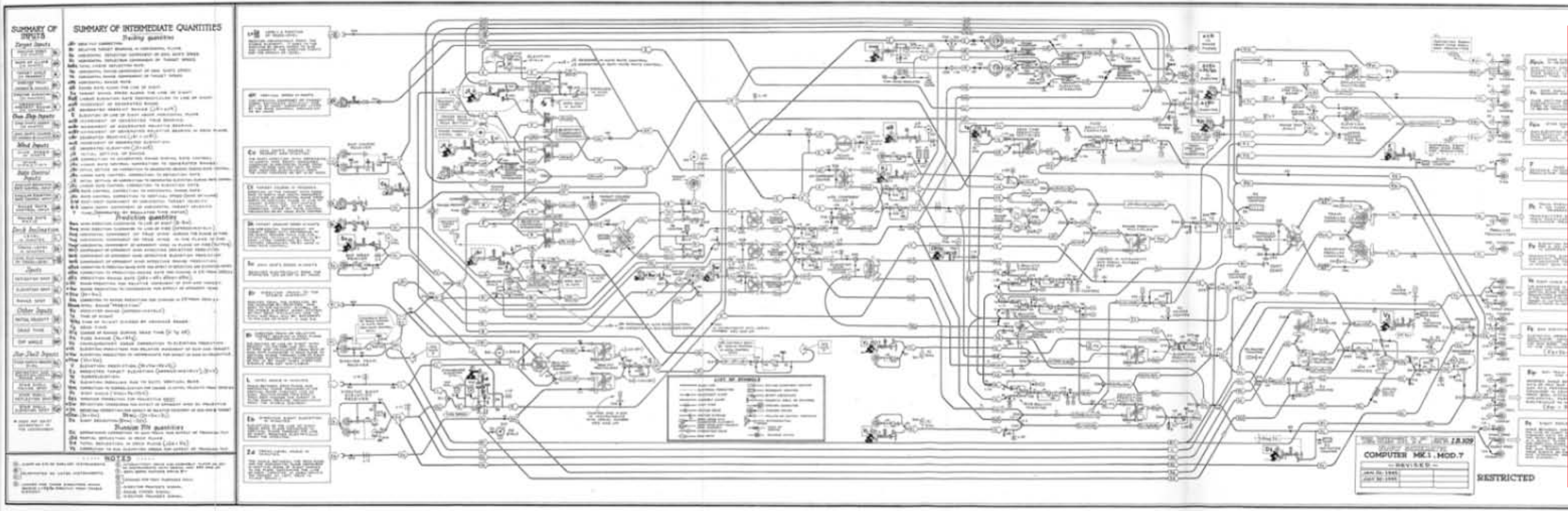
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SUMMARY OF INTERMEDIATE QUANTITIES
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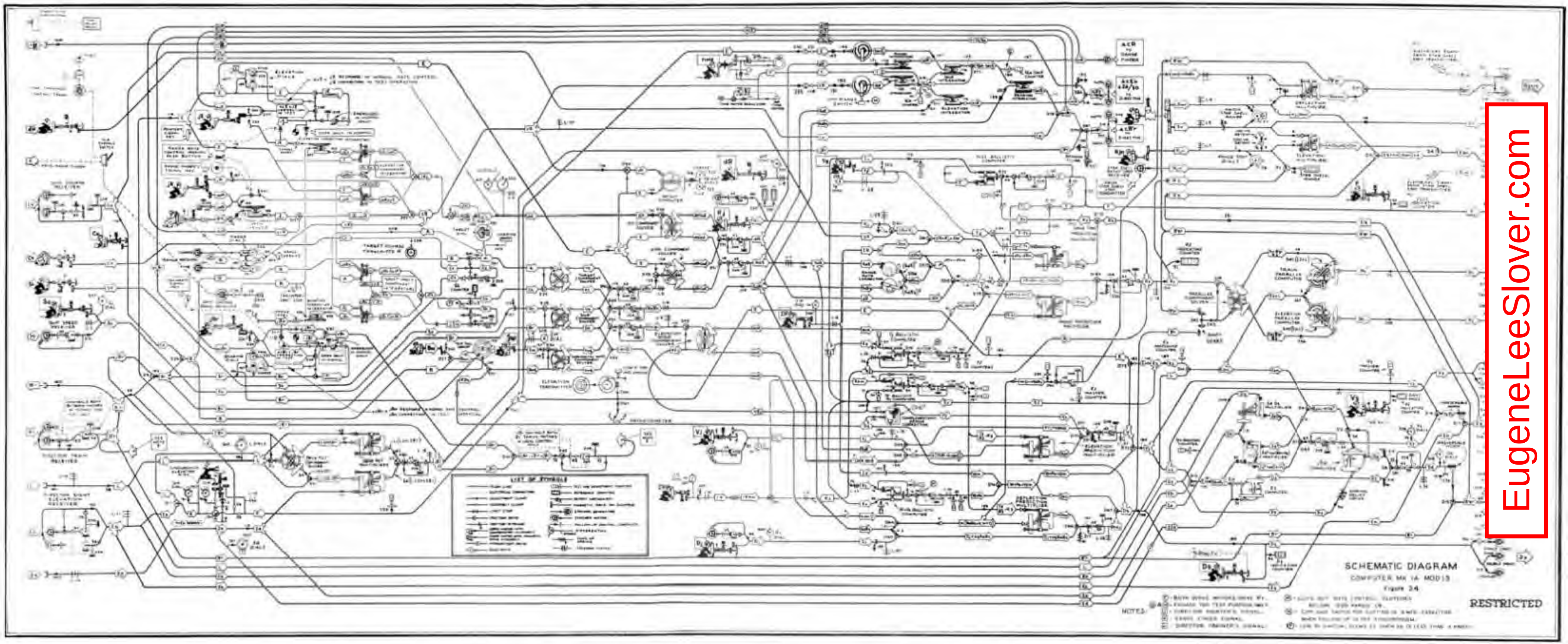
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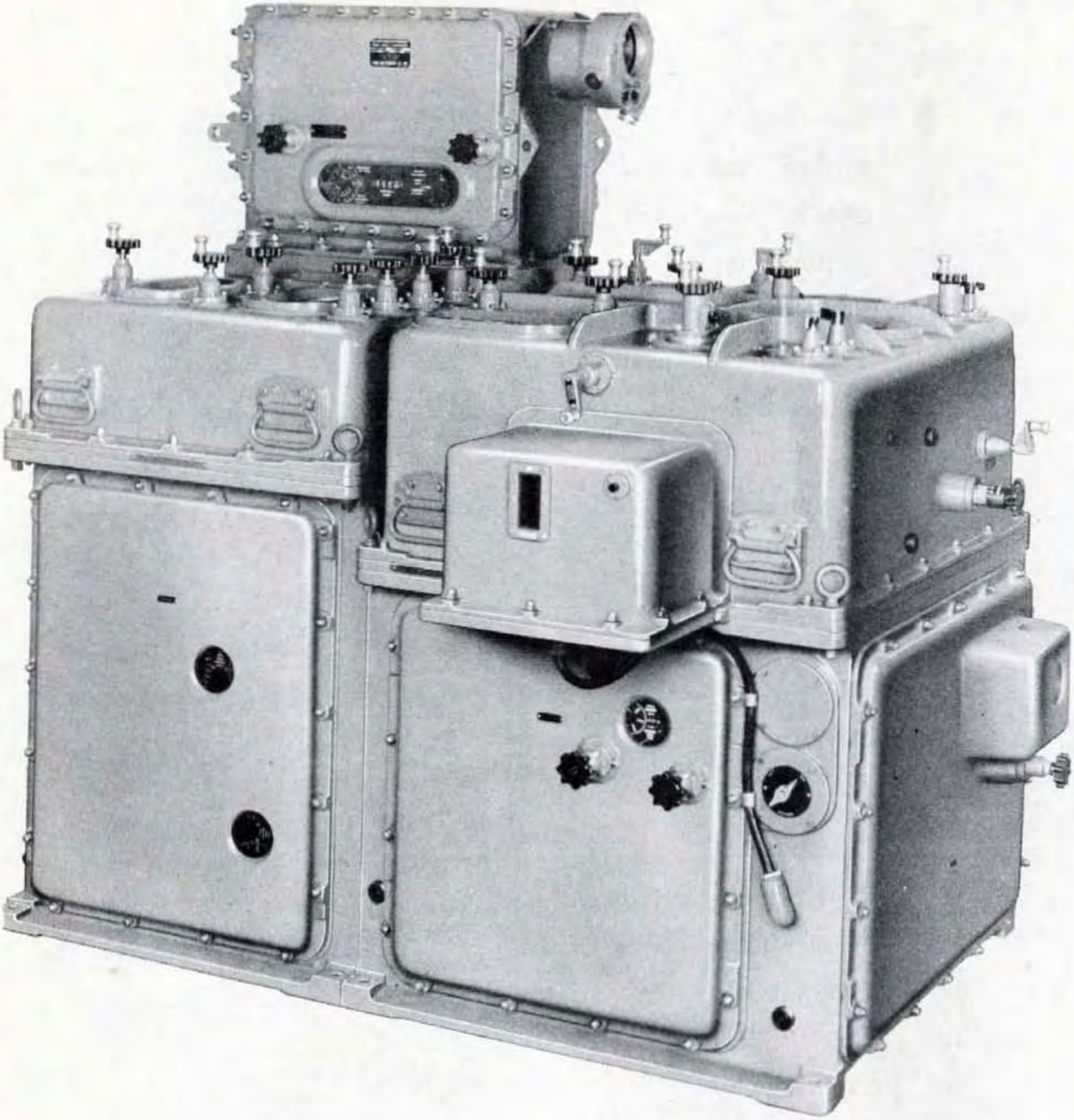


Figure 1. Computer Mk 1A and Star Shell Computer Mk 1.

COMPUTER MK 1A

INTRODUCTION

The purpose of this addendum is to bring OP 1064 "Computer Mk 1 and Mods — Description and Operation" up to date by describing the changes made in the computer since the publication date of OP 1064. All changes up to and including those authorized by NavOrd Ordalts 2331A, 2332, 2336, 2339, 2620, 2626, 2894, 2963, and 3091 are covered in this addendum. The changes authorized under the ordalts enumerated above are of such extent that after their performance on a Computer Mk 1, the designation of that instrument is changed to Computer Mk 1A. These changes modernize the instrument in the following respects:

1. Improve the anti-aircraft performance of the computer by replacing the North-South vector rate control mechanism of the Computer Mk 1 with a target vector rate control mechanism.
2. Double the limits of target speed and rate of climb.
3. Change the ballistic quantities used in all computers having 5"/38 cal. ballistics to correspond with revised 5"/38 cal. ballistic data contained in OP 551A, dated 11 February 1946.
4. Provide transmission of target elevation angle (*E*) from a potentiometer and from a synchro generator.
5. Provide computer control circuit changes which improve the operation of the instrument and reduce the task of the operating crew during rate control.

The major part of the description of Computer Mk 1 given in OP 1064 is applicable to Computer Mk 1A. Features wherein Computer Mk 1A differs from Computer Mk 1 as described in OP 1064 are treated in this addendum. Use of the addendum in conjunction with OP 1064 should therefore furnish an adequate description of Computer Mk 1A. For convenience in reference, arrangement of the material in the addendum parallels that in OP 1064. An index listing the pages in OP 1064 that do not accurately describe Computer Mk 1A, and specifying where the corrective information can be found in the addendum, is included at the back of the addendum.

GENERAL DESCRIPTION

All modifications of Computer Mk 1A (figure 1) are essentially the same in appearance, function, and operation. They differ mainly with respect to the self-contained ballistic data which adapt them to particular guns. The mod numbers vary according to the guns to be controlled as follows:

Mods 8, 12, 17, and 18	5"/54 cal.
Mods 13 and 19	5"/38 cal.
Mods 14 and 16	6"/47 cal.
Mod 15	8"/55 cal.

Mods 8 to 16 inclusive are covered in the addendum.

Mods 17 to 19 are in the design stage and sufficient information is not available for their inclusion. Mods 17 and 19 are to be used in Gun Fire Control System Mk 67 as follows:

a. Mod 17 in GFCS Mk 67 Mod 0, which has the usual 60 cycle synchro transmission system.

b. Mod 19 in GFCS Mk 67 Mod B, which provides for the use of 400 cycle supply in a large part of the synchro transmission system.

Computer Mk 1A differs from Computer Mk 1 in the following general respects:

1. The dials and gearing have been altered to make the limits of operation of the ship speed, target speed, rate of climb, and wind speed inputs of Computer Mk 1A twice the values of those in Computer Mk 1. Computer Mk 1A, therefore, can be operated effectively against modern aircraft.

2. The rate control mechanism is changed. It differs functionally; components of target motion are taken along and at right angles to the line of sight rather than with respect to a North-South axis. One of the principal mechanical differences is the elimination of the vector solver, which was made possible by the functional change. Another mechanical difference is the addition of a rate of climb (*dH*) follow-up. The sensitivity of the mechanism has been increased, or, stated another way, the time constant, which is the time required to reduce an error to 37% of its initial value, has been decreased. Greater flexibility of operation is obtained by the addition of the means whereby the time constant can be varied at the will of the operator.

3. A number of automatic operating controls have been added, resulting in more satisfactory operation of the gun fire control system as a whole, and in simplification of the task of the computer operating crew.

4. An additional *I.V.* correction is applied in the predictor section of Computer Mk 1A Mods 13, 14, 15, and 16 by means of an *I.V.* knob on the front of the computer.

5. Certain servo motor circuits have been modified to reduce oscillations in the fuze *(F)*, and gun elevation order *(E'g)* outputs.

6. The fuze computation network has been changed.

7. In Computer Mk 1A Mods 8 and 12, provision is made for obtaining superelevation for ranges beyond 20,000 yards in surface fire.

8. All mods of Computer Mk 1A transmit target elevation *(E)* in two ways: by synchro transmission, and through the output of a potentiometer.

9. Computer Mk 1A Mod 15 computes and transmits values of parallax range instead of parallax in elevation due to a horizontal base *(Pv)*.

All of these features are dealt with in detail later.

The content of this addendum is divided into three major sections corresponding to the three major sections of OP 1064 and having the same designations, viz., General Description, Operation, and Detailed Description. The General Description given in OP 1064 is applicable to Computer Mk 1A when modified as indicated in the General Description section of this addendum. The headings used in this section of the addendum correspond to those under which the same features are described in OP 1064, i.e., corresponding descriptions in the General Description sections of OP 1064 and the addendum appear under the same headings. This is not exactly true for the Operation and Detailed Description sections; but the system has been followed as closely as possible. Reference to the comparative index at the back of this addendum will help in correlating the material in the addendum with that in OP 1064.

Basic Mechanisms

In general, Computers Mk 1 and 1A contain the same types of basic mechanisms, but they do not contain the same number of each type. The principal difference is the elimination of the vector solver and the addition of a time delay relay (agastat).

Where basic mechanisms have been added or removed in converting a Mk 1 to a Mk 1A, the fact will be indicated in the pertinent descriptive material.

Types of Targets and Attack

Computer Mk 1A produces gun orders for combating the same types of targets and attack as does Computer Mk 1. However, it should be noted that Computer Mk 1A can be operated successfully against targets having twice the maximum horizontal and vertical speeds as Computer Mk 1. As an example, Computer Mk 1A computes gun orders for continuous fire against dive bombers attacking other ships when the vertical component of target speed is as much as −500 knots, in contrast to the previous maximum rate of −250 knots.

Automatic Fire Control in the Gun Director Mk 37 System

The description under this heading in OP 1064 (page 24) applies to Computer Mk 1A except for that portion given under item 4 "Correcting the target motion estimates".

When operating Computer Mk 1A it is unnecessary for the computer crew to apply estimates of target motion (either initial or corrective). Horizontal target speed *(Sh)* and rate of climb *(dH)* are automatically brought to zero when the computer time motor is stopped. As soon as the computer is engaged in the tracking problem (starting the time motor) target course *(Ct)* is slewed to the proper quadrant for tracking, and *Sh* and *dH* are brought to their computed values automatically. Thus, the proper values of target motion are established to produce accurate outputs of generated range, elevation, and bearing.

Tracking the Target

The description given under this heading in OP 1064 is entirely adequate for Computer Mk 1A with one exception. With reference to item 2 on page 29, it has already been stated that the computer crew need not apply estimates of target motion when in Automatic (Normal) control.

It should be noted that provision has been made in Computer Mk 1A for the increased speeds of targets. This was accomplished by doubling the values of the target speed, rate of climb, ship speed, wind speed, and related shaft lines in the Control Section, and changing the target diving speed, ship speed, wind speed, and rate of climb dials. A complete description of the changes involved is given in the Detailed Description section of this addendum.

The Rate Control Group

The description given under the heading "Rate Control Group" in OP 1064 (page 50) is applicable to Computer Mk 1A when modified by the statements given hereunder.

a. The function of the rate control group is to establish and correct the values of *Sh*, *dH*, and *A* applied in the computer.

b. In Local control, initial settings of target speed and course are determined from estimates of target motion. In Automatic control, however, estimates of target motion are not necessary.

c. In Computer Mk 1A the determination of relative motion rates, which is one of the major steps in the solution of the fire control problem, is made from known values of own ship motion and of target position, and from determined values of target motion. When the determined values of target motion are correct, the relative motion rates will also be correct. In Local control, target motion must be determined by progressively setting in estimates and correction of horizontal target speed *(Sh)*, and target angle *(A)*. In Automatic control, this process is carried on automatically. The process of establishing the correct values of target motion, either by estimate or mechanically, is termed "Rate Control".

d. The rate control computing mechanism of Computer Mk 1A consists of four component integrators, two disc integrators, and related gearing.

e. The rate control computing mechanism of Computer Mk 1A is used only in Automatic Control. The term "Normal Control" is used to designate Automatic control in Computer Mk 1A.

Automatic Rate Control. The description given on page 52 of OP 1064 for Automatic Rate Control is applicable to Computer Mk 1A, but the description on page 53 for Semi-Auto is not.

Putting in range rate control corrections. The description given under this heading in OP 1064 (pages 54 and 55) is applicable to Computer Mk 1A with the following exceptions.

In paragraph two of page 54 it is stated that range is received only intermittently. Computer Mk 1A receives continuous inputs of range whenever the radar equipment with which the gun fire control system is equipped is utilized for ranging.

With reference to the description under the heading "In Automatic Operation" it should be noted that Computer Mk 1A operates to bring *cR* into synchronism with *R* whenever the range rate control switch is at AUTO, independently of the operation of the rangefinder's signal key. However, the input of range will not affect operation of the range rate control computing mechanism unless the key is pressed.

The description under the sub-heading "In Semi-Automatic Operation" is misleading in that it implies that the mode of operation described is applicable only when the computer is set for Semi-Automatic control. In both Computer Mk 1 and Computer Mk 1A the mode of operation of the range rate control mechanism is controlled by one switch, the range rate control switch, while the mode of operation of the elevation and bearing rate control mechanism is controlled by another switch, designated the control switch. The computer is said to be in the type of control for which the control switch is set; but range rate control will be either automatic or manual for any type of computer control, depending entirely on the setting of the range rate control switch. In considering operation of Computer Mk 1A it should be borne in mind that there is no Semi-Automatic control, and that Automatic control is designated Normal control.

The range correction ratio changer. The description contained under the heading "The range correction integrator" in OP 1064 accurately describes this mechanism with the following exceptions. The range rate ratio knob of Computer Mk 1A is graduated from 0 to 16 rather than from 1 to 5. The new figures represent range time constants in seconds (the time required to reduce the error in range to 37% of its initial value), rather than purely arbitrary numbered positions as formerly. Throughout the description the term "range correction integrator" should be construed as meaning "range correction ratio changer" as the name of the mechanism has been changed to "the range correction ratio changer" in Computer Mk 1A. This more accurately designates the function of the mechanism, which is to provide a means of applying a variable ratio in the *jRc* input line, rather than performing integrations.

How Rate Control Corrects Rate of Climb, Target Speed, and Target Angle

For illustrations pertaining to this subject reference should be made to figures 9, 10, 11, and 24 of the addendum rather than to those given on pages 56 and 57 of OP 1064. Figure 24 is a flow schematic diagram which will be found at the end of the addendum.

The description contained in OP 1064 under this heading is correct in so far as the determination of the vertical target component correction *(jHc)* and the horizontal component of correction *(jdRh)* by the elevation component integrators is concerned. However, determination of the rate corrections to target speed and target angle differs in Computer Mk 1A from the description given in OP 1064. In this instrument, components of the horizontal rate corrections *jdRh* and *jBc* are applied directly to the target vector, rather than first being resolved into North-South and East-West components. In consequence, the cumbersome target vector solver is eliminated. In order to apply *jdRh* and *jBc* directly to the target vector, target angle (rather than true bearing) is used to drive the vector gears of the *jdRh* and *jBc* component integrators. See figure 24.

Included in the rate control system of Computer Mk 1A are sensitivity units that establish the time taken for the system to reduce rate errors to values where the rates can be used for computing adequate gun orders. The time required for reducing a rate error to approximately 37% of its initial value is referred to as the time constant *(Tc)*. The time constant can be used as an indication of the system's sensitivity; the lower the value of *TC*, the quicker the system responds to changes in inputs. The rate control system of Computer Mk 1A is treated in detail in the Detailed Description section of this addendum.

Another Way to Think About Rate Control

The description contained under this heading in OP 1064 (page 58) is applicable to Computer Mk 1A if it is considered that the computer is in Local control.

The Rate Control Group Completes the Tracking Section

In the description under this heading in OP 1064, the last two paragraphs on page 61 are not applicable to Computer Mk 1A. In this instrument a faster solution of the rate control problem will be obtained by using the rate control computing mechanism, i.e., with the Computer in Automatic control.

Parallax Correction

The description under this heading (page 66 in OP 1064) is applicable to Computer Mk 1A except as follows. Mod 15 of the Computer Mk 1A does not compute elevation parallax due to horizontal base *(Pv)* as do all other mods. Instead, it computes parallax range, a partial computation, which it transmits to the guns where the computation of parallax is completed. The mechanism for computing parallax range occupies the space made available by the omission of the elevation parallax computer.

The Star Shell Computer

The various mods of Star Shell Computer Mk 1 used with Computer Mk 1A are listed here according to the mod of Computer Mk 1A with which they are used:

MOD OF COMPUTER MK 1A	MOD OF S.S. COMPUTER MK 1
13	0 and 1
8, 12	2
14, 16	3
17	4
19	6

OP 1064 (pages 107, and 356 to 367) adequately describes Star Shell Computer Mk 1 Mods 0, 1, 2. The description of Mods 1 and 2 is applicable to Mod 3, because Mod 3 is the same as these mods except for the extent of certain limits. Data for the description of Mods 4 and 6 are not available, as these mods are in the design stage.

Inputs and Outputs of the Computer Mk 1A

The inputs to Computer Mk 1A are the same as those for the Computer Mk 1 (see pages 70 and 71 of OP 1064). It should be noted, however, that for Computer Mk 1A, the target motion inputs *Sh, dH, A,* and *Ct* are as described in item 1 under the above heading in OP 1064 only during Local control. In Computer Mk 1A, these quantities are determined mechanically in the instrument during Normal control.

The outputs are the same except that Computer Mk 1A (all mods) has an additional output of target elevation *(E)*, and the Mod 15 has parallax range instead of *Pv* as an output.

Target elevation *(E)* is transmitted electrically from a potentiometer and from a synchro unit. The potentiometer supplies information to Indicator Mk 22 Mod 0 in Radar Equipment Mk 25 Mod 2 for use during target acquisition. The synchro signal is available for use in target practice analysis.

SUMMARY OF COMPUTER MK 1A DATA

Size

When shipped, the Computer Mk 1A is stripped of protruding components, such as handcranks, switches, etc. It is shipped in one, two, or four pieces. For use in shipping and handling, the overall dimensions of the separate pieces are given in figures 2, 3, and 4.

With Star Shell Computer Mk 1 in place, the overall height is approximately 63.4 inches. A clear height of 65 inches, measured from the base of the computer, is required for removal of the star shell computer.

Weight

The total weight of Computer Mk 1A is approximately 3150 pounds. Star Shell Computer Mk 1 weighs approximately 240 pounds. Weights of parts of Computer Mk 1A, when separated as indicated in figures 3 and 4, are indicated in these figures.

Power Supply

The power and synchro circuits of Computer Mk 1A require 115 volt, 60 cycle, A.C. supply. The requirements of these circuits are tabulated below. The figures given for the power circuit represent the peak requirements for operating all servo motors of the computer. The figures given for the synchro circuit represent the peak requirement for excitation of the synchros in the computer only. Normal operating power for this circuit will be somewhat higher.

CIRCUITS ENERGIZED	WATTS	VOLTS	AMPS	POWER FACTOR
Power	1060	113	9.4	1.0
Synchro	496	108	42.8	.11

Limits of Operation

The limits of operation of Computer Mk 1A are given in the following tables. They differ in many instances from those for Computer Mk 1.

LIMITS OF OPERATION

INTERMITTENT DRIVES

SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
Ds	320 Mils	680 Mils	13
	390 Mils	590 Mils	15
Vs	2000′	3800′	13
	2000′	4460′	15
R2	1500 Yards	18,900 Yards	8, 12, 14, 15, 16
E2	0°	90°	ALL
cR	750 Yards	22,500 Yards	ALL
E	−2°	+85°	ALL
Eb + *Vs*	1640′	7160′	ALL
dRs	−900 Knots	+900 Knots	ALL

Note: Only the mods listed for a particular quantity are provided with an intermittent drive for that quantity.

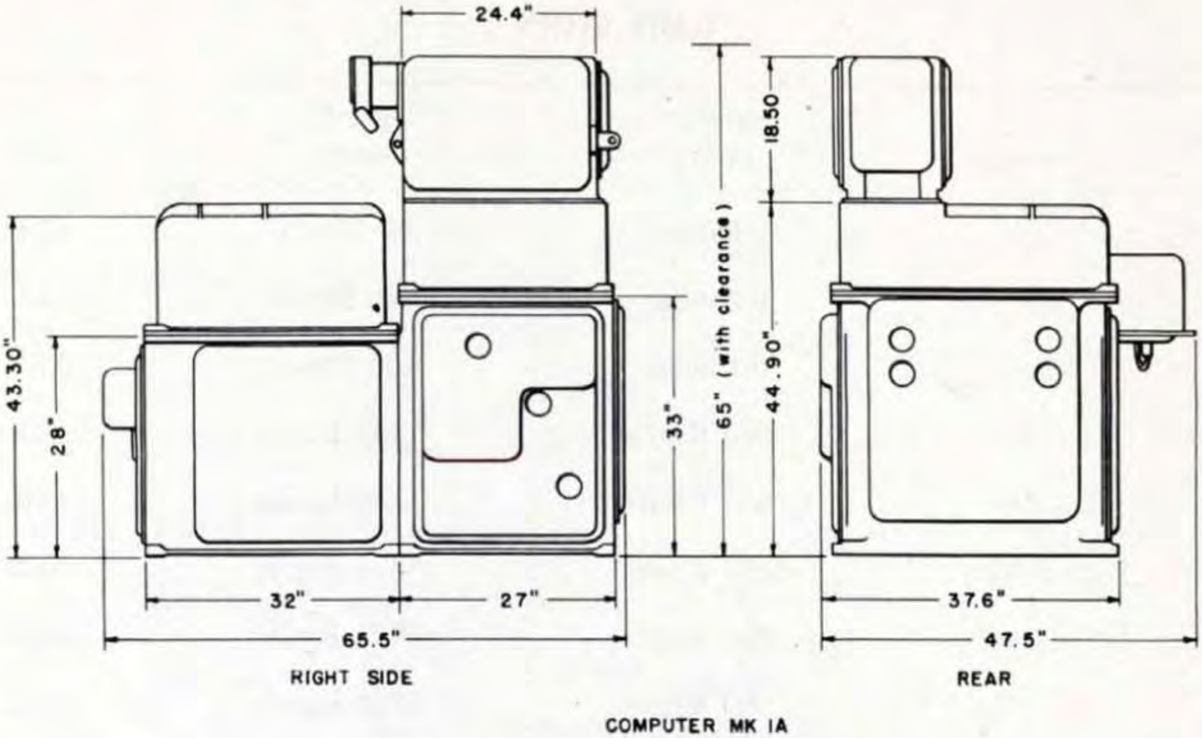


Figure 2. Outline Dimensions (One Piece).

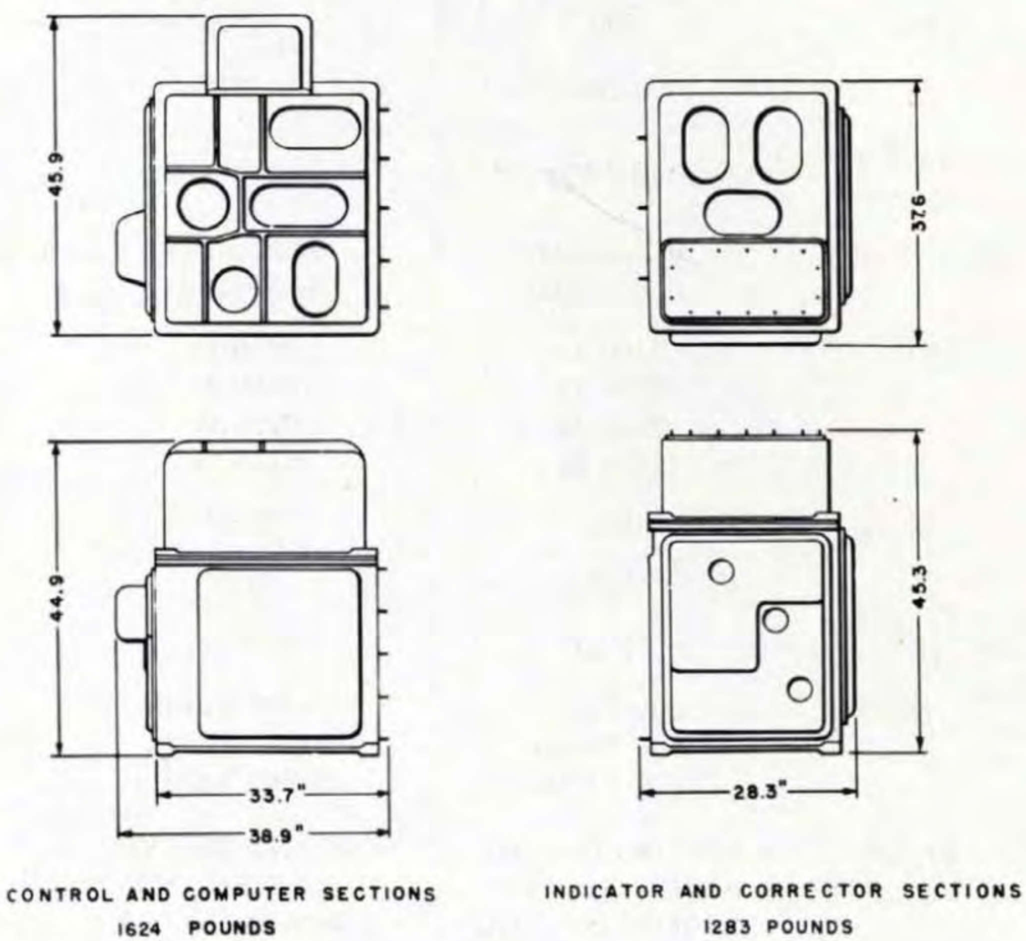


Figure 3. Outline Dimensions and Weights (Two Pieces).

LIMIT STOPS

STOP NO.	SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
L-1	*So*	0 Knots	90 Knots	ALL
L-2	*Sh*	0 Knots	800 Knots	ALL
L-3	*Sw*	0 Knots	120 Knots	ALL
L-4	*dH*	−500 Knots	+300 Knots	ALL
L-5	*dRh*	−880 Knots	+880 Knots	ALL
L-6	*RdBs*	−800 Knots	+800 Knots	ALL
L-7	*RdE*	−800 Knots	+800 Knots	ALL
L-8	*dR*	−900 Knots	+900 Knots	ALL
L-9	*Ywgr*	−200 Knots	+200 Knots	ALL
L-10	*cR*	0 Yards	35,000 Yards	ALL
L-11	*Eb*	500′	8600′	ALL
L-12	*E*	−25°	+85°	ALL
L-13	*Range Time Constant*	1 Second (Approx.)	16 Seconds	ALL
L-14	$Tg + F - Tf$	0 Seconds 0 Seconds	50 Seconds 49 Seconds	8, 12, 13, 14, 16 15
L-15	*I.V.*	2400 fs 2350 fs 2250 fs 2400 fs	2650 fs 2600 fs 2720 fs 2700 fs	8, 12 13 14, 16 15
L-16	*L*	480′	3520′	ALL
L-17	*Zd*	480′	3520′	ALL
L-18	*jB'r*	11°40′	348°20′	ALL
L-19	*R2*	500 Yards 500 Yards 500 Yards	18,000 Yards 20,000 Yards 20,200 Yards	13 8, 12, 15 14, 16
L-20	*Tf/R2*	0.001184 Sec./Yd. 0.00122 Sec./Yd. 0.001185 Sec./Yd. 0.001150 Sec./Yd.	0.002674 Sec./Yd. 0.00336 Sec./Yd. 0.002600 Sec./Yd. 0.002300 Sec./Yd.	8, 12 13 14, 16 15

LIMIT STOPS *(continued)*

STOP NO.	SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
L-21	*R2*	*300 Yards	*20,200 Yards	8, 12
	R2m	*300 Yards	*18,200 Yards	13
	R2m	*300 Yards	*20,400 Yards	14, 16
	R2m	*300 Yards	*20,200 Yards	15
L-22	*Vf + Pe*	0′	1800′	8, 12
		0′	2500′	13
		0′	1600′	14, 16
		0′	1250′	15
L-23	*R2*	*300 Yards	*20,200 Yards	8, 12, 15
		*300 Yards	*18,200 Yards	13
		*300 Yards	*20,400 Yards	14, 16
L-24	*Tf*	0.6 Seconds	50.6 Seconds	8, 12, 14, 15, 16
			60.6 Seconds	13
L-25	*R2*	*300 Yards	*20,200 Yards	8, 12, 15
		*300 Yards	*18,200 Yards	13
		*300 Yards	*20,400 Yards	14, 16
L-28	*Dtwj*	—518 Mils	+518 Mils	ALL
L-29	*Rj*	IN 12,000 Yards	OUT 1800 Yards	ALL
L-30	*Dj*	LEFT 180 Mils	RIGHT 180 Mils	ALL
L-31	*Vj*	DOWN 180 Mils	UP 180 Mils	13, 14, 15, 16
		DOWN 180 Mils	UP 342.5 Mils (24,600 Yards)	8, 12
L-32	*Dd*	—120°	+120°	ALL
L-34	*Vz*	—2940′	+1860′	ALL
L-35	*F*	0.6 Seconds	49.0 Seconds	8, 12, 14, 15, 16
		0.6 Seconds	55.0 Seconds	13
L-37	*V*	200′	3800′	ALL
L-38	*Tg*	0 Seconds	6 Seconds	ALL
L-39	*I.V.*	2350 fs	2600 fs	13
		2250 fs	2720 fs	14, 16
		2400 fs	2700 fs	15

*Limit cannot be reached when ballistic unit containing limit stop is installed in computer.

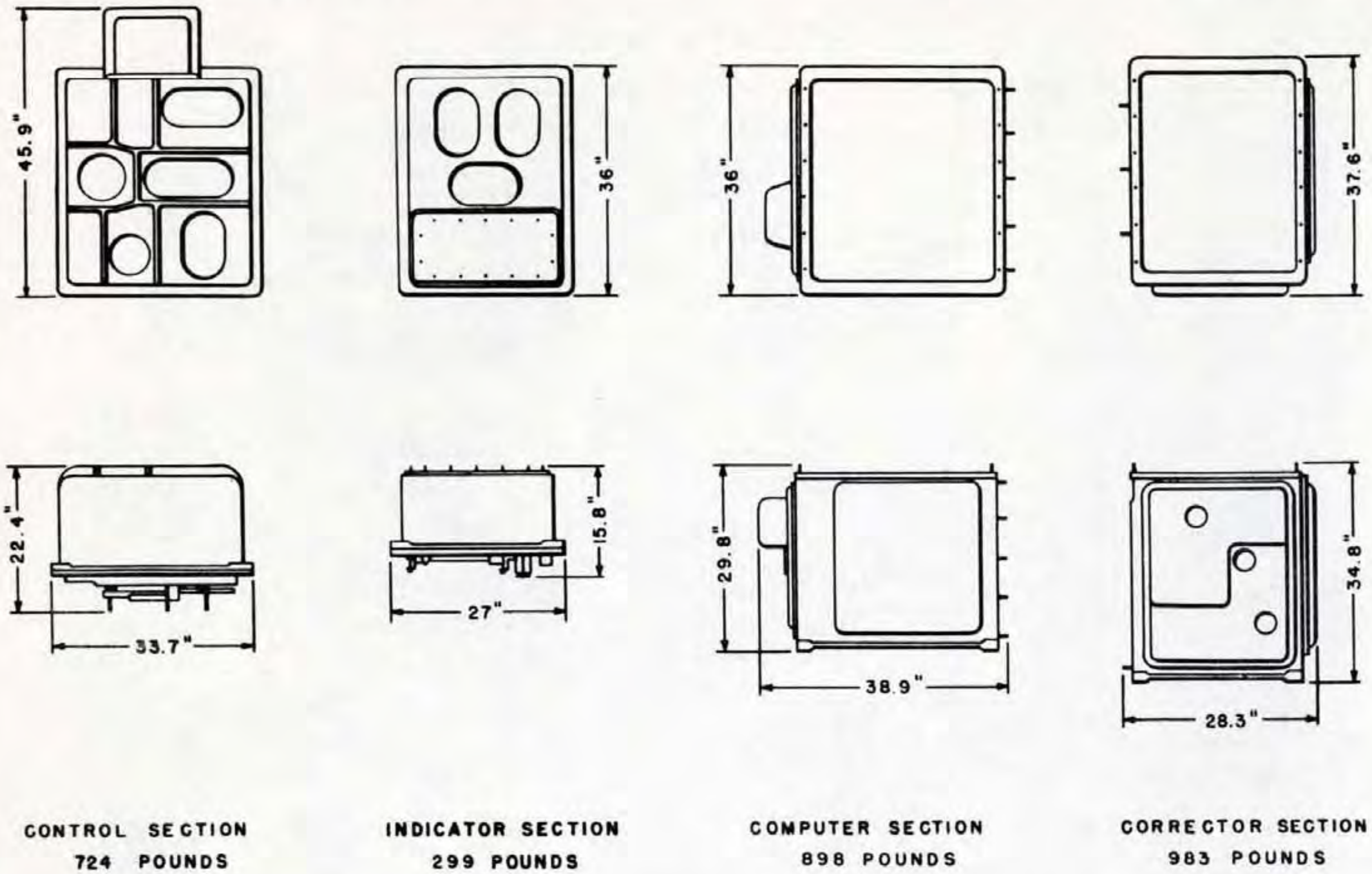


Figure 4. Outline Dimensions and Weights (Four Pieces).

STAR SHELL COMPUTER MK 1

STOP NO.	SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
L-1	*WrD + KRdBs*	−60 Knots (Read as 940 Knots on counter)	+60 Knots	ALL
L-2	*Rjn*	IN 2857 Yards IN 2700 Yards	OUT 1500 Yards OUT 1500 Yards	0, 1 2, 3
L-3	*Fn*	8.20 Seconds 9.70 Seconds 8.10 Seconds	41.55 Seconds 46.70 Seconds 46.02 Seconds	0, 1 2 3
L-4	*jDwn*	4000 Yards 8000 Yards 7000 Yards	15,000 Yards 19,500 Yards 20,000 Yards	0, 1 2 3

SYNCHROS IN THE COMPUTER MK 1A

NAME		LOCATION		VALUE PER REV.	SIZE	MOD
		SECTION	COVER			
Range Correction Transmitter		Control	1	1000 Yards	5G	ALL
Range Receiver	Coarse	Control	1	72,000 Yards	5F	ALL
	Fine	Control	1	2000 Yards	5F	ALL
Rate Control Range Receiver		Control	1	72,000 Yards	1F	ALL
Time Constant Control Transmitter		Control	1		1G	ALL
Target Course Transmitter		Control	1	360°	5G	ALL
Bearing Correction Ind. Transmitter		Computer	3	10°	5G	ALL
Bearing Correction Auto. Transmitter		Computer	3	5°	6G	ALL
Elevation Correction Ind. Transmitter		Computer	3	10°	5G	ALL
Elevation Correction Auto. Transmitter		Computer	3	5°	6G	ALL
Elevation Transmitter		Computer	5	180°	5G	ALL
		Computer	5	40 Ohms/Deg	POT	ALL
Ship Course Receiver	Coarse	Computer	5	360°	5B	ALL
	Fine	Computer	5	10°	5F	ALL
Deflection Spot Receiver		Indicator	2	360 Mils	5B	ALL
Elevation Spot Receiver		Indicator	2	360 Mils	5B	ALL
Range-Spot Receiver		Indicator	2	4000 Yards	5B	ALL
Ship Speed Receiver		Indicator	2	40 Knots	5B	ALL
Fuze Setting Order	Coarse	Indicator	2	100 Sec.	7G	8, 12, 13, 14, 16
	Coarse	Indicator	2	360/7 Sec.	7G	15
	Fine	Indicator	2	2 Sec.	7G	8, 12, 13, 14, 16
	Fine	Indicator	2	20/7 Sec.	7G	15

SYNCHROS IN THE COMPUTER MK 1A *(continued)*

NAME		LOCATION SECTION	LOCATION COVER	VALUE PER REV.	SIZE	MOD
Single Speed Sight Angle Transmitter		Indicator	2	2400 Min.	6G	13
Double Speed Sight Angle Transmitter	Coarse	Indicator	2	7200 Min.	6G	13
	Coarse	Indicator	2	7200 Min.	7G	8, 12, 14, 16
	Coarse	Indicator	2	3600 Min.	7G	15
	Fine	Indicator	2	200 Min.	6G	13
	Fine	Indicator	2	200 Min.	7G	8, 12, 14, 16
	Fine	Indicator	2	100 Min.	7G	15
Single Speed Sight Deflection Trans.		Indicator	2	442.23 Mils	6G	13
		Indicator	2	210.48 Mils	7G	15
Double Speed Sight Deflection Trans.	Coarse	Indicator	2	4000 Mils	6G	8, 12, 14, 16
	Coarse	Indicator	2	4000 Mils	7G	13
	Fine	Indicator	2	100 Mils	6G	13
	Fine	Indicator	2	100 Mils	7G	8, 12, 14, 16
Gun Train Order Ind. Transmitter	Coarse	Corrector	8	360°	7G	ALL
	Fine	Corrector	8	10°	7G	ALL
Gun Train Order Auto. Transmitter	Coarse	Corrector	8	360°	7G	ALL
	Fine	Corrector	8	10°	7G	ALL
Gun Train Order Information Trans.		Corrector	8	10°	7G	14, 15, 16
Director Train Receiver	Coarse	Corrector	8	360°	5B	ALL
	Fine	Corrector	8	10°	5F	ALL

RESTRICTED

SYNCHROS IN THE COMPUTER MK 1A *(continued)*

NAME		LOCATION — SECTION	LOCATION — COVER	VALUE PER REV.	SIZE	MOD
Gun Elevation Order Ind. Trans.	Coarse	Corrector	6	10,800 Min.	7G	ALL
	Fine	Corrector	6	600 Min.	7G	ALL
Gun Elevation Order Auto. Trans.	Coarse	Corrector	6	10,800 Min.	7G	ALL
	Fine	Corrector	6	600 Min.	7G	ALL
Director Sight Elevation	Coarse	Corrector	6	180°	5B	ALL
	Fine	Corrector	6	10°	5F	ALL
Train Parallax Transmitter		Corrector	6	30°/100 Yards	7G	ALL
Elevation Parallax Transmitter		Corrector	6	10°/100 Yards	7G	8, 12, 13, 14, 16
Parallax Range Transmitter		Corrector	6	.001 Rad./Yard	7G	15
Star Shell Gun Elev. Order Trans.	Coarse	Star Shell		10,800 Min.	6DG	0, 1
	Coarse	Star Shell		10,800 Min.	6G	2
	Fine	Star Shell		600 Min.	6DG	0, 1
	Fine	Star Shell		600 Min.	6G	2
Star Shell Fuze Setting Order Trans.	Coarse	Star Shell		100 Sec.	6G	0, 1, 2
	Fine	Star Shell		2 Sec.	6G	3
Star Shell Gun Train Order Trans.	Coarse	Star Shell		360°	6DG	0, 1
	Coarse	Star Shell		360°	6G	2
	Fine	Star Shell		10°	6DG	0, 1
	Fine	Star Shell		10°	6G	2
Star Shell Range Spot Receiver		Star Shell		4000 Yards	1F	0, 1

Design Features

All design features given under this heading in OP 1064 are applicable to Computer Mk 1A except that pertaining to initial velocity (*I.V.*). The design *I.V.* of Computers Mk 1A varies with the mod, as follows:

Mods 8, 12, 17, and 18	2550 fs
Mod 13	2500 fs
Mods 14 and 16	2565 fs
Mod 15	2600 fs
Mod 19	2500 fs

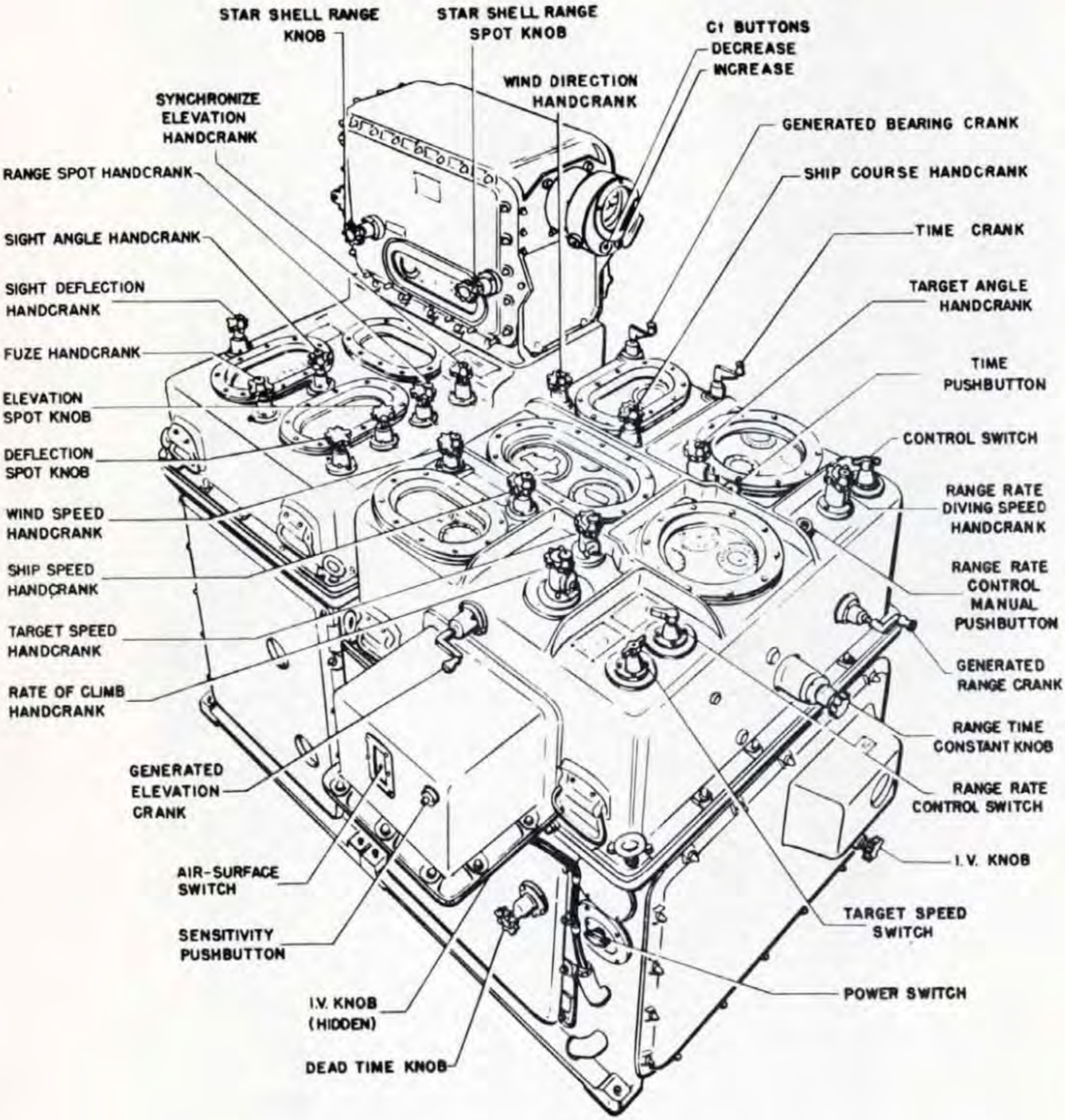


Figure 5. Computer Mk 1A — Operating Controls.

OPERATION

OPERATING CONTROLS

The arrangement of dials, handcranks, and switches of Computer Mk 1A is the same as that of Computer Mk 1, with the following exceptions:

1. The rate of climb handcrank has been relocated. The radar range receiver has been removed, and the rate of climb handcrank is located in the cover opening previously occupied by the radar range receiver window.
2. The time motor switch has been removed, and a time motor push button installed adjacent to the target speed dial group.
3. A sensitivity push button and an air-surface selector switch have been added at the elevation station.

Note: The locations of the operating controls mentioned in items 1, 2, and 3 are indicated in figure 5.

4. Three vernier dials have been added to increase the accuracy with which test problems can be set up. These are for range (R), target angle (A), and rate of climb (dH).

Operating dials and counters are the same as those on Computer Mk 1, except that some can indicate double their former values in order to permit tracking of targets having greater speeds.

The Dials on the Front of Computer Mk 1A

The Target and Ship Dial Group. The target and ship dial group (see figure 6) has been altered as follows:

1. The target dial gearing is equipped with a vernier dial that indicates target angle in tenths of a degree. The vernier dial is primarily for test purposes.
2. The wind speed dial is graduated from 0 to 120 knots.
3. The ship speed dial is graduated only from 0 to 50 knots, but can make a complete revolution, representing 90 knots.

The Target Speed Dial Group. This group is shown in figure 7. The target speed counter shows horizontal ground speed of the target (Sh) in knots, from 0 to 800 knots.

The rate of climb dials show rate of climb (dH) in knots. The coarse dial is graduated every ten knots from DIVE 500 knots through 0 to CLIMB 300 knots. A fine dial graduated every five knots, but unnumbered, has been added in Computer Mk 1A. When reading intermediate values on the fine dial, note should be taken of the fact that it turns in a direction opposite to that of the coarse dial.

The target speed diving dial shows diving speed (Ss). The dial is capable of rotating from 0 to ± 900 knots. However, since its primary purpose is to indicate diving speed (negative range rate), only the DIVE (minus) part is graduated and numbered. The graduations are at 20-knot intervals.

The Range Dial Group. The range dial group is the same as that of Computer Mk 1 except that the radar range dial and receiver are not included in the Mk 1A.

The range gearing of Computer Mk 1A is equipped with a vernier range dial. The vernier dial is located behind the threaded plug located in the side of the cover just below the range receiver dials. By means of the vernier, which has graduations at 5-yard intervals, range can be read or set to the nearest yard during test procedures.

Time Motor and Power Switches

A push button, located at the range station, has been substituted for the time mo-

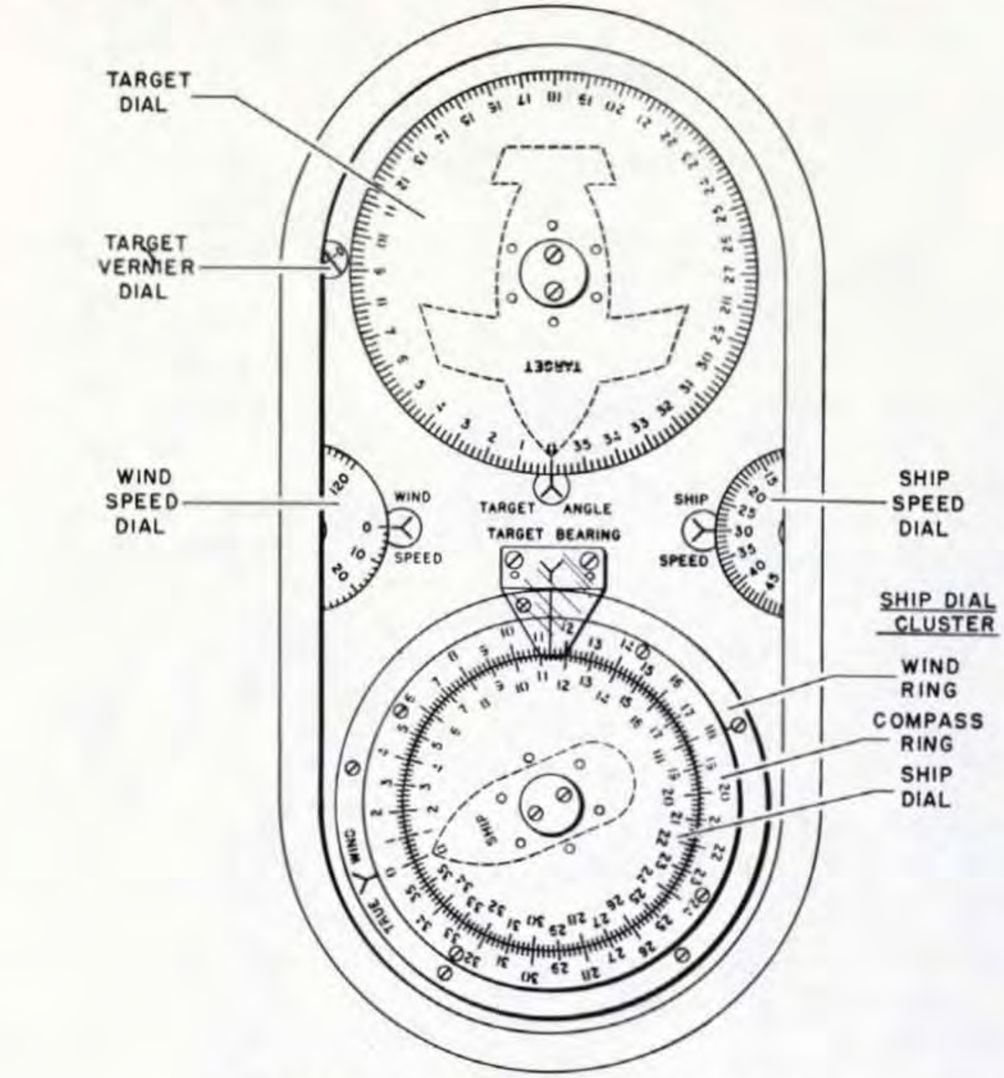


Figure 6. Target and Ship Dial Group.

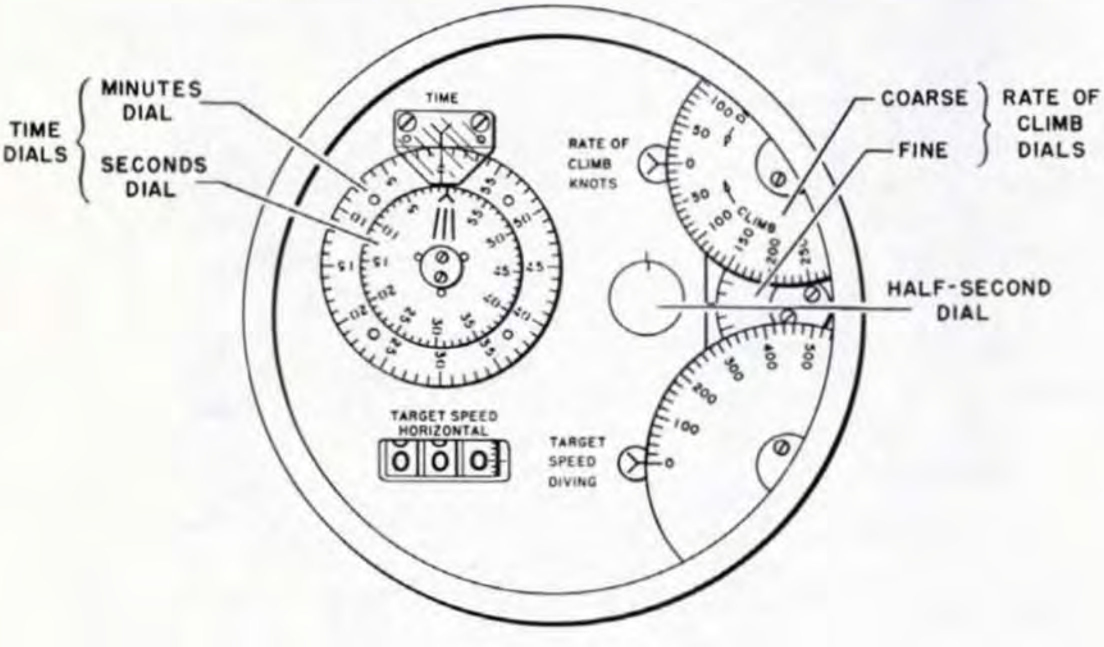


Figure 7. Target Speed Dial Group.

tor switch, which has been removed from the computer. Operation of the new arrangement is given under the heading, "The Controls at the Range Station".

The power switch is unchanged.

Initial Velocity and Dead Time

Computer Mk 1A Mods 13, 14, 15, and 16 have two sets of initial velocity dials and knobs. One set is located on the lower left side, as in the Computer Mk 1. The other set is located on the lower front side. Both sets are identical. These dials show the value of initial velocity (*I.V.*) set into the computer. They are graduated in feet per second from:

2350 fs to 2600 fs for Mod 13
2250 fs to 2720 fs for Mods 14, 16
2400 fs to 2700 fs for Mod 15

Values of initial velocity are properly set into the computer only when both dials read alike. A legend plate stating this is located above the front *I.V.* dial.

The initial velocity dial and knob arrangement for Computer Mk 1A Mods 8 and 12 is the same as that of Computer Mk 1. The *I.V.* dial of Mods 8 and 12 is graduated in feet per second from 2400 fs to 2650 fs.

The dead time dial and knob are the same as those for Computer Mk 1.

The Controls on the Front of Computer Mk 1A

The controls on the front of Computer Mk 1A include the controls of the target and ship group, and those of the range station, the bearing station, and the elevation station. Differences between the controls and the description given in OP 1064 are set forth under the headings covering these separate groups below.

The Controls in the Target and Ship Group

The description in OP 1064 (pages 94 and 95) adequately covers this group for Computer Mk 1A.

The Controls at the Range Station

The description given under this heading in OP 1064 (page 96) is applicable to Computer Mk 1A except as noted below.

The Control Switch. In Computer Mk 1A, the three positions of the control switch are labeled NORMAL, TEST, and LOCAL instead of AUTO, SEMI-AUTO, and LOCAL.

With the control switch at NORMAL, bearing and elevation corrections are made automatically on signal from the trainer and pointer in the director.

With the control switch at TEST, no rate corrections can be made with the generated elevation and generated bearing cranks, as formerly. These cranks, whether IN or OUT, merely turn the generated elevation and generated bearing dials.

With the control selector at LOCAL, the rate control mechanism is inoperative. This type of operation is used against surface targets when the director is not operating.

The Range Rate Control Switch. The description for this switch given in OP 1064 is applicable to Computer Mk 1A if it is borne in mind that there is no Semi-Auto control of Computer Mk 1A.

The Range Time Constant Knob. This knob is called the range rate ratio knob on Computer Mk 1. The only identification appearing on it in Computer Mk 1A is the legend, SECONDS TIME CONSTANT, on the sleeve. The sleeve is graduated to indicate seconds (time constant), from 0 to 16, in 2-second intervals. The knob must be IN to make and hold a setting. Rotation of the knob in the IN position is limited from 1 (approximately) to 16 seconds. The value set at the knob indicates the time, in seconds, required for the range rate control mechanism to reduce a range rate error to approximately 37% of its initial value. For example, if range rate is in error by 150 knots and the knob is set at 2, in two seconds the range rate error will have decreased to approximately 55 knots. The OUT position is provided only to permit removal of the cover for adjustment or repair.

The Time Push Button. In Computer Mk 1A, the time push button is located beside the time dials and adjacent to the range rate control manual push button (see figure 5). The time motor can be stopped or started by momentarily depressing the button.

The Controls at the Bearing Station

The description of the controls at the bearing station given in OP 1064 (page 100) is applicable to Computer Mk 1A with the exceptions given below.

The Generated Bearing Crank. Since there is no Semi-Automatic control, it is immaterial whether this crank is in the IN or OUT position. (The gear for receiving hand inputs has been removed from the *jBr* line.)

The Controls at the Elevation Station

The controls at the elevation station consist of the generated elevation crank, the rate of climb handcrank, the air-surface switch, and the sensitivity push button. The location of the generated elevation crank is the same as for a Computer Mk 1. The other three controls are located as indicated in figure 5.

The Generated Elevation Crank. The function of the generated elevation crank is the same as described in OP 1064 for Computer Mk 1 with the exception that, there being no Semi-Auto control, no elevation rate corrections are introduced by the knob, and the knob can be left IN or OUT. (The gear for receiving hand inputs has been removed from the *jE* line.)

The Rate of Climb Handcrank. This hand crank has two operating positions, HAND and AUTO, selected by means of a lever. When the lever is at the HAND position, the handcrank is connected to the rate of climb gearing, allowing values of rate of climb to be put in manually. Shifting the lever to AUTO disconnects the handcrank from the rate of climb gearing and closes a switch that energizes the *dH* follow-up. In this condition, values of rate of climb are changed automatically by corrections coming from the rate control mechanism.

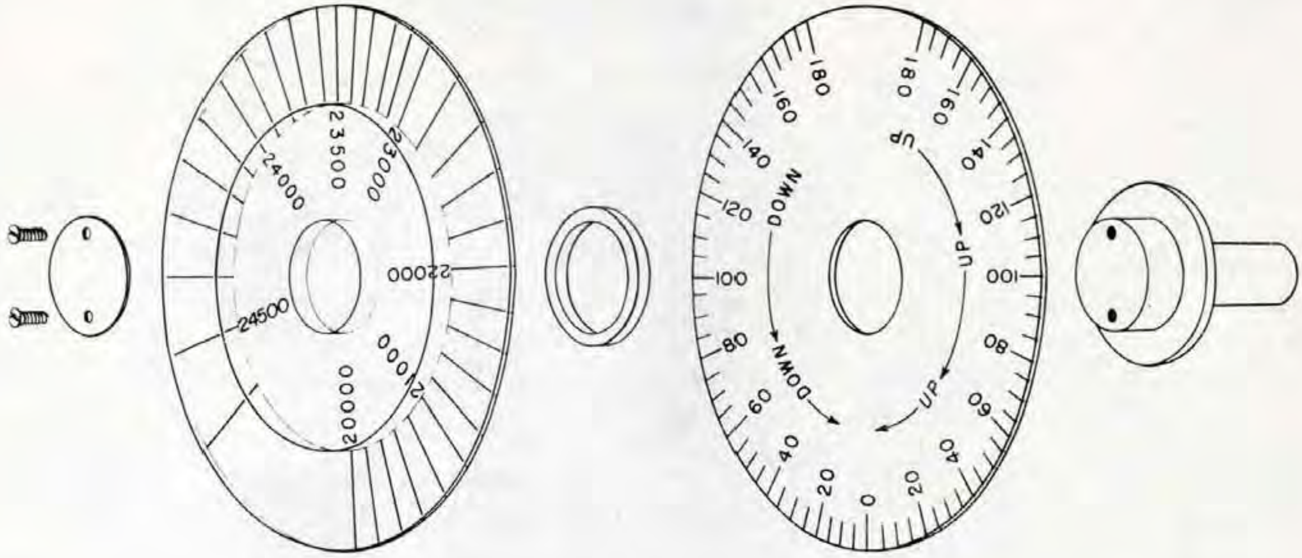
Air - Surface Switch. The air - surface switch, as the name implies, has two positions, AIR and SURFACE. It should be set at AIR for an air target, and at SURFACE for a surface target. When so positioned it adapts the operation of the sensitivity control system to the particular type of target, as described in the Detailed Description section of the addendum.

Sensitivity Push Button. The sensitivity push button provides a means of varying the action of the sensitivity mechanism of the Computer Mk 1A. The push button controls a switch that is normally closed. Depressing the push button opens the switch and causes the sensitivity mechanism to assume the position of maximum sensitivity. The mechanism is held in this position for a pre-set delay time after the push button is released, and then returns to the normal position. For a detailed description of the push button and sensitivity controls, refer to the Rate Control description in the Detailed Description section of this addendum.

Handcranks and Dials on the Rear Top of the Computer

The handcranks and dials on the rear top of Computer Mk 1A Mods 13, 14, 15, and 16 are the same as those for Computer Mk 1 (see page 102 of OP 1064). On Computer Mk 1A Mods 8 and 12, a dial has been added to the spot dial group as described below.

The Spot Group. The spot group of Computer Mk 1A is identical with that of Computer Mk 1 except for the elevation spot dial used in Computer Mk 1A Mods 8 and 12. In these modifications a transparent dial (figure 8) is secured directly over the *Vj* dial, on the same hub. The transparent dial is graduated in terms of range from 20,000 yards to 24,600 yards. The 20,000-yard graduation is aligned with the 0-graduation of the *Vj* dial. The spacing between each succeeding pair of graduations increases with range, as indicated in figure 8.



TRANSPARENT OVERLAY DIAL

ELEVATION SPOT DIAL

Figure 8. Elevation Spot Dials.

In the computer, the output of the superelevation cam is limited to values corresponding to a maximum range of 20,000 yards. However, at low position angles the extreme range of the guns exceeds this value of 20,000 yards.

When firing against surface targets at ranges beyond 20,000 yards, additional superelevation can be set into the instrument by means of the elevation spot knob. The correct amount to be set in is determined by means of the transparent range spot dial. The spacing of the graduations on this dial corresponds to the additional superelevation required for values of range beyond 20,000 yards. Therefore, when the transparent dial is set at a selected value of range, an amount of elevation spot (Vj) is introduced which will supply the additional superelevation required for that extended value of range.

The Target Course Indicator

The description of the target course indicator in OP 1064 (page 106) is applicable except that the target signal light is omitted from Computer Mk 1A.

The Star Shell Computer

The operating controls for the various modifications of Star Shell Computer Mk 1 are described on pages 107, and 356 to 367 in OP 1064. While Mod 3 is not specifically mentioned in OP 1064 because it was not designed at the time of writing, the controls for this mod are the same as for Mods 1 and 2.

It should be noted here that the knob designated STAR SHELL RANGE on the Mod 0 is replaced by a handcrank on the other mods. This handcrank is designated FUZE RANGE. Likewise, the knob designated STAR SHELL RANGE SPOT on the Mod 0 is designated as STAR SHELL RANGE on Mods 1, 2, and 3. Despite the two changes in designation, the functions of these knobs are unchanged.

Mods 1, 2, and 3 instruments have two additional handcranks: the deflection handcrank, and the elevation handcrank. As explained on pages 366 and 367, these handcranks are used to position elevation and deflection spot and search dials, which have also been added.

OPERATING INSTRUCTIONS

The automatic tracking controls incorporated in Computer Mk 1A as a result of Ordalt 2626 cause its operation to differ considerably from that of Computer Mk 1. The operator should, therefore, familiarize himself with these devices as described in the Detailed Description section of the addendum, and as shown schematically in figure 17. The operating instructions for Computer Computer Mk 1A differ from those for Computer Mk 1, as noted in the following description.

The Conditions of the Computer

The statements appearing under this heading in OP 1064 (page 111) are applicable to Computer Mk 1A except for those pertaining to basic types of operation. Computer Mk 1A has three basic types of operation: NORMAL, which is similar to AUTOMATIC for Computer Mk 1; and LOCAL and MANUAL which are the same as for Computer Mk 1.

Types of Operation

The description given in OP 1064 under the heading "The Types of Operation" (page 112) is applicable to Computer Mk 1A only to the extent defined in the following description. It should be noted that there is no Semi-Automatic operation of Computer Mk 1A.

In Normal operation the Rate Control Group computes corrected values of *Sh*, *dH*, and *A*. It does not function in Test or Local Operation.

Normal Operation. The description of Automatic Operation on page 112 of OP 1064 adequately describes Normal operation for Computer Mk 1A.

SWITCH POSITIONS:
Control Switch at NORMAL
Range Rate Control Switch at AUTO or MANUAL

Manual Operation. Manual operation is adequately described in OP 1064 (page 113).

SWITCH POSITIONS:
Control Switch at TEST
Range Rate Control Switch at MANUAL

Local Operation. This is the same as described in OP 1064 for Computer Mk 1.

SWITCH POSITIONS:
Control Switch at LOCAL
Range Rate Control Switch at MANUAL

Instructions for Operating Computer Mk 1A

Operation of Computer Mk 1A differs from that of Computer Mk 1 in such important respects as:

a. There is no Semi-Automatic control.

b. In setting up for Normal (Automatic) operation it is not necessary to apply inputs of estimated target angle, target speed, and rate of climb. Neither is it necessary for the computer operator to apply range inputs nor match the range dials during the search and tracking periods.

c. The computer time motor can be started from the director.

Because of the extensive differences between the operation of Computers Mk 1 and Mk 1A, the operating instructions given in OP 1064, pages 114 to 135 are NOT APPLICABLE to Computer Mk 1A except as specifically noted below.

Secured Condition

The nature of this condition is such that the instructions given in OP 1064 (page 114) are applicable for Computer Mk 1A with the following exceptions:

Securing the Computer Mk 1A.

AT THE RANGE STATION:

1. Stop the time motor by depressing the time motor push button.

Setting the Handcranks and Dials in Secured Condition.

AT THE RANGE STATION:

1. Turn the Control Switch to NORMAL.
3. Turn the Range Rate Control Switch to AUTO.
5. Set the Target Speed Handcrank Selector at AUTO.
6. Set the Range Time Constant Knob at 16.

AT THE ELEVATION STATION:

1. Set the Rate of Climb Handcrank Selector at AUTO.
6. Pull the initial velocity knobs OUT; set *I.V.* according to mod, as follows:

MOD	*I.V.*
8 & 12	2550 fs
13	2500 fs
14 & 16	2565 fs
15	2600 fs

8. Set Air-Surface switch at AIR.

AT THE BEARING STATION:

4. Set the Target Angle Handcrank at AUTO.

AT THE OTHER STATIONS:

4. With the Star Shell Fuze Range Handcrank IN, set the inner dial at 10,000 yards. Pull the handcrank OUT and set the outer dial at 10,000 yards. Push the handcrank IN.

Standby Condition

Initial standby, standby for search, and standby during search, are as described on page 116 of OP 1064 for Computer Mk 1.

Changing from Secured Condition to Standby for Search and Standby During Search. This procedure is as described on page 116 of OP 1064, except that the control switch of Computer Mk 1A is set at NORMAL.

Note: In Computer Mk 1A Mods 13, 14, 15, and 16 both initial velocity dials should be set at the ordered value of *I.V.*

Standby for an Air Target

When changing from standby during search to standby for an air target:

AT THE ELEVATION STATION:

1. With the Ship Speed Handcrank at IN set in the correct value of ship speed (*So*), then set the Ship Speed Handcrank at OUT. Note that *So* continues at the correct value.
2. With the Wind Speed Handcrank, set in wind speed (*Sw*).
3. Check that dead time (*Tg*) and initial velocity (*I.V.*) are at their ordered values.

AT THE BEARING STATION:

1. With the Wind Direction Handcrank, set in wind direction (*Bw*).

AT OTHER STATIONS:

1. Connect, synchronize, and lock the Selector Drive.
4. Pull Spot Knobs OUT, noting that correct values of *Rj*, *Vj*, and *Dj* are indicated.

Automatic Operation

Computer Mk 1A is ready for Automatic operation when properly set up for standby. Automatic operation commences as soon as the time motor is started. The normal procedure for starting the time motor is for the trainer to close his signal key; but the time motor also can be started by depressing the TIME push button on the computer.

Tracking in Automatic (Normal) Operation. The Computer will commence tracking when the trainer depresses his signal key, thus starting the computer time motor and closing the rate control clutches. During automatic (normal) operation:

AT THE RANGE STATION:

1. Keep the setting of the Range Time Constant Knob as low as possible without causing instability.
2. Computer Mk 1A matches *cR* with *R* automatically. If the range dials are out of synchronism and do not approach agreement with sufficient rapidity, they can be brought into synchronism more rapidly by momentarily shifting the range time constant knob to a high value. It should be noted that the range dials can also be matched by rotating the generated range crank in the OUT position.

AT THE ELEVATION STATION:

1. If range is below 8000 yards and the target maneuvers radically (the solution indicators spin), momentarily press the sensitivity push button.

Manual Operation Against an Air Target

This type of operation for Computer Mk 1A is the same as that described in OP 1064 (pages 126 to 131) for Computer Mk 1.

Standby for a Surface Target

Standby for a surface target is the same as standby for an air target (as described in the addendum) with the following exceptions:

AT THE RANGE STATION:

Note should be taken of the setting of the time constant control transmitter. This setting is normally made as a matter of adjustment procedure, the value of the setting being determined by doctrine.

AT THE ELEVATION STATION:

4. Set the Air-Surface switch at SURFACE.

Automatic (Normal) Operation (Surface Target)

Computer Mk 1A differs from Computer Mk 1 in that it can be operated against high speed (15 knots or higher) surface targets in Normal (Automatic) control. For low speed surface targets, manual rate control should be used. Tracking in automatic operation against a surface target is similar to that described for an air target. As long as the *dH* handcrank is kept at AUTO, the low elevation switch causes *dH* to be kept at zero in the instrument.

Local Operation

The procedure for Local operation is the same as described on page 136 of OP 1064.

Main Battery Operation

The use of Computer Mk 1A for main battery operation is the same as described in OP 1064 (page 144) for Computer Mk 1. Operation of the Mk 1A is, of course, limited to Automatic, Local, and Manual control.

Operating Cautions

The operating cautions given in OP 1064 (pages 156 to 159) for Computer Mk 1 are applicable to Computer Mk 1A, except for those pertaining to Semi-Auto operation. However, where limits are specified, the new limits of Computer Mk 1A should be substituted. Likewise, under the sub-heading "Setting *I.V.*", the design *I.V.* of the mod being considered should be substituted for the 2550 fs value given in the text.

It should be noted that Mods 13, 14, 15, and 16 instruments have two *I.V.* dials. The computer is not properly set up unless these dials are in agreement.

DETAILED DESCRIPTION

The Detailed Description section of OP 1064 is applicable to Computer Mk 1A when modified by the information contained hereunder.

RELATIVE MOTION AND INTEGRATOR GROUPS

The detailed descriptions of the relative motion group and the integrator group given in OP 1064 for Computer Mk 1 are applicable to Computer Mk 1A without any exceptions or alterations other than addition of the following material on the increase of target speed.

Increase of Target Speed

The speeds of potential targets have greatly increased. Therefore, alterations converting Computer Mk 1 to Computer Mk 1A include those which enable the relative motion group to handle higher input values of target speed. The maximum values at which normal operation can now be maintained are 800 knots horizontal target speed (*Sh*) and —500 knots vertical target speed (rate of climb, *dH*), in contrast to 400 knots and —250 knots, respectively.

Shaft Values

The basic alteration to increase range of operation of the relative motion group was the doubling of the values of the *Sh* and *dH* shafting (one revolution now equals twice as many knots as formerly). To keep the ship and wind mechanisms in agreement with the target mechanisms, the ship speed (*So*) and wind speed (*Sw*) shaft values also were doubled.

Speed Dials and Counter. Doubling of shaft values in the relative motion group was accomplished by changing the indicating ability of the speed dials and counter. The gear ratio at the target speed counter was changed so that the counter now indicates twice as large a number for a given position of the *Sh* shaft line. The ship speed dial was redesigned to indicate 45 knots at one-half revolution, the spacing of the graduations being halved in order to maintain its ability to indicate one knot intervals. It is graduated and numbered to 50 knots. In the case of wind speed and rate of climb, new dials, having the same graduations but doubled numbering, were supplied. It is to be noted that, while the ship speed dial is graduated only from 0 to 50 knots, one revolution of the dial is equivalent to 90 knots ship speed.

Integrator Group

Doubling the values of the speed input shafting results in doubling of the values of the relative motion rates (*dR*, *RdE*, and *RdBs*) shafting. Thus, the carriages of the range, elevation, and bearing integrators are moved one-half as much by a given change of relative motion group output as formerly. If this were not compensated for, indicated changes of range, elevation, and bearing would be only half the amounts called for by given relative motion rates over a particular time interval. In order to produce the proper output of range, elevation, and bearing, the integrator discs are driven at double their former speeds. That is, their former values per revolution were halved, each revolution now representing only half as much time. This was accomplished by changing a gear ratio in the time shaft line near the time motor.

RATE CONTROL

The necessity for more rapid rate control solutions and greater flexibility of operation is met by a new type of rate control system in Computer Mk 1A.

The target vector rate control system of Computer Mk 1A is, in general, similar to the rate control system of Computer Mk 1. The methods of rate control for Computer Mk 1A are the same as those for Computer Mk 1 except as noted hereunder.

There are three principal differences between the rate control group of Computer Mk 1A and that of Computer Mk 1, as follows:

1. Resolution of horizontal rate corrections is taken relative to the target vector, rather than to compass directions.
2. Inclusion of a sensitivity control mechanism in the elevation and bearing networks of Computer Mk 1A.
3. The use of additional automatic tracking controls in Computer Mk 1A.

Because of these differences, the target vector rate control system improves the performance of the computer by providing a faster rate solution. Converting to the target vector method of rate control makes it possible to operate the computer in automatic control against high speed (15 knots or over) surface targets by eliminating the low speed limitations imposed by the target vector solver. Introduction of the controls mentioned in item 3. simplifies the task of the computer operating crew during target acquisition.

Handcranks and Dials Used in Rate Control

The dials, handcranks, and switches used for rate control in Computer Mk 1A are shown in figure 5. These differ from those of Computer Mk 1 in the following respects:

a. Relocation of the *dH* handcrank.

b. Addition of the Air-Surface selector switch.

c. Addition of the sensitivity push button.

d. Addition of the time motor push button, and removal of the time motor switch.

How the Dials Receive Observed and Generated Values. In Computer Mk 1A the comparison of observed and generated values of range, elevation, and bearing is the same as described in OP 1064 (pages 216 and 217) for Computer Mk 1.

The Rate Control Computing Mechanism

The mechanisms of the rate control group of Computer Mk 1A (see figures 9 and 10) are the same as those in Computer Mk 1, with the following exceptions:

1. There is no vector solver.
2. Mechanism for controlling sensitivity of the elevation and bearing networks (figure 10) has been added. This comprises the following separate mechanisms: two 3-inch disc integrators, a single-speed rate control range receiver, a time constant control transmitter, and a time delay relay.
3. A follow-up for the *jHc* output has been added. This is designated as the *dH* follow-up.

The arrangement of the rate control computing mechanism for Computer Mk 1A is shown schematically in figure 24.

Because of the extensive differences between the Computer Mk 1 and Computer Mk 1A rate control systems, the arrangement of the following description of the Computer Mk 1A rate control system cannot closely parallel the arrangement of the description given in OP 1064. Reference to the comparative index on page 57 of this addendum will be a help in correlating the two descriptions.

The Rate Error Correction Measuring Network

In this network the differences between the generated and observed changes in range, bearing, and elevation are measured;

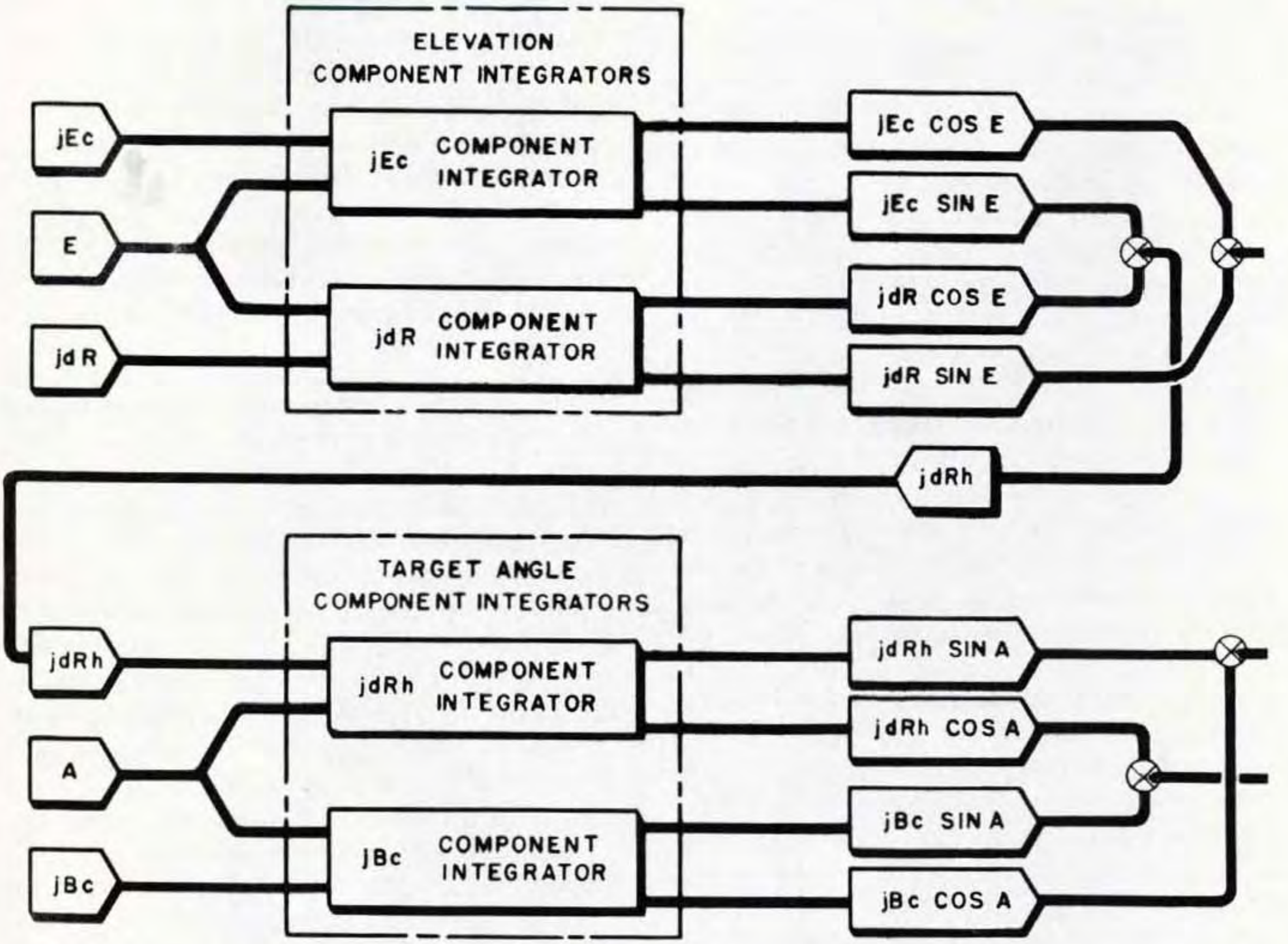
and the corrections to the target motion rates to be applied in the computer are determined. Measurement of the differences is accomplished in the same manner and by the same mechanisms in both Computer Mk 1 and Computer Mk 1A. This can be verified by reference to pages 242 to 247 in OP 1064 (particularly the diagrams on pages 243, 245, and 247) and by tracing the origin of *jdR*, *jE*, and *jBr* in the schematic diagram (figure 24). This diagram will be found at the back of this addendum. Determination of the rate control rate corrections (*jEc* in elevation, *jBc* in bearing) is different in Computers Mk 1 and Mk 1A. The measured elevation rate error (*jE*) and the measured bearing rate error (*jBr*), being angular quantities, are converted into linear quantities. In Computer Mk 1A this is accomplished by means of the elevation correction integrator and the bearing correction integrator, which are shown in figures 10 and 24. It can be seen that the integrator discs are driven by the angular measurements, while the carriages are positioned by range. Thus, the roller outputs of the integrators are products of the angular rate errors and range. The linear rate error corresponding to a given angular rate error is proportional to range, therefore the outputs of the integrators represent the linear rate error, *jEc* for elevation, *jBc* for bearing. These outputs are the rate error corrections set into the component integrators of the computer. For purposes of stability, it is desirable to make these corrections correspondingly less than the measured errors. This is accomplished by introducing less-than-unity gear ratios, *Ke* and *Kb*, in the *jE* and *jBr* shaft line inputs to the correction integrator discs. This affects the time constant of the instrument (the time required to reduce the error to 37% of its original value) as will be discussed in detail later. Change gears are provided so that the ratios may be conveniently altered if it is found desirable to do so.

Range rate errors are measured and corrected in Computer Mk 1A in exactly the same manner as in Computer Mk 1; see pages 246 and 247 in OP 1064.

Target Motion Correction Computing Network

Because of the method employed for computing relative motion rates in the Computer Mk 1A, the range rate correction (*jdR*), the elevation rate correction (*jEc*), and the bearing rate correction (*jBc*) cannot be added directly to the respective computed rates of *dR*, *RdE*, and *RdBs*. They must be resolved and applied as corrective changes to horizontal target speed (*Sh*), target angle (*A*), and rate of climb (*dH*). These corrective changes are obtained by resolving the rate corrections *jdR*, *jEc*, and *jBc* into horizontal and vertical components in the target motion correction computing network. This network consists of the elevation component integrators, the target angle component integrators, and related gearing and follow-ups. (See figure 9.) These basic mechanisms are the same as the corresponding ones in Computer Mk 1.

The elevation component integrators resolve range rate correction (*jdR*) and elevation rate correction (*jEc*) into horizontal and vertical components as described on pages 222 and 223 of OP 1064. The horizontal component (*jdRh*) is applied as an input to the target angle component integrators (see figure 10). The vertical component (*jHc*) is applied as a correction to *dH* at the *dH* follow-up. This follow-up is of the limited error type like the *jSh* and *jCt* follow-ups. Referring to figure 24, it is seen that in this type of follow-up, the follow-up differential spider shaft operates a limit stop, and that there is a friction drive in the input line. The arrangement is such that if either the *jHc* or the *dH* line is rotated while the follow-up is de-energized, a limit of the stop is soon reached, after which the friction drive permits continued rotation of either line. When energized, the follow-up needs to drive but a very short amount to synchronism, after which it will amplify any further input of *jHc*. This avoids having inputs that were made while the follow-up was de-energized upset by the follow-up running to synchronism when power is applied.


ELEVATION
COMPONENT INTEGRATORS
jEc
E
jdR
jEc COMPONENT INTEGRATOR
jdR COMPONENT INTEGRATOR
jEc COS E
jEc SIN E
jdR COS E
jdR SIN E
jdRh
TARGET ANGLE
COMPONENT INTEGRATORS
jdRh
A
jBc
jdRh COMPONENT INTEGRATOR
jBc COMPONENT INTEGRATOR
jdRh SIN A
jdRh COS A
jBc SIN A
jBc COS A

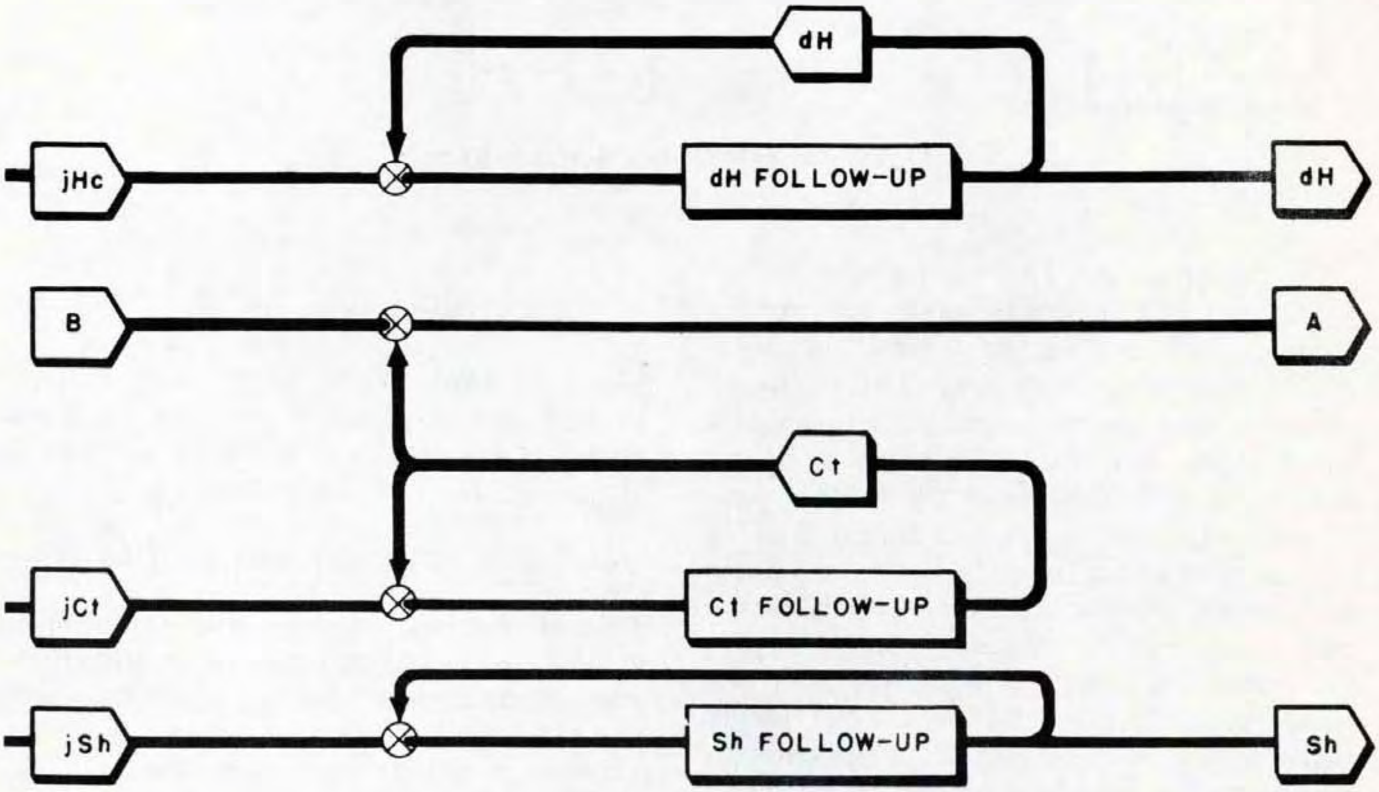


Figure 9. Target Motion Correction Computing Network.

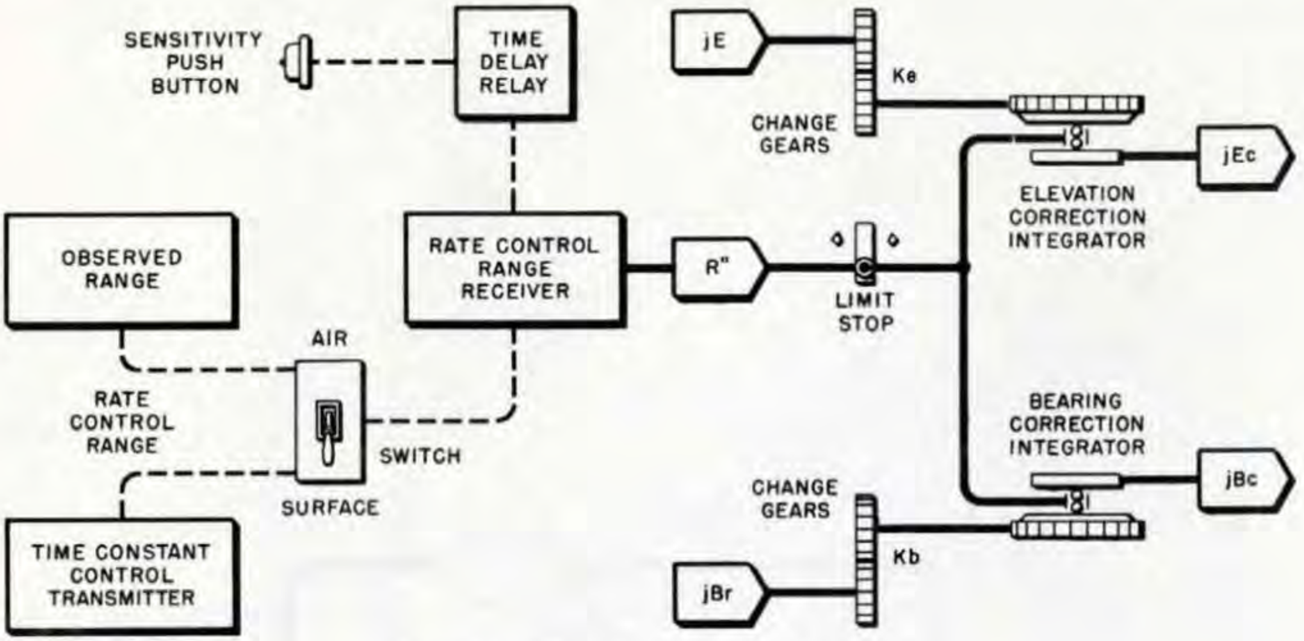


Figure 10. Sensitivity Control System.

In Computer Mk 1A bearing rate correction (jBc) and horizontal range rate correction ($jdRh$) are resolved into horizontal components taken with respect to the vertical plane through the target path (see figure 11), rather than with respect to a North-South line as in Computer Mk 1. Therefore, target angle (A) instead of target bearing (B) is used as an input to the target angle component integrators. The outputs from this component integrator group are jSh, the correction to target speed, and $jCt1$, the linear correction to the direction of target motion. Because these outputs are taken with respect to the line of target motion, the cumbersome vector solver used in Computer Mk 1 can be eliminated. One output, jSh, is applied to horizontal target speed (Sh) at the Sh follow-up. The other output, $jCt1$, is converted to the angular quantity $jCt1$ in the instrument gearing and applied to target angle (A).

Application of the linear correction $jCt1$ to the angular quantity A is as follows: It will be noted that changes in Ct are accompanied by corresponding changes in A. From figure 11 it is seen that the increment of change of target course (jCt) can be expressed by the equation:

$$jCt = \tan^{-1}\left[\frac{jCt1}{jSh}\right]$$

For such small angles as are involved, the tangent can be assumed equal to the corresponding arc expressed in radians. Thus the expression for jCt can be taken as:

$$jCt = \frac{jCt1}{2\pi Sh} \text{ x } 360 \text{ in degrees, or } jCt = \frac{jCt1}{K'Sh}$$

This expression indicates that for a given value of $jCt1$, jCt will vary with jSh. However, it has been determined that sufficiently accurate results can be obtained by assuming a constant speed, the expression thus becoming:

$$jCt = \frac{jCt1}{K}$$

This simplifies the mechanism, enabling the linear correction, $jCt1$, to be converted to an angular correction to Ct by means of gear ratios. This correction, jCt, is applied to Ct at the Ct follow-up. As indicated in figure 24 it is ultimately applied to target angle, A, in differential D-41 ($A = 180° + B - Ct$).

Sensitivity Control

Considered functionally, the sensitivity control of Computer Mk 1A is comprised of

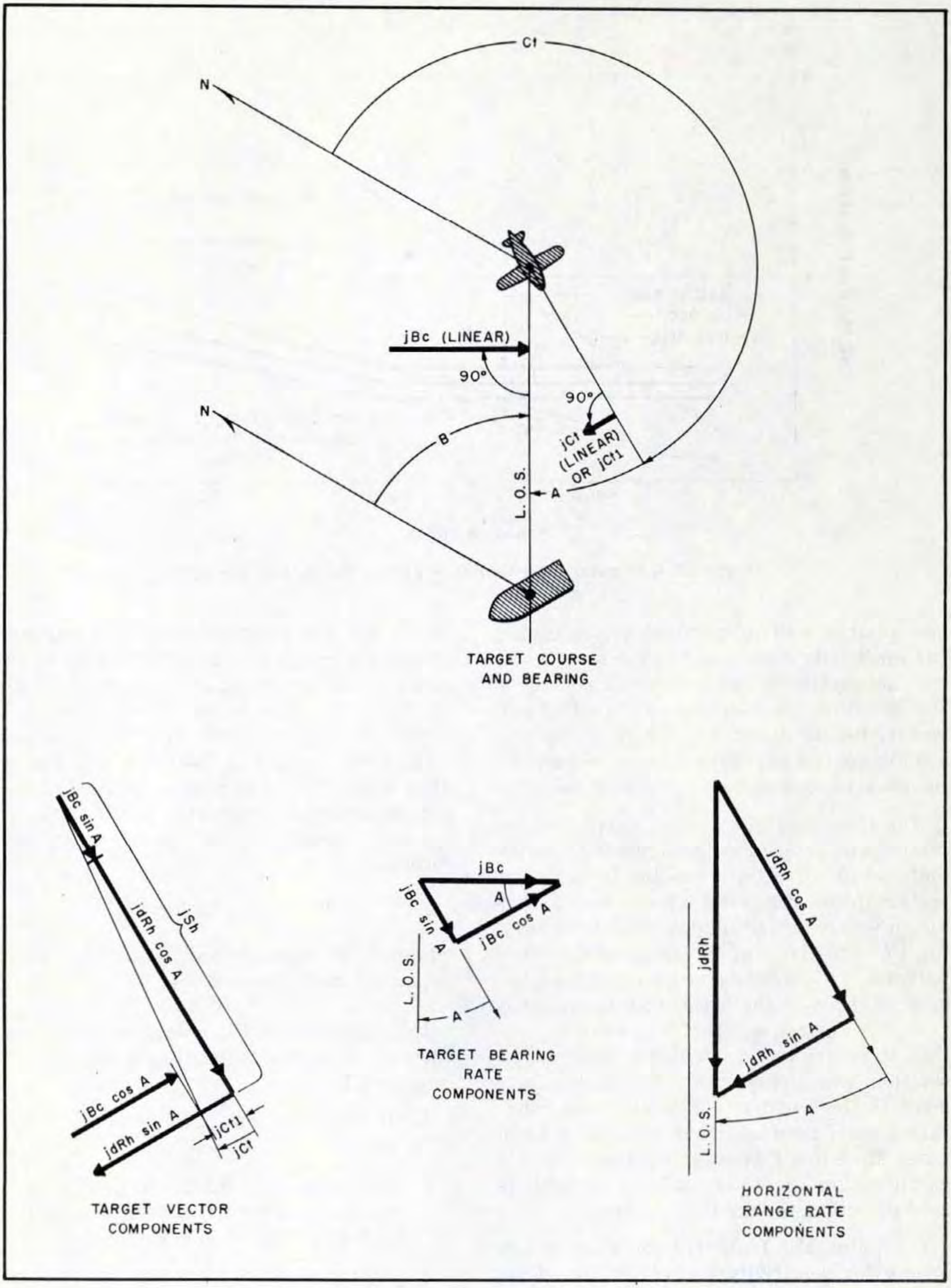


Figure 11. Vector Diagrams.

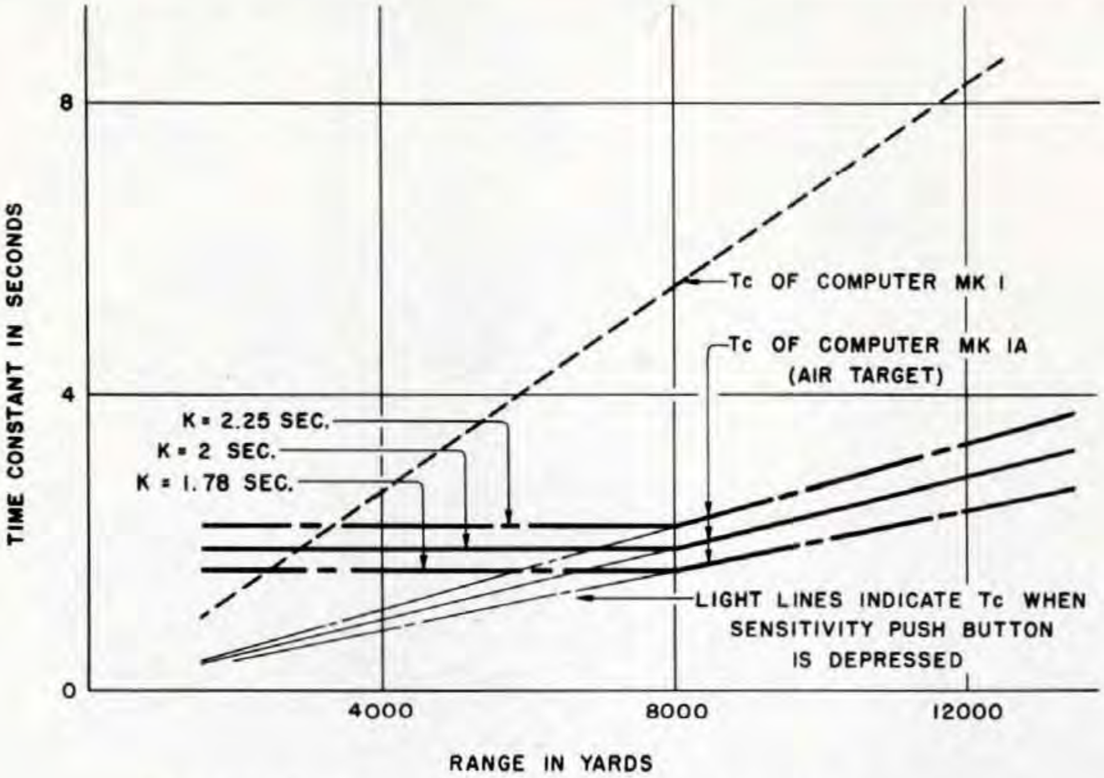


Figure 12. Computer Time Constant Versus Range (Air Target).

two separate and independent networks; i.e., the sensitivity control of the range rate control network, and the sensitivity control of the elevation and bearing rate control networks. Before describing either of the sensitivity control networks a more general description of sensitivity control must be given.

The time constant and sensitivity of the instrument determine the amount of target motion rate correction resulting from a given instantaneous rate error measurement. Provision was made in Computer Mk 1 for varying the sensitivity of the range rate control network. This made it possible for the operator to increase the sensitivity temporarily to hasten the reduction of large errors; and then to return to a more stable value as the solution was approached. No change was made in the sensitivity control of the range rate control network when altering a Computer Mk 1 to a Computer Mk 1A except for recalibrating the range rate ratio knob to read directly as range time constant.

Computer Mk 1 did not incorporate any means for sensitivity control of the elevation and bearing rate networks. The ratio of the difference between observed and generated changes in elevation or bearing to the resulting linear correction was fixed. Thus, the operator had no control over the sensitivity of these networks, and the time constant (Tc) varied at a fixed rate with range. (See figure 12.) The rate of change of the time constant of Computer Mk 1 with respect to range can be expressed by the formula:

$$Tc = \frac{R}{1430} \text{ (Approx.)}$$

where Tc is time constant in seconds, and R is present range in yards.

In Computer Mk 1A, operation of the elevation and bearing rate control networks is improved by:

1. Increasing the sensitivity of these networks.
2. Provision for maintaining the time constant uniform between the ranges of 500 yards and 8000 yards.
3. Provision of means whereby the operator can vary the sensitivity temporar-

ily (by temporarily changing the time constant).

These features are incorporated in the elevation and bearing sensitivity control network, a detailed description of which follows:

Sensitivity control mechanisms. The mechanisms involved in the sensitivity control network are the bearing, elevation, and range correction integrators; the time constant change gears; the rate control range receiver, the time constant control transmitter, the Air-Surface switch, the sensitivity push button, and the time delay relay. (See figures 10 and 24.)

CORRECTION INTEGRATORS. The integrators are of the disc type, the integrator for range having a four-inch disc and the integrators for elevation and bearing three-inch discs. The integrator for range is designated as the range correction ratio changer.

TIME CONSTANT CHANGE GEARS. Two sets of time constant change gears are provided for the elevation rate mechanism. Two identical sets are provided for the bearing rate mechanism also. The gears are engraved with time constant values and letters. The letters indicate the shafts on which they are installed. The gears engraved "A, $Tc = 2.00$" and "B, $Tc = 2.00$" form one set. When these gears are installed on shafts A and B, the basic time constant of the network in which they are installed is 2.00 seconds. The basic time constant is that value of Tc that is maintained uniform between the ranges of 500 yards and 8000 yards. It is also one of the factors determining the slope of the line representing the changing values of Tc beyond 8000 yards range. (See figure 12.) The basic time constant will be described further in the ensuing functional description; but it should be noted here that the basic time constant is inherent in the gearing of the system; the change gears merely providing a means of altering it.

The other change gears are engraved as follows:

Gear number 616728 (smaller gear)
A, Tc 2.25
B, Tc 1.78

Gear number 616729 (larger gear)
B, Tc 2.25
A, Tc 1.78

When the smaller gear is installed on shaft A and the larger gear on shaft B, the basic time constant is 2.25 seconds. When they are installed in the reverse manner, the basic time constant is 1.78 seconds.

It will be shown in the functional description that the time constant of the bearing rate control network varies with elevation as well as with range. Thus, in the bearing network, the value indicated by the installed gears is the basic time constant for this network only when the secant of target elevation (E) is 1.1, which occurs when E is approximately 25 degrees.

RATE CONTROL RANGE RECEIVER. The rate control range receiver is a single-speed receiver. Range is received by a 1F synchro motor. The synchro motor controls the position of the servo motor through a contact arrangement similar to that of the fine contact assembly of the range receiver located under the fine and coarse present-range dials.

TIME CONSTANT CONTROL TRANSMITTER. This is a 1G synchro transmitter. It transmits a predetermined value of rate control range. The transmitted range is indicated by a drum dial graduated from 0 to 10, representing zero to 10,000 yards. The transmitter can be set at predetermined values by turning a worm and gear type of adjustment on the transmitter shaft. Access to the adjustment is had by removing a pipe plug located below, and to the left of, the range time constant knob. It is called the time constant control transmitter because signals from it to the rate control range receiver affect the value of the time constant in surface fire.

AIR-SURFACE SWITCH. This is a double-pole, double-throw switch.

SENSITIVITY PUSH BUTTON. The sensitivity push button actuates a switch in which the contacts are normally closed. Pushing the button opens the contacts.

TIME DELAY RELAY. The time delay relay is a double-pole, double-throw, solenoid-operated switch. The time delay characteristic is obtained by requiring the switch-actuating rod to compress and expel air from a chamber in the timing head before tripping the toggle switch. When the solenoid is energized, motion of the solenoid core compresses a spring. The spring, acting on a diaphragm, compresses the air in the timing head. The time delay is controlled by means of a regulating screw that governs the rate at which the air can be expelled through a needle valve. The switch operates at a predetermined point in the stroke of the diaphragm. When the coil is de-energized, the spring quickly returns the solenoid plunger and actuates the switch in the opposite direction.

Sensitivity Control of Range Rate Control Network

Sensitivity of the range rate control network is controlled through the range correction integrator. This unit functions in the same manner as it did in the Computer Mk 1 (see pages 236 to 239 in OP 1064). The only difference is in the knob used for positioning the carriage of the range correction integrator. As previously stated under "Operating Controls", this knob is now designated the range time constant knob, and the graduations used in setting it have been changed. In the Computer Mk 1A, it is graduated in terms of the time constant, from 0 to 16 seconds. The number at which the knob is set indicates the time (in seconds) required for a range rate error to be reduced to approximately 37% of its initial value.

Sensitivity Control of the Elevation and Bearing Rate Control Networks

Figure 10 shows schematically the network for controlling the sensitivity of the elevation and bearing rate control networks of Computer Mk 1A. In the figure, the dotted lines indicate electrical circuits. Inputs to the sensitivity control network are angular elevation rate error *(jE)*, angular bearing rate error *(jBr)*, and rate control range *(R″)*. The latter quantity, *R″*, is the value of range represented by the actual position of the mechanism. It may, or may not, equal observed range, depending on circumstances of the fire control problem or on the conditions of operation. Changes in the input of *R″* cause simultaneous changes in the sensitivity of the elevation and bearing rate control networks. The operation of the sensitivity control network in determining the amount of linear rate correction that is applied to reduce a given rate error is the same for both elevation and bearing. Therefore a description of the operation as applied to one network will serve for both.

Determination of elevation rate control sensitivity. It was indicated previously that the elevation correction integrator is used to multiply the angular elevation rate error *(jE)* by present range to obtain the equivalent linear elevation rate correcton. Accordingly, if rate control range *(R″)* equals present range *(R)* then either of the equations; $(R)\ (jE) = jEc$ or $(R'')\ (jE) = jEc$ expresses the value of the linear correction. But it also has been indicated that, for purposes of stability, the value of the linear rate correction actually applied in the instrument should be less than that expressed by the above formulas. This reduction is effected in two ways, as follows:

1. By introducing a fixed ratio having a value less than unity in the *jE* input.
2. By varying the value of *R″*.

The ratio in the *jE* input is incorporated in the gearing. It is thus fixed and not controllable by the operator. Designating this ratio as *Q*, the input to the elevation correction integrator disc becomes $[(Q)(jE)]$. Thus, with *R″* equal to *R* the formula for *jEc* becomes:

$$jEc = R\ [(Q)(jE)]$$

However, if *R″* is varied with respect to *R*, the output of the integrator varies in the same proportion. Thus, the complete expression for *jEc* is:

$$jEc = \frac{R''}{R}(R)\left[(Q)(jE)\right]$$

this can be rewritten to read:

$$jEc = \left[(Q)\frac{R''}{R}\right]\left[(R)(jE)\right]$$

The expression $(Q)\frac{R''}{R}$ indicates the actual sensitivity of the complete network. In discussing the operation of the network, it is more convenient to refer to the time constant (Tc), which is the reciprocal of the sensitivity factor; or $\left[\left(\frac{1}{Q}\right)\left(\frac{R}{R''}\right)\right]$. Letting $Ke = \frac{1}{Q}$, this becomes:

$$Tc = (Ke)\frac{R}{R''}$$

The subscript, e, indicates that the constant is applied to the elevation network.

The constant, Ke, is the basic time constant of the network. As long as the input of R'' equals R (i.e., the ratio $\frac{R}{R''} = 1$), Tc equals Ke, which, expressed in seconds, represents the time required for the network to reduce the error to 37% of the initial value. The constant Ke is introduced throughout the gearing of the instrument, the change gears previously referred to merely providing a selection of the values 1.78, 2.00, or 2.25 seconds.

The range input to the sensitivity control network is limited to a maximum value of 8000 yards. Referring to figure 10, it is seen that the input of R'' is derived from range sent to the rate control range receiver from either the rangefinder or the time constant control transmitter. When R'' is received from the rangefinder and is not more than 8000 yards, R'' equals R, and the time constant of the network is Ke. For ranges beyond 8000 yards but below 22,500 yards, the time constant increases uniformly because the ratio $\left(\frac{R}{R''}\right)$ no longer equals unity, R'' being held at 8000 yards while R continues to increase. As an example, with R at 16,000 yards, and 2-second change gears installed:

$$Tc = Ke\left(\frac{R}{R''}\right) = 2\left(\frac{16{,}000}{8000}\right) = 4 \text{ seconds.}$$

The values of Tc for all values of range is shown graphically in figure 12. The increasing values of Tc beyond 8000 yards provide greater stability but larger errors at long ranges. However, the increased stability improves the pattern of the projectiles at these ranges. Means are provided for changing the upper limit of the range stop from 8000 yards to 3000, 4000, 5000, 6000, or 7000. The effect of decreasing the upper limit of R'' is indicated in figure 13. It can be seen that, below the limit, Tc remains constant; while for values of range beyond the limit, the time constant increases as the value of the limit decreases.

Determination of bearing rate control sensitivity. As previously stated, bearing rate control sensitivity is similar to that for elevation. It differs in but one respect; the time constant of the bearing network varies with the value of elevation (E), as well as with range, because the horizontal projection of range ($R \cos E$) determines the linear bearing rate correction required. Accordingly, the relationship between linear and angular bearing rates is:

$$jBc = (R \cos E)(jBr)$$

Inserting the sensitivity factor:

$$jBc = Q\left[\frac{R'' \cos E''}{R \cos E}\right](R \cos E)(jBr)$$

in which E'' is the value of elevation actually entering the sensitivity control mechanism. A constant value of E'' is selected as satisfactory for the purpose of computing rate corrections, as explained below. Since the cosine of a constant angle is itself a constant, $\cos E''$ can be replaced in the equation by $K1$. Thus, the expression for jBc becomes:

$$jBc = (Q)\left[\frac{(R'')\ (K1)}{R \cos E}\right](R \cos E)(jBr)$$

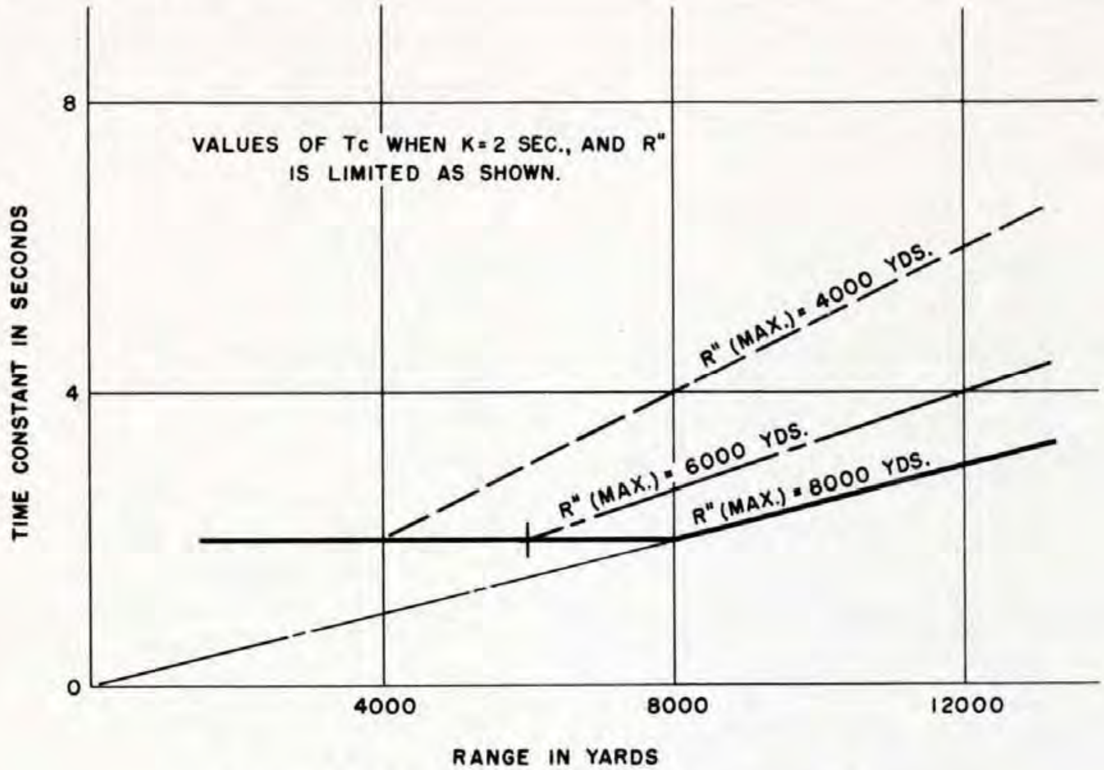


Figure 13. Effect of Decreasing Upper Limit of R″.

Letting $Kb = \frac{1}{Q}$ the expression for the time constant of the bearing rate control network becomes:

$$Tc = Kb\left[\frac{R\ (\cos E)}{(R''K1)}\right]$$

The subscript b of Kb merely indicates that the constant applies to the bearing network.

The formula for Tc in bearing can be re-written as follows:

$$Tc = Kb\left[\left(\frac{R}{R''}\right)\cos E\right]\frac{1}{K1},\ \text{or}$$

$$Tc = Kb\left[\left(\frac{R}{R''}\right)\cos E\right]\sec E'',$$

$\sec E''$ being $\frac{1}{\cos E''}$ or $\frac{1}{K1}$.

From the above, the desirability of selecting a value for $K1$ that approximates the secant of E over a wide range of variation can readily be seen. The constant 1.1 is applied in the instrument gearing as $K1$. The secant of 0° being 1.0, and the secants of 25° and 35° being approximately 1.1 and 1.2, respectively, the selection of 1.1 as the value of $K1$ represents a reasonable mean value for usual fire control problems. Thus, as long as target elevation does not exceed 35° the values of Tc given in figure 12 can be applied to the bearing network without serious error.

Summary of Operation of the Elevation and Bearing Sensitivity Control Network

It has been shown that the only difference between the elevation and bearing time constant in Computer Mk 1A is the factor $\frac{K1}{\cos E}$. For simplicity, this distinction will be ignored in the following description, the elevation and bearing time constants being considered equal.

The bearing and elevation time constant of Computer Mk 1 can be expressed by the formula $Tc = \frac{R}{1430}$, in which R equals range in yards. (See figure 12.) No provision was made for operational control of this time constant.

As indicated in figure 12, the time constant of Computer Mk 1A was made shorter than that for Computer Mk 1 at long ranges. However, these values of Tc are still large enough to provide sufficient stability to insure small dispersion patterns. The constant value of Tc shown for short ranges is a compromise between stability and fast solution time. In Computer Mk 1A, provision is made for altering the value of Tc at the will of the operator. Thus faster solution times can be obtained than those provided by the uniform value of Tc, as indicated by the light lines in the figure. The operator controls the operation of the sensitivity control network by means of the Air-Surface switch and the sensitivity push button.

Air targets. For operation against air targets the Air-Surface switch is positioned at AIR. The range input from the rangefinding equipment then actuates the rate control range receiver, and the value of R'' applied in the network is equal to R, up to the limit of 8000 yards. With the 2-second Tc gears installed, the formula for the time constant $\left(Tc = K\frac{R}{R''}\right)$ becomes:

1. For ranges to 8000 yards, $Tc = 2$.
2. For ranges beyond 8000 yards,

$Tc = 2 \times \frac{R}{8000} = \frac{R}{4000}$. Figure 12 shows this graphically.

If conditions of the problem indicate the desirability of increased sensitivity, it can be obtained when range is 8000 yards or less by depressing the sensitivity push button.

The rate control range receiver (figure 10) is of the type wherein both coils of the servo motor stator are energized directly by the power supply when the input and output are in synchronism. Depressing the sensitivity push button opens the time delay relay solenoid circuit. The relay then operates as previously described under the heading "sensitivity control mechanism", and shifts the single letter side of the power supply from the center contact of the receiver follow-up to the left lead of the rate control servo motor, at the same time disconnecting the left follow-up contact from the left side of the servo. With the left side of the servo connected directly to the power supply, the motor then drives range to the upper limit. After the sensitivity push button is released, the time delay relay maintains the direct connection to the left lead of the servo for the duration of the delay period, which is usually set at approximately two seconds.

From the above, it is seen that depressing the sensitivity push button causes the input, R'', to remain at 8000 yards for a brief period. During this time the ratio, $\frac{R}{R''}$, in the formula, $Tc = (2)\frac{R}{R''}$ will not equal unity, and the time constant for any range under 8000 yards will be shortened as indicated by the light lines in figure 12.

Figure 14 shows the effect of depressing the sensitivity push button on a typical problem in which range is changing.

Surface fire. It has already been indicated that Computer Mk 1A can be operated automatically against surface targets (normal control in Computer Mk 1A being the same as automatic control in Computer Mk 1). For such operation, the Air-Surface switch is set at SURFACE. When so positioned, it disconnects the rate control range receiver from the rangefinder, and connects it instead to the time constant control transmitter. The input to the rate control range receiver from the time constant control transmitter is equivalent to a fixed value of range. Assuming the control transmitter to be set to transmit a value equivalent to 3000 yards, the formula expressing the time constant of Computer Mk 1A (2-second time constant gears being installed) for surface fire is:

$Tc = (2)\frac{R}{3000}$ or $Tc = \frac{R}{1500}$. This gives values of Tc with respect to range approximately equal to those shown in figure 12 for Computer Mk 1. The effect of other settings on the time constant is indicated in figure 15. Increased sensitivity can be obtained by depressing the sensitivity push button. This has the effect of setting R'' at a fixed value equal to the upper limit of the stop. The R''

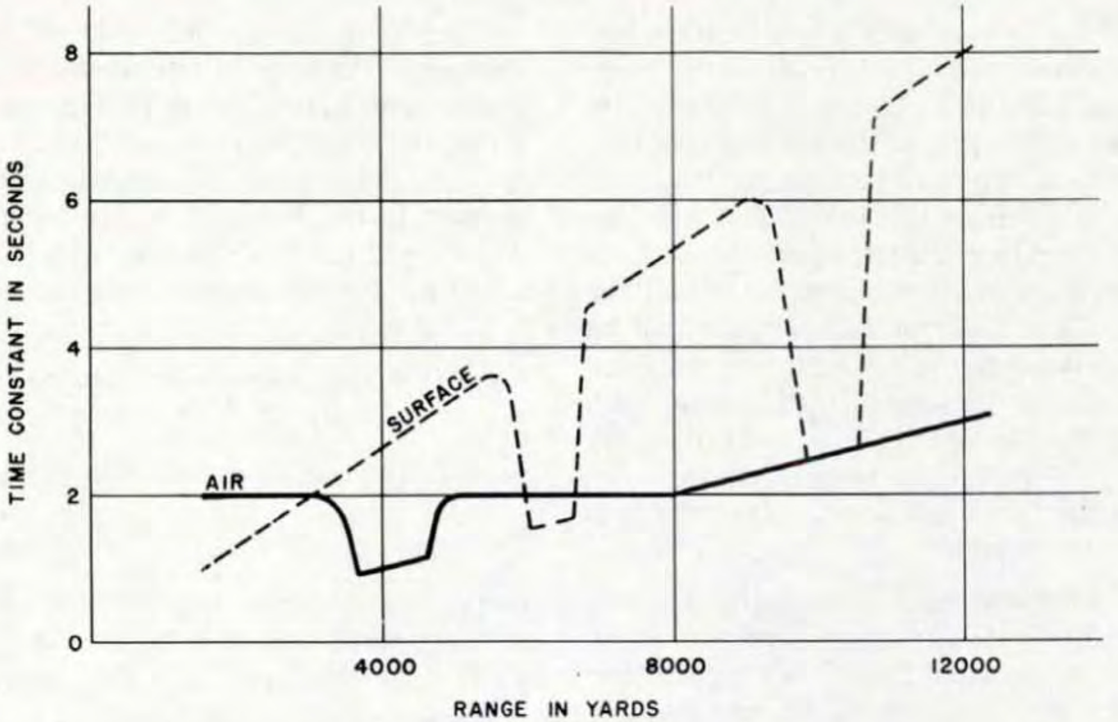


Figure 14. Effect of Depressing Sensitivity Push Button on Computer Time Constant.

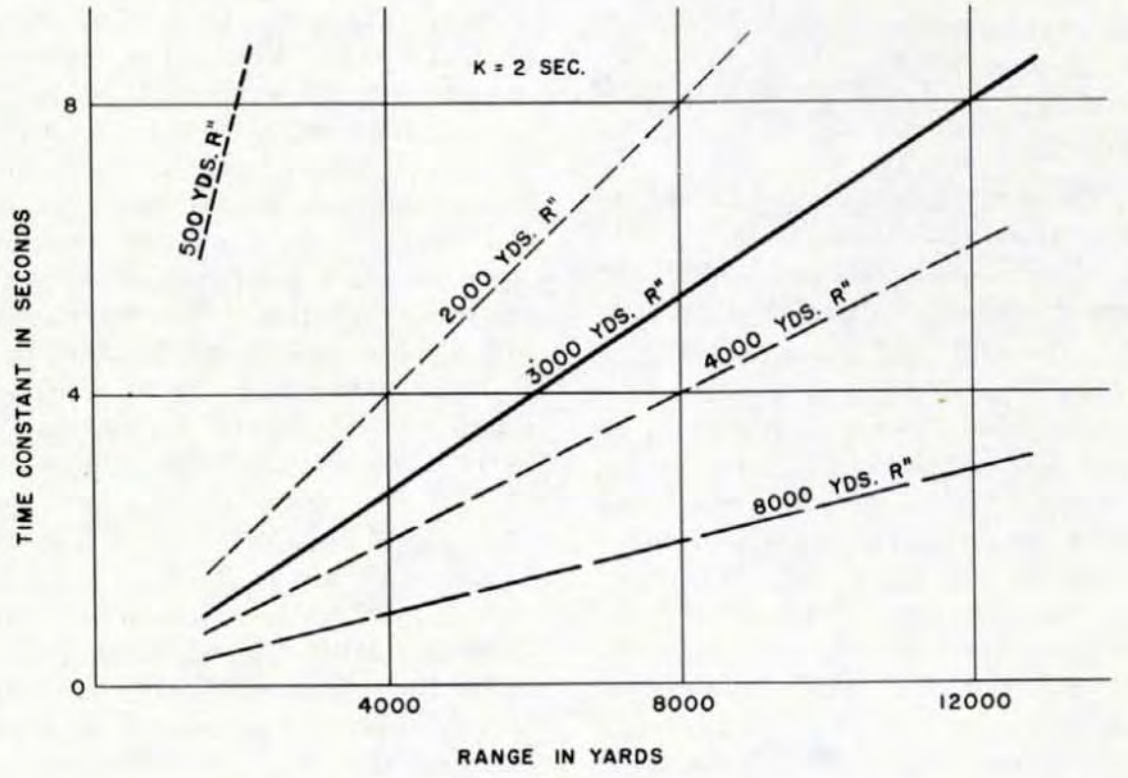


Figure 15. Effect of Time Constant Control Transmitter Setting on Tc.

input is held at this higher value for approximately two seconds after the sensitivity push button is released. The resultant effect on a typical problem is indicated in figure 14. Two conditions are shown; one for a range greater than 8000 yards, one for a shorter range.

Local Control

In local control the rate control computing mechanism is inoperative. In this form of operation Computer Mk 1A performs in the same manner as described in OP 1064 for Computer Mk 1 (pages 208 to 213).

Normal (Automatic) Control

Normal control of Computer Mk 1A corresponds to automatic control of Computer Mk 1. Therefore, the description of automatic operation contained on pages 241 to 247 of OP 1064 is adequate for Computer Mk 1A when modified by the information given in this addendum. However, it should be noted that illustrations on these pages of OP 1064 showing the rate control computing mechanisms do not show the parts entirely as they are in Computer Mk 1A. To rectify this condition, reference should be made to figures 9, 10, 16, 17, and 24 in this addendum.

Differences in the Mk 1 and Mk 1A rate control mechanisms have already been described in this addendum. Figure 16 shows the Mk 1A rate control mechanism in Normal Control. The control circuits governing the operation of the rate control mechanism of Computer Mk 1A differ from those of Computer Mk 1. The Mk 1A circuits are described below, and are shown schematically in figure 17.

Automatic Tracking Controls

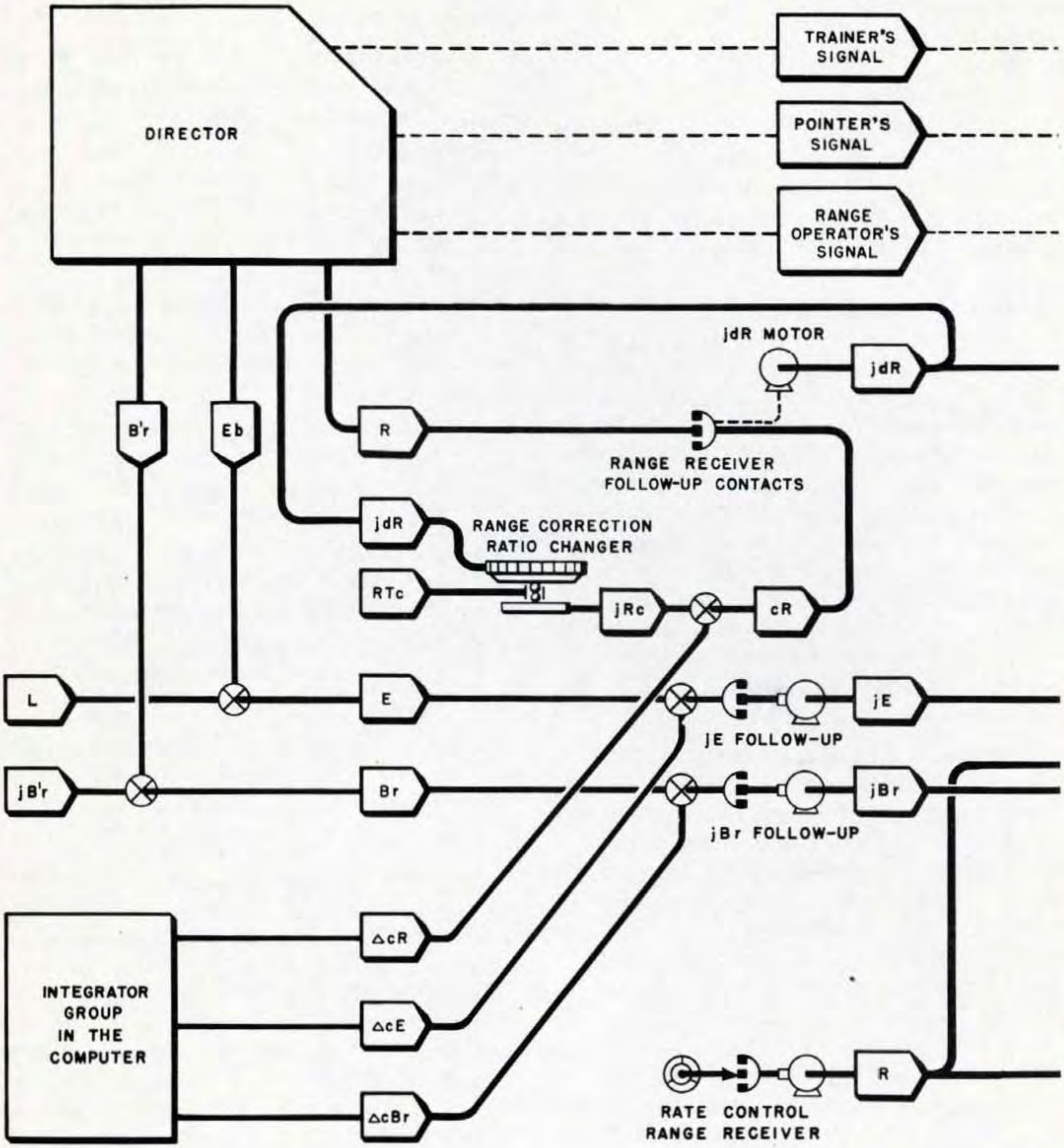
For full automatic operation of Computer Mk 1A the Control Switch is set at NORMAL and the Range Rate Control Switch is set at either AUTO or MANUAL. The basic features of operation in this condition are fully described above. However, normal operation is affected by operation of the automatic tracking controls which are described in detail below. Reference should be made to figures 16 and 17 throughout the following description.

The automatic tracking controls added to Computer Mk 1A operate to:

1. Automatically start the time motor when the director first indicates that it is "on target".
2. Automatically keep the generated range and the observed range dials in agreement even though the rangefinding equipment does not indicate that it is "on target".
3. Prevent the *jdR* clutch from being closed unless generated range is within 700 yards of agreement with observed range.
4. Automatically slew target angle until rate control increases target speed (*Sh*) above four knots, and target angle (*A*) is less than 90° in error.
5. Automatically set target speed (*Sh*) and rate of climb (*dH*) at zero when the time motor is not running.
6. Transmit an electrical signal to the director when target elevation (*E*) is less than two degrees.

The purpose of these controls is to simplify and improve the operation of the gun fire control system in the following respects:

In Computer Mk 1, initial estimates of target motion (*A*, *Sh*, and *dH*) must be set in the computer to establish initial target motion rates. But when the time motor is started, these rates are transmitted to the director where they are superimposed on whatever signal is positioning the director, and thus tend to drive the director off the target. In addition, if an incorrect estimate of *A* has been applied (or if no estimate of *A* is available), so that the applied value of *A* differs greatly from the actual value, considerable time is required for the computer to arrive at a correct rate control solution. A further disadvantage of this system is that during the interval between the time the


DIRECTOR
TRAINER'S SIGNAL
POINTER'S SIGNAL
RANGE OPERATOR'S SIGNAL
jdR MOTOR
jdR
B'r
Eb
R
RANGE RECEIVER FOLLOW-UP CONTACTS
jdR
RANGE CORRECTION RATIO CHANGER
RTc
jRc
cR
L
E
jE
jE FOLLOW-UP
jB'r
Br
jBr
jBr FOLLOW-UP
INTEGRATOR GROUP IN THE COMPUTER
ΔcR
ΔcE
ΔcBr
R
RATE CONTROL RANGE RECEIVER

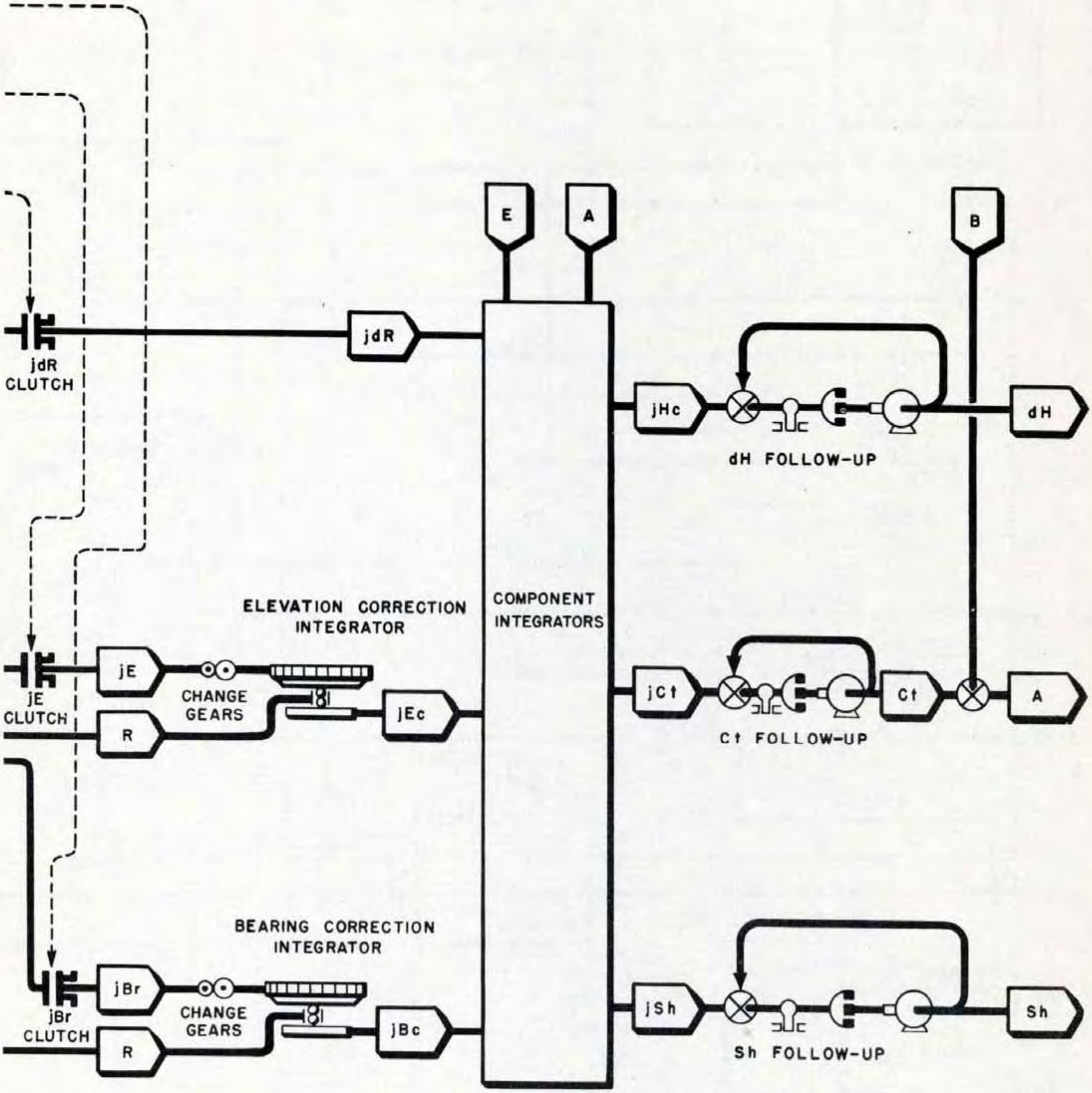
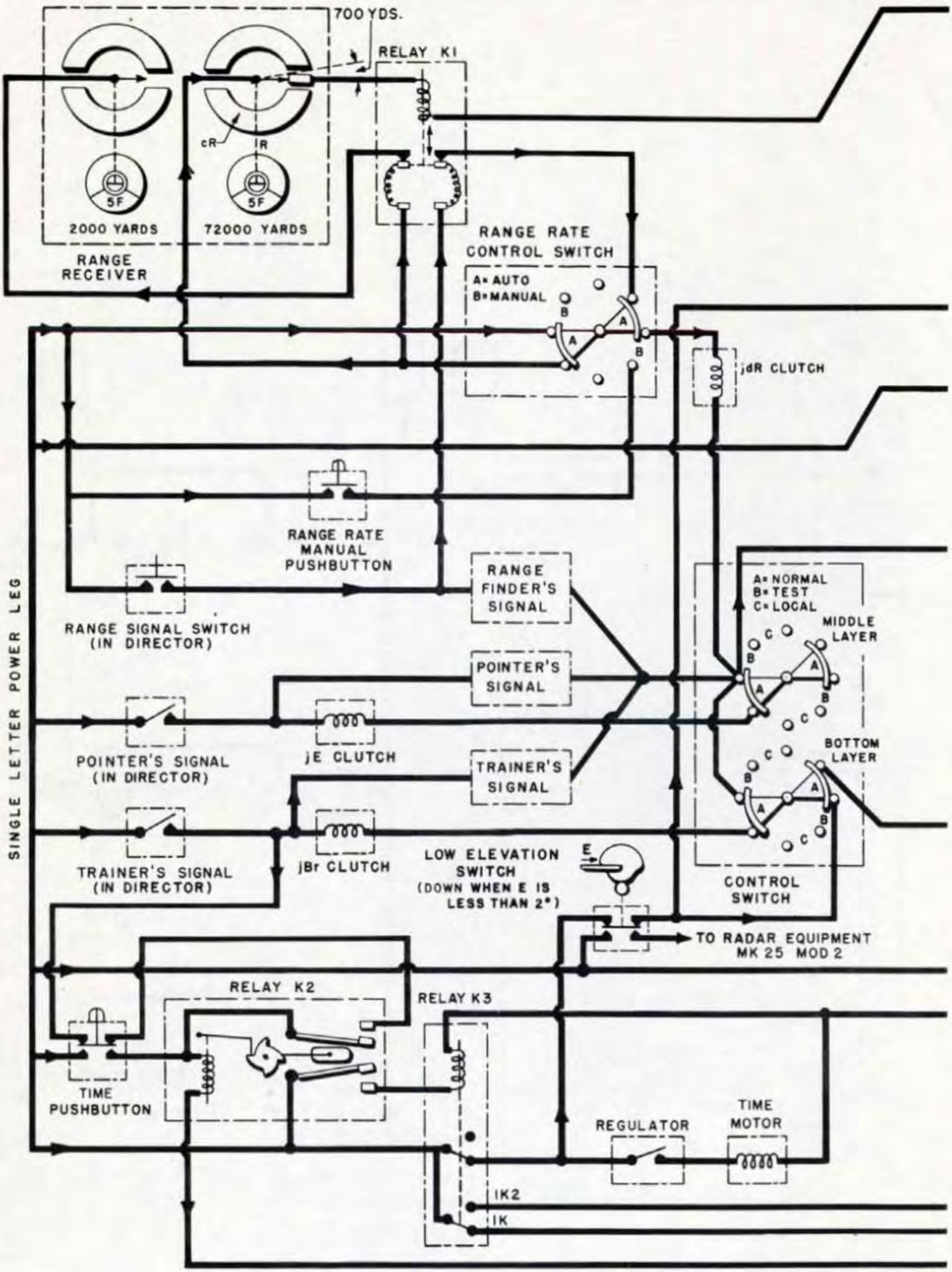


Figure 16. Flow Schematic (Normal Control).


700 YDS.
RELAY K1
cR
IR
5F
5F
2000 YARDS
72000 YARDS
RANGE RECEIVER
RANGE RATE CONTROL SWITCH
A= AUTO
B=MANUAL
A
B
jdR CLUTCH
RANGE RATE MANUAL PUSHBUTTON
RANGE FINDER'S SIGNAL
RANGE SIGNAL SWITCH (IN DIRECTOR)
A= NORMAL
B= TEST
C= LOCAL
MIDDLE LAYER
POINTER'S SIGNAL
SINGLE LETTER POWER LEG
POINTER'S SIGNAL (IN DIRECTOR)
jE CLUTCH
BOTTOM LAYER
TRAINER'S SIGNAL
TRAINER'S SIGNAL (IN DIRECTOR)
jBr CLUTCH
LOW ELEVATION SWITCH (DOWN WHEN E IS LESS THAN 2°)
E
CONTROL SWITCH
TO RADAR EQUIPMENT MK 25 MOD 2
RELAY K2
RELAY K3
TIME PUSHBUTTON
REGULATOR
TIME MOTOR
IK2
IK

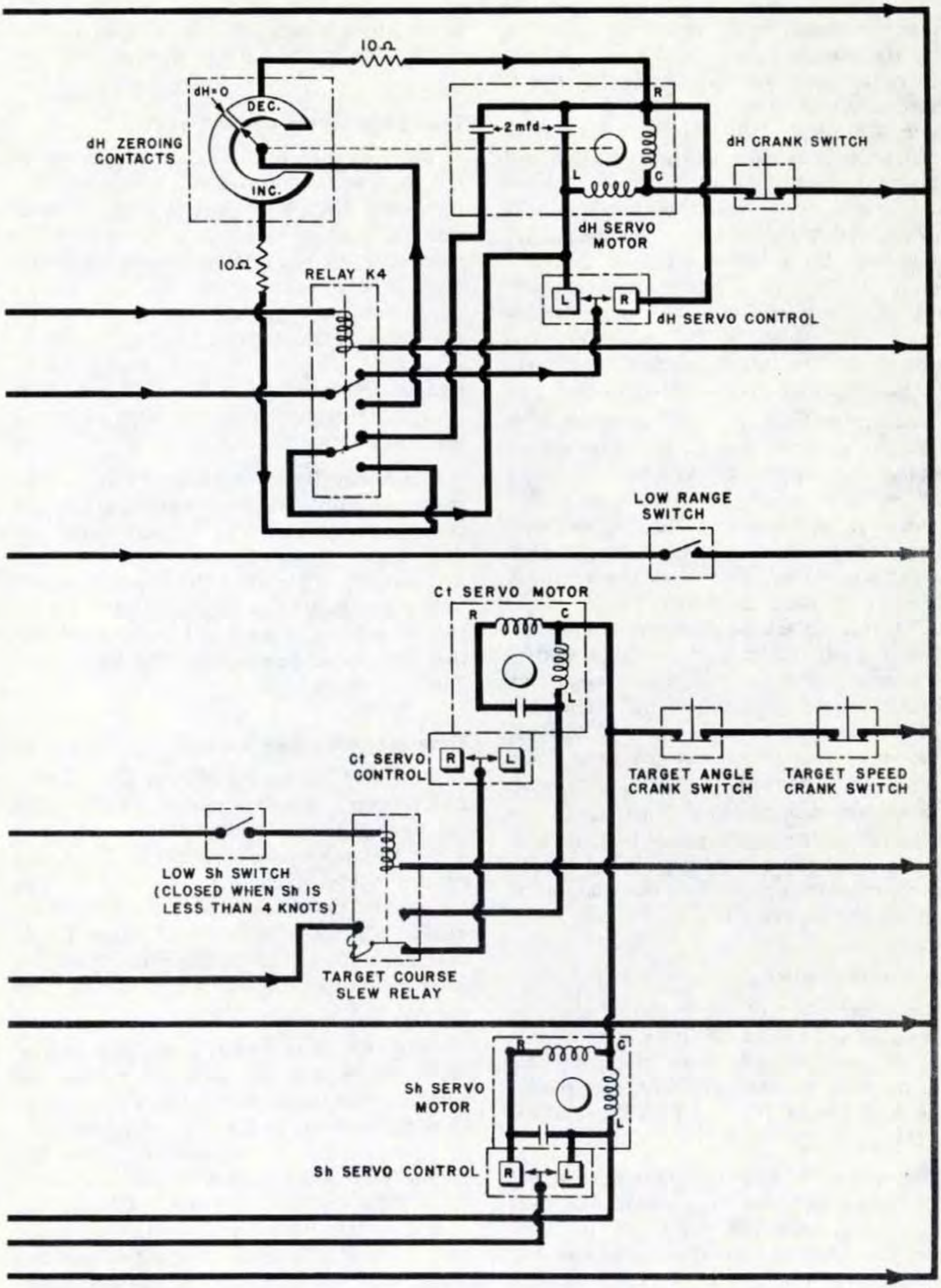


Figure 17. Automatic Operating Controls.

trainer indicates he is "on target" and the time the computer operator starts the time motor, the computer rate system is upset. These disadvantages are reduced in Computer Mk 1A by the control mechanisms which operate as indicated in items 1, 4, and 5 above. In Computer Mk 1A, the computer rates are at zero when the time motor is started, and the director is not driven off the target. With the starting of the time motor, *A* will be slewed to the proper quadrant if necessary, and the correct rates quickly established in the computer. The necessity for the introduction of target motion rates by the operator is eliminated.

Another purpose of the added controls is to relieve the operator of the necessity of keeping the generated and observed range dials matched during the period of target acquisition. In Computer Mk 1A, the electrical circuits have been so arranged that the *jdR* motor keeps these dials synchronized whenever the range rate control switch is at AUTO. If observed range changes too rapidly for the *jdR* motor to follow, the control mechanism opens the *jdR* clutch when the difference between observed and generated range becomes 700 yards (item 3 above). This prevents erroneous range rates from being set into the computer.

There are several other functions of the automatic control mechanisms of Computer Mk 1A. These will be explained in the following description which gives the details of each control separately.

The Control Switch

The description of the control switch on pages 258 and 259 of OP 1064 is applicable to Computer Mk 1A when the following substitutions in the wording are made: NORMAL for AUTO, and TEST for SEMI-AUTO.

The pointer's and the trainer's signal keys. These switches function as described in OP 1064, pages 258 and 259. In Computer Mk 1A, the trainer's signal key has the additional function of starting the time motor upon a shift to Normal control. This is explained in detail in this addendum under the heading "Time Motor Control System".

The Range Rate Control Switch

The description of this switch given in OP 1064, pages 260 and 261, is adequate for Computer Mk 1A when it is borne in mind that there is no Semi-Auto rate control in Computer Mk 1A. Another important difference is that in Computer Mk 1A, turning the range rate control switch to AUTO energizes the range receiver. This operation is entirely independent of the completion of circuits in the director. Thus, in automatic control, the range dials are kept in agreement at all times.

The Range Operator's Signal Button. The range operator's signal button in the director controls the operation of the *jdR* clutch and rangefinder signal, as described on pages 260 and 261 of OP 1064. However, relay K1 of the automatic tracking controls modifies this operation, as described under the heading "Control of Range Input" in this addendum.

Time Motor Control System

Figure 18 shows the system for starting and stopping the time motor. As shown in the figure, the system is in the "Power On—Time Motor Stopped" condition. Thus, the ratchet operated contacts of relay K2 are closed, and the solenoid of relay K3 is energized. When the solenoid of relay K3 is energized, the switch of this relay opens the time motor line, thereby stopping the time motor.

Relay K2 is so constructed that successively energizing its solenoid causes the ratchet mechanism alternately to open and close the contacts in the relay; i.e., one cycle of operation of the solenoid will cause the contacts to open, the next will cause them to close. With the computer power ON, depressing the time motor push button energizes this solenoid. Likewise, closing the trainer's signal key will energize the solenoid when the system is in the condition shown in

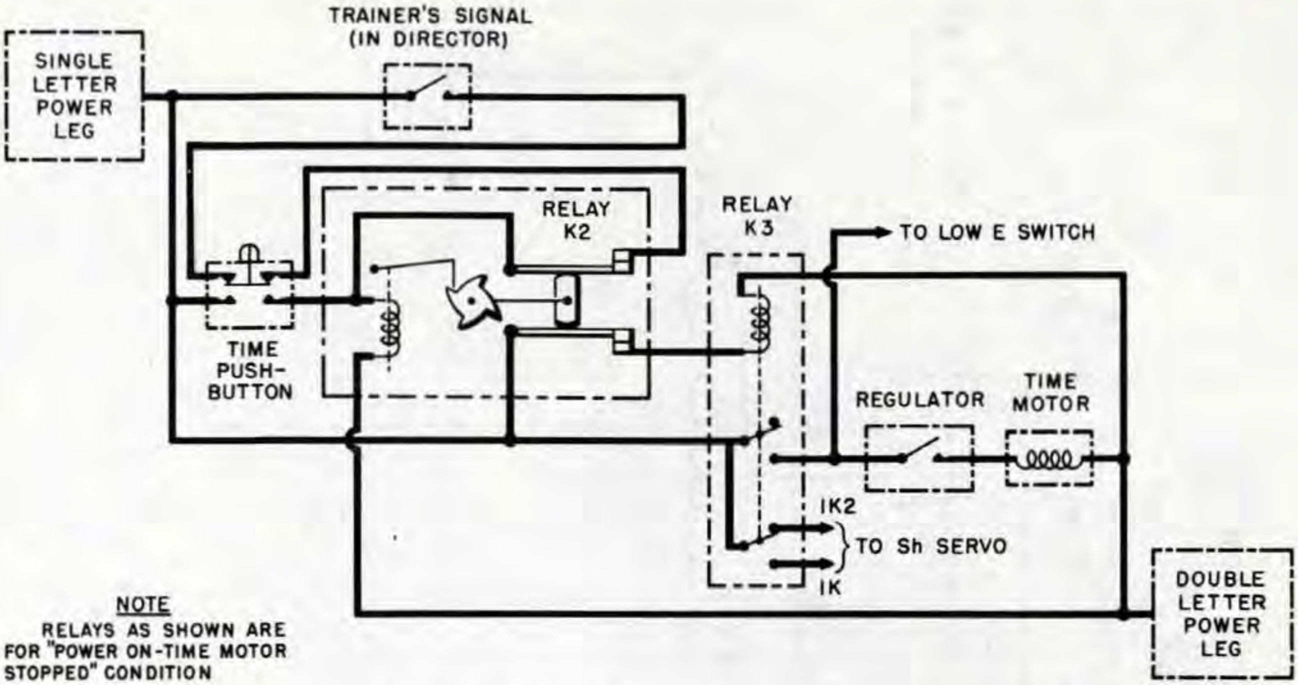


Figure 18. Time Motor Control System

figure 18 ("Power On—Time Motor Stopped" condition).

With the system in the condition shown in the figure, depressing the trainer's signal key starts the time motor in the following manner. The initial effect is to energize the solenoid of relay K2. This actuates the ratchet mechanism of the relay and opens the relay contacts. Since power for the solenoid must come through one pair of the contacts, the solenoid is de-energized, setting the relay for the next cycle of operation. As soon as the relay contacts are opened, the solenoid of relay K3 is de-energized also. This causes relay K3 to close the time motor line to start the time motor.

To stop the time motor, the time motor push button on the computer is depressed. Reference to either figure 17 or figure 18 shows that this energizes the solenoid of relay K2, causing the relay to cycle and restore the condition illustrated in figure 18, wherein the contacts are closed, relay K3 is energized, and the time motor stopped.

The time motor cannot be stopped by means of the trainer's signal key because, in starting the time motor, the contacts of relay K2 were opened, thereby disconnecting this switch from the relay solenoid.

The time motor control system also governs the operation of the *Sh* and the *dH* servo motors in the manner described under the following two headings.

Zeroing *Sh*. Referring to figure 17, it is seen that power for operating the *Sh* servo motor is supplied through either line 1K or line 1K2.

When the solenoid of relay K3 is energized, the relay is actuated to connect line 1K2 to the power supply, while at the same time disconnecting line 1K. Line 1K2 is connected to the left leg of the *Sh* servo motor. Thus when this line is energized, the *Sh* servo motor drives in the decreasing direction; in other words, when the time motor is stopped, *Sh* is set at zero also.

In starting the time motor the solenoid of relay K3 is de-energized. The relay then disconnects line 1K2 from the power supply, connecting line 1K instead. Thus, when the time motor is started, the *Sh* servo motor is again governed by the *Sh* servo control.

Zeroing *dH*. As long as the solenoid of relay K4 is energized, the switch of the relay

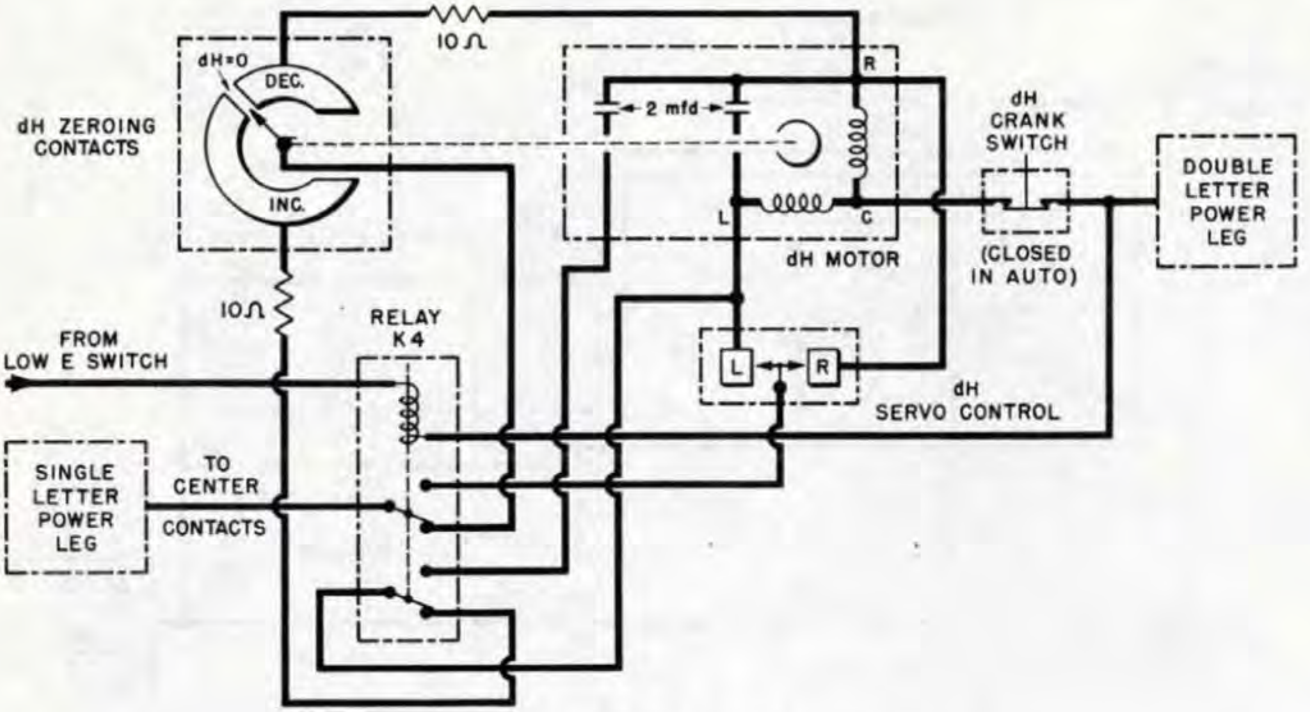


Figure 19. The dH Zeroing System.

will be positioned as shown in figure 17, and operation of the *dH* servo motor will be governed by the *dH* servo control. It is seen in the figure that the power supply to the solenoid is taken from the time motor line and passes through the low elevation switch. Thus, if the time motor control operates to stop the time motor or if the line is opened by the low elevation switch, the solenoid of relay K4 is de-energized and connections to the *dH* servo motor are as indicated in figure 19. The *dH* motor is then controlled by the *dH* zeroing contacts, which cause it to be driven to and held at the zero *dH* position.

These contacts consist of two fixed segments and a rotating contact that is driven by the servo motor. Each segment is connected to one lead of the *dH* servo motor as indicated in the figure. Power is applied through the rotating contact. The connections are such that, when the contacts are in control, the motor drives until it reaches the zero position, at which time the rotating contact is between the two segments. Since connection is then equally to both motor coils, the motor stops running.

Referring to figures 17 and 19 it will be noted that two 2-mfd capacitors are connected in the motor circuit when the relay is set for operation of the *dH* servo control, while when the zeroing contacts are operative one of the capacitors is cut out of the circuit and a 10-ohm resistor is connected in series with each coil of the motor. This arrangement prevents excessive over-travel of the zero point when zeroing *dH*.

The Low *E* Switch

The low elevation switch is a cam-operated double-throw micro switch. The cam is mounted on the elevation transmitter shaft, and the switch is electrically connected as indicated in figure 17. When *E* is greater than 2° the switch is positioned as shown.

When *E* becomes less than 2° the cam moves the switch to the opposite position, thereby de-energizing the solenoids of the target course slew relay and relay K4, and causing a 115 volt, 60 cycle signal to be transmitted to a signal light in the director. The effect of de-energizing the solenoid of relay K4 has already been described. The effect of de-energizing the target course slew relay solenoid is described below.

The Target Course Slew System

The principal purpose of this system is to establish the instrument setting of target angle (*A*) in the proper quadrant as soon as the time motor is started, so that the computer will rate control properly. The component parts of the system are the low *Sh* switch, and the target course slew relay.

The low *Sh* switch. The low *Sh* switch is a micro switch actuated by the *Sh* limit stop (see figure 24). When *Sh* is less than four knots the switch is closed.

The target course slew relay. Figure 17 indicates the manner in which the low *Sh* switch, the target course slew relay, and the *Ct* servo motor are electrically connected. It is seen from the figure that the single letter power input to the *Ct* servo motor passes through the relay. With the low *Sh* switch open, the relay solenoid is de-energized and connections at the relay are as indicated in the figure. This causes operation of the *Ct* servo motor to be under control of the *Ct* follow-up control. When *Sh* is less than four knots the low *Sh* switch is closed, energizing the target course slew relay solenoid. This causes the relay to disconnect the power supply from the *Ct* servo control, and to connect the left lead of the *Ct* servo motor directly to the power supply. The motor then drives until the relay position is reversed, as described below.

Operation of target course slew system. It has been shown in the description of the time motor control system that, when the time motor is stopped, the value of *Sh* applied in the instrument is automatically brought to zero. A study of the rate control mechanism (particularly the component integrators) will show that when the input of target angle (*A*) is more than 90° in error, the mechanism reduces the computed value of *Sh*. Thus, if the input of *A* is more than 90° in error when the time motor is started, the rate control mechanism operates to hold *Sh* at zero, until *A* is positioned less than 90° in error. Under these conditions the target course slew system operates as described in the preceding paragraph, slewing target course (*Ct*), bringing it rapidly to the proper quadrant. As *A* enters this position, the rate control mechanism commences moving *Sh* in the increasing direction. When *Sh* exceeds four knots the low *Sh* switch is opened, the target course slew relay solenoid is de-energized, and operation of the *Ct* servo motor is again governed by the *Ct* follow-up control. If, for any reason, target angle (*A*) is positioned more than 90° in error after rate control has commenced, operation to restore it to the proper quadrant is similar to that described above.

It should be noted here, that it is still possible to slew the *Ct* motor by means of the increase and decrease buttons on the target course indicator (see page 106 of OP 1064), if *Sh* is more than four knots. When operating against surface targets, this operation can be performed when *Sh* is below four knots. It can be seen from figure 17 that when the low elevation switch is positioned for an elevation of less than 2°, the solenoid of the target course slew relay will not be energized, even though the low *Sh* switch is closed. This makes Normal operation against surface targets possible.

Control of Range Input

It has already been stated that when the range rate control switch is at AUTO the range receiver is energized. Thus, range is set into Computer Mk 1A even though the range keeper operator does not indicate he is on target. To make it unnecessary for a computer operator to match the range dials during the target acquisition period, and to prevent erroneous range rates from being generated if the range signal switch is closed before *R* and *cR* are in agreement, relay K1 is provided (see figure 17). It can be seen in the figure that the solenoid of the relay is energized from the island contact of the coarse range receiver motor contact group. When *cR* in the computer is within 700 yards of agreement with the input of range, the solenoid is energized, and the relay switch is positioned as shown. When so positioned, the switch closes two circuits: one connecting the fine range receiver follow-up contact to the power supply, the other connecting the *jdR* clutch and range signal switch. Thus, *R* and *cR* can be brought into exact agreement, and the *jdR* clutch can be closed whenever the range signal button is pressed. When the difference between *cR* and *R* exceeds 700 yards, the center coarse contact is moved sufficiently from the synchronized position (in which it is shown in the figure) to de-energize the solenoid of relay K1 thus opening the relay. It is then impossible to close the *jdR* clutch and rate control while the range receiver is out of synchronism. The range finder signal is, however, still operable. Also, the range receiver is then in coarse control only.

Low Range Switch

If rate inputs are set into the rate control computing mechanism when range is less than 1500 yards, erroneous values of target angle and target speed are generated because the $1/cR$ cam has a constant radius below 1500 yards. In Computer Mk 1A a micro-switch is installed to prevent these inputs when *R* is less than 1500 yards. This switch is connected electrically to the rate control clutches as indicated in figure 17, and is actuated by the carriage of the $1/cR$ cam (see figure 24). When *cR* passes below 1500 yards the switch is opened preventing the energization of the clutches. Thus, inputs of *jE*, *jBr*, and *jdR* are prevented when range is less than 1500 yards.

PREDICTION SECTION

The material included under this heading in OP 1064 applies generally to the Computer Mk 1A. However, some additional information must be presented in order to cover changes that were made in the Computer Mk 1 since the book was published. These changes were made chiefly in dead time range prediction, initial velocity correction, and in the arrangement of the fuze ballistic computer. Certain other material is included here to cover new modifications of the computer.

It has been shown that, to provide for increased target speed, shaft values in the relative motion and integrator groups were doubled. This causes the inputs of *Xo*, *Yo*, *Sw*, *RdBs*, and *RdE* to be applied in the prediction section at double the shaft values formerly used in Computer Mk 1. This is desirable in so far as operation of the prediction multipliers is concerned. By doubling the values of the rack inputs to the prediction multipliers the values of the multiplier outputs are doubled; i.e., the full travel of the output rack represents twice the prediction in Mk 1A that it did in Mk 1. This makes it possible to obtain predictions corresponding to the increased target speeds. However, before applying the prediction multiplier outputs to the rest of the prediction mechanism the shafting must be restored to the original value per revolution, otherwise it would be necessary to redesign the rest of the prediction mechanism (including the ballistic cams). This is accomplished by installing halving gear ratios in the multiplier output lines. Beyond the points where these gears are installed, the prediction mechanism shafting moves the same amount as previously for a given change of rate input. The correct numerical values are thus registered on the advance range, sight angle, and sight deflection counters.

The changes made in the relative motion group doubled the value of the *WrD* + *KRdBs* shaft lines. To offset the effect of this change, the gearing in the input to the follow-up was changed to restore the follow-up to its former value per revolution. This was necessary because the star shell computer was not affected by the conversion ordalts.

Computing Advance Range, *R2*

The description contained in OP 1064 under this heading applies to Computer Mk 1A, with the following exceptions.

The range prediction multiplier. It is stated in the description on page 276 of OP 1064, that the sum of *cR* and *Rt*, as obtained in the range prediction multiplier system, gives an accurate value of advance range (*R2*); when wind is zero the value of *I.V.* applied in the instrument is 2550 fs. This is true only for Mods 8 and 12 of Computer Mk 1A, because these are the only ones having such a value for design *I.V.* The design *I.V.'s* of other mods of Computer Mk 1A are listed under the heading "Initial Velocity" in this addendum. When the *I.V.* set into the instrument corresponds to the design *I.V.* listed for that particular mod, the value of *R2* obtained as described above is correct.

The *Tf* ballistic computer. The following feature, which has the effect of reducing oscillations in *R2*, *F*, and *E'g*, has been incorporated in Computer Mk 1A Mod 13. Without this feature, undesirable oscillations could occur whenever the problem set in the computer involved high negative range rates. The size of the permanently connected capacitor on the *Tf* servo motor has been reduced to one mfd. In addition, a 4-mfd capacitor is provided. This capacitor is connected to the motor through a micro switch, which is actuated by a cam mounted on the comparison differential spider shaft (see figure 24). When the spider is one-third of a revolution from the synchronized position the switch is closed, and the 4-mfd capacitor is cut into the *Tf* servo motor circuit.

The Elevation Prediction Network

The elevation prediction network in Computer Mk 1A Mod 8 and Mod 12 conforms exactly to the description given on pages 282 and 283 of OP 1064 for Computer Mk 1. In Computer Mk 1A Mods 13, 14, 15, and 16 the network is similar to that described in OP 1064, except that the quantity *R2m* is substituted for *R2* as an input to the ballistic computer (see figure 20). The quantity *R2m* is equal to *R2* plus the initial velocity correction *jR2m*, indicated in the figure. This correction is additional to those described under the heading "Initial Velocity" on page 309 of OP 1064. Following is a description of this additional correction.

Correcting *Tf/R2*. When using *R2* as an input to the *Tf/R2* ballistic cam, as in Computer Mk 1, the output, *Tf/R2* contains an error due to the variation of the *I.V.* setting from the value of initial velocity for which the ballistic cams were designed. It should be noted, that a partial correction for this variation has been incorporated in *R2* (see figure 24). The accuracy of the *Tf/R2* computation is increased by applying the supplementary *I.V. correction*, *jR2m*, to the *R2* input to the *Tf/R2* ballistic computer. An *I.V.* dial and a knob are provided at the front of the computer for the purpose of introducing this supplementary *I.V. correction*. They are indicated schematically in figure 24.

The supplementary correction (*jR2m*) is obtained by means of a gear ratio in the shaft line from the front *I.V.* dial. The quantity *jR2m* is added to *R2* in differential D-91 to produce *R2m*, the altered advance range input to the *Tf/R2* ballistic computer (see figures 20 and 24). One branch of the *R2m* shaft line drives the *Tf/R2* cam; the other by-passes the cam and is multiplied by a constant *K*, through gearing to produce *KR2m*, which is the straight line approximation of *Tf/R2*. The output of the cam

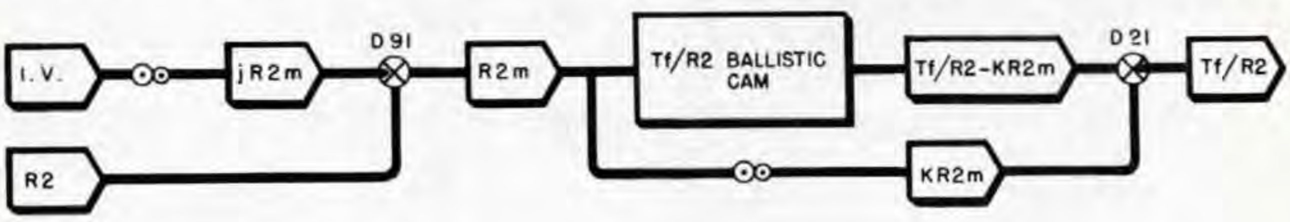


Figure 20. Supplemental I.V. Correction for Tf/R2.

$(Tf/R2 - KR2m)$ is added to $KR2m$ in differential D-21, to produce $Tf/R2$.

The $Vf + Pe$ ballistic computer. In Computer Mk 1A Mod 13 only, with $Vf + Pe$ ballistic computer follow-up is provided with a capacitor and micro switch arrangement similar to that just described for the Tf ballistic computer follow-up (see figure 24). The purpose of this is to further reduce oscillations of the gun elevation order output. The only difference between the two arrangements is that the switch actuating cam of the $Vf + Pe$ follow-up is designed to cut in the 4-mfd capacitor immediately upon any movement from the synchronized position, rather than after approximately one-third revolution of the cam shaft.

Computing Sight Deflection, *Ds*

The description contained under this heading in OP 1064 (page 286) is applicable to Computer Mk 1A, except that where reference is made to 2550 *I.V.*, the design *I.V.* of the particular mod should be substituted.

Computing Fuze Setting Order, *F*

The following description of the computation of fuze setting order (F), rather than that given in OP 1064, should be applied to Computer Mk 1A.

The fuze of a projectile must be so timed that the projectile will burst at the predicted target position. If the fuze could be set in the gun at the instant the projectile is fired, the fuze setting order (F) would be equal to the value of time of flight (Tf) corresponding to the current value of advance range ($R2$). But since the fuze must be set several seconds before the projectile is fired, the fuze time must equal time of flight corresponding to the value that advance range will have at the time the fuzed projectile is fired. The elapsed time between setting the fuze and firing the fuzed projectile is dead time (Tg). The value that advance range will have at the end of dead time is called fuze range ($R3$).

In the instrument, fuze range ($R3$) is determined by computing the change in advance range during dead time (RTg), and then adding RTg to the current value of $R2$. Thus,

$$R3 = R2 + RTg$$

It should be noted here that, as range changes during time of flight, and the difference in the amount of this change during Tg must be accounted for, the value of RTg derived in the instrument includes a compensating factor for this difference.

Computing fuze range. The change in advance range during dead time can be determined from the quantities that make up advance range ($R2$) and fuze range ($R3$). $R3 = cR + (dR{+}dRxe)\ Tg + (dR{+}dRxe)\ F + Rw + (I.V.\ Correction)$, and $R2 = cR + (dR{+}dRxe)\ Tf + Rw + (I.V.\ Correction)$. Transposing the formula of the preceding paragraph we have:

$$RTg = R3 - R2$$

Subtracting the equation for $R2$ from that for $R3$ we have:

$$RTg = [(dR{+}dRxe)Tg] + [(dR + dRxe)(F - Tf)].$$

The quantity $[(dR + dRxe)Tg]$ is the actual range change during Tg, and the quantity $[(dR + dRxe)(F - Tf)]$ the compensating factor for the difference in range prediction mentioned in the previous paragraph.

In the instrument solution, RTg is computed in the dead time prediction multiplier. (See figure 21.) As can be seen from the preceding paragraph, the equation on which the computation is based is: $RTg = (dR + dRxe)(Tg + F - Tf)$. Because of mechanical considerations, the factor $(dR + dRxe)$ is not used as an input to the multiplier. Instead, its equal $(dRs - dRm)$ is used. It is explained in the "Initial Velocity" section of OP 1064 that the corrected value of range rate is:

$$dRs = dR + dRxe + dRm,$$

where dRm is a correction for initial velocity. Subtracting dRm from both sides of the equation:

$$dRs - dRm = dR + dRxe$$

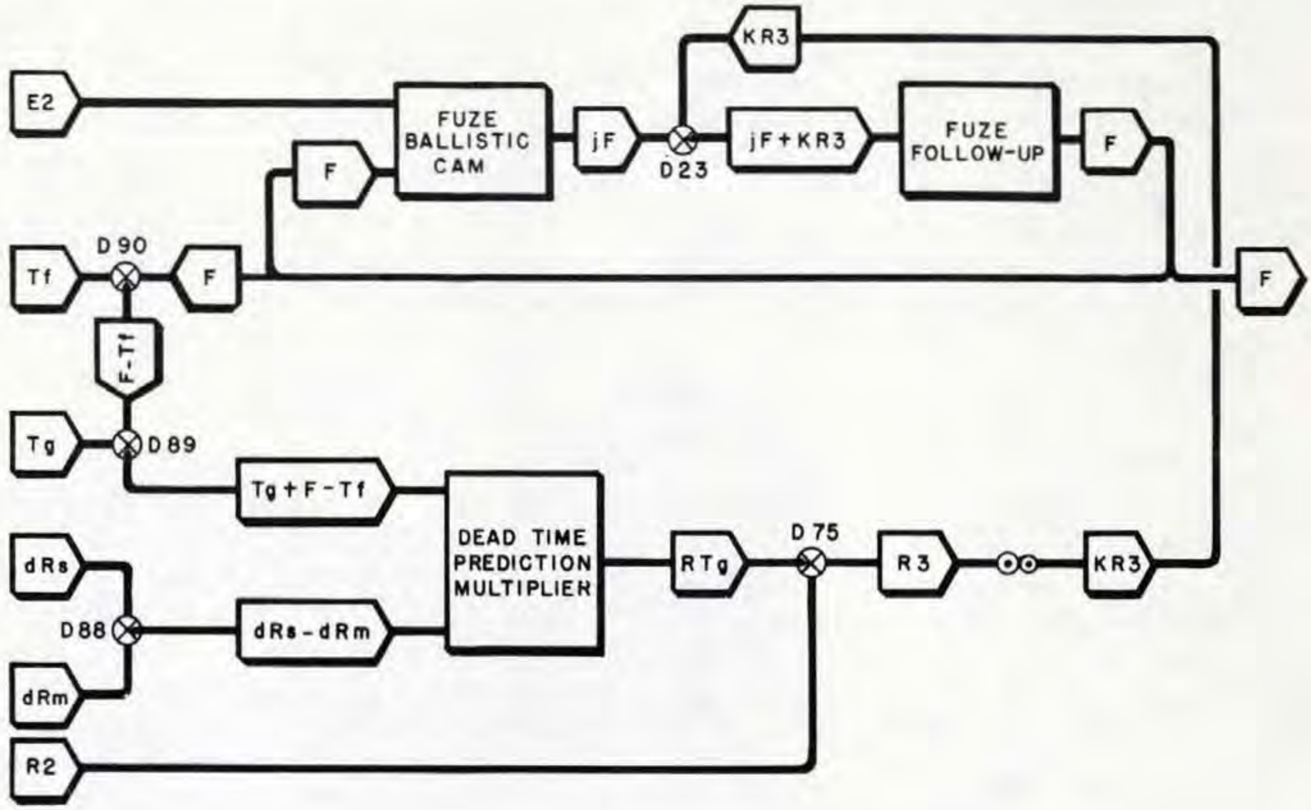


Figure 21. Fuze Computation Network.

From this, the formula for the instrument solution of RTg becomes:

$$RTg = (dRs - dRm)(Tg + F - Tf)$$

The subtraction of dRm from dRs is accomplished in differential D-88. The output of D-88 positions the input rack of the dead time prediction multiplier. Time of flight (Tf) is subtracted from fuze time (F) in differential D-90, and the difference is added to dead time (Tg) in differential D-89 resulting in ($Tg + F - Tf$), which becomes the input to the screw of the multiplier. The output of the multiplier is RTg.

The quantity, RTg, is added to advance range ($R2$) in differential D-75, producing fuze range ($R3$). The latter quantity is then used in the fuze ballistic computer to compute fuze setting order (F).

The fuze ballistic computer. The computation of fuze setting order is made in the following manner. Fuze range is multiplied by a constant (K) through gearing to produce the straight line approximation of fuze time ($KR3$). The quantity, $KR3$, drives through differential D-23 (figure 22) and offsets the contacts of the fuze follow-up control, causing the servo motor to rotate the cam of the fuze ballistic computer. The cam follower, which is also positioned axially by predicted target elevation ($E2$), puts out partial fuze setting order (jF). This supplies the second input to differential D-23. The output of D-23 then becomes the sum of $KR3$ and jF, or fuze setting order (F), which is amplified in torque by the fuze follow-up. The output of the fuze servo motor positions the fuze setting order transmitter, and acts regeneratively by supplying inputs to the fuze cam and to the dead time prediction multiplier. The use of the fuze servo motor to rotate the fuze cam relieves the load on the dead time prediction multiplier and other mechanisms.

Initial Velocity

The description given in OP 1064 (page 308) under the heading "Initial Velocity" is applicable to Computer Mk 1A if it is borne in mind that, wherever the value 2550 fs appears, it refers to the design *I.V.* of the instrument. Only Mods 8 and 12 have a design *I.V.* of 2550 fs. In applying the description to other mods, the appropriate values should be substituted.

Mods 13, 14, 15, and 16 contain a supplementary initial velocity correction to $Tf/R2$. It has already been described in this addendum under the heading, "The Elevation Prediction Network."

SPOTS

The description under the heading SPOTS given in OP 1064 (page 312) is applicable to the Computer Mk 1A. In the case of Mods 8 and 12, however, additional information is necessary since these mods are designed to permit firing at surface targets beyond the maximum value of the advance range limit stop by a system of elevation spots.

Elevation Spot for Surface Fire

Mods 8 and 12 compute superelevation in the same manner as other mods for values of advance range within the limits of 500 and 20,000 yards. Since 5"/54 cal. guns to which Mods 8 and 12 apply have extreme ranges exceeding 20,000 yards at low position angles (target elevation, E), it might be desired to fire at surface targets at these longer ranges. In such a case, computed superelevation will stop at the value corresponding to 20,000 yards advance range. The additional superelevation necessary is introduced as an UP elevation spot (Vj). This acts to increase gun elevation order. To aid in computing the magnitude of spot required, a transparent dial is superimposed on the elevation spot dial. (See figure 8.) This dial is calibrated in yards range, from 20,000 to 24,600. In operation, the elevation spot knob is turned until the overlay dial indicates the value of advance range, which, in such a case, must be determined independently of the computer. Range graduations on the overlay dial are spaced so that the value of the spot input will equal the additional superelevation required above 20,000 yards. The 20,000-yard graduation is aligned directly over the zero graduation of the Vj dial. Although the graduations for ranges greater than 23,500 overlay the DOWN graduations on the Vj dial, they have no meaning unless they have been brought to the fixed index by application of an UP spot.

Gun Orders

The description on gun orders given in OP 1064 (page 324) is applicable to Computer Mk 1A. However, Computers Mk 1A Mods 14, 15, and 16 transmit values of gun train order information in addition to the quantities covered in OP 1064.

This quantity is transmitted by a single, 10-degree per revolution, 7G synchro generator. The transmitter is equipped with a dial that has a single index mark engraved on it. The index, when matched against a fixed index, indicates the electrical zero position of the transmitter. Values of gun train order ($B'gr$) position the transmitter, which transmits these values to the multiple turret indicators.

THE SYNCHRONIZE ELEVATION GROUP

The description of the synchronize elevation group of Computer Mk 1 given in OP 1064 is applicable to Computer Mk 1A with the following addition.

The Elevation Transmitter

Computer Mk 1A (all mods) also transmits the value of target elevation (E). It is transmitted in two ways, by a synchro generator and by a potentiometer. The output of the potentiometer is used in conjunction with Radar Equipment Mk 25 Mod 2 for stabilizing a scope presentation on Radar Indicator Mk 22 Mod 0 with the display selector in the $\triangle E$ position. The synchro signal is available for later use in target practice analysis and for indication in Elevation Indicator Mk 6, in the director, if required.

PARALLAX

The description under the heading "PARALLAX" in OP 1064 is applicable to Computer Mk 1A with the exceptions given below.

Computer Mk 1A Mod 15 does not compute parallax in elevation due to a horizontal base (Pv). Instead, it computes another parallax quantity, parallax range, described below. With the omission of the Pv computation in Mod 15, a cosine output rack is not required in the parallax component solver and is therefore omitted.

Parallax Range

The Computer Mk 1A Mod 15 computes parallax range. This is a factor in the computation of the parallax correction that must be applied to gun train order to correct gun train for the horizontal base between the reference point and the gun. Since the train parallax computer provides Ph for the directors, another mechanism is needed to compute Ph for the guns. Such a mechanism is located at each gun. However, the Computer Mk 1A aids the computation by supplying one factor, namely, parallax range, equal to $sec\frac{(E2+L)}{R2}$. Transmitted to the guns, this quantity is then multiplied by sin $B'gr$ and the applicable constants to produce the required parallax correction.

In computing parallax range, the train parallax computer supplies sec $(E2+L)$, which is multiplied by $1/R2$ in the parallax range computer (see figure 22). The parallax range computer is a single-cam computing multiplier. The cam is positioned by advance range ($R2$) and computes $1/R2$. The input rack is positioned by sec $(E2+L)$ supplied by the train parallax computer. The output of the parallax range computer is $\frac{\sec(E2+L)}{R2}$.

Parallax range is transmitted to the guns by a single-speed transmitter. The transmitter dial is graduated in yards, from 1500 to infinity. The space between graduations varies inversely with advance range; that is, as the range increases the space between graduations decreases (see figure 23). This

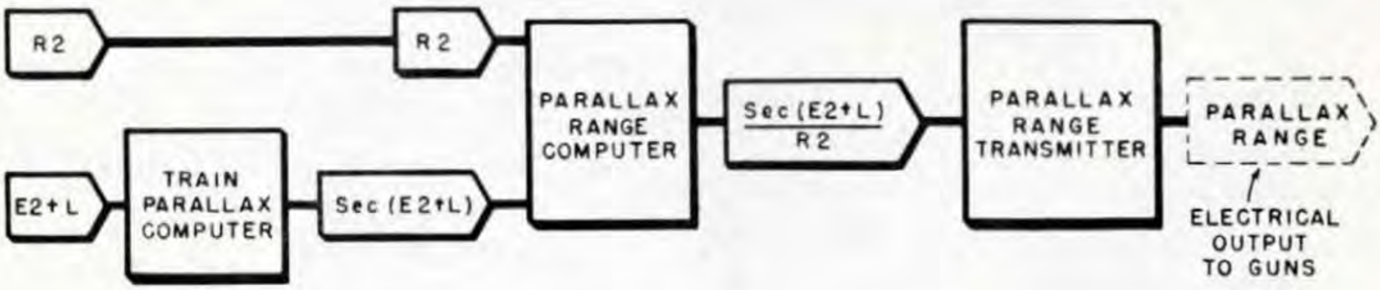


Figure 22. Parallax Range Network.

dial is used for test purposes only, the infinity mark indicating electrical zero of the transmitter, and a white dot on the dial (see figure 23) being used when adjusting the parallax range computer. The range graduations are used to test the accuracy of the instrument computations, *E2* and *R2* being set in the computer and the resulting value of parallax range being read on the dial.

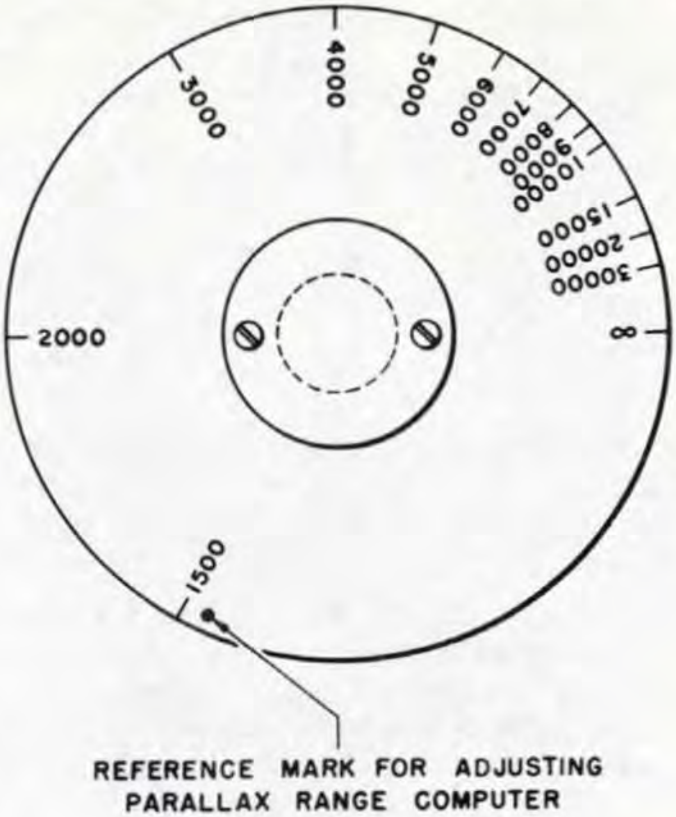


Figure 23. Parallax Range Dial.

Elevation Parallax Correction, *Pe*

The vertical base for the computation of elevation parallax correction (*Pe*) for the various modifications of Computer Mk 1A is as follows:

Mods 8, 13, 15 .... 30 feet
Mod 12 .... 55 feet
Mod 14 .... 40 feet
Mod 16 .... 15 feet
Mod 17 .... 39 feet
Mod 18 .... 0 feet
Mod 19 .... 20 feet

MOD DIFFERENCES

Serial Numbers

The code used in assigning serial numbers to Computers Mk 1A indicates where the instrument was modernized, as follows:

SERIAL NUMBERS	MODERNIZED BY
1001 to 1699	Ford Instrument Company, Division of The Sperry Corporation
1700 to 1799	Mare Island Naval Shipyard
1800 to 1826	New York Naval Shipyard
1900 to 1925	Naval Gun Factory

Note: Serial numbers 2001 and up designate computers Mk 1 which were manufactured by the International Business Machines Corporation.

List of Fordalts

The list of Fordalts given on pages 388 and 389 of OP 1064 should be supplemented by the following:

FORDALT

192—Increases limits of *E*, and adds *F* intermittent drive.

193—Disconnects (*T*/*cR*) sec *E* counter drives.

194—Replaces fabricated cover for sensitivity unit with a cast cover.

195—Redesigns 5-inch integrator to restrain carriage from rocking in the direction of travel.

199—Converts Mk 1 Mod 6 (Serial No. 101 to 215) to Mk 1A Mod 13.

200—Alters Ordalt 2331 into 2331A to provide adjustable smoothing of solution data for surface fire control.

201—Redesigns 5-inch integrator to strengthen ball retaining studs, and to provide finer adjustment of horizontal rollers.

202—Redesigns 5-inch integrator to align integrator carriage correctly.

206—Converts two Computers Mk 1 Mod 8 and two Computers Mk 1 Mod 12 to Mk 1A Mod 17.

221—Converts Computer Mk 1 Mod 13 to Computer Mk 1A Mod 19.

List of Ordalts

The list of Ordalts given on page 390 of OP 1064 should be supplemented by the following:

ORDALT

2331A—Provides target vector rate control system (Mods 8, and 12 to 16).

2332—Increases limits of *Sh*, *So*, *Sw*, *dH*, *dR*, *dRh*, *RdE*, and *RdBs* (Mods 8, and 12 to 16).

2336—Provides for the transmission of *E* from both a potentiometer and a synchro generator (Mods 8, and 12 to 16).

2338—Changes, by replacement, *I.V.* dial under cover No. 3 (Mods 0 to 7, 9, 10, and 13).

2339—Replaces ballistic cams to incorporate new 5"/38 cal. data as compiled in OP 551A (Mods 0 to 7 and 13).

2612—Alters Star Shell Computer Mk 1 Mod 2 by replacing 6DG synchro generators with 6G synchro generators.

2614—Provides for aleration of Mods 8, 13, and 14 instruments for use in AG128: On Mods 8 and 14, by replacement of dip dial and $Vf + Pe$ cam; on Mod 13, by replacement of dip dial and all ballistic cams.

2620—Installs micro-switch on $1/cR$ cam to open rate control clutch circuits below 1500 yards (all mods).

2626—Incorporates operating control circuit changes which provide for:

1. Starting time motor automatically.
2. Automatically matching generated and observed range dials when range rate control switch is at AUTO.
3. Elimination of the requirement for an initial estimate of target motion (Mods 8, 12, 13, and 15).

2694—Provides *Pe* for vertical base of 55 feet and dip correction for 100 feet director height (six Mod 12 instruments only — two each on CVB 41, 42, and 43).

2894—Reduces oscillations in *R2*, *E'g*, and *F* (Mod 13 only).

2918—Removes limit stop L-36 (Mods 8, and 12 to 16).

2963—Same as Ordalt 2626 (for Mods 14 and 16 only).

3091—Changes time switch and removes target speed (Mods 8, and 12 to 16).

Table of Modification Differences

Information concerning modification differences of Computer Mk 1A Mod 8, and Mod 12 through Mod 19 is given in tabular form on the following pages. This information corresponds to that given on pages 399 and 399A of OP 1064 for Computer Mk 1.

It should be noted here that Computer Mk 1A Mods 17 and 19 are for use in Gun Fire Control System Mk 67. They therefore differ from the other modification in more ways than can be indicated in the tables. Reference should be made to OP 1064G Computer Mk 1A Mods 17 and 19 for further information on these modifications.

MISCELLANEOUS									
MOD NUMBER	8	12	13	14	15	16	17	18	19
Gun	5"/54	5"/54	5"/38	6"/47	8"/55	6"/47	5"/54	5"/54	5"/38
Pe Base	30 ft.	55 ft.	30 ft.	40 ft.	30 ft.	15 ft.	39 ft.	0	20 ft.
Dip Base	22 yd.	13 yd.	17.83 yd.	70 ft.	59 ft.	45 ft.	Variable		Variable
Parallax Driven By	Either by *B'gr* or *B'r* Selected by A-242								
Star Shell Computer	Mk 1 Mod 2	Mk 1 Mod 2	Mk 1 Mod 0 or 1	Mk 1 Mod 3	None	Mk 1 Mod 3	Mk 1 Mod 4	Mk 1 Mod 2	Mk 1 Mod 6
LIMITS									
Present Range	0 35,000 yd.								
Advance Range (yd.)	500 20,000	500 20,000	500 18,000	500 20,200	500 20,000	500 20,200	500 20,000	500 20,000	500 18,000
Target Height	0 50,000 ft.								
Range Spot	IN 12,000 yd. OUT 1800 yd.								
Mech. Fuze (sec.)	0.60 49.00	0.60 49.00	0.60 55.00	0.60 49.00	0.60 49.00	0.60 49.00	0.60 49.00	0.60 49.00	0.60 55.00
Time of Flight (sec.)	0.60 50.60	0.60 50.60	0.60 60.60	0.60 50.60	0.60 50.60	0.60 50.60	0.60 50.60	0.60 50.60	0.60 60.60
Ship Speed	0 90 kn.								
I.V. (ft/sec.)	2400 2650	2400 2650	2350 [illegible]	2250 [illegible]	2400 [illegible]	2250 [illegible]720	2400 2650	2400 2650	2350 2600

TABLE OF MODIFICATION DIFFERENCES (*Continued*)

LIMITS (*Continued*)									
MOD NUMBER	8	12	13	14	15	16	17	18	19
Elevation Spot (mils)	UP 342.5 DOWN 180	UP 342.5 DOWN 180	UP 180 DOWN 180	UP 180 DOWN 180	UP 180 DOWN 180	UP 180 DOWN 180	UP 342.5 DOWN 180	UP 342.5 DOWN 180	UP 180 DOWN 180
Elevation	−25° +85°								
INTERMITTENT DRIVES									
Ds	None	None	320 680	None	390 590	None	None	None	None
Vs	None	None	2000 3800	None	2000 4460	None	None	None	None
cR	750 yd. 22,500 yd.								
E	−2° +85°								
R2 (yd.)	1500 18,900	1500 18,900	None	1500 18,900	1500 18,900	1500 18,900	1500 18,900	1500 18,900	None
RECEIVERS									
So	40.0 kn.								
R	2000 yd. and 72,000 yd.								
$L+\frac{Zd}{30}$ Shaft							None	Prov.	None

TABLE OF MODIFICATION DIFFERENCES (*Continued*)

TRANSMITTERS									
MOD NUMBER	8	12	13	14	15	16	17	18	19
Train Parallax	7G's 30°						5HG's 10° 360°	7G 30°	5HG400 30°
Elevation Parallax	7G's 10°				None	7G 10°	5HG's 10° 360°	7G 10°	None
Parallax Range	None				7G 0.001	None	None	None	None
Sight Angle	7G's 200′ 7200′		6G's 2400′ 200′ 7200′	7G's 200′ 7200′	7G's 100′ 3600′	7G's 200′ 7200′	18CX4's 1-speed 36-speed	7G's 200′ 7200′	5HG400's 200 7200
Sight Deflection (Mils)	7G's 100 4000		6G's 442.24 100 4000	7G's 100 4000	7G 210.48	7G's 100 4000	18CX4's 1-speed 36-speed	7G's 100 4000	5HG400's 100 4000
Fuze (sec.)	7G's 2 100				7G's 20/7 360/7	7G's 2 100	5HG's 72/7 360/7	7G's 2 100	5HG400's 2 100
Elevation & Bearing Correction	6G's — 5° Auto. 5G's — 10° Ind.						5G's 10°	6G's 5° 5G's 10°	5G's 10°
B'gr Information	None			7G's 10°			None	None	None

RESTRICTED

COMPARATIVE INDEX

Index of Pages in OP 1064, wherein description does not accurately cover Computer Mk 1A, and corresponding pages in Addendum covering differences.

OP 1064 Page	OP 1064 Addendum No. 1 Page	Remarks
12, 13	2	Basic Mechanisms.
22, 23	3	Types of Targets and Attack.
24	3	Variation in determination of target motion rates.
28, 29, 30	3	Tracking.
50 to 55	3	The Rate Control Group.
56 to 61	4, 5	Rate Control. Also see Detailed Description of rate control in Addendum.
67	5	Parallax.
68, 69	5	Star Shell Computer — additional mods.
70, 71	5	Additional Outputs.
72 to 75	6 to 13	Operating Limits.
77	14	Design *I.V.*
80	15	Operating Controls
84, 85	15	
86	15	
87	15	
92	15, 17	
93	17	
94 to 101	17, 18	No Semi-Auto. Ordalt 2626 changes.
104	18	Use of *Vj* spot for ranges beyond 20,000 yards on Mods 8, 12.
106	19	Signal light omitted.
107	19	
110 to 113	20	No Semi-Auto.
114, 115	20, 21	
116 to 137	21, 22	
142	22	
156, 157	22	
172 to 201	23, 24	Values of speed and related lines only.
202 to 265	24 to 46	Rate Control
268 to 269	46	Shaft Values
276	47	Design *I.V.* of particular mod must be applied.
277	47	*Tf* ballistic computer.
282, 283	47	*R2m* input to *Tf/R2* ballistic cam.
285	48	*Vf* + *Pe* ballistic computer.
286, 287	48	Design *I.V.* not 2550 fs for all mods.
288, 289	48, 49	Fuze
290, 308, 309, 310	50	Design *I.V.* not 2550 fs for all mods.
312	50	Elevation spots for long range surface fire (Mods 8, 12).
324	50	Gun Train Order Information (Mods 14, 15, and 16).
332	50, 51	Elevation Transmitter.
338 to 351	51	Parallax Range; Vertical Parallax Base.

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