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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.

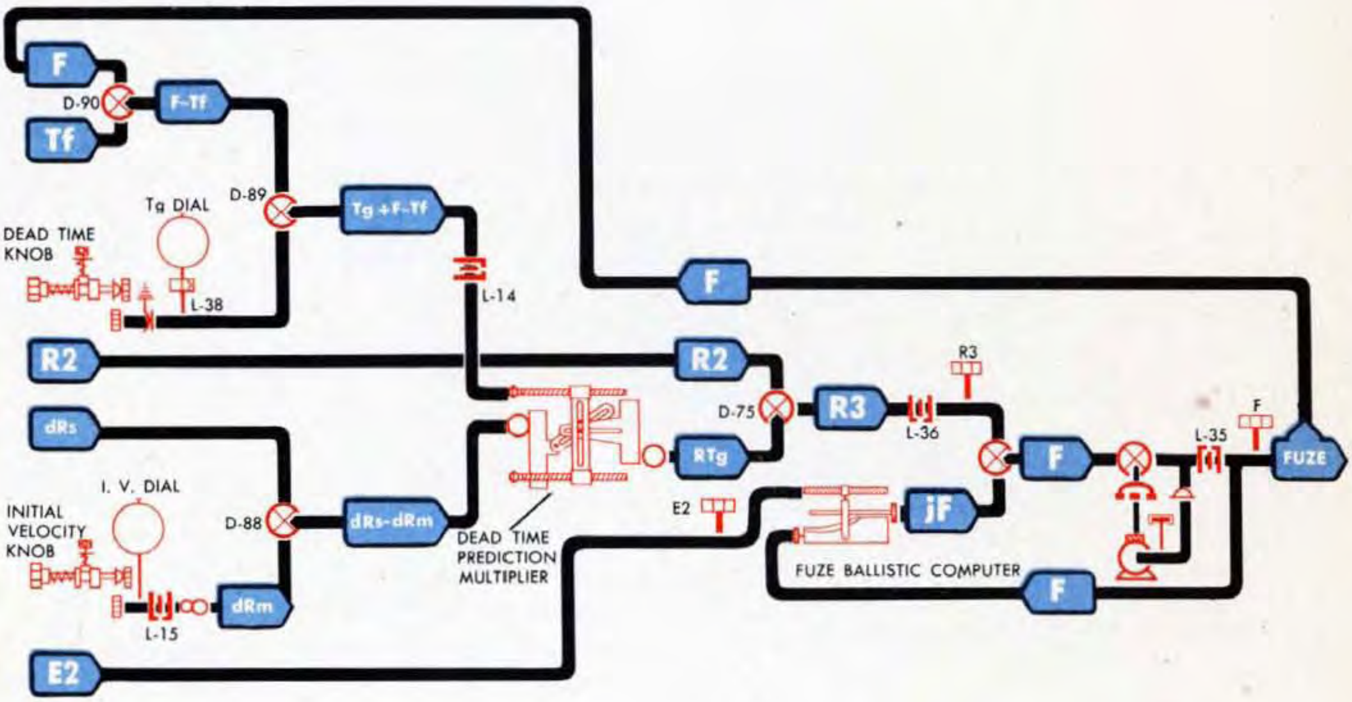
The output of the Dead Time Prediction Multiplier is RTg. The old equation was $RTg = K \times dR \times Tg$. The new equation is $RTg = K\ (dR + dRxe)\ (Tg + F - Tf)$. For convenience of design, the factor $(dR + dRxe)$ is computed as $(dRs - dRm)$.

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						
2		5"/38 single	DD's Aux.			B'gr	
1	21-28 45-56	5"/38 twin	BB's CL's				None
9	29	5"/38 both	CV3				
3		5"/38 twin	BB's 58-60			B'r	
10	100	5"/38 both	CV3				
4	Below 101 Above 100	5"/38 twin	CL's CA's BB's	30 feet	17.83 yards		
6		5"/38 single	DD's			B'gr	
5	58-59		CV8				
"Old" 7	187-188 193-200		CV's DD'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
"Univ" 7	216-389 390-518 519-567	5"/38 both					
11	*		All	0			
13	568-780 781-810 811-			30 feet			
8	*				22 yards	Either B'gr or B'r selected by A-242	Star Shell Computer Mk 1 Mod 2
12	*	5"/54	CVB	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 40			
2	0 22,500	1500 18,000	0 25,000	IN 1800 OUT 1800	0.60 45.05	1.80 61.80				
1										
9										
3										
10				IN 12,000 OUT 1800	0.60 55.00					–5 +85
4								Originally 2450-2600; changed to 2350-2600 by OD 5106	UP 180 DOWN 180	
6				IN 1800 OUT 1800		0.60 60.60	0 45			
5					0.60 45.00					
"Old" 7	0 35,000	500 18,000	0 50,000							
"Univ" 7										
11					0.60 55.00			2350 2600		
13										
8				IN 12,000 OUT 1800						–25 +85
12		500 20,000			0.60 49.00			2400 2650	UP 342.5 DOWN 180	
15		*			0.60 45.60	0.60 50.60		2400 2700	UP 180 DOWN 180	
14					0.60 49.00			2250 2720		

Intermittent Drives and Receivers

Mod No.	Ds	Vs	cR	E	R2	So	Radar Range	Range	$L + \frac{Zd}{30}$ Shaft
0						None			None
2	320 680	2000 3800	None			21.8 34.5 40.0			
1									
9						30.0 34.5			
3	None	None							
10				None		30.0 34.5			
4					None	40.0			
6						25.0 40.0	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	Provided
5						34.5			
"Old" 7	320 680	2000 3800	750 22,500						
"Univ" 7									
11									
13						40.0			
8				–2 +85					
12	None	None					None	2000 and 72000 yards	
15	390 590	2000 4460			1500 18900				
14	None	None							

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
0							ORDALT 2266		
2	6 G's @ 30°			6 G's @ 2400	6 G's @ 442.24	6 G's @ 2 and 100			
1				6 G's @ 200 & 7200	6 G's @ 100 & 4000				None
9		None		ORDALT 1182	ORDALT 1182				
3				7 G's @ 200 and 7200	7 G's @ 100 and 4000				
10				ORDALT 1182	ORDALT 1182				
4				7 G's @ 200 and 7200	7 G's @ 100 and 4000				
6			None	7 G's @ 2400	7 G's @ 442.24			None	
5						7 G's @ 2 and 100	6 G's @ 5° Auto. and 5 G's @ 10° Ind.		Originally provided; removed by OD 5146
"Old" 7	7 G's @ 30°								
"Univ" 7		7 G's @ 10°		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				
11									
13									
8									
12				7 G's @ 200 and 7200	7 G's @ 100 and 4000				None
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			
14		7 G's @ 10°	*	7 G's @ 200 and 7200	7 G's @ 100 and 4000	7 G's @ 2 and 100		7 G's @ 10°	

*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

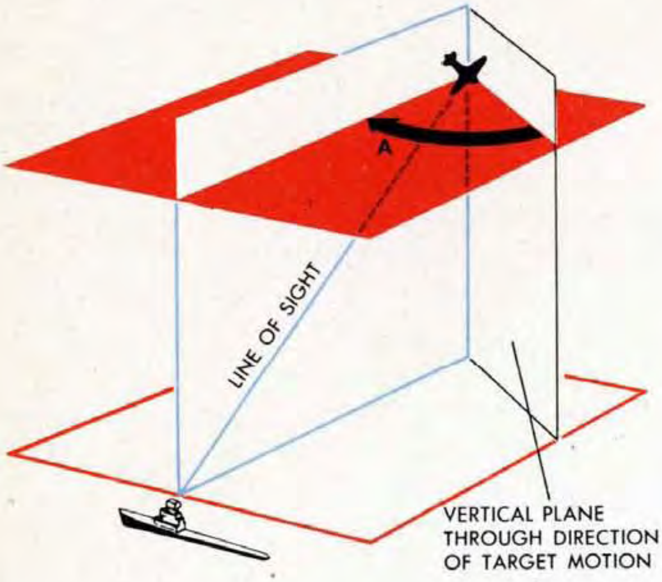
f( ) Function of the quantity in parentheses

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).

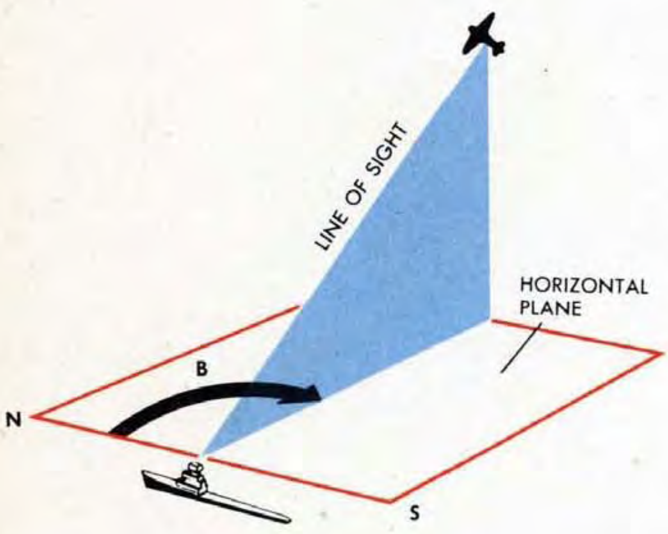
3 After a quantity indicates that it is the predicted value of that quantity for fuze position; i.e., for the instant a projectile, fired dead time seconds from the present time, hits (bursts for anti-aircraft fire).



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.

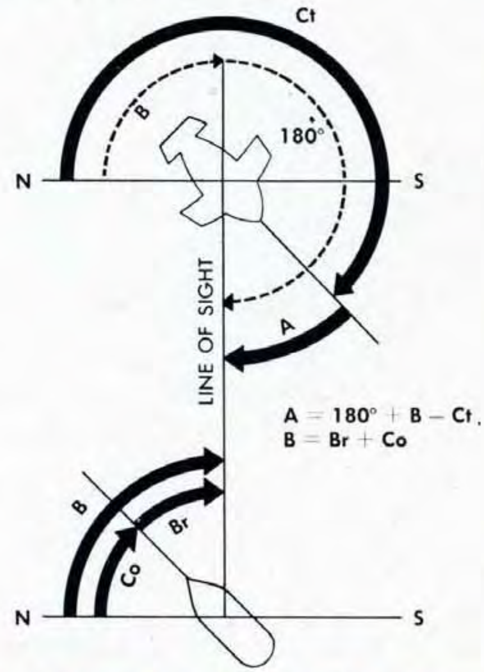
$$A = 180^\circ + B - Ct$$



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

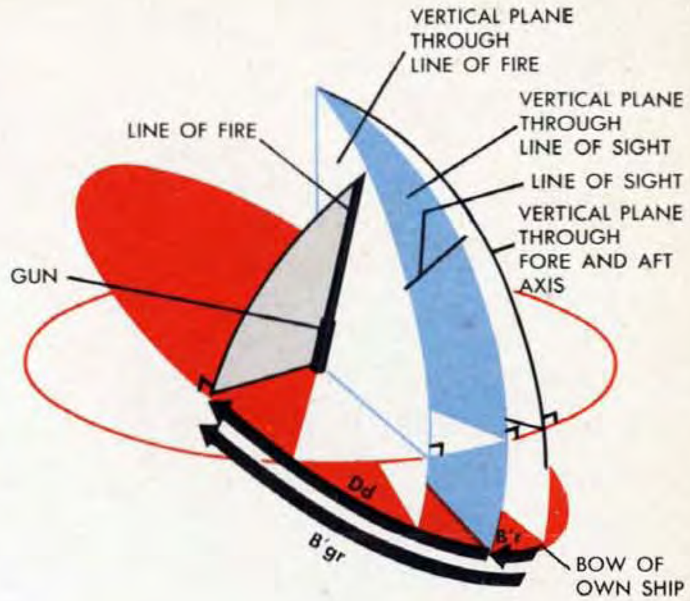
Changes of Relative Target Bearing computed by the instrument.

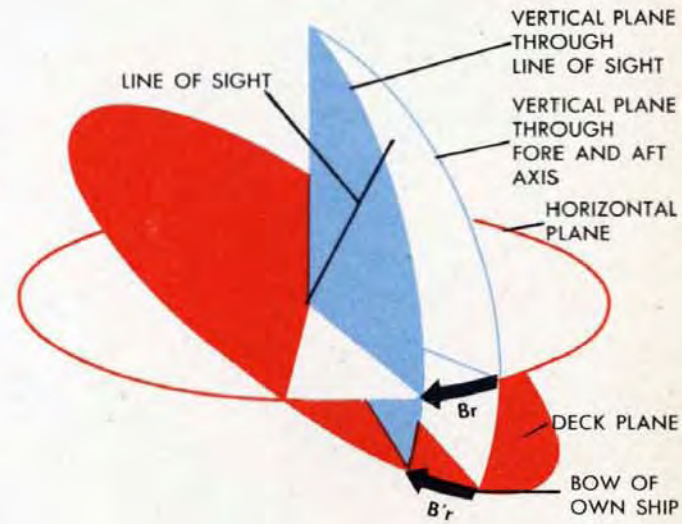
$$\triangle cBr = \triangle cB - Co$$

ΔcB'r INCREMENT OF GENERATED DIRECTOR TRAIN

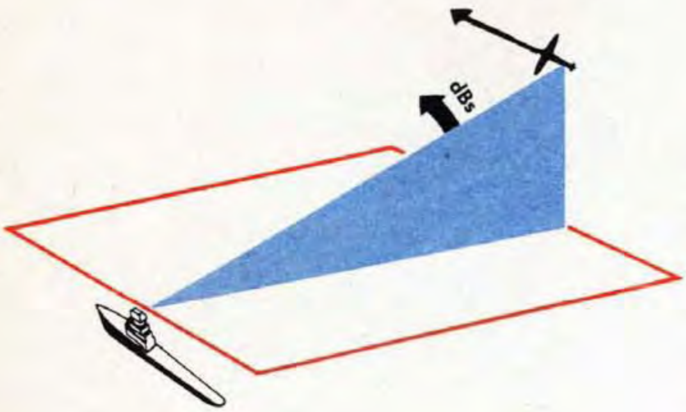
Changes of Director Train computed by the instrument. (Bearing Correction.)

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





jBr INITIAL OR CORRECTIVE SETTING OF GENERATED RELATIVE TARGET BEARING

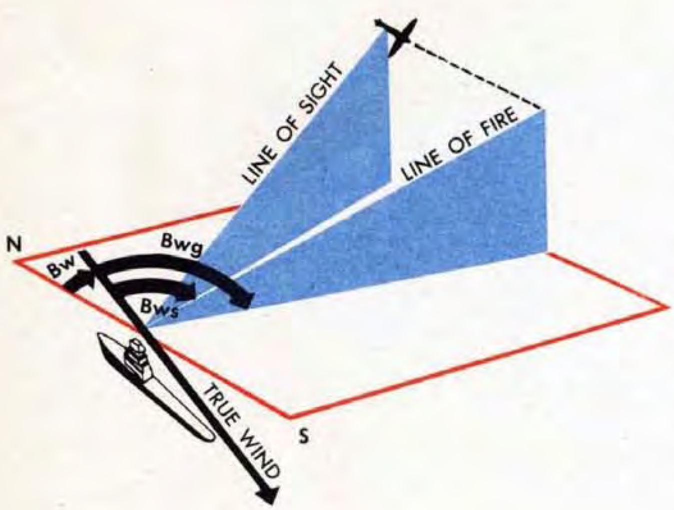


jB'r DECK TILT CORRECTION

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

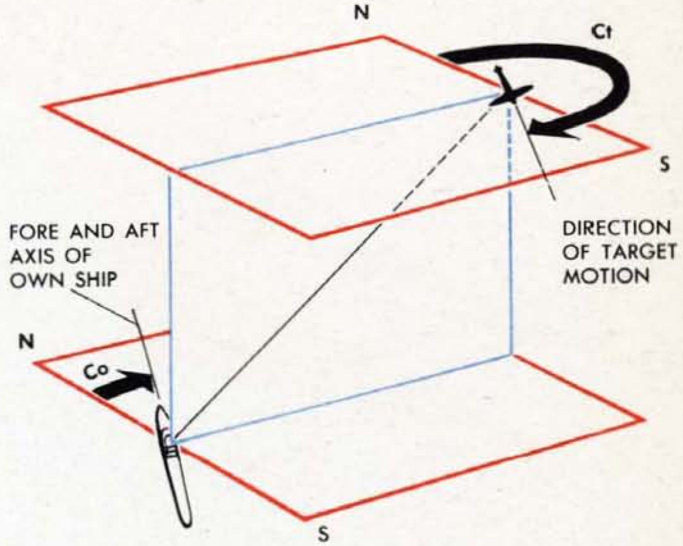
The angle between the direction *from* which the Wind is blowing and the vertical plane through the Line of Sight, measured in the horizontal plane clockwise from the direction from which the Wind is blowing.

Co SHIP COURSE

Compass heading of Own Ship.

Ct TARGET COURSE

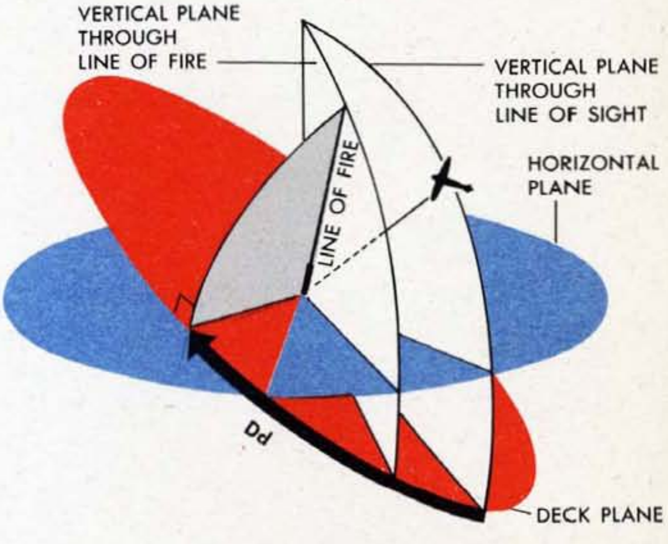
Compass Direction toward which the Target is moving.



Dd DECK DEFLECTION

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

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



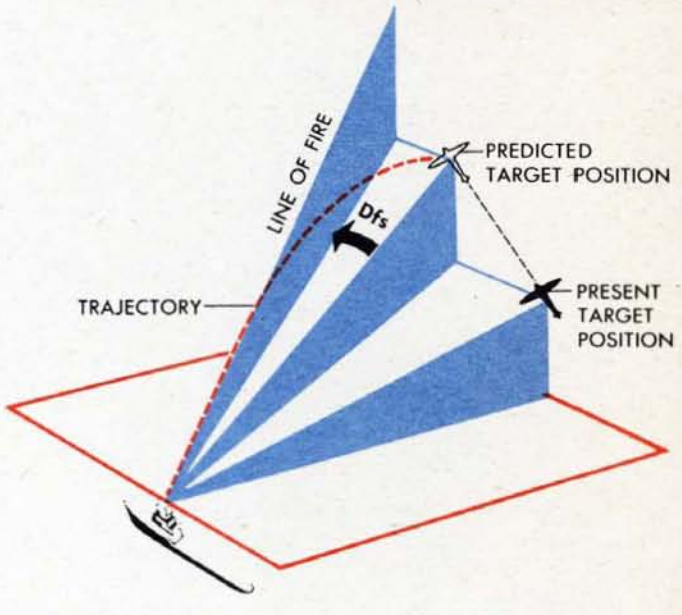
jDd PARTIAL DECK DEFLECTION

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

Dfs DRIFT CORRECTION

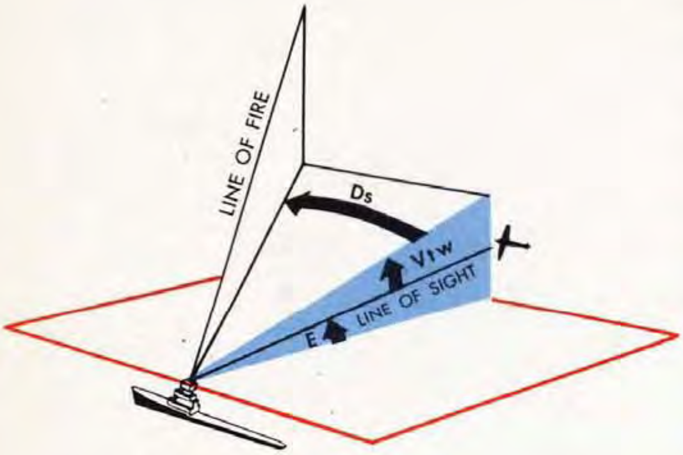
The lateral Deflection angle to compensate for drift of a projectile, measured in the slant plane through the Predicted Target Position.

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



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

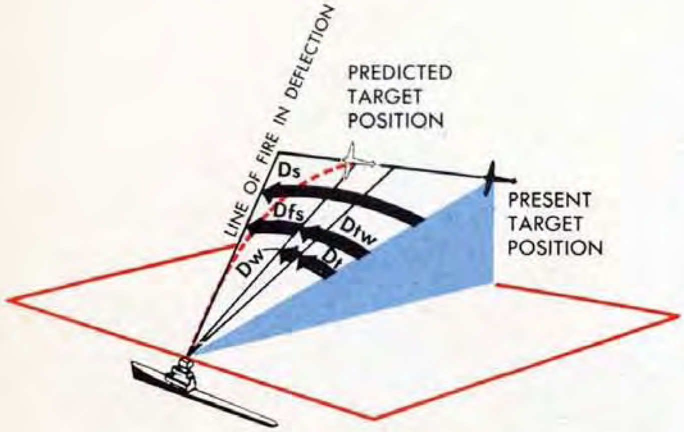
The angle between the vertical plane containing the Line of Sight and the vertical plane through the Line of Fire, measured in the plane at right angles to the vertical plane containing the Line of Sight, at angle *Vtw* above the Line of Sight. *Ds* is positive when the gun is trained to the right of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

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

$$Ds = Dtwj - Dfs$$

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.)



HERE Dt, Dw, Dtw, AND Ds ARE NEGATIVE

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

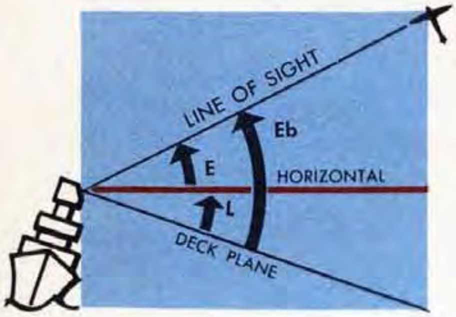
One term of a mechanism equation used in computing *Dd;* it represents approximately the Trunnion Tilt Train Correction to compensate for Cross-level.

$$Dz + jDd = Dd$$

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

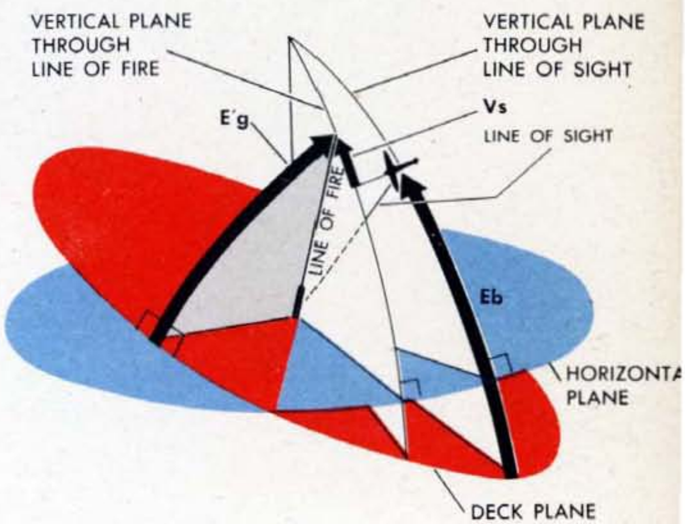
jEc LINEAR ELEVATION RATE CORRECTION

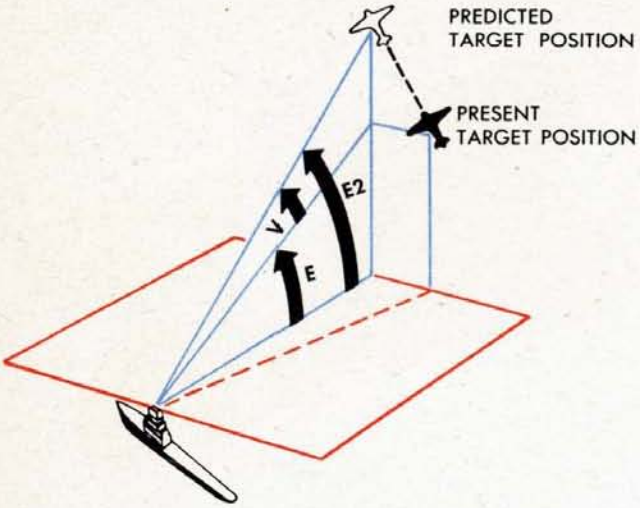
Rate Control Correction primarily affecting Linear Elevation Rate.

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.

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



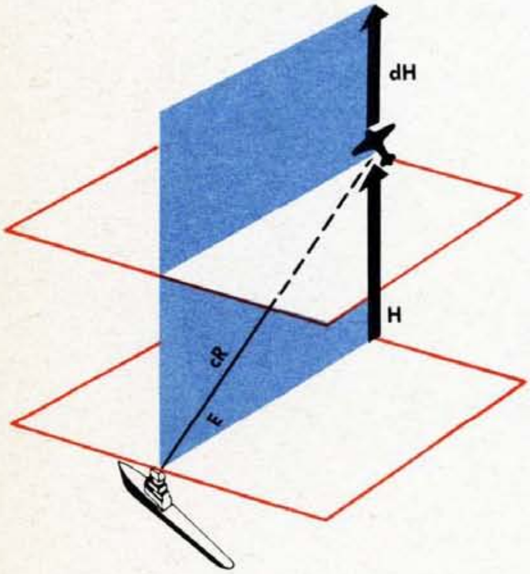


E2 PREDICTED TARGET ELEVATION

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.

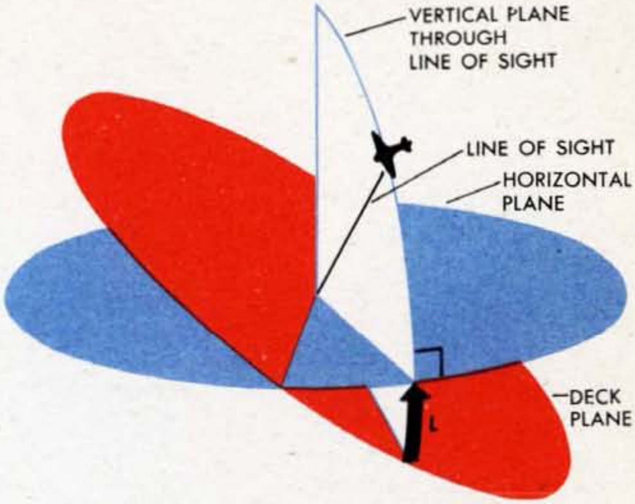
I. V. INITIAL VELOCITY OF PROJECTILE

K, K_1, K_2, etc. CONSTANTS

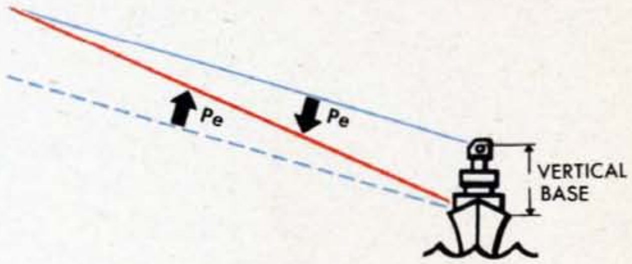
Two or more constants in the same expression are distinguished by numbers.

L LEVEL ANGLE

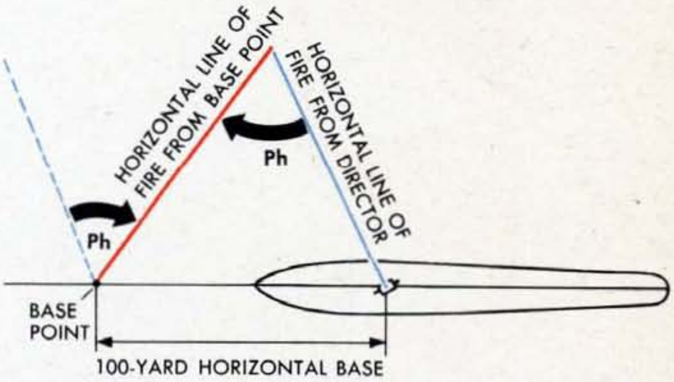
The angle between the horizontal plane and the deck plane, measured in the vertical plane through the Line of Sight. *L* is positive when the deck toward the Target is tilted down.



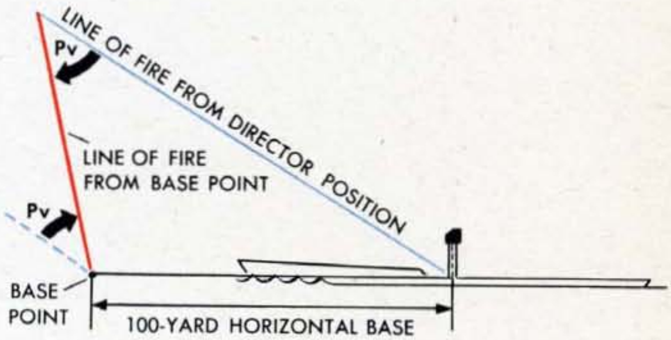
Pe ELEVATION PARALLAX CORRECTION FOR VERTICAL BASE



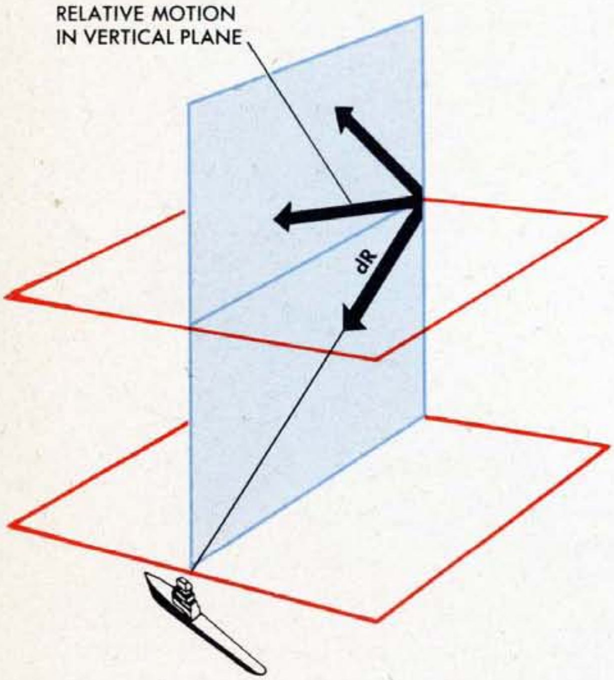
Ph TRAIN PARALLAX CORRECTION FOR HORIZONTAL BASE

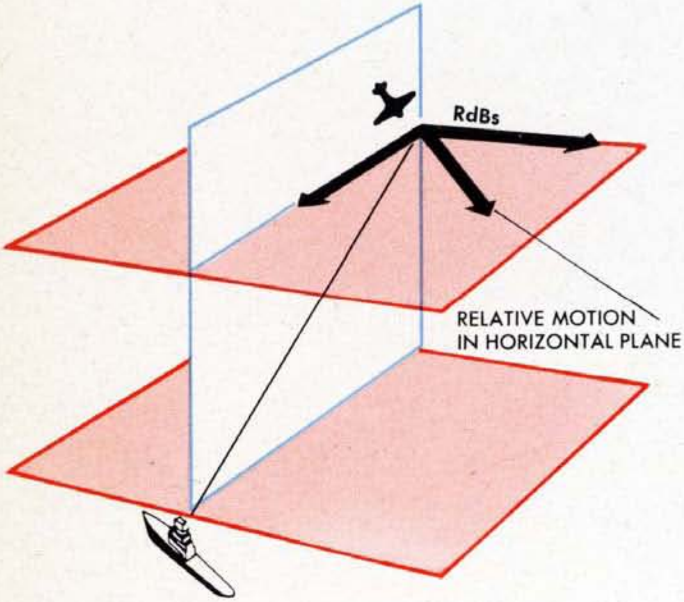


Pv ELEVATION PARALLAX CORRECTION FOR HORIZONTAL BASE



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

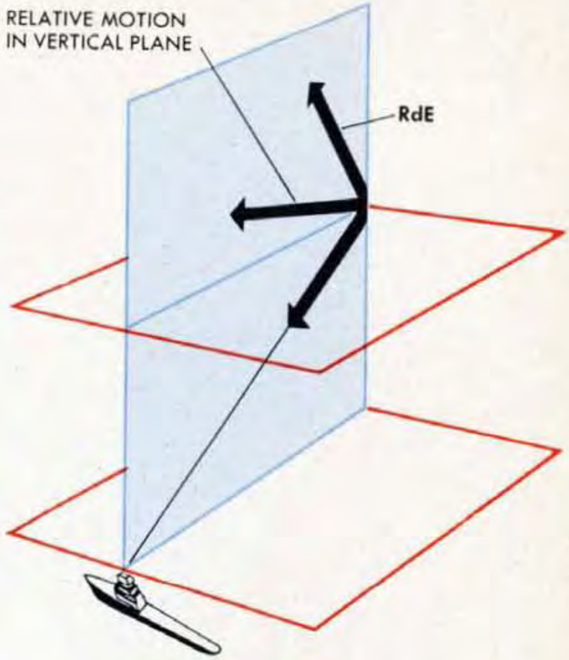
Applied to Generated Range.

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.

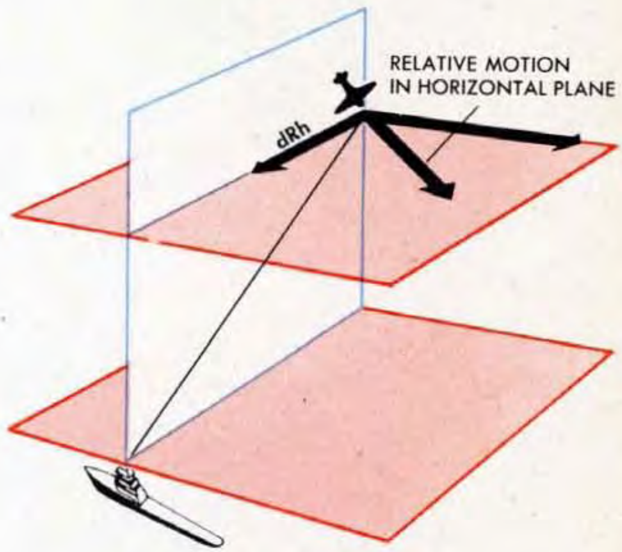
RdE LINEAR ELEVATION RATE

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.

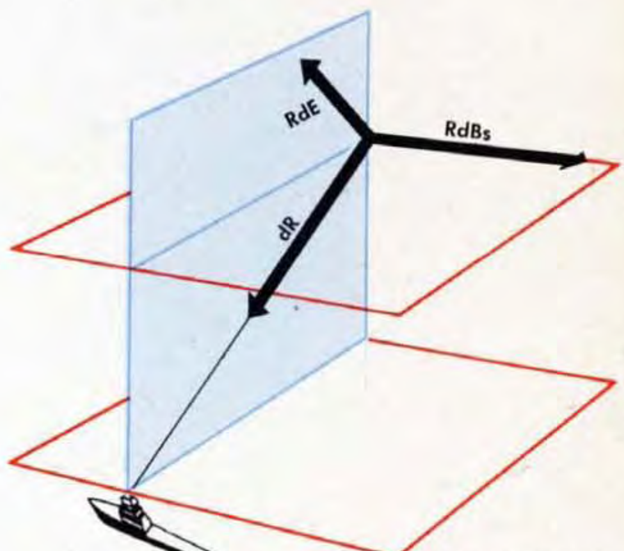
Rj RANGE SPOT

Rm

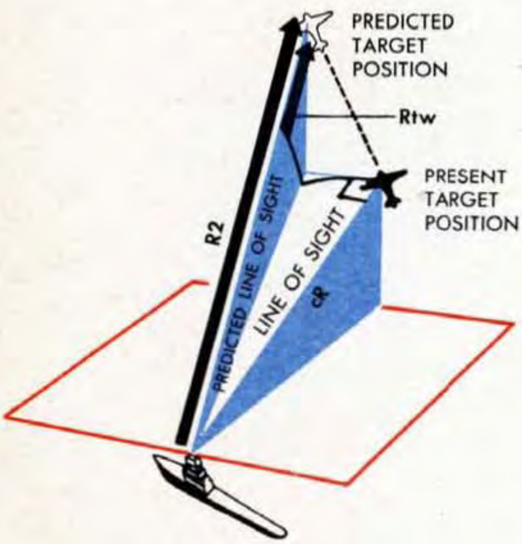
Correction to Range Prediction for a change in *I.V.* from 2550 f.s.

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)

$$R2 = cR + Rtwm + Rj$$

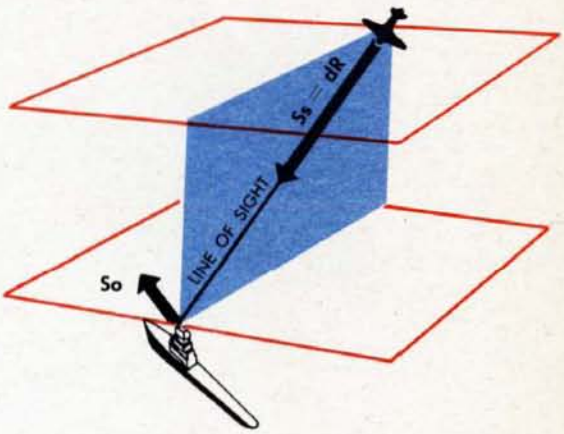
R3 FUZE RANGE

$$R3 = R2 + RTg$$

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.

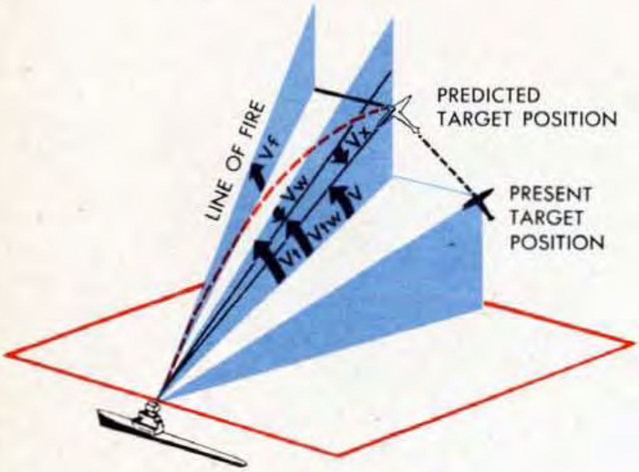
T/cR **TIME DIVIDED BY GENERATED PRESENT RANGE**

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.

$$V = Vtw - Vx + Vj$$

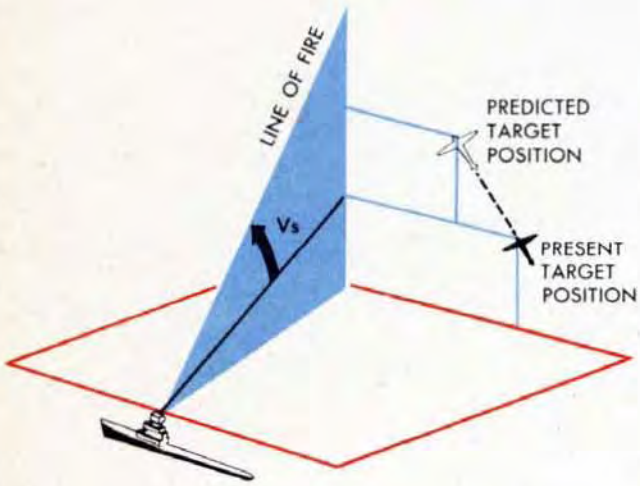
Vf SUPERELEVATION

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



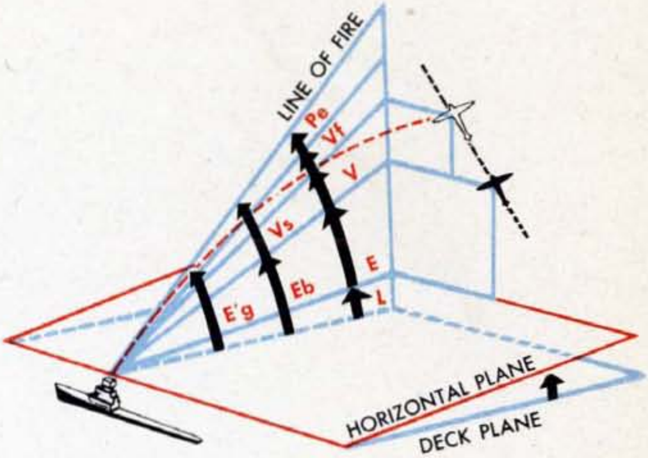
Vs SIGHT ANGLE

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

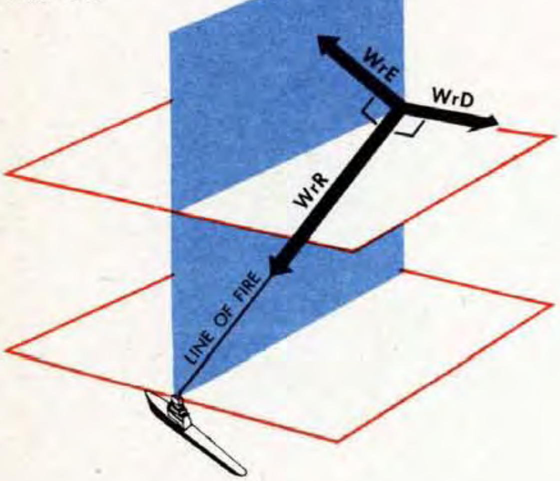
$$Vtw = Vt + Vw$$

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.

$$WrE = Ywgr \sin K \cdot E2$$

WrR RANGE WIND RATE

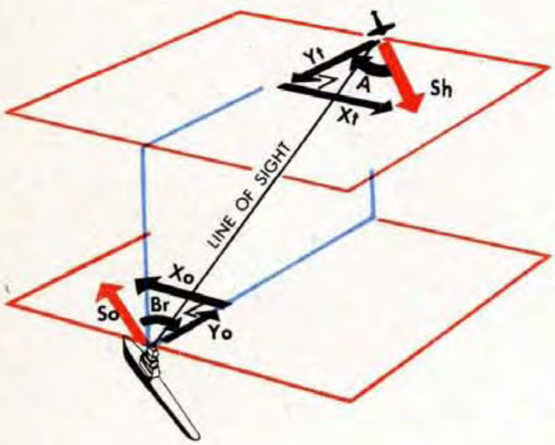
The component of Apparent Wind Velocity affecting Range Prediction.

$$WrR = Ywgr \cos K \cdot E2$$

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

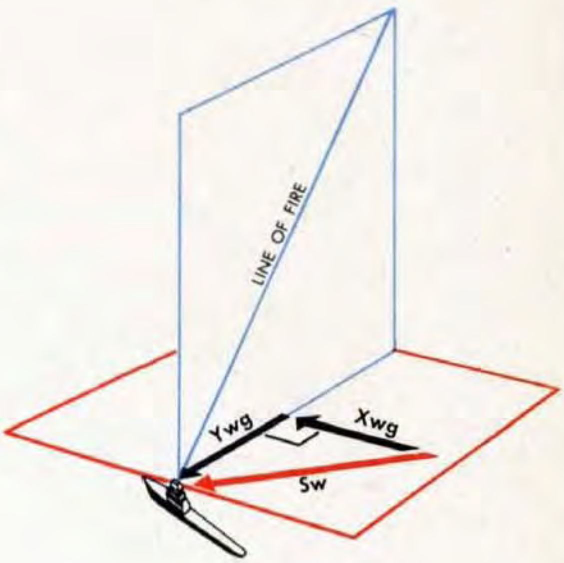
Horizontal component of Target Velocity at right angles to the vertical plane through the Line of Sight. (Deflection component.)

$$Xt = Sh \sin A$$

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

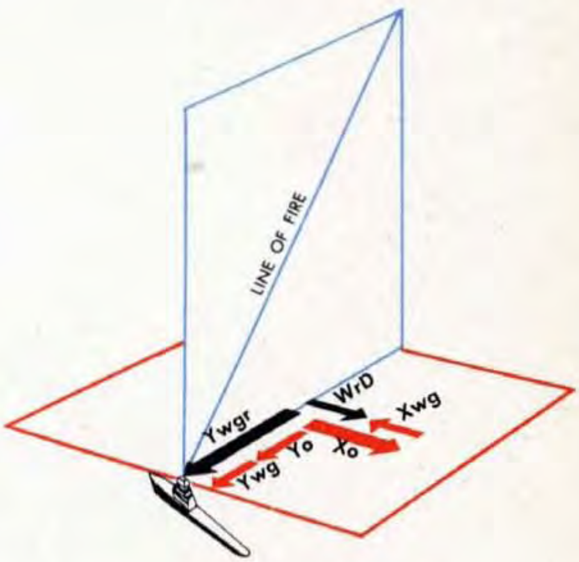
Horizontal component of Own Ship Velocity in the vertical plane through the Line of Sight. (Horizontal range component.)

$$Yo = So \cos Br$$

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.)

$$Ywg = Sw \cos Bwg$$

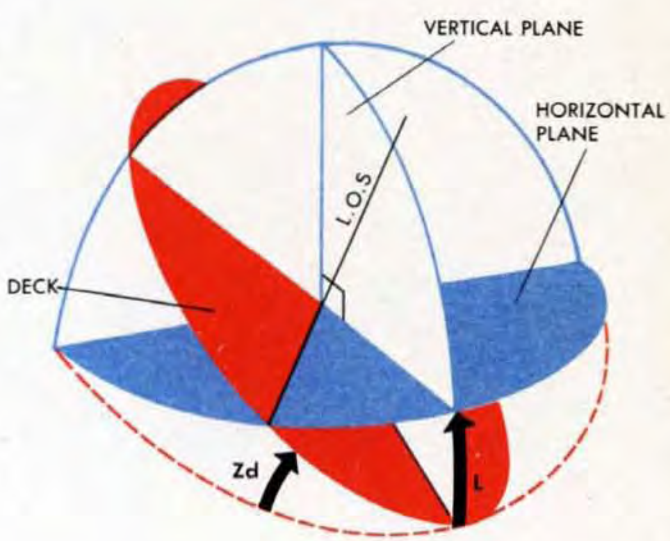
Ywgr

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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SUMMARY OF INPUTS

Target Inputs

Own Ship Inputs

Wind Inputs

Rate Control Inputs

Deck Inclination

Spots

Other Inputs

Star Shell Inputs

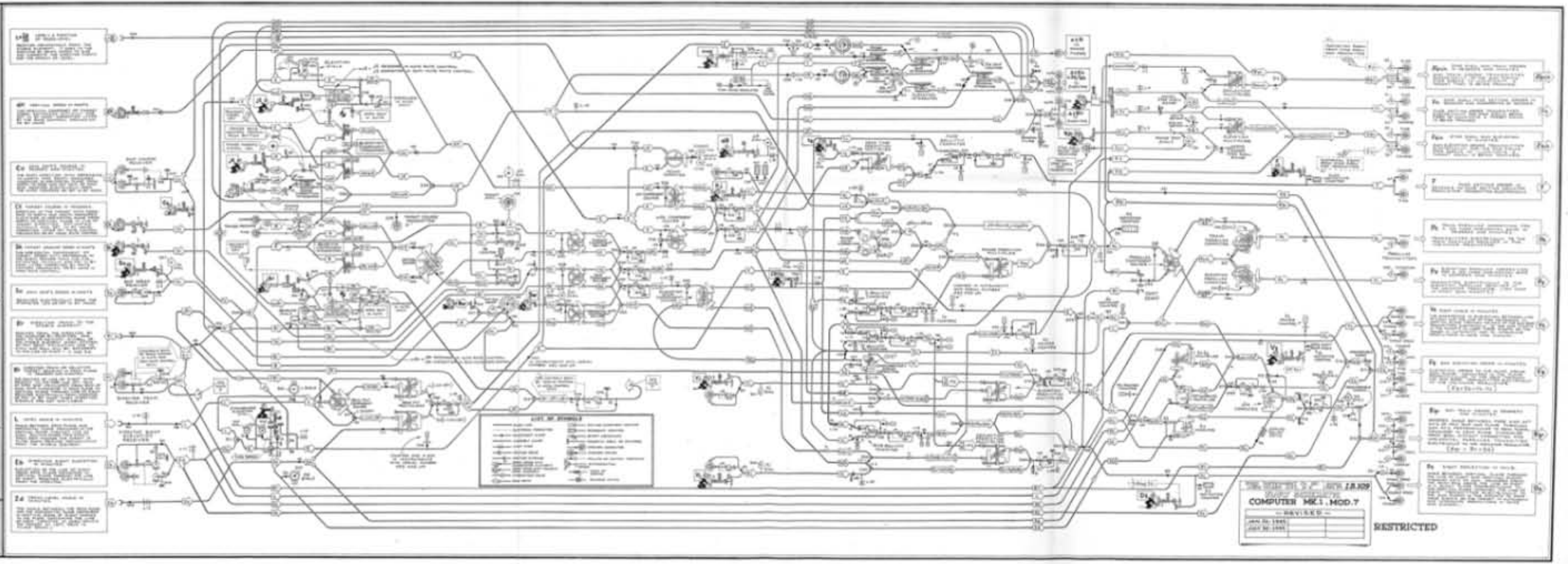
SUMMARY OF INTERMEDIATE QUANTITIES

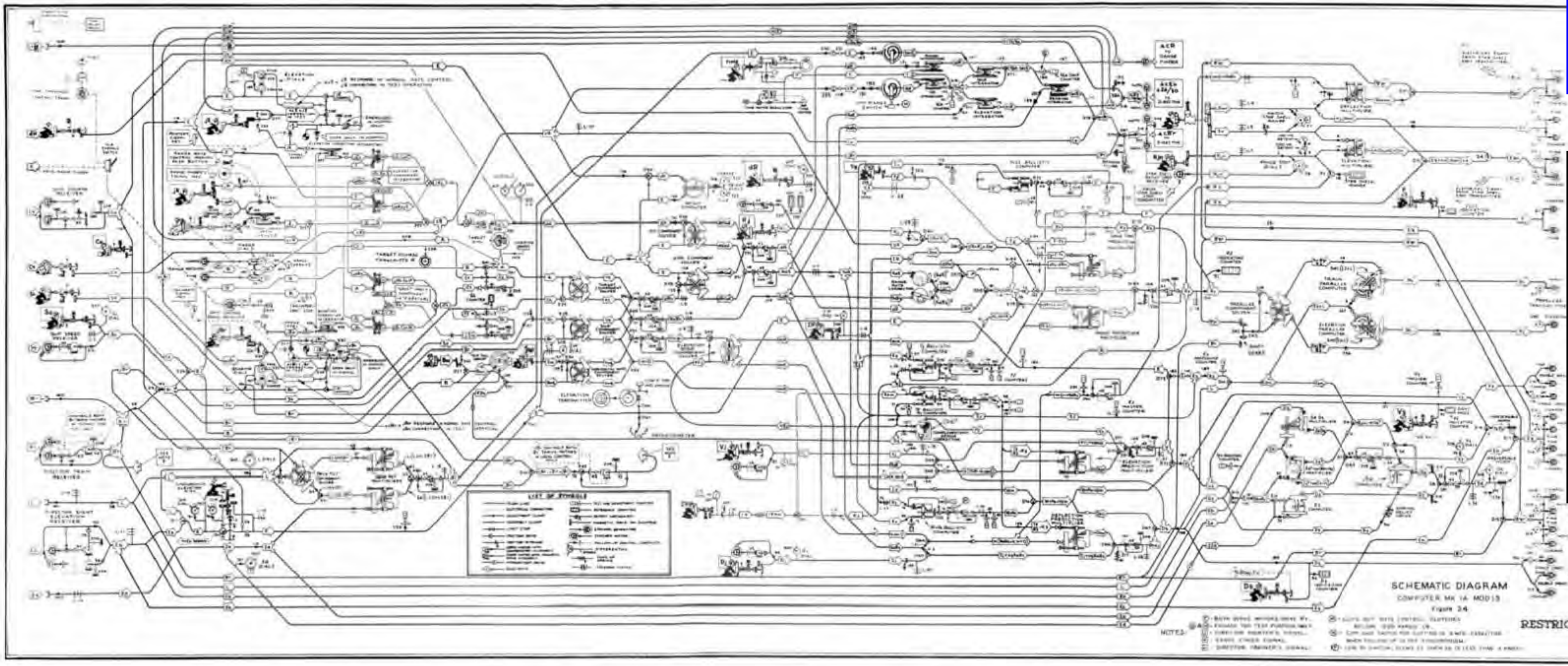
Tracking quantities

Prediction quantities

Fuze setting quantities

NOTES




LIST OF SYMBOLS
SCHEMATIC DIAGRAM
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