RESTRICTED OP 1064

COMPUTER MARK I AND MODS.

DESCRIPTION AND OPERATION

A BUREAU OF ORDNANCE PUBLICATION 29 JUNE 1945

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RESTRICTED OP 1064

COMPUTER MARK I
AND MODS

DESCRIPTION AND OPERATION

DEPARTMENT OF THE NAVY
BUREAU OF ORDNANCE

29 JUNE 1945

This publication is RESTRICTED and will be handled in accordance with Article 76, United States Navy Regulations, 1920.

NAVY DEPARTMENT

BUREAU OF ORDNANCE

WASHINGTON 25, D. C.

RESTRICTED
ORDNANCE PAMPHLET 1064
COMPUTER MARK 1 AND MODS

29 JUNE 1945

1. Ordnance Pamphlet 1064 describes the theory and operation of the Computer Mark 1 and Mods. A companion publication, Ordnance Pamphlet 1064A which is now in preparation, will cover care and maintenance of these equipments.

2. This publication is to be used by: operating personnel, both during instruction and while on actual duty; personnel of installing activities; and inspectors and other officers of the Bureau of Ordnance.

3. This pamphlet supersedes NAVORD OD 4184 (Revision B) which should be destroyed.

4. The following NAVORD OD'S which will be superseded when Ordnance Pamphlet 1064A has been completed contain additional information on Computers Mark 1 and Mods:

NAVORD OD 4174 (Revision C)
NAVORD OD 3133 (Revision A)
NAVORD OD 3137
NAVORD OD 3139
NAVORD OD 3140 (Revision B)
NAVORD OD 3180
NAVORD OD 3181
NAVORD OD 3183
NAVORD OD 3184 (Revision A)
NAVORD OD 3185 (Preliminary)
NAVORD OD 4186
NAVORD OD 5157
ORDNANCE PAMPHLET 1453 (Preliminary)

5. This publication is RESTRICTED and should be handled in accordance with Article 76, U.S. Navy Regulations, 1920.

G. F. HUSSEY, JR.
Rear Admiral, U.S. Navy
Chief of the Bureau of Ordnance

Prepared For
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Long Island City, New York

QUICK REFERENCE INDEX

More detailed breakdown on next two pages.

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CONTENTS

There is a detailed ALPHABETICAL INDEX on page 421

There are schematic diagrams of the entire Computer Mark 1 at the end of this pamphlet

INTRODUCTION

Ordnance Pamphlet 1064 describes the Computer Mark 1 and tells how to operate it. All maintenance information is covered in a continuation of this pamphlet which is bound separately and designated as Ordnance Pamphlet 1064A.

Ordnance Pamphlets 1064 and 1064A are written for beginners on the Computer Mark 1, but they are not intended for beginners in fire control. These pamphlets assume that although the reader knows very little about the Computer Mark 1, he is already acquainted with some of the simpler mechanical computers, and with the fire control problem.

The reader is assumed to be thoroughly familiar with the basic fire control mechanisms described in OP 1140.

The reader is also assumed to be familiar with the general nature of the fire control problem. Many of the fundamentals of fire control are discussed in this pamphlet, but usually on the assumption that they are already fairly well understood and need only a brief review.

All diagrams in this OP are presented in such a way that little or no previous experience in reading schematic diagrams is necessary.

NOTE: Since the majority of the Computers Mark 1 in service are Mark 1 Mod 7, and since the other Computers Mark 1 are very similar to the Mod 7, all references to the Computer Mark 1 in this OP apply to a Computer Mark 1 Mod 7 equipped with a Star Shell Computer Mark 1, a Selector Drive Mark 1, and a Target Course Indicator Mark 1.

The chapter on Modification Differences describes how other modifications differ from the Mod 7.

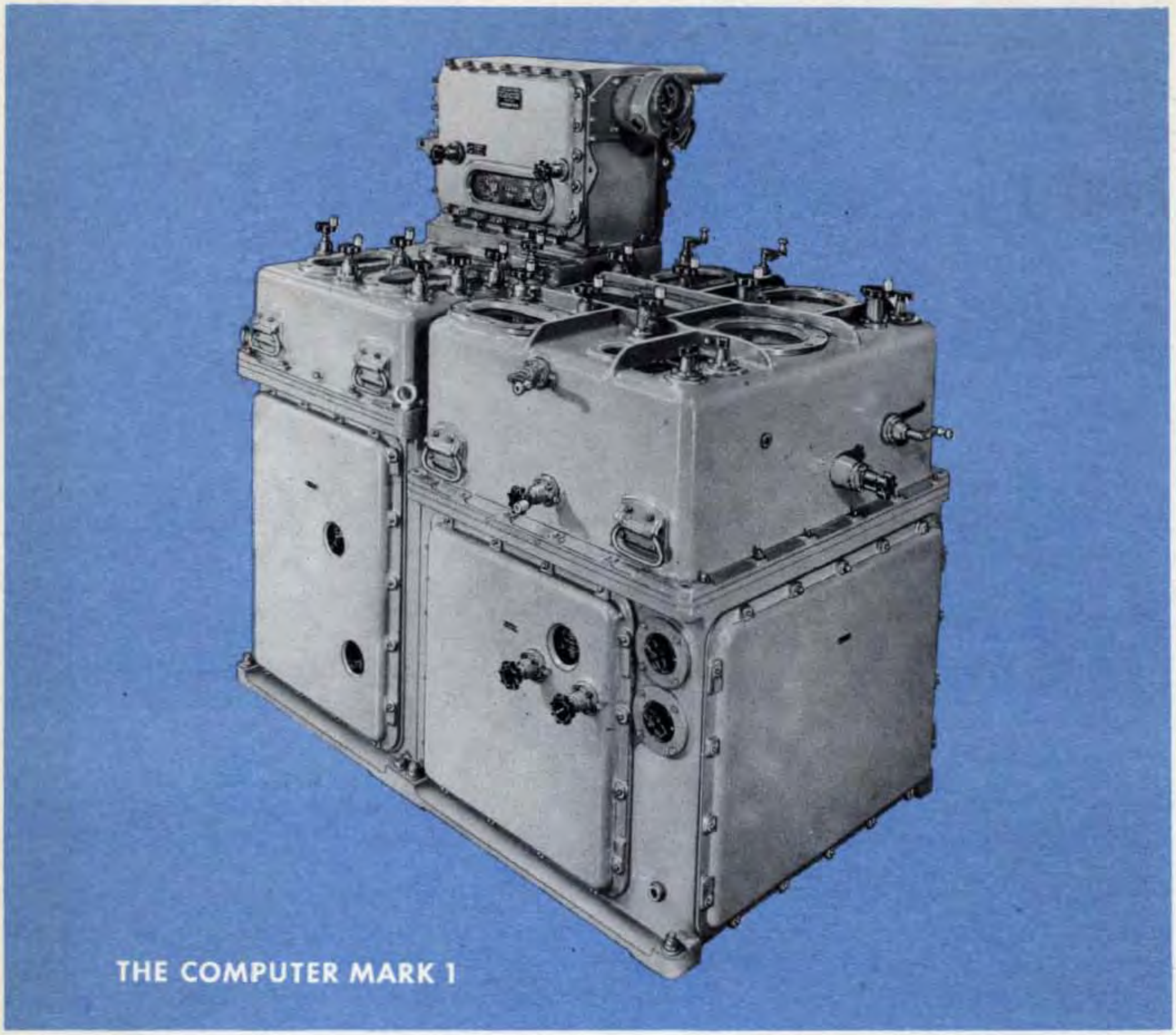
PART 1

GENERAL DESCRIPTION

The General Description is intended to give an over-all picture of the Computer Mark 1, and its place in the Gun Director Mark 37 System of fire control. The General Description familiarizes the reader with the main features of the Computer, and the fire control problem it solves, before he tackles the Detailed Description.

Those readers whose interest in the Computer Mark 1 is only general, and does not extend into the details of operation and maintenance, will probably find that the General Description contains most of the information they need.

The General Description includes the following subjects:

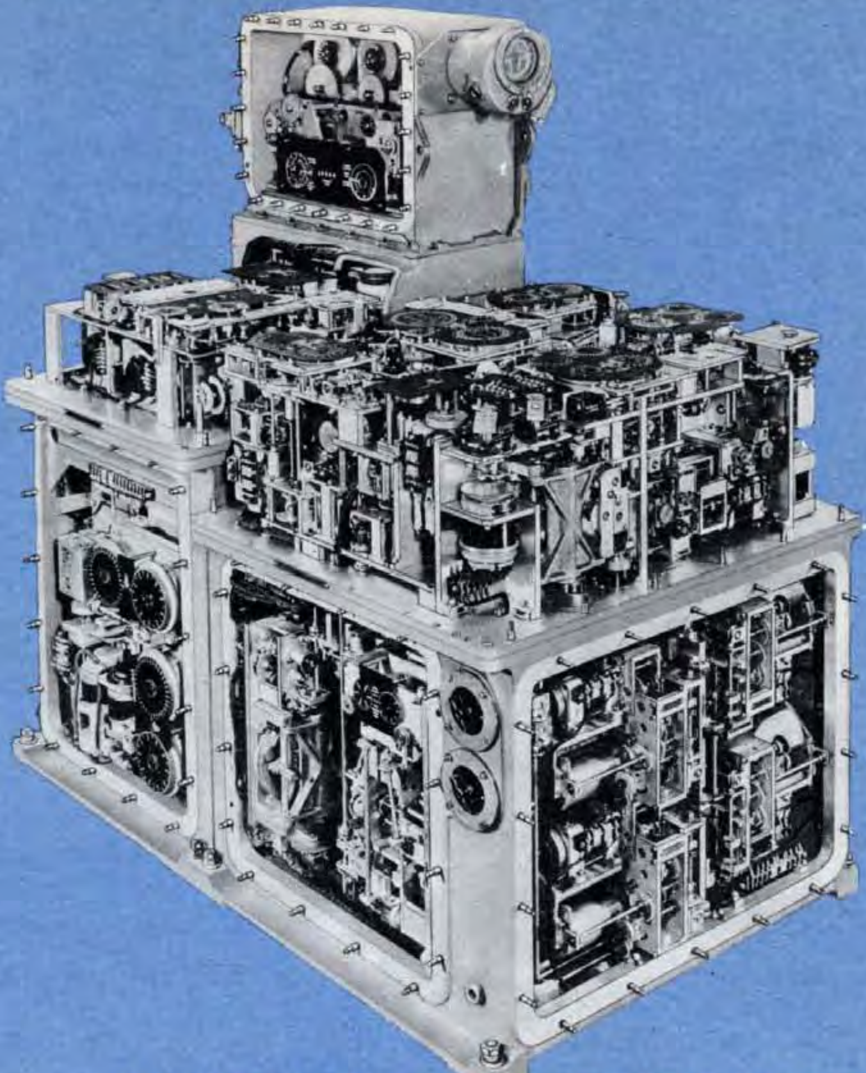


THE COMPUTER MARK 1

The Computer Mark 1 is the mechanical brain of the Gun Director Mark 37 System of Automatic Fire Control. This system controls the fire of the 5"/38 cal. dual-purpose guns against both air and surface targets. The system is also used to control 40-mm. guns at short ranges and main battery guns in barrage fire. Later modifications of the Computer Mark 1 calculate gun orders for 5"/54, 6"/47, and 8"/55 cal. batteries.

The Computer Mark 1 computes continuous gun orders containing corrections for all the significant factors affecting antiaircraft and surface fire. The corrections allow for the motion of Ship and Target during the time the projectile is in flight; for the curvature of the projectile path caused by gravity, drift, and wind; for pitch and roll of the Ship; and for a number of other factors.

These gun orders, a fuze setting order, and parallax corrections, are continuously transmitted from the Computer to the gun mounts. At the mounts, these orders are used to point the guns continuously and to time the fuzes so that the projectiles will explode at the predicted position of the target.



COMPUTER MARK 1 WITHOUT ITS COVERS

At first the Computer Mark 1 looks like a chaotic maze of gearing and motors, but actually it is an orderly collection of connected basic mechanisms. The important thing to realize is that the thousands of gears and shafts which look so complicated do one of the simplest jobs in the Computer. Most of them just connect one mechanism to another. The mechanisms themselves—component solvers, integrators, multipliers, differentials and so on—do the computing. The gears and shafts merely transmit motion from one mechanism to another so that all the mechanisms in the Computer work together as a big network. The gearing is fairly intricate in construction, but the job it does is simple.

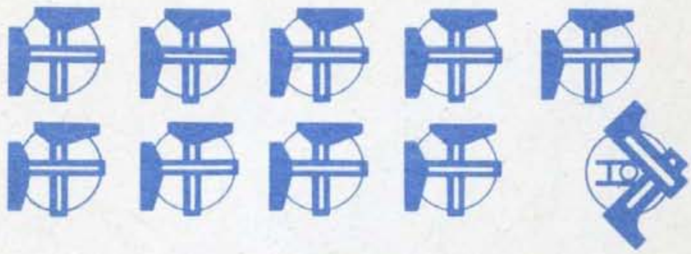
One does not have to be a mechanical engineer to understand the Computer Mark 1. The detailed description of the Computer breaks it down into about four sections which can be understood one at a time without too much difficulty. It is a good idea to become very familiar with this material because it contains information that will be useful in operating, testing, setting, and maintaining the Computer.

Here are the BASIC MECHANISMS

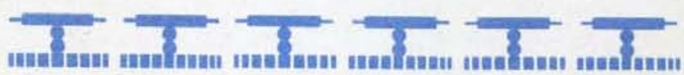
The Computer Mark 1 is made up almost entirely of the Basic Fire Control Mechanisms described in OP 1140. If the Basic Mechanisms were taken out of the Computer there would be nothing left but the case, a few special mechanisms, the shaft assemblies, and the wiring. Anyone who knows the Basic Mechanisms described in OP 1140 already knows a lot about the Computer Mark 1.

The Computer Mk 1 Mod 7 contains the following Basic Mechanisms:

9 COMPONENT SOLVERS AND 1 VECTOR SOLVER

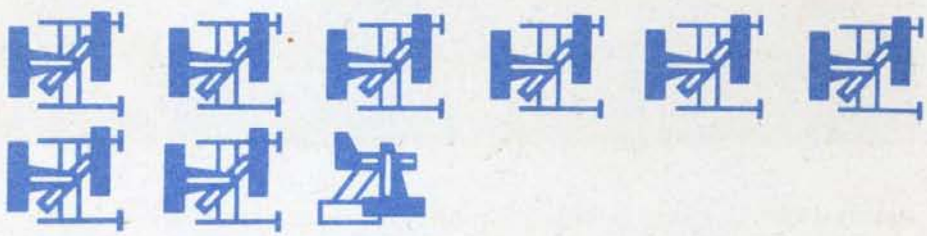


6 DISK INTEGRATORS



4 COMPONENT INTEGRATORS

9 MULTIPLIERS

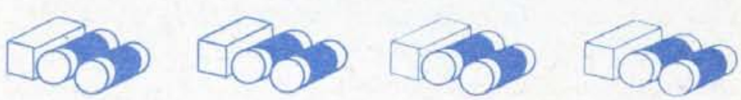


6 COMPUTING MULTIPLIERS

8 CAMS IN ADDITION TO THE CAMS IN THE COMPONENT SOLVERS AND MULTIPLIERS.

5 SINGLE-SPEED RECEIVERS

4 DOUBLE-SPEED RECEIVERS



in the COMPUTER MARK 1

10 SINGLE-SPEED TRANSMITTERS

10 DOUBLE-SPEED TRANSMITTERS

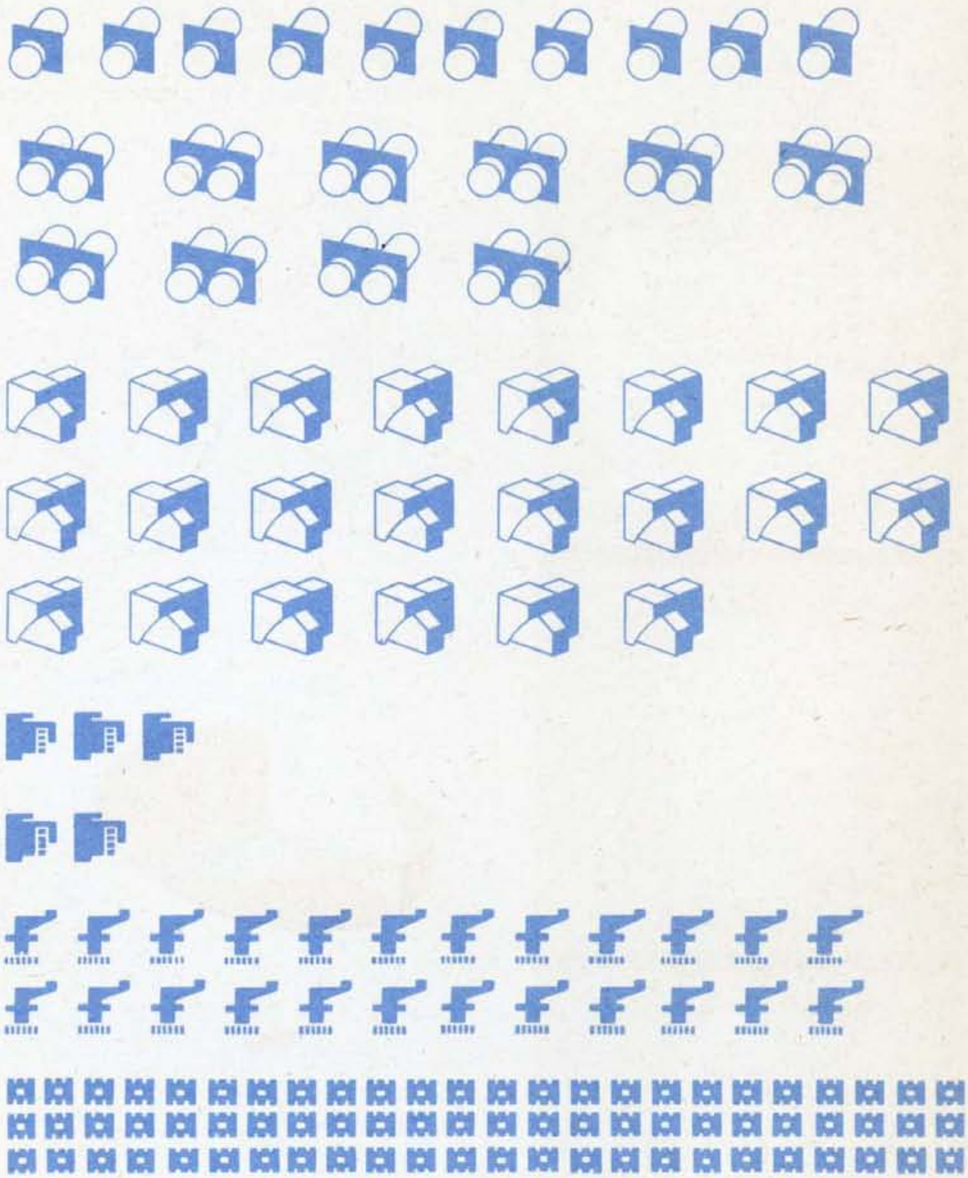
22 FOLLOW-UP CONTROLS

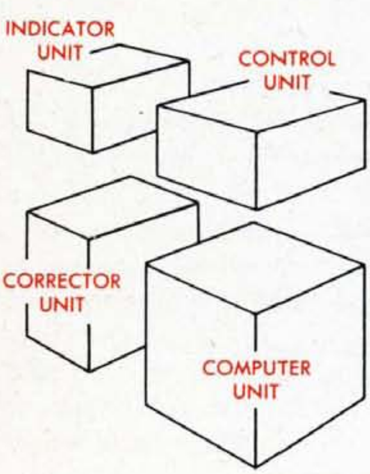
3 SOLENOID CLUTCHES

2 SOLENOID LOCKS

24 HANDCRANKS

MORE THAN 150 DIFFERENTIALS





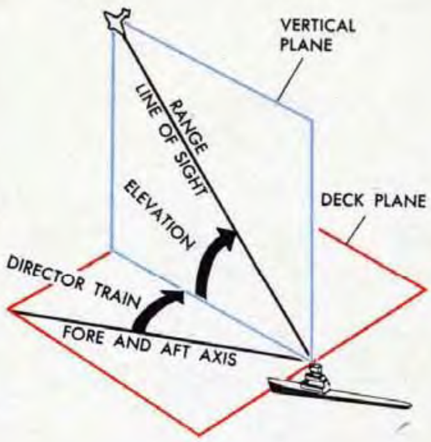
In order that the Computer Mark 1 may be installed more easily in certain types of ships, it is so constructed that it can be separated into four installation units.

Thousands of man-hours of skilled labor are required to make and assemble the parts of this Computer.

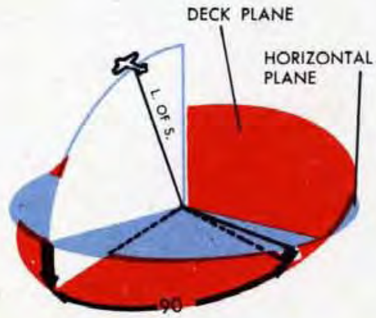
The finished instrument costs about $75,000. It should be treated with care.

COMPANION INSTRUMENTS of

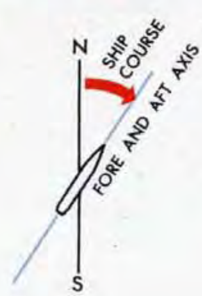
The Computer Mark 1 is one of a group of instruments which are connected together to form a system of anti-aircraft and surface fire control known as the Gun Director Mark 37 System.



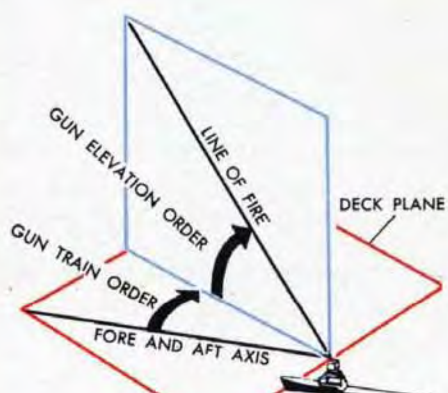
The Gun Director Mark 37 is the eyes of the system. After picking up the Target, the Director observes its location in relation to Own Ship. The Director measures the Target's Range and Elevation in relation to the deck plane. It also measures the Bearing in the deck plane clockwise from the bow of Own Ship to the vertical plane through the Line of Sight. This angle is called Director Train.



The Stable Element Mark 6 measures the inclination of the deck in relation to the horizontal plane and the Line of Sight.



The Gyro Compass measures Own Ship Course.

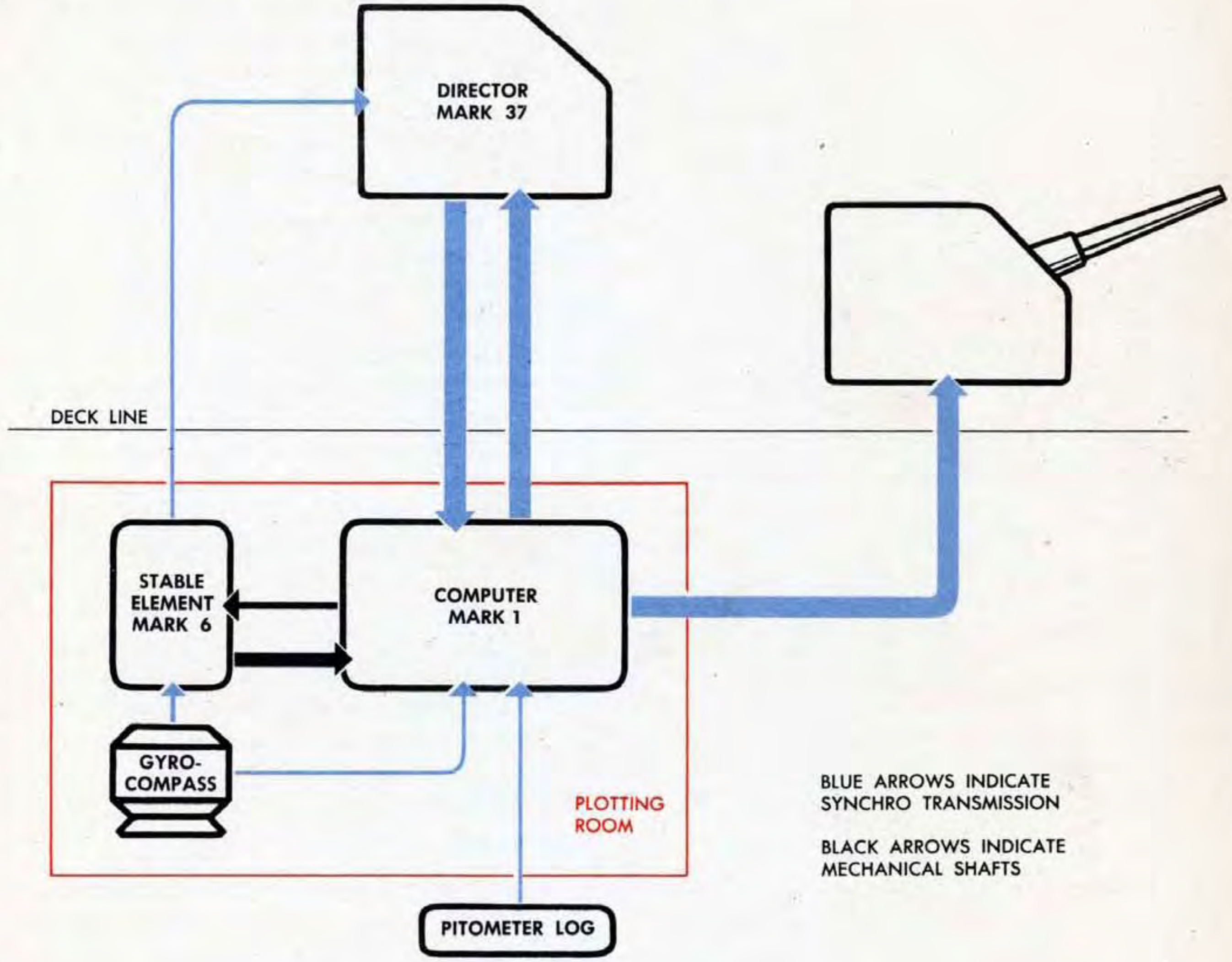


In the mounts, there are mechanical, electrical, or electrohydraulic mechanisms which keep the guns pointed and the fuzes set to agree with the gun and fuze order signals from the Computer. There are also provisions for introducing parallax corrections where necessary.

the COMPUTER MARK 1

There are a number of other elements in the Gun Director Mark 37 System, including the Pitometer Log which measures Own Ship Speed, a switchboard, and intercommunication telephones.

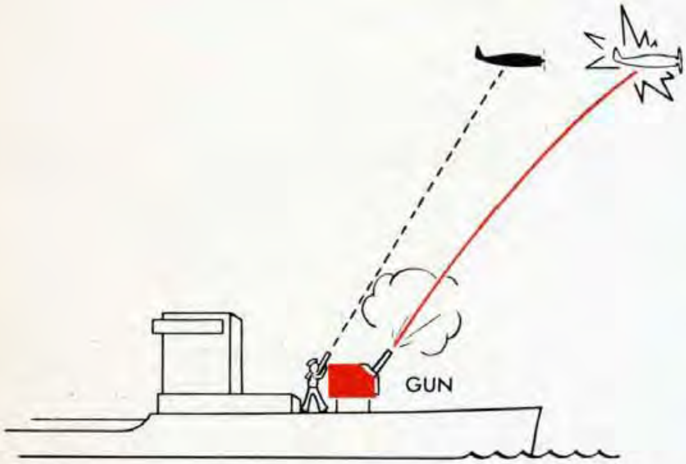
The various instruments are related to one another like this:



The Director is usually about 30 feet or more above the deck. The guns are located in various places on the deck depending on the type of ship.

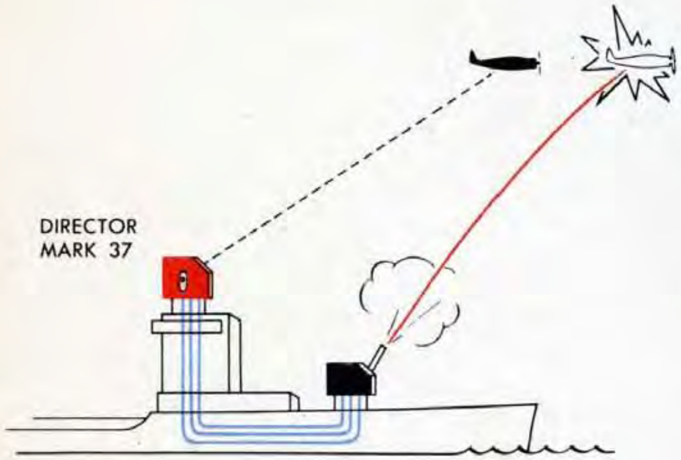
The Computer and the Stable Element stand together in the plotting room of the ship and are connected mechanically by shafts. The Gyro Compass and the switchboard are also in the plotting room. Most of the instruments in the system are connected electrically by synchro transmission.

The place of the COMPUTER MARK 1 in the GUN DIRECTOR MARK 37 SYSTEM



Since the Computer Mark 1 is part of the Gun Director Mark 37 System, it is essential to know the function of each unit of this system in order to understand the Computer itself. The Mark 37 System can best be built up by starting with the guns alone.

It would be possible to direct the fire of the guns from each gun mount, independently of other mounts or observation stations. But fire control from the mounts alone has several disadvantages. Visibility from the mount is often bad because of the smoke. Observation of surface targets is restricted by the relatively small height of the mounts above the water line. Also, it is difficult to coordinate the fire of several gun mounts when each is separately controlled.

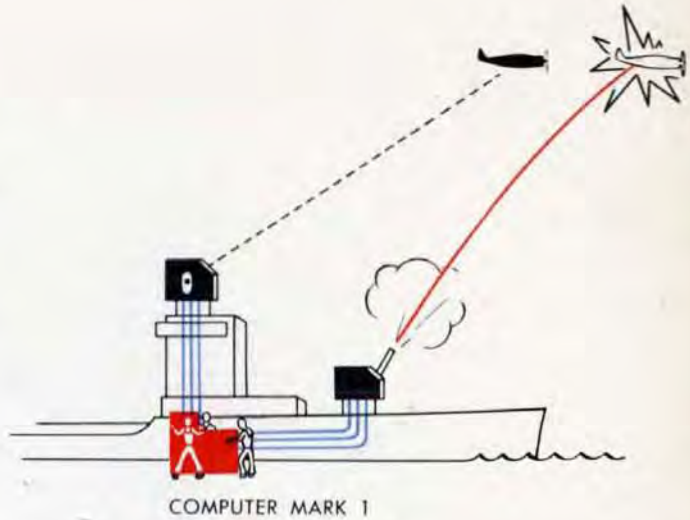


These difficulties are overcome by having a Gun Director aloft, high enough for the Director Crew to see above the smoke and to observe surface targets at great distances. With a Gun Director, the fire of all the gun mounts can be coordinated.

Firing with the combination of mounts and a Gun Director is better than firing from the gun mounts alone. In such a simple fire control system, however, all corrections for motion of Ship and Target, curvature of the projectile path, and the pitch and roll of the Ship would have to be made by guess work.

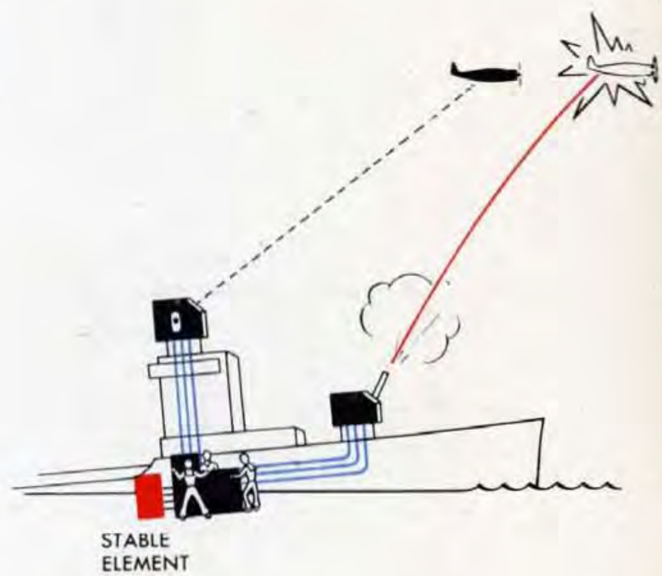
An instrument is needed to compute all these corrections instantaneously and continuously. In the Gun Director Mark 37 System of fire control, the instrument that fills this need is the Computer Mark 1.

The Computer Mark 1 is located in the plotting room. In the plotting room the Computer is better protected than it would be in the Director or at the gun mount. If the Director is put out of action, the Computer can still continue to function. In fact, one of the features of the Computer Mark 1 is that, without any Director inputs, it can generate enough of the values normally received from the Director to track a surface target.

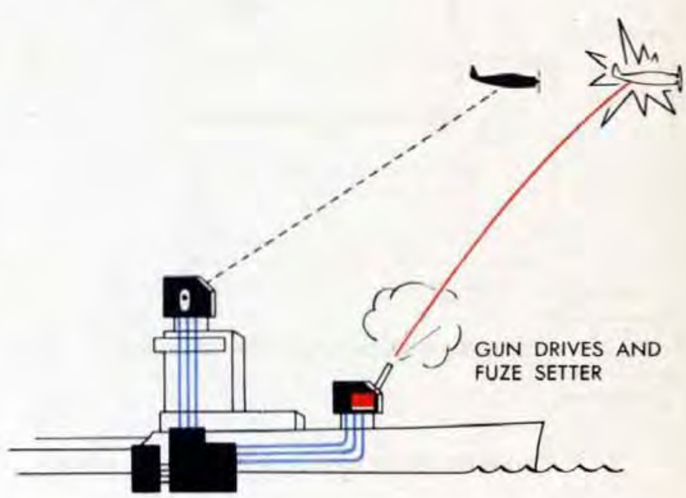


The Director and Computer in the Gun Director Mark 37 System are able to track the Target and compute predictions for relative motion and for curvature of the projectile path, but by themselves they cannot allow for pitch and roll of Own Ship.

In order to fire continuously during pitch and roll, the Director, Computer, and guns must be corrected continuously for the effects of deck inclination. To measure deck inclination, the Gun Director Mark 37 System uses the gyro mechanism called the Stable Element Mark 6. The Stable Element measures the amount of deck inclination from the horizontal plane with reference to the Line of Sight.



Because of the number and variety of the factors which enter into the fire control problem, the outputs of the Computer Mark 1 are continually changing. In order to keep the guns pointed in accordance with these varying orders from the Computer, there are electrical or electrohydraulic mechanisms at the gun mounts which receive the changing signals and control power drives. The power drives point the guns continuously by turning the whole mount in train, and moving the guns themselves in elevation. Another electrical mechanism, the Fuze Setter, receives the fuze order from the Computer Mark 1 and automatically sets the fuzes of the projectiles as they wait to be loaded.



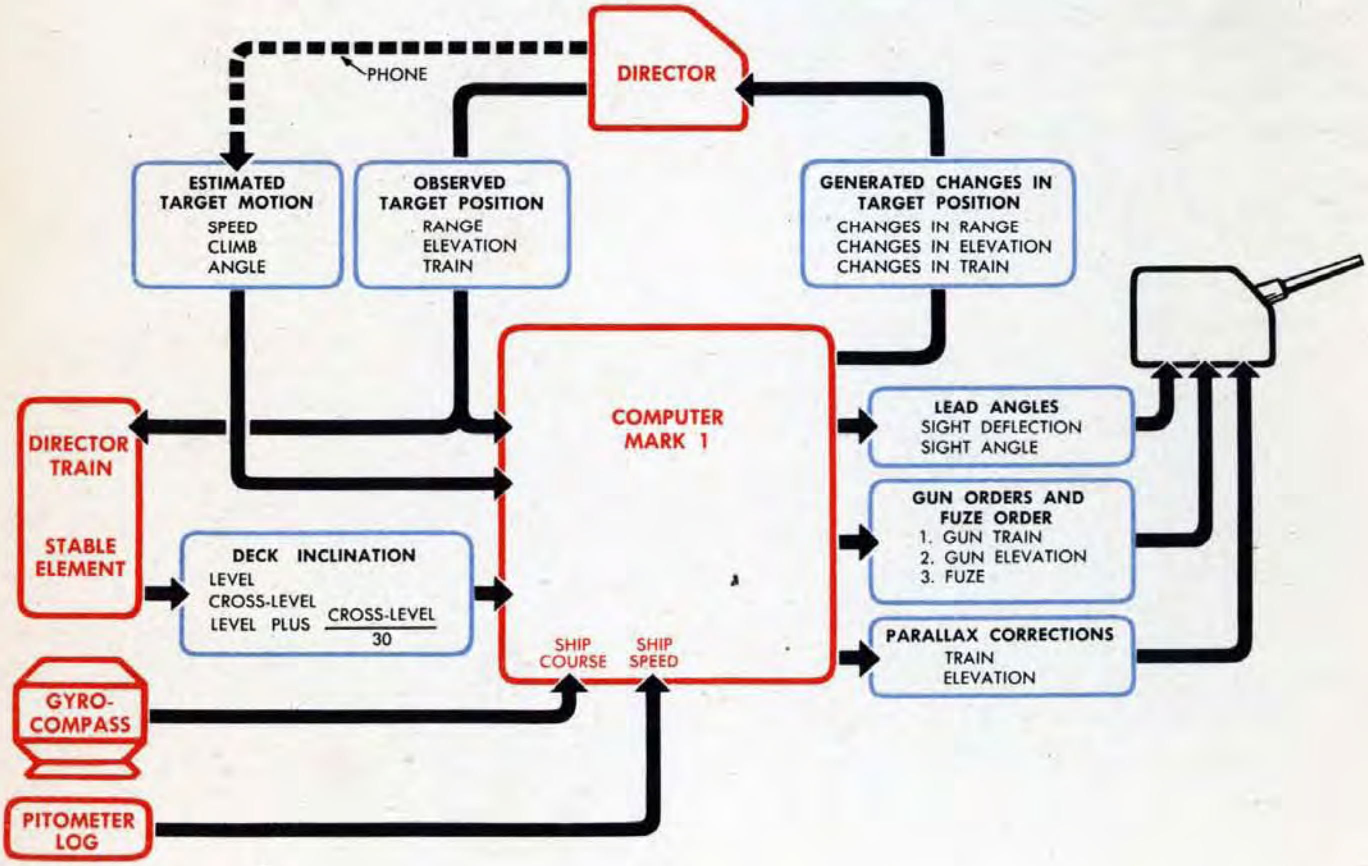
What the COMPUTER MARK 1 does in the

In the Gun Director Mark 37 System, all the instruments except those at the gun mounts are used to furnish inputs to the Computer Mark 1.

The Director Crew "pick up" a target with the telescopes and Range Finder. By turning their handwheels and the Range Knob, they keep their crosshairs continuously on the target, and transmit values of Range, Director Elevation, and Director Train to the Computer.

The Stable Element receives the value of Director Train from the Computer, and continuously measures the angles of Level and Cross-level, which are the vertical components of deck inclination from the horizontal, in and at right angles to the plane of sight. Level, Cross-level, and Level plus a function of Cross-level, are transmitted mechanically from the Stable Element to the Computer.

Besides the inputs from the Director and the Stable Element, the Computer receives the values of Ship Speed from the Pitometer Log, Ship Course from the Gyro Compass, and *estimates* of Horizontal Target Speed, Target Course, and Rate of Climb, by phone from the Control Officer in the Director.



GUN DIRECTOR MARK 37 SYSTEM

Using these inputs together with some other hand inputs, the Computer goes to work. Briefly, this is what it does:

1 The Computer Mark 1 computes and transmits to the gun mounts continuous Gun and Fuze Orders containing:

a Corrections for movement of Ship and Target during the time of flight of the projectile.

b Corrections for curvature of the projectile path caused by gravity, drift, wind, and changes in initial velocity.

c Corrections for the effects on the gun of roll and pitch of the Ship.

2 The Computer computes continuous values of the Lead Angles in elevation and deflection. These Lead Angles are called Sight Angle and Sight Deflection. They are transmitted electrically to the gun mounts to offset the gun sights.

3 The Computer Mark 1 computes and transmits two Parallax Corrections, which may be applied at the individual gun mounts to compensate for differences in location of guns and Directors.

4 Through the Star Shell Computer, gun and fuze orders are computed for firing star shells to illuminate surface targets which the Computer Mark 1 is tracking.

5 The Computer corrects the estimated Target Motion inputs. It does this by generating changes of Range, Director Elevation, and Director Train which are transmitted electrically to the Director to drive the Director sights. By comparing the generated Computer values with the observed Director values of Range, Elevation, and Train, the Computer checks and corrects the original estimates of Target Horizontal Speed, Course, and Rate of Climb, and puts accurate values of these three quantities into the computing mechanism. When the estimated values are correct, the generated quantities keep the Director sights on Target. This process of correcting the Target Motion estimates is called Rate Control.

NOTE:
Unless the Target goes into a dive attack, Rate of Climb usually has a value close to zero. For this reason it is seldom necessary for an estimate of Rate of Climb to be phoned down from the Director. Instead, Rate of Climb can simply be set at zero, unless dive attack is indicated. The correct value of Rate of Climb will be computed during Rate Control.

For convenience, this special characteristic of the Rate of Climb estimate has been ignored throughout the General Description.

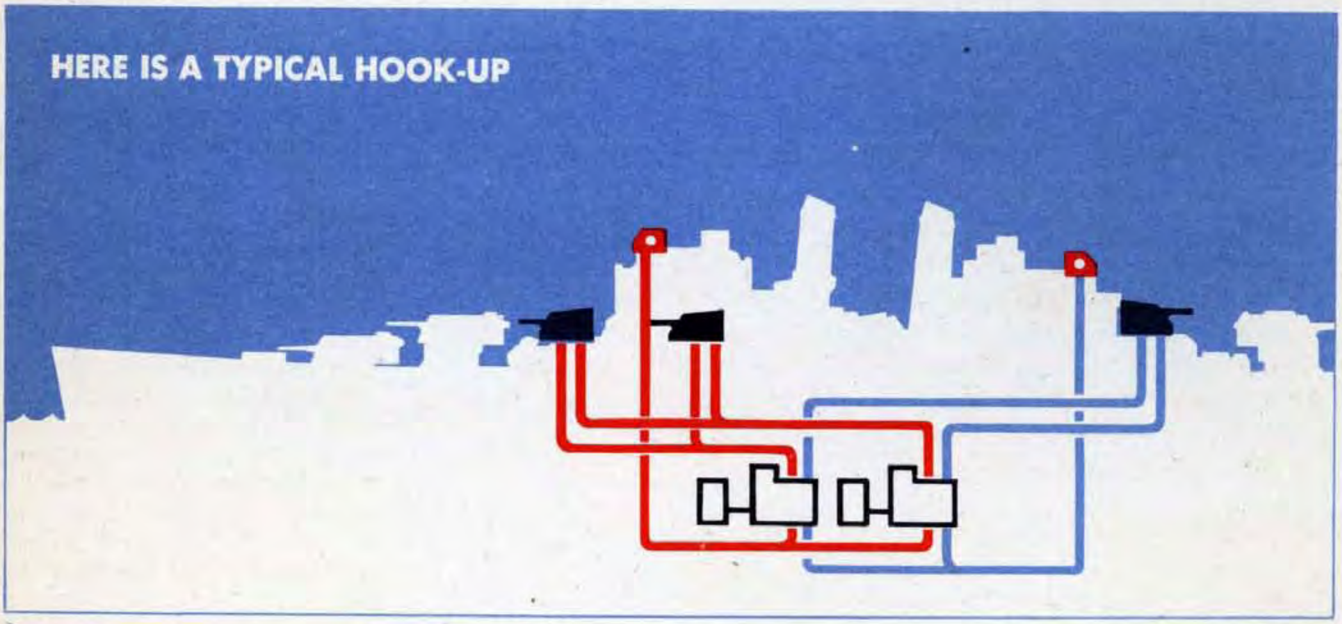
The ships using the COMPUTER MARK 1

The Computer Mark 1 and the other elements of the Gun Director Mark 37 System are used on the following types of ships:

Destroyers, all types after DD409 and some earlier
Light and heavy cruisers, after CL51 and CA68
Battleships, after BB55 and some earlier
Aircraft carriers of the types CV9 and CVB41
Some auxiliary vessels

Sometimes the computers are installed singly, sometimes in pairs, sometimes in groups of four, depending mainly on the type of ship.

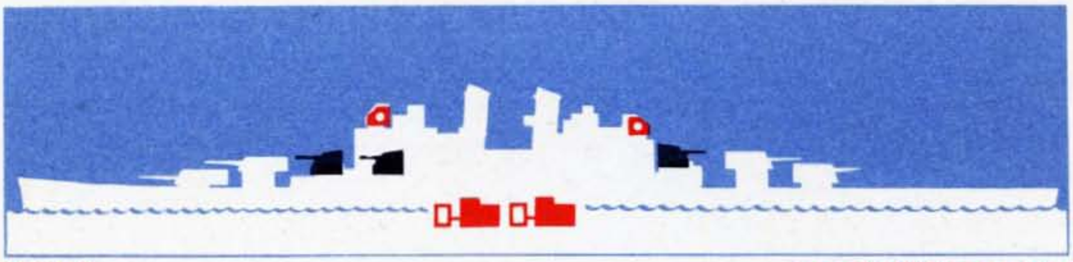
On ships having more than one computer, each computer has a gun director. The installation is usually designed so that any director can be connected to any computer, and any computer can be used with any gun or group of guns. The limits of the possible cross-connection of directors, computers and guns are the limitation of shipboard wiring, and the fact that a director can control only those guns training in about the same arc of bearing as the director.



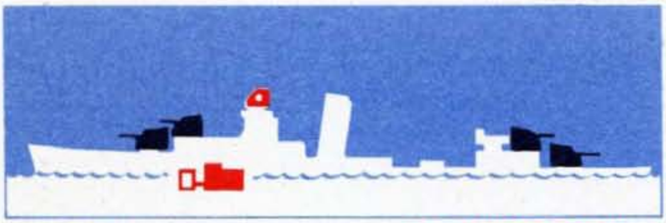
Here are typical locations of the Gun Director Mark 37 System on various kinds of ships. There are other variations. These are only a few examples.

AIRCRAFT CARRIER — 2 COMPUTERS MARK 1

BATTLESHIP — 4 COMPUTERS MARK 1



CRUISER — 2 COMPUTERS MARK 1



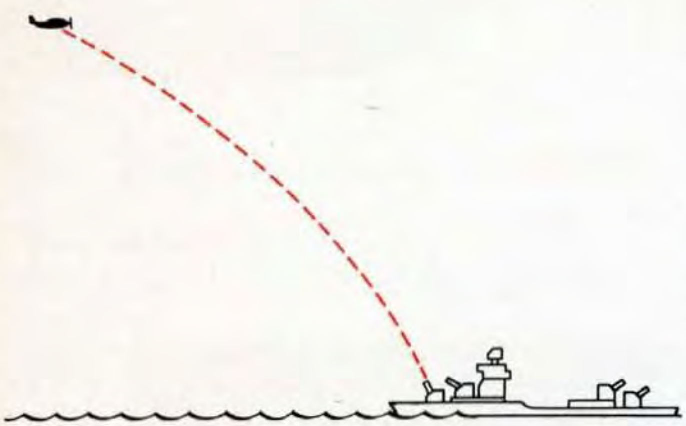
DESTROYER — 1 COMPUTER MARK 1

Types of TARGETS and ATTACK

Air targets

The Computer Mark 1 is primarily designed for use against air targets.

It computes accurate gun orders for Continuous Fire against nearly all types of air targets, such as:

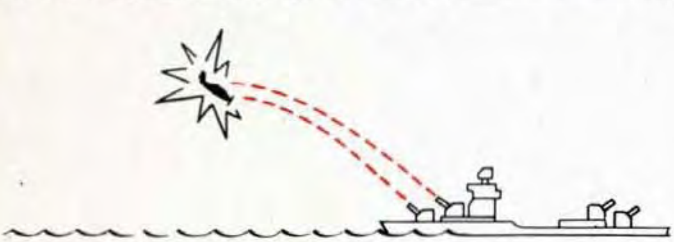


1 High-level Horizontal Bombers

2 Low-level Torpedo Planes

3 Dive Bombers attacking Own Ship

4 Dive Bombers attacking other ships (when the vertical component of Target Speed does not exceed −250 knots).



The Computer may also be used for antiaircraft barrage fire by the 5″ guns, or by the main battery guns.

Surface and land targets

The Computer also computes accurate gun orders for Continuous or Selected Fire against all types of surface targets:

1 Other ships, destroyers, cruisers, etc.

2 High-speed torpedo boats which travel at speeds outside the limits of the main battery computers.

3 Stationary land targets such as shore installations, and moving land targets such as tanks.

The Computer may also be used for barrage fire against a surface target both by the 5″ guns and the main battery guns.

Types of SELECTED FIRE

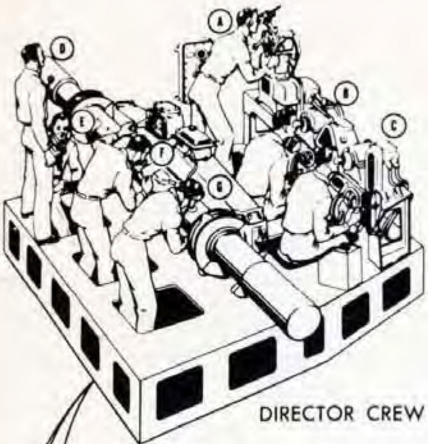
Two kinds of Selected Fire are possible in this system:

1 Selected Level Fire, in which the value of Level may be selected at either the Director or the Stable Element.

2 Selected Cross-level Fire, in which the value of Cross-level is always selected at the Stable Element.

In Selected Level Fire against a surface target the Computer Mark 1 can produce gun orders without Director inputs.

AUTOMATIC FIRE CONTROL in the



DIRECTOR CREW

The Gun Director Mark 37 System is referred to as a system of Automatic Fire Control for continuous fire. However, it is important to realize that it falls considerably short of completely automatic fire control. It falls short in ways which require skill in operation. The role of the operating personnel in the Mark 37 System is not predominantly stand-by or in any sense auxiliary. Their functions are vitally important just because the System does leave gaps which must be filled in by the operating personnel.

Here is a list of the main functions of a fire control system, showing which functions are accomplished automatically in the Gun Director Mark 37 System, and which require manual operation by the crews.

1 Locating the target

There are two methods of locating targets in the Gun Director Mark 37 System, optical and radar. Neither of these is automatic. Both systems depend on observation by the operating personnel. The use of either system is a matter of discretion on the part of the officer in charge of the Director.

2 Tracking the target

Tracking is far from automatic. The sights must be kept on the Target by the Pointer, Trainer and Range Finder Operator, aided by some outputs from the Computer.

3 Communicating information

In the Gun Director Mark 37 System most information is communicated automatically by synchro transmission. Estimated values, however, are transmitted by phone.

4 Correcting the target motion estimates

The Mark 37 System has no way of measuring Target Motion directly. The Computer crew puts the *estimates* of Target Motion into the Computer, as values of the Horizontal Target Speed, Target Angle, and Rate of Climb. The Computer computes Relative Motion Rates and uses them to generate changes of Range, Elevation, and Bearing, which it compares with the Observed Changes of these three quantities. The differences between the Generated and the Observed Changes of each of these quantities are used by the Computer to correct the estimated values of Target Motion.

COMPUTER CREW

GUN CREW

GUN DIRECTOR MARK 37 SYSTEM

When the Target Motion values are correct, the Computer will automatically generate Changes of Range, Elevation, and Bearing which will be equal to the Observed Changes.

The process of using the difference between the Generated and the Observed Changes of Range, Elevation, and Bearing to correct estimated Target Motion is called Rate Control. It is the main job in operating the Computer. Correcting these estimates requires skill on the part of Computer Operators, and knowledge of how the fire control problem is solved in the Computer Mark 1.

After Rate Control is completed, the target values are correct and the Computer automatically computes correct Relative Motion Rates and generates correct Changes of Range, Elevation, and Bearing, which keep the Director sights on Target AS LONG AS THE TARGET CONTINUES IN THE SAME DIRECTION AT THE SAME SPEED.

As soon as the Target changes its course or speed, Rate Control must be started all over again.

5 Predicting

Prediction is automatic in the Computer Mark 1 except for two hand inputs. These two inputs are the value of Initial Velocity, and the value of Dead Time. Dead Time is time between the setting of the fuze and the firing of the gun.

6 Stabilizing the guns and the director

The stabilizing of both the Director sights and the guns is fully automatic in the Director Mark 37 System.

7 Pointing the guns

Pointing the guns in response to signals from the Computer can be fully automatic.

8 Setting the fuzes

Fuzes are set automatically by the Automatic Fuze Setter.

9 Loading the guns

The projectiles must be taken from the setter and loaded into the gun by hand.

The sections of the COMPUTER MARK 1

The Computer Mark 1 has three main jobs. The first is to correct the estimated inputs of Horizontal Target Speed, Target Angle, and Rate of Climb and so establish three correct Relative Motion Rates. This job can be called *establishing the correct Relative Motion Rates* and is done in the Tracking Section.

The second main job is to compute two lead angles and a fuze order which will keep the guns pointed so that the projectile and Target will meet at the end of the Time of Flight. These computations may be called *establishing the Line of Fire* from a horizontal deck. This second job is done by the Prediction Section.

The third main job is to *stabilize the Line of Fire*. This is done by the Trunnion Tilt Section, which computes corrections to offset the effect of tilt of the gun trunnions on the Line of Fire.

There are four sections in the Computer Mark 1:

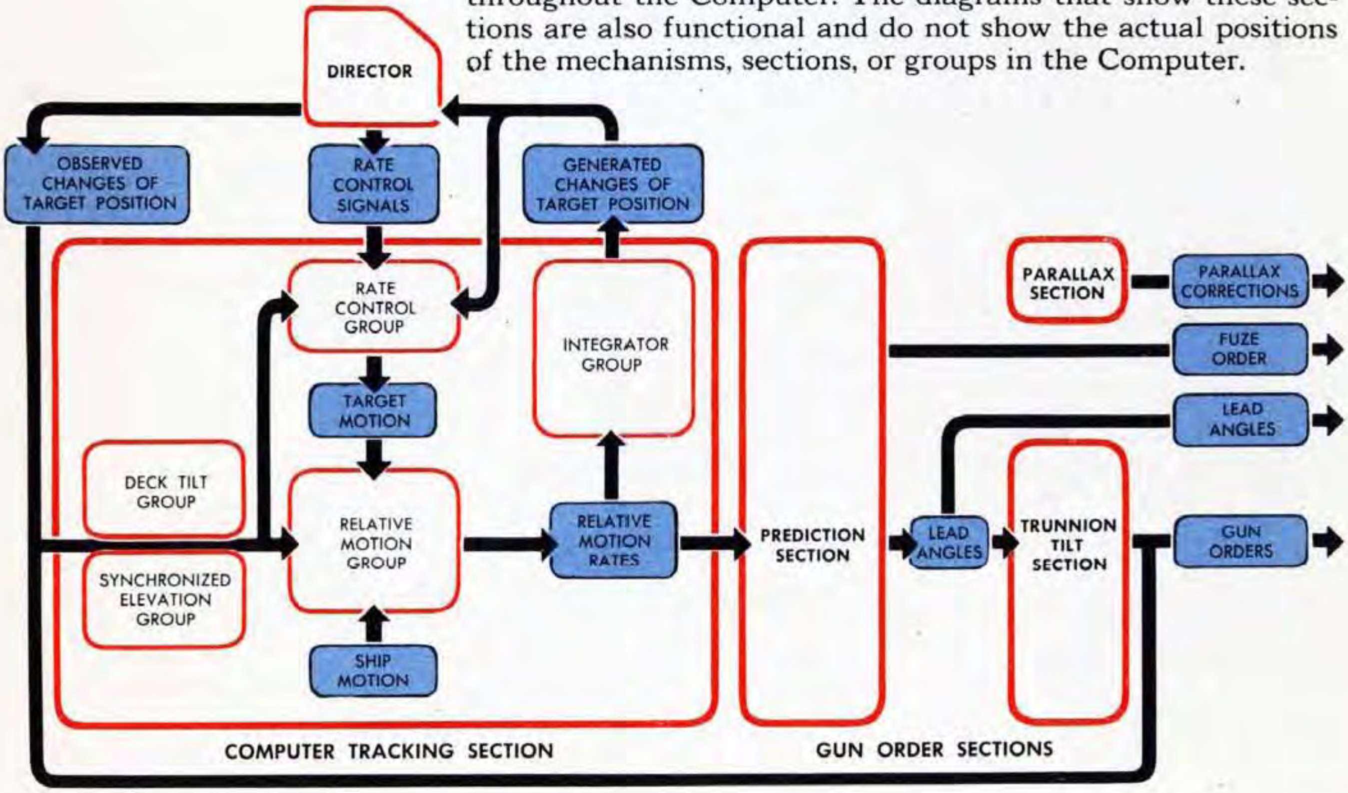
1 THE TRACKING SECTION
2 THE PREDICTION SECTION
3 THE TRUNNION TILT SECTION
4 THE PARALLAX SECTION

The Tracking Section can be divided into five groups:

1 The Deck Tilt Group
2 The Relative Motion Group
3 The Integrator Group
4 The Rate Control Group
5 The Synchronize Elevation Group

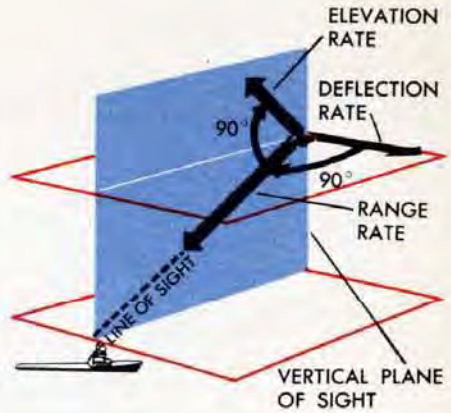
The Parallax Corrections are not included in the Gun Orders but are transmitted separately to the guns.

This grouping of the sections is merely a functional grouping. The mechanisms that form each section are actually scattered throughout the Computer. The diagrams that show these sections are also functional and do not show the actual positions of the mechanisms, sections, or groups in the Computer.



THE TRACKING SECTION

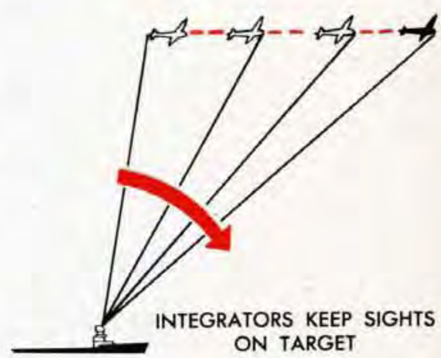
The Relative Motion Group of the Computer Mark 1 combines the motions of Own Ship and the Target into three rates of Relative Motion in relation to the Line of Sight.



The Integrator Group uses these rates to generate changes of Target Position in Range, Elevation, and Bearing. These changes are continuously transmitted to the Director to position the telescopes and the Range Finder.

If the generated values of Target Position do not keep the sights on the Target, the operators in the Director press their Rate Control keys and turn their handwheels to keep the sights on the Target.

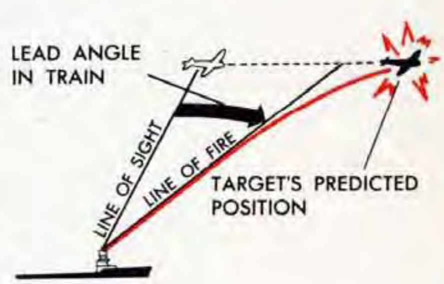
The turning of the handwheels in the Director with the Rate Control keys closed sends Rate Control corrections to the RATE CONTROL GROUP in the Computer.



The Rate Control Group converts these Range, Elevation, and Bearing rate corrections into corrections to the values of Target Motion, and puts the corrected values of Target Motion into the Relative Motion Group. The values of Target Motion in the Relative Motion Group initially were estimates made by the Control Officer.

The Deck Tilt and Synchronize Elevation Groups are each used to refer one value from the deck plane to the horizontal plane. The Deck Tilt Group computes the correction necessary to convert Director Train in the deck plane to Relative Target Bearing in the horizontal plane. The Synchronize Elevation Group converts Director Elevation above the deck to Target Elevation above the horizontal.

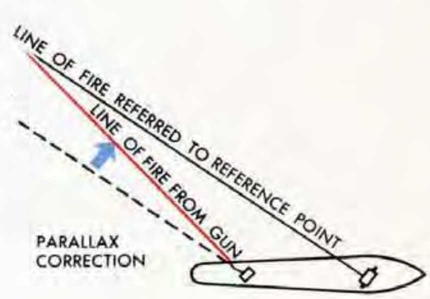
THE PREDICTION SECTION uses the three Relative Motion Rates to compute the amount the guns must lead the Target. It computes two lead angles and a fuze setting order.



The Lead Angles include computations for the change in Target Position while the projectile is in the air and for the projectile's curved path. To obtain the Lead Angles, the Prediction Section computes the Target Position at the end of the Time of Flight and corrections for the effect of gravity, drift, wind, and changes in initial velocity on the projectile path.

The Fuze Setting Order includes a correction for the change in Range during the time the projectile is being loaded.

THE TRUNNION TILT SECTION computes corrections for the effects of pitch and roll on the gun trunnions. The lead angles and the Trunnion Tilt Corrections are combined with Director Elevation and Train to form the two Gun Orders.



THE PARALLAX SECTION computes Train and Elevation Parallax Corrections for a horizontal distance of 100 yards along the fore and aft axis. These two Parallax Corrections may be transmitted separately to the guns and Directors. Each gun or Director may use a fraction of each correction according to its distance from the Reference Point.

A SIMPLIFIED ACCOUNT OF TRACKING, PREDICTION, AND STABILIZATION

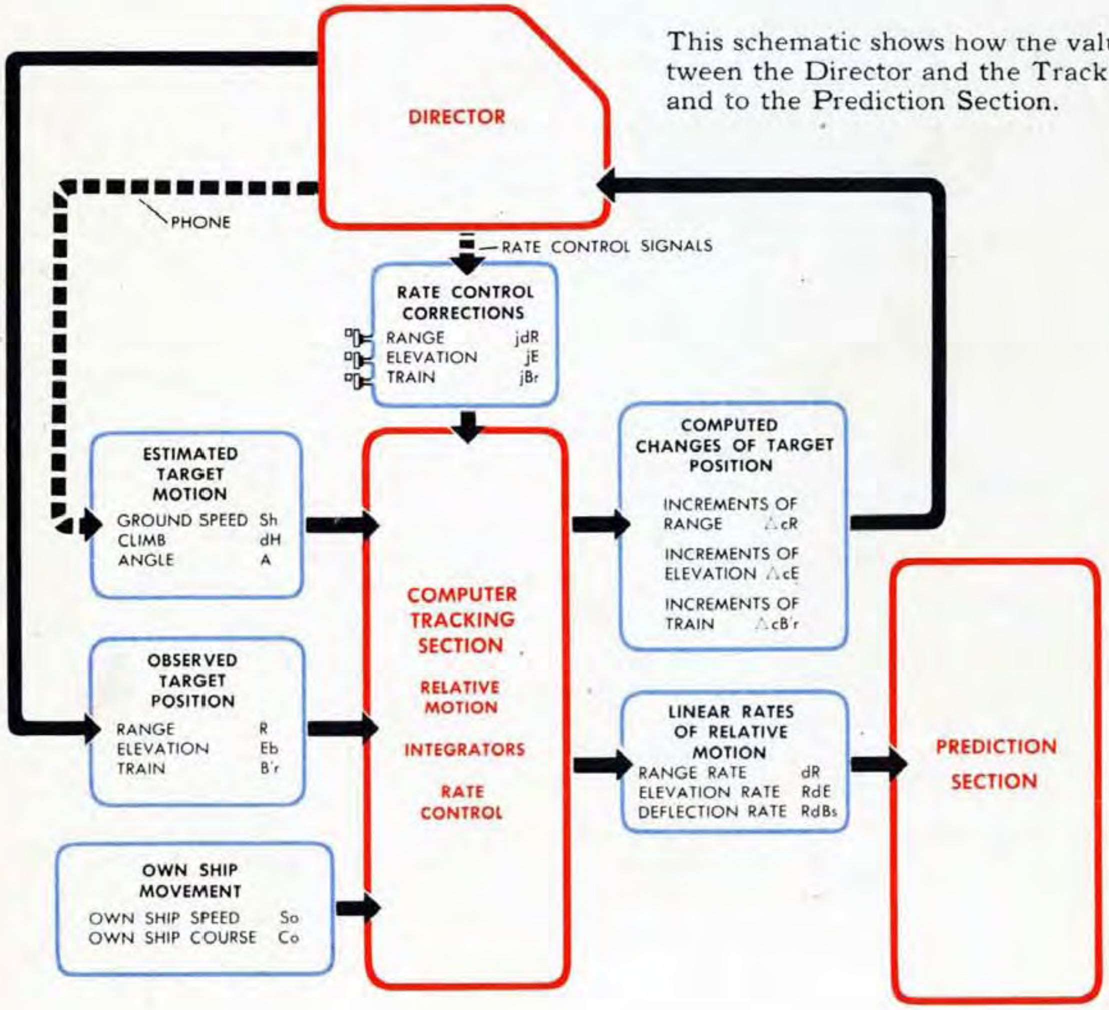
TRACKING the TARGET

It is easier to understand how the Computer tracks a Target and computes gun orders if Own Ship is first considered as being steady, that is, as if Own Ship were neither pitching nor rolling but had its deck horizontal all the time.

On a steady horizontal ship, the Deck Tilt Group, Trunnion Tilt Section, and the Stable Element may be disregarded. Since Parallax Corrections are not included in the Gun Orders, the Parallax Section may also be left out for the moment. With the deck horizontal, only two sections are needed in order to go through tracking and the computation of Gun and Fuze Orders.

The two sections needed are the Tracking and Prediction Sections. In the Tracking Section the Deck Tilt and Synchronize Elevation Groups may be disregarded at this time.

This schematic shows how the values flow between the Director and the Tracking Section, and to the Prediction Section.



1 When a Target is sighted, the Trainer, Pointer and Range Operator in the Director immediately pick it up and continuously measure its *Position* in Range, *R*, Elevation, *Eb*, and Director Train, *B'r*. These three quantities, *R*, *Eb*, and *B'r*, are transmitted electrically to the Computer.

2 The values of Target *Motion* are estimated by the Control Officer and phoned down to the plotting room, where they are set into the Tracking Section by hand by the Computer Crew. The Target Motion values are: Target Horizontal (Ground) Speed, *Sh*, Target Angle, *A*, and Rate of Climb, *dH*.

In addition to the Target Position values and Target Motion values, the Tracking Section receives the values of Ship Speed, *So*, and Ship Course, *Co*.

3 With these three groups of inputs the Tracking Section goes to work. The Relative Motion Group combines Ship and Target Motion into three linear Relative Motion Rates: Range Rate, *dR*, along the Line of Sight, Elevation Rate, *RdE*, perpendicular to the Line of Sight in the vertical plane, and Deflection Rate, *RdBs*, at right angles to the Line of Sight in the horizontal plane.

The Integrator Group uses these Relative Motion Rates to generate continuous Changes of Target Position: Generated Changes of Range, $\triangle cR$, Generated Changes of Director Elevation, $\triangle cEb$, and Generated Changes of Director Train, $\triangle cB'r$. These three quantities are continuously transmitted to the Director. If they keep the sights on the Target, the Relative Motion Rates are correct and the estimates of Target Motion are correct.

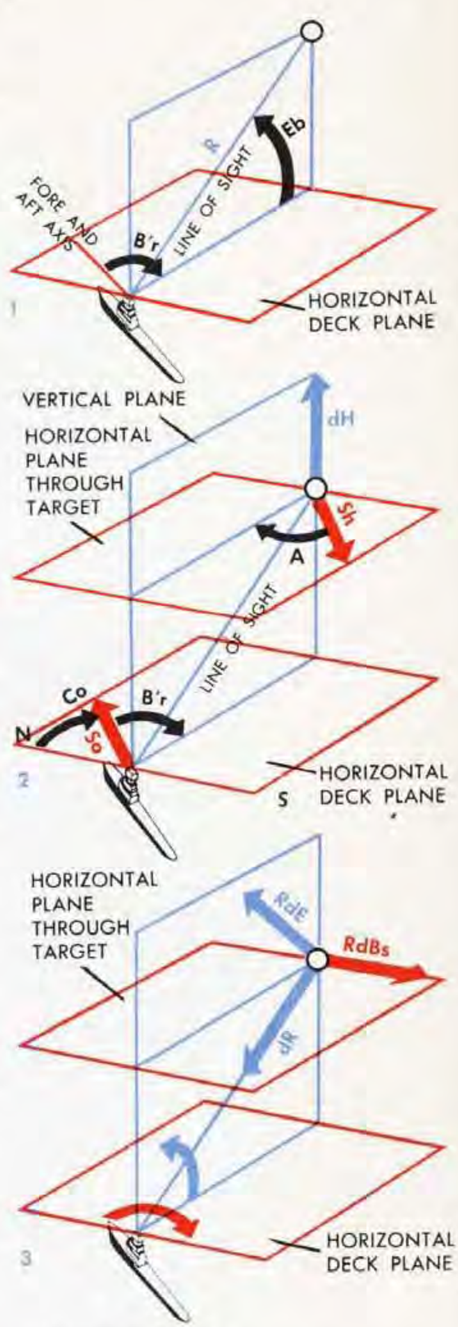
It is impossible to estimate the exact speed and direction of a plane. At the beginning of tracking, the generated quantities, which are based on these estimates, seldom keep the sights on Target.

If the sights do not stay on the Target, the estimates of Target Motion need correction. The Trainer, Pointer, and Range Operator turn their handwheels to bring the sights back on the Target.

By pressing their Rate Control keys as they turn the handwheels, the Director Crew automatically transmit Rate Control signals down to the Computer. These signals allow corrections to go into the Rate Control Group.

The Rate Control Group analyzes these Rate Control Corrections and decides how much the Target Motion estimates must have been wrong to have caused the errors in the generated values. The Rate Control Group then computes a set of more nearly correct Target Motion values.

When the Generated Changes of Target Position, $\triangle cR$, $\triangle cEb$, and $\triangle cB'r$, keep the sights on Target, a tracking solution is reached, and the Computer Crew know that the Target Motion values are correct. The Relative Motion Rates going into the Prediction Section are also correct and will result in accurate predictions.



GENERATED VALUES CONTINUALLY POSITION SIGHTS

NOTE:
In the *General Description*, the Pointer's and Trainer's Handwheels and Range Operator's Range Knob are all referred to as "handwheels." Similarly, the Pointer's and Trainer's Signal Keys and Range Operator's Signal Button are referred to as "signal keys."

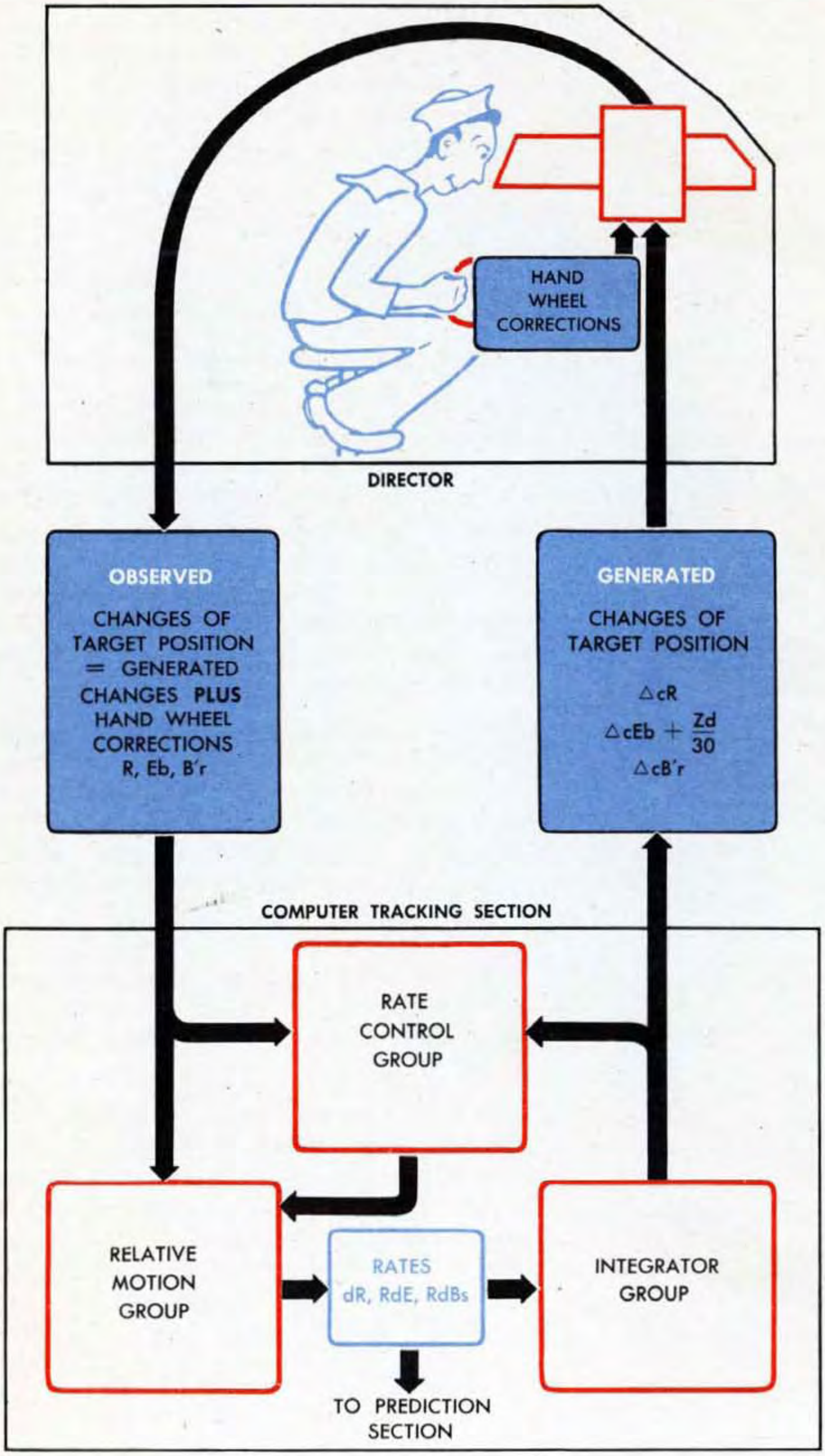
A summary of the tracking cycle for a horizontal deck

In the Gun Director Mark 37 System, tracking on a horizontal deck can be divided into the following operations:

1. Locating a Target and keeping the Director sights on it in order to measure Target Position and transmit this position continuously to the Computer.
2. Estimating the speeds and direction of Target Motion and using these estimates along with other quantities, to compute approximate Rates of Relative Motion.
3. Using the approximate Rates of Relative Motion and other quantities to generate continuous Changes of Target Position.
4. Using the Generated Changes of Target Position to position the Director sights.
5. Comparing the *Observed* Changes of Target Position, from the Director, with the *Generated* Changes of Target Position from the Computer.
6. Using the difference between the *generated* and *observed* values in the Computer to correct the estimates of Target Motion.

When a solution has been reached and the estimates of Target Motion are correct, the Generated Changes of Target Position drive the sights and Range Finder automatically. The Director sights then remain on Target even though the Target is temporarily out of sight. The guns can be fired accurately even though the Target is obscured. As long as the Target continues at the same speed and in the same straight line, the sights will be on the Target when it reappears.

The regeneration of quantities between the Director and Computer is such that, before a solution is reached, the Observed Changes of Range, Elevation, and Director Train, going to the Computer consist of the Generated Changes of those three quantities, plus any corrections the Director Crew put in by hand to keep the sights on Target. After a solution has been reached, the Observed Changes consist entirely of the Generated Changes, no handwheel corrections being necessary.



WHEN TRACKING ON
A HORIZONTAL DECK

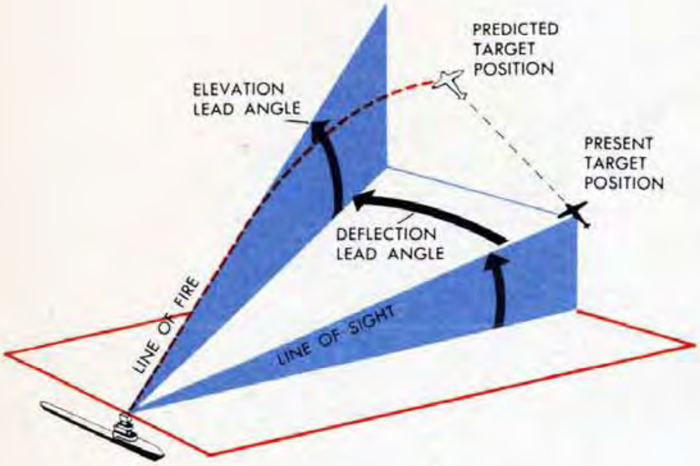
$Eb = E$

$B'r = Br$

$\triangle cEb = \triangle cE$

$\triangle cB'r = \triangle cBr$

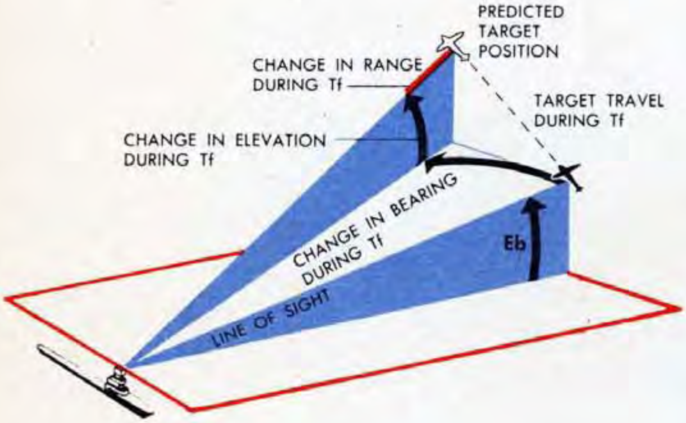
Establishing the LINE OF FIRE



The Relative Motion Rates from the Tracking Section are used in the Prediction Section to compute the Lead Angles. The Lead Angles are the angles in Elevation and Deflection by which the gun must lead the Target in order to make a hit. The Line of Fire is the line along which the gun must be pointed.

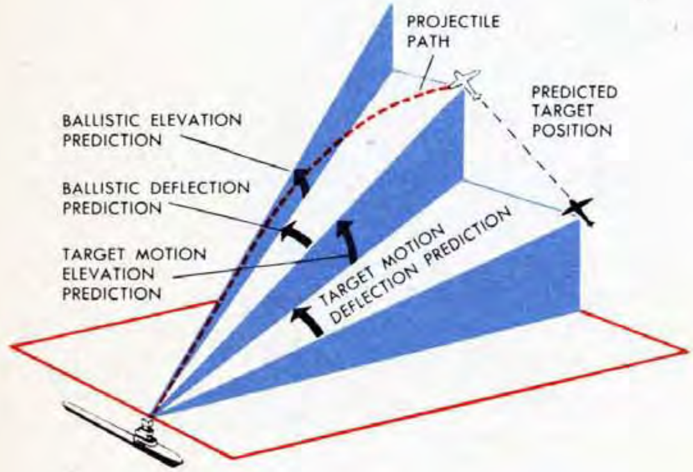
The Prediction Section computes two types of predictions to obtain the Lead Angles:

1 Relative Motion Predictions
2 Ballistic Predictions



The Relative Motion Predictions determine the Target's position relative to Own Ship at the end of the Time of Flight by computing Target travel during the time the projectile is on its way. The Prediction Section uses the three Relative Motion Rates and a computed Time of Flight, *Tf*, to obtain the Predicted Target Position in Range, Elevation, and Bearing.

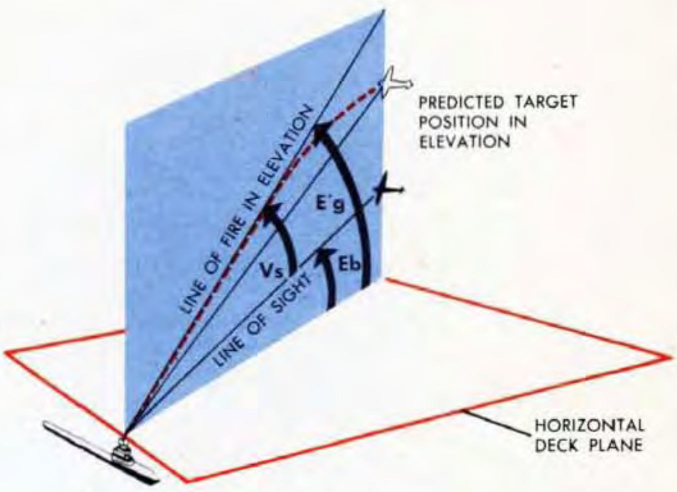
The gun cannot be aimed at this Predicted Target Position because the projectile follows a curved path. The projectile curves downward and over to one side as a result of the combined effects of gravity, drift, wind, and initial velocity. Therefore additional corrections are needed, which are called Ballistic Predictions. The Ballistic Predictions determine the amount the guns must be offset from the Predicted Target Position to allow for the curvature of the projectile path.



By combining the Relative Motion and Ballistic Predictions, the Prediction Section establishes two Lead Angles which determine a Line of Fire. Projectiles fired along this Predicted Line of Fire will hit the Target at the end of the time of projectile flight.

The Relative Motion Prediction in Elevation combined with the Ballistic Prediction in Elevation gives the Elevation lead angle, called Sight Angle, *Vs.*

On a steady horizontal deck, Sight Angle *Vs,* plus Director Elevation, *Eb,* is the Gun Elevation Order, *E′g.*



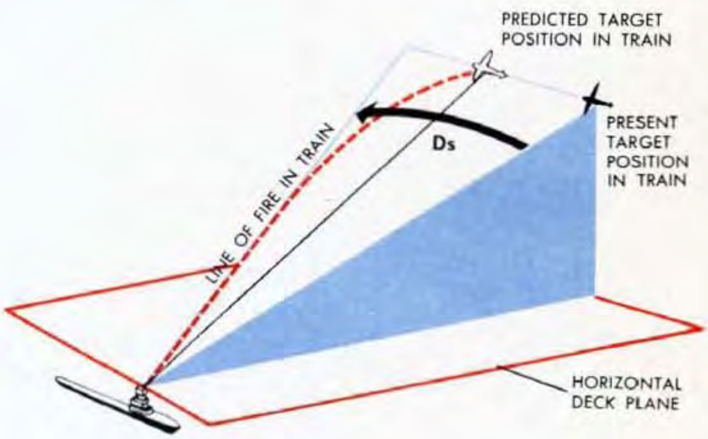
The Relative Motion Prediction in Train combined with the Ballistic Prediction in Train is the Deflection lead angle, called Sight Deflection, *Ds.*

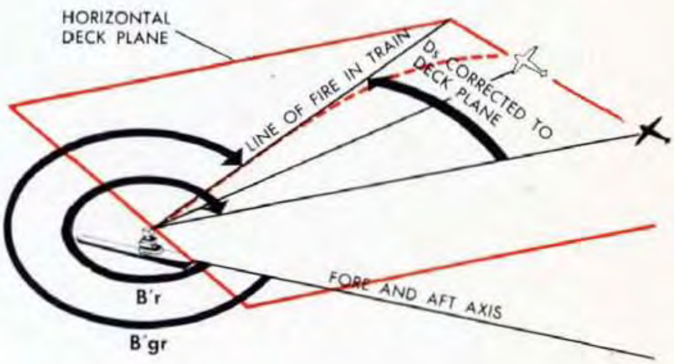
Since *Ds* is computed in a slant plane it must be corrected to the deck plane before it can be used in the Gun Train Order.

On a steady horizontal deck, Gun Train Order, *B′gr,* is made up of Sight Deflection, *Ds,* corrected to the deck plane, plus Director Train, *B′r.*

Ds is actually measured in a slant plane somewhat above or below the elevation of the Line of Sight.

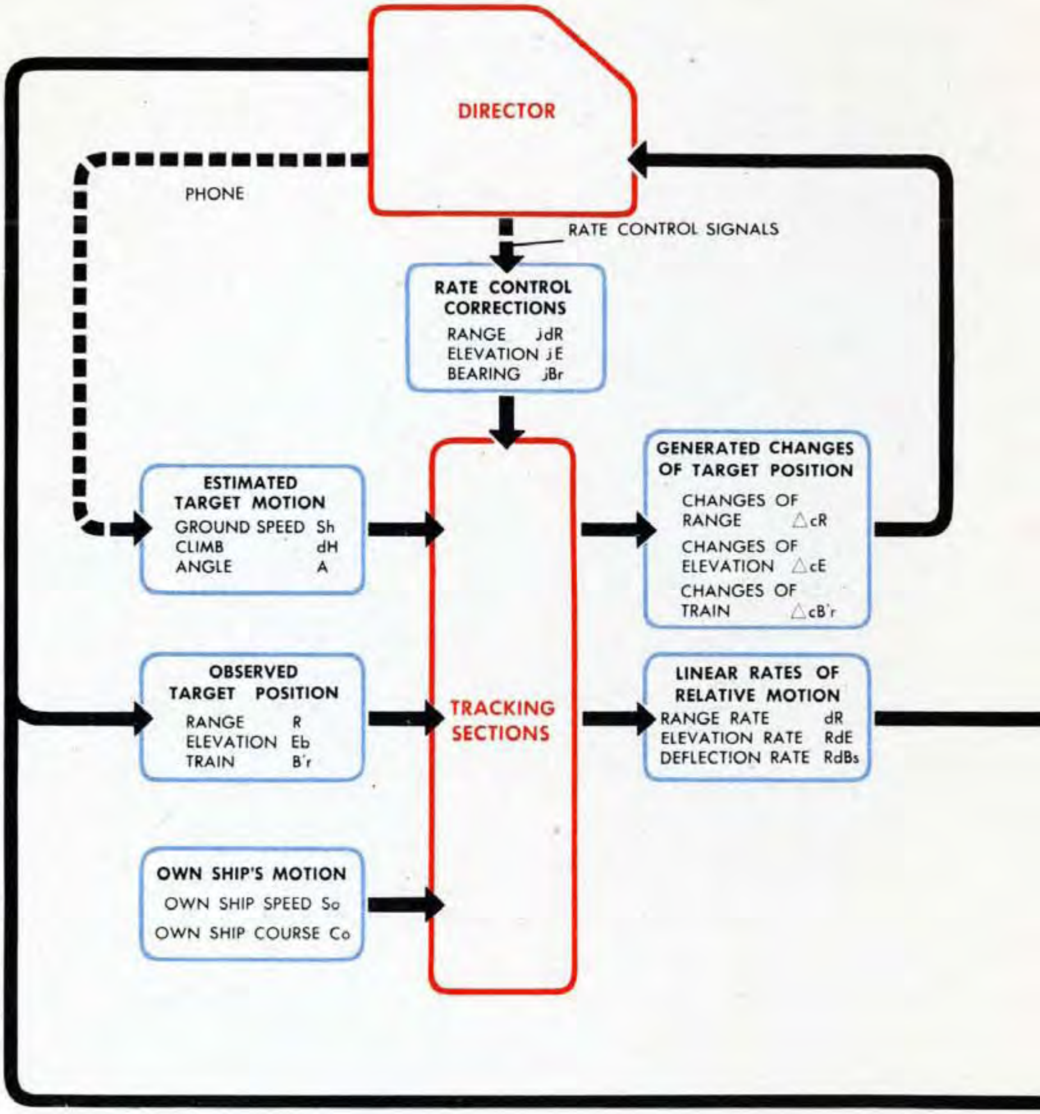
The Computer Mark 1 does not compute the Target Motion and Ballistic Predictions separately and add them. Instead, to save mechanisms, it computes them together.



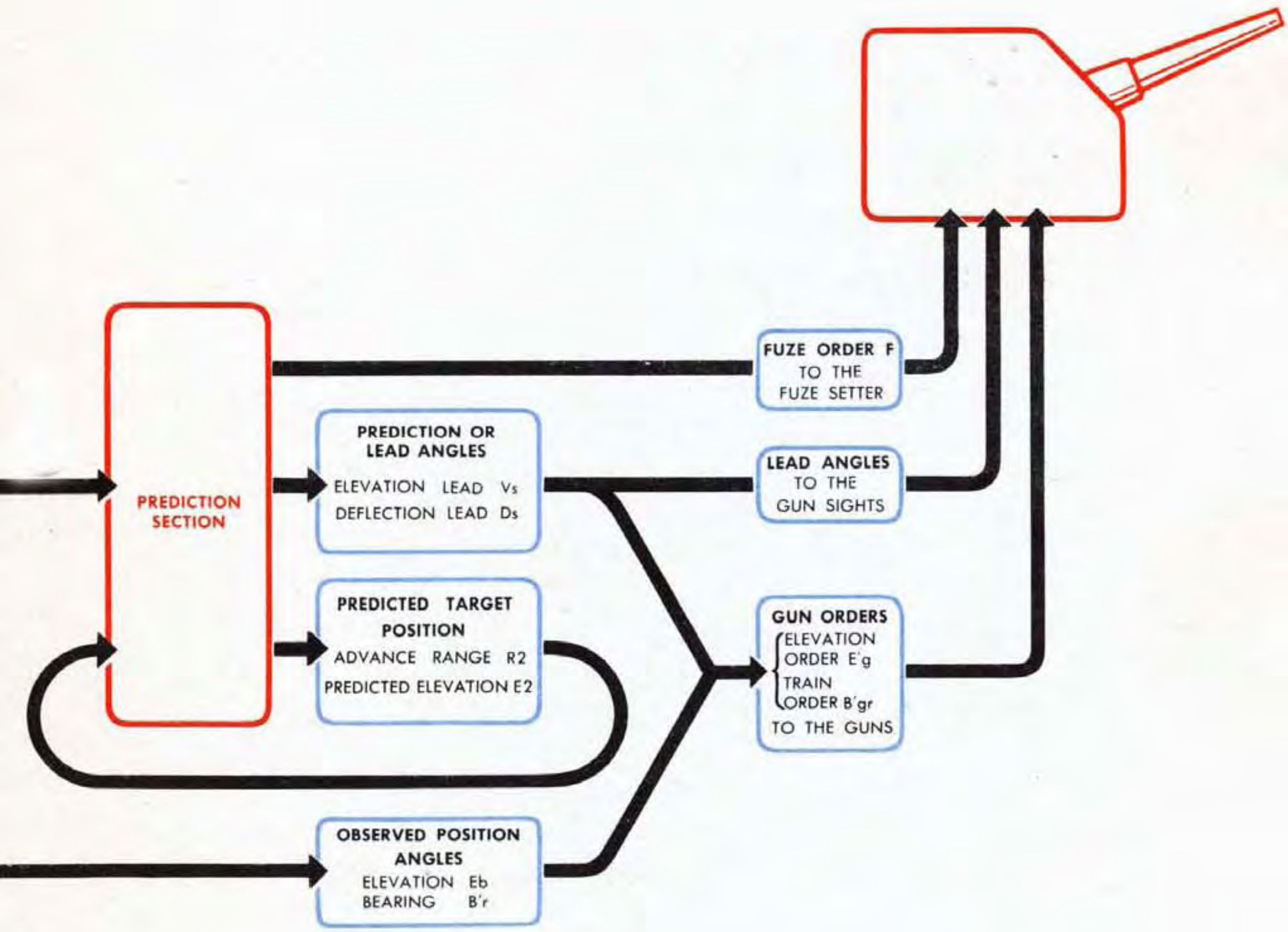


How the sections work together

This schematic shows how the Tracking and Prediction Sections of the Computer are connected to one another and to the Director and guns. Only the sections used in the computation from a horizontal deck are shown in this diagram.



The value of Time of Flight, Tf, which is used in these predictions is the time the projectile will take to reach the Predicted Target Position. Advance Range, $R2$, is approximately the Range to the predicted position of the Target. Predicted Elevation, $E2$, is approximately the Elevation to the predicted position of the Target. To compute a value of Time of Flight, Tf, both $R2$ and $E2$ must be used. After $R2$ and $E2$ have been approximately computed in the Prediction Section, they are used again as INPUTS to this section to compute values of Time of Flight and other ballistic quantities.

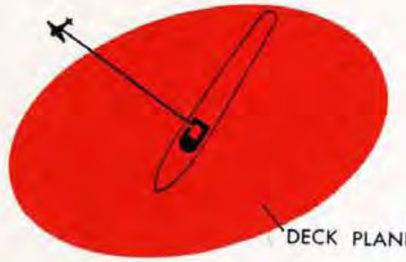


Because they are both outputs from and inputs to the Prediction Section, *R2* and *E2* are called *regenerative* quantities.

R2 and *E2* are quantities used only for computations within the Computer. They are not outputs to the guns or the Fuze Setter.

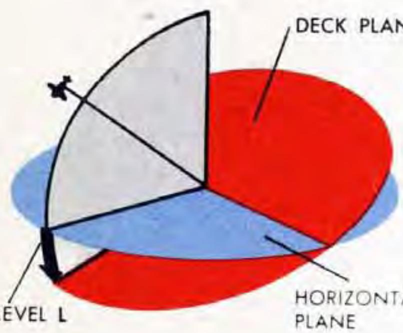
The Fuze Setting Order, *F*, is computed by a ballistic cam in the Prediction Section and is transmitted electrically to the automatic Fuze Setter Indicator Regulator at the gun mounts. Gun Orders are transmitted electrically to the Indicator Regulators in the mounts. The Lead Angles go to the gun sights.

STABILIZATION

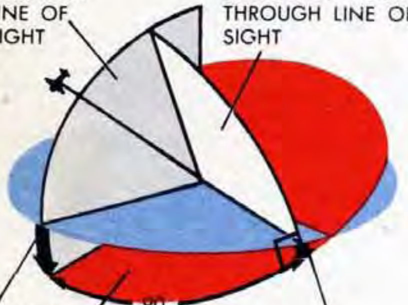


So far the Trunnion Tilt Section and the Deck Tilt and Synchronize Elevation Groups have not entered the discussion because the Ship was assumed to be steady and horizontal. Now they must be fitted into the pattern of Computer Mark 1 computations.

On a pitching and rolling ship there are three main needs for stabilization:



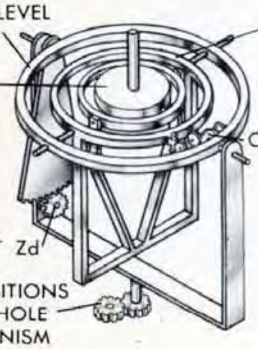
1. The values of Director Elevation and Director Train from the Director must be stabilized, or corrected for the inclination of the deck, before they can be used by the Tracking Section of the Computer. The pitching and rolling of the deck cause the values of Director Elevation and Train to vary, since they are measured from the tilting deck plane. These values have to be referred to the horizontal plane before they can be used for computations, since the Tracking and Prediction Sections of the Computer compute for the horizontal plane.
2. The generated values sent by the Computer to the Director to keep the Director sights on Target must also be corrected to allow for the inclination of the deck.
3. The Gun Orders must include corrections to allow for the tilt of the gun trunnions due to inclination of the deck.



The quantities used in stabilizing are Level, *L*, and Cross-Level, *Zd*. These quantities are the measurements of deck inclination in and at right angles to the plane through the Line of Sight.

Level, *L*, is the angle between the deck and the horizontal plane, measured in the vertical plane through the Line of Sight.

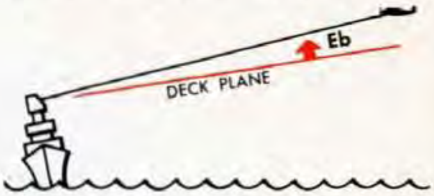
Cross-level, *Zd*, is the angle between the deck plane and the horizontal plane measured in a plane at right angles to the vertical plane through the Line of Sight and at right angles to the deck.



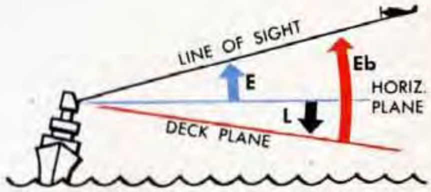
Both Level and Cross-level are measured by the Stable Element. The Stable Element mechanism is positioned by the value of Director Train, *B'r*, from the Computer, so that the Stable Element can always make its measurements in relation to the vertical plane through the Line of Sight.

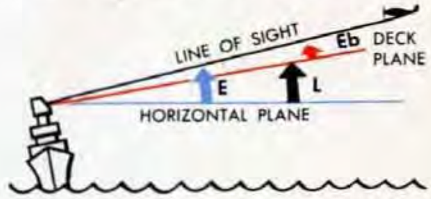
Stabilizing elevation

Since the base of the Director is always parallel to the deck, the whole Director rolls and pitches with the deck, and the measurements made from the Director sights are in or from the deck plane.



Director Elevation, *Eb*, is the elevation of the Line of Sight above the deck. *Eb* is continuously increasing and decreasing as the deck pitches and rolls. For computation, Target Elevation, *E*, above the HORIZONTAL is needed. *E* varies only as the actual elevation of the Target changes. *E* is used in computing Relative Motion Rates, since these rates are computed in relation to the horizontal plane.





To obtain Target Elevation, *E*, the changing value of Level, *L*, is continuously subtracted from Director Elevation, *Eb*. $Eb - L = E$. This subtraction takes place in the Synchronize Elevation Group. *Eb* from the Director and *L* from the Stable Element are the inputs to this group. The output is *E*, which goes to the Relative Motion Group.

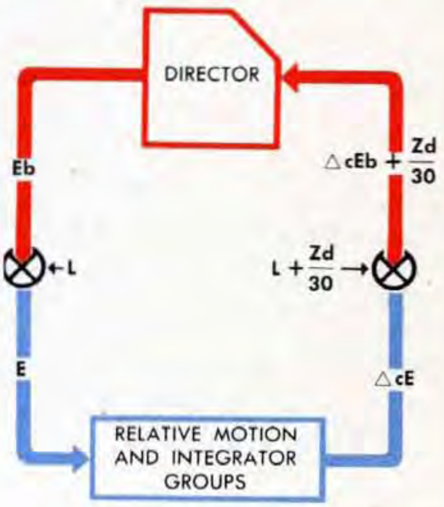
Zd is used to stabilize the Director sights in Cross-level and is always sent directly from the Stable Element to the Director. Therefore, the Director measures *Eb* in the vertical plane through the Line of Sight.

Changes of Target Elevation, $\triangle cE$, are generated by the Integrator Group, using the Linear Elevation Rate, *RdE*, obtained from the Relative Motion Group. $\triangle cE$ positions the Director sights to follow the changing elevation of the Target, but $\triangle cE$ alone cannot keep the sights on Target because of the rolling and pitching of the deck. The value of Level, *L*, which was subtracted from *Eb* to obtain a value of *E* must now be continuously added to $\triangle cE$ to compensate the sights for the motion of the deck. $\triangle cE + L = \triangle cEb$. $\triangle cEb$ is the Generated Changes of Director Elevation.

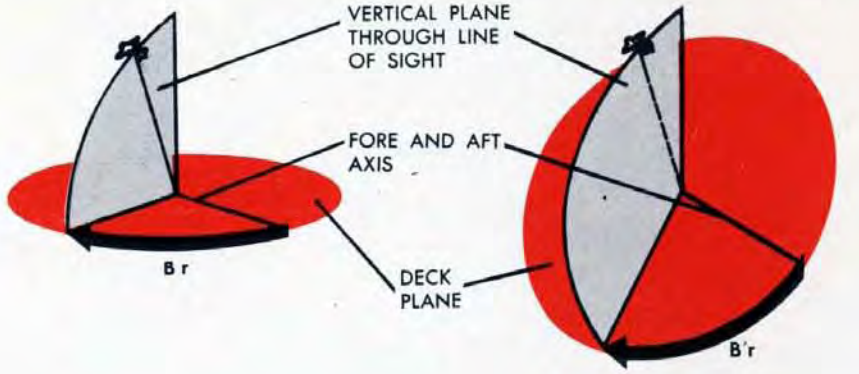
A function of Cross-level, $Zd/30$, is also added. $Zd/30$ permits Cross-level Corrections to be made without affecting Director Elevation.

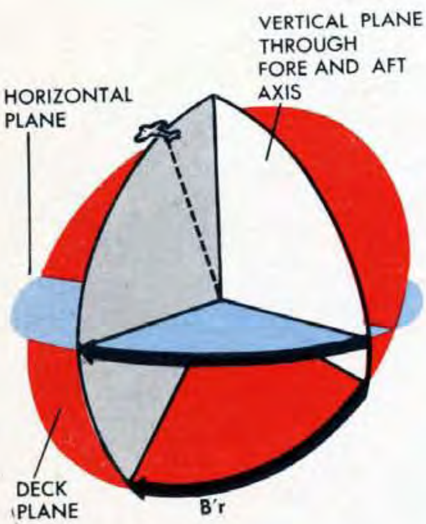
$L + Zd/30$ is usually added to $\triangle cE$ in the Computer and the whole value of $\triangle cEb + Zd/30$ is transmitted to the Director by one transmitter.

In some installations $L + Zd/30$ goes up directly from the Stable Element. $\triangle cE$ goes up alone from the Computer and is added to $L + Zd/30$ in the Director.



Stabilizing relative bearing

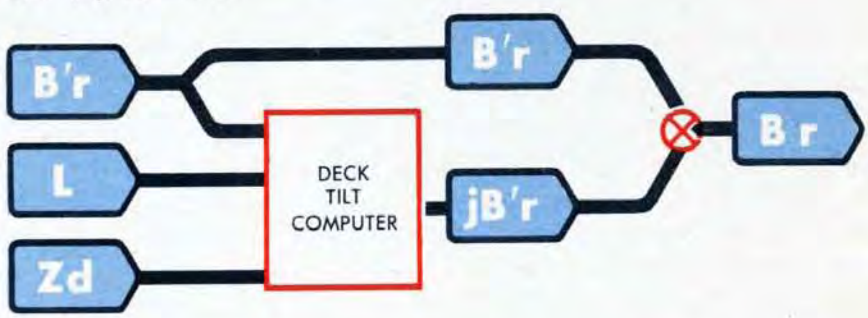


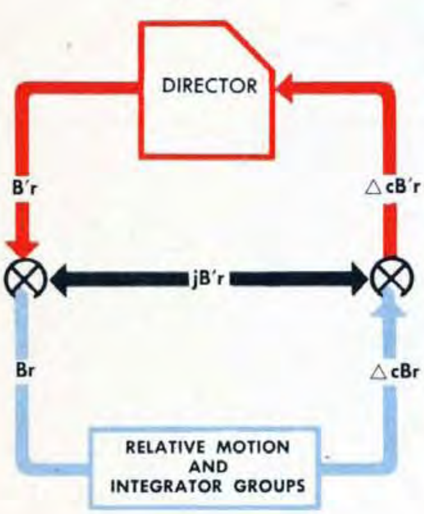


Director Train, $B'r$, is the angle measured in the deck plane from the bow of Own Ship clockwise to the vertical plane of the Line of Sight. When the deck is tilting, the Director must be continuously trained back and forth in order to keep the Line of Sight on the Target. Therefore $B'r$ is continuously increasing and decreasing as the Ship rolls and pitches. This change in $B'r$ due to deck tilt is difficult to visualize. It will be described in detail later in the chapter on Deck Tilt.

For computation in the Tracking Section, the value of Relative Target Bearing in the horizontal plane, Br, is needed. The calculated difference between Br and $B'r$ is a Deck Tilt Correction called $jB'r$. Br is produced by adding $jB'r$ to the measured value of Director Train, $B'r$.

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





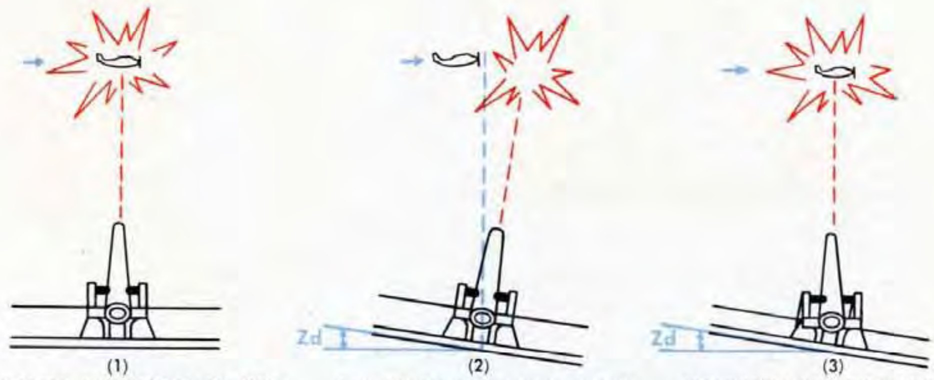
Deck Tilt Correction, $jB'r$, is computed by the Deck Tilt Group. The job of the Deck Tilt Group is to use L, Zd, and $B'r$ to produce this one correction, $jB'r$.

$jB'r$ is also used to convert the Generated Changes of Relative Target Bearing, $\triangle cBr$, computed by the Integrator Group, to Generated Changes of Director Train, $\triangle cB'r$. The Deck Tilt Correction, $jB'r$, is continually subtracted from $\triangle cBr$ to obtain $\triangle cB'r$.

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

$\triangle cB'r$ is the quantity required to keep the Director sights trained on the Target.

Stabilizing the guns



(1)
GUN ORDERS ARE CORRECT SO THAT PROJECTILE BURSTS ON TARGET. GUN TRUNNIONS ARE HORIZONTAL.

(2)
GUN ORDERS HAVE SAME VALUES AS IN (1) BUT TRUNNIONS ARE TILTED. PROJECTILE BURSTS LOW AND TO RIGHT OF TARGET.

(3)
TRUNNIONS ARE TILTED BUT GUN ORDERS ARE CORRECTED BY TRUNNION TILT CORRECTIONS. PROJECTILE BURSTS ON TARGET.

To prevent the guns being thrown off Target by the pitch and roll of the deck, continuous corrections are made to the Gun Orders, in Elevation and in Train.

These corrections are included in the two outputs from the Trunnion Tilt Section, *Vz* and *Dd*.

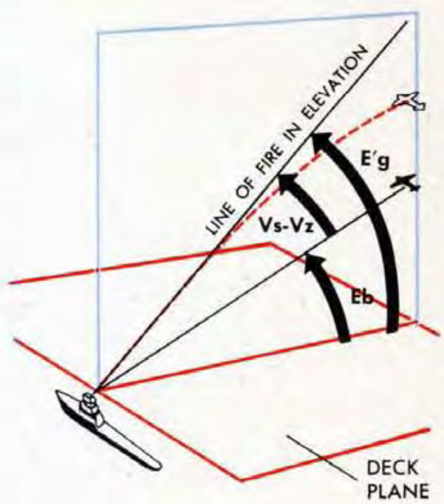
Vz is a correction to gun elevation to offset the tilting of the trunnions. *Vz* is subtracted from Director Elevation, *Eb*, plus Sight Angle, *Vs*, to give Gun Elevation Order, *E′g*.

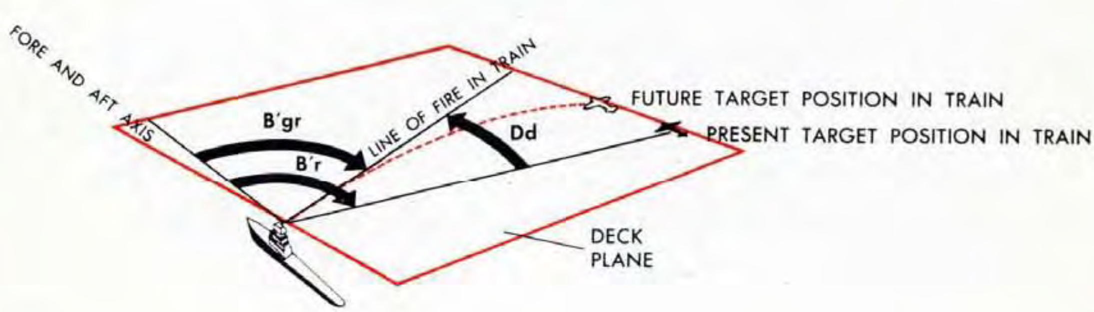
$Eb + Vs - Vz = E'g$

Dd is different from *Vz*. Instead of just correcting the Gun Train Order for Trunnion Tilt, *Dd* includes the whole Deflection Prediction, *Ds*, brought down to the deck plane, plus a train correction for Trunnion Tilt. *Dd* is the total deflection in the deck plane.

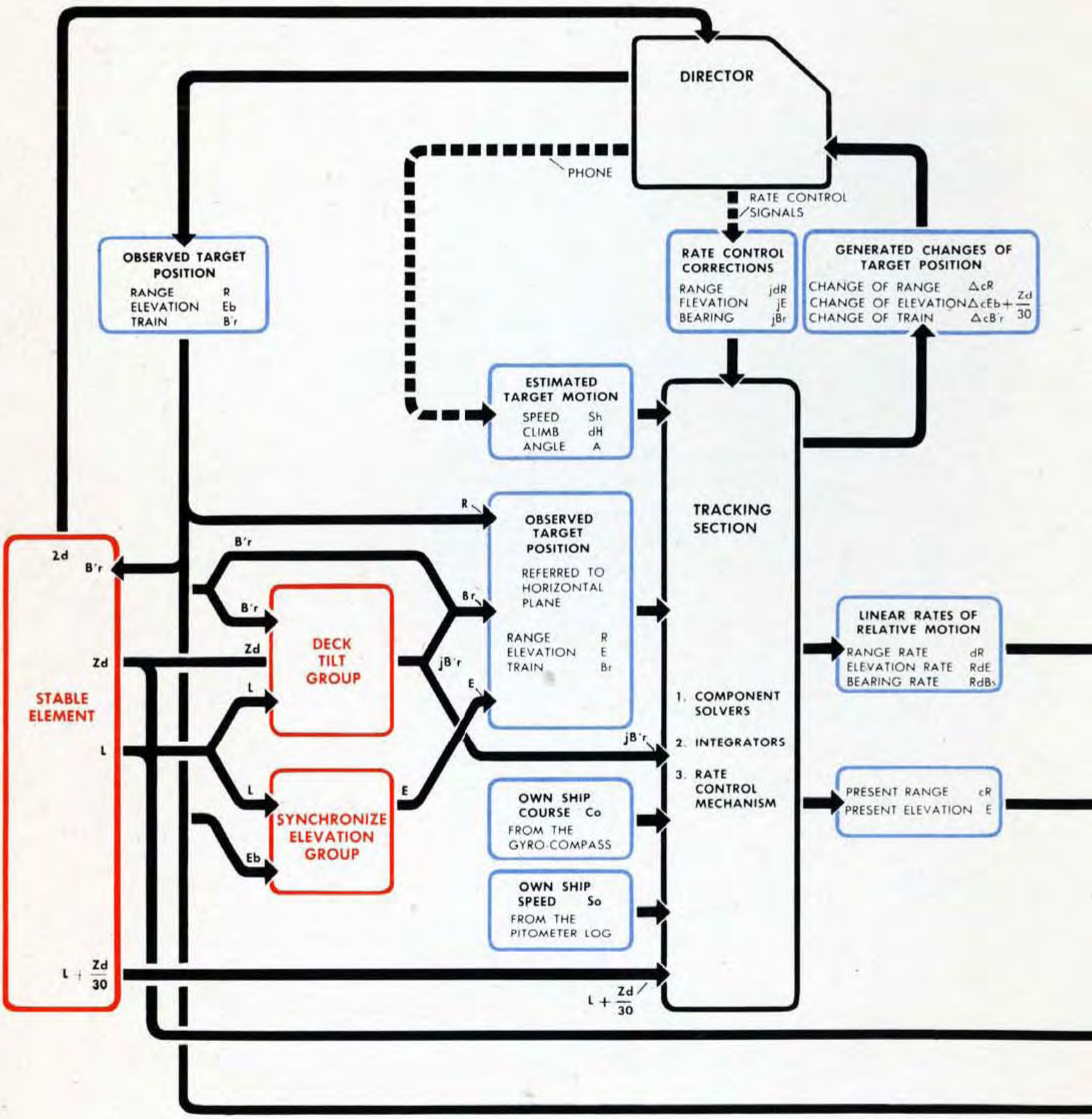
Dd is added directly to Director Train, *B′r*, to obtain Gun Train Order, *B′gr*.

$B'r + Dd = B'gr$

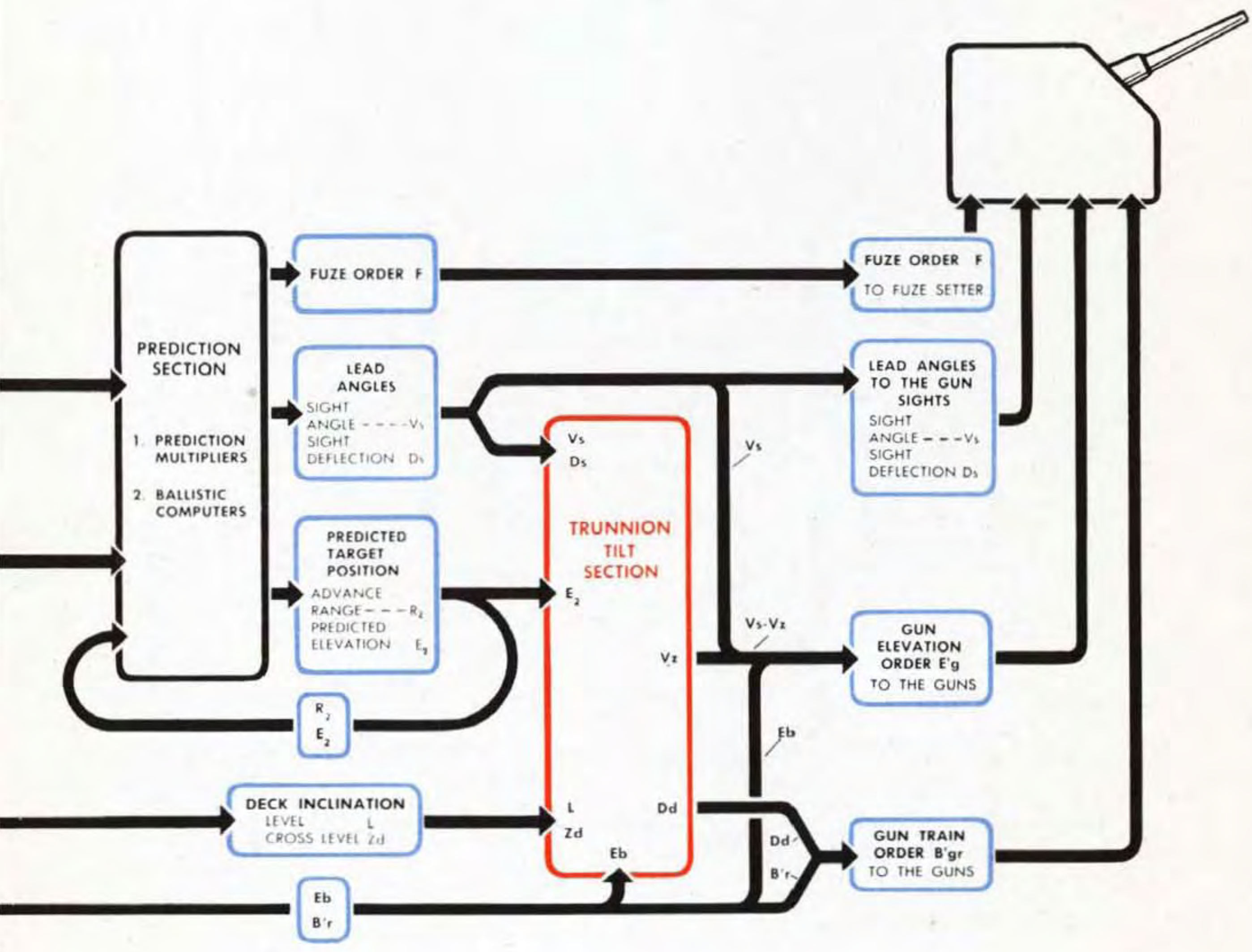




This schematic shows how the stabilizing sections



are connected with the other sections



The tracking cycle for a tilting deck

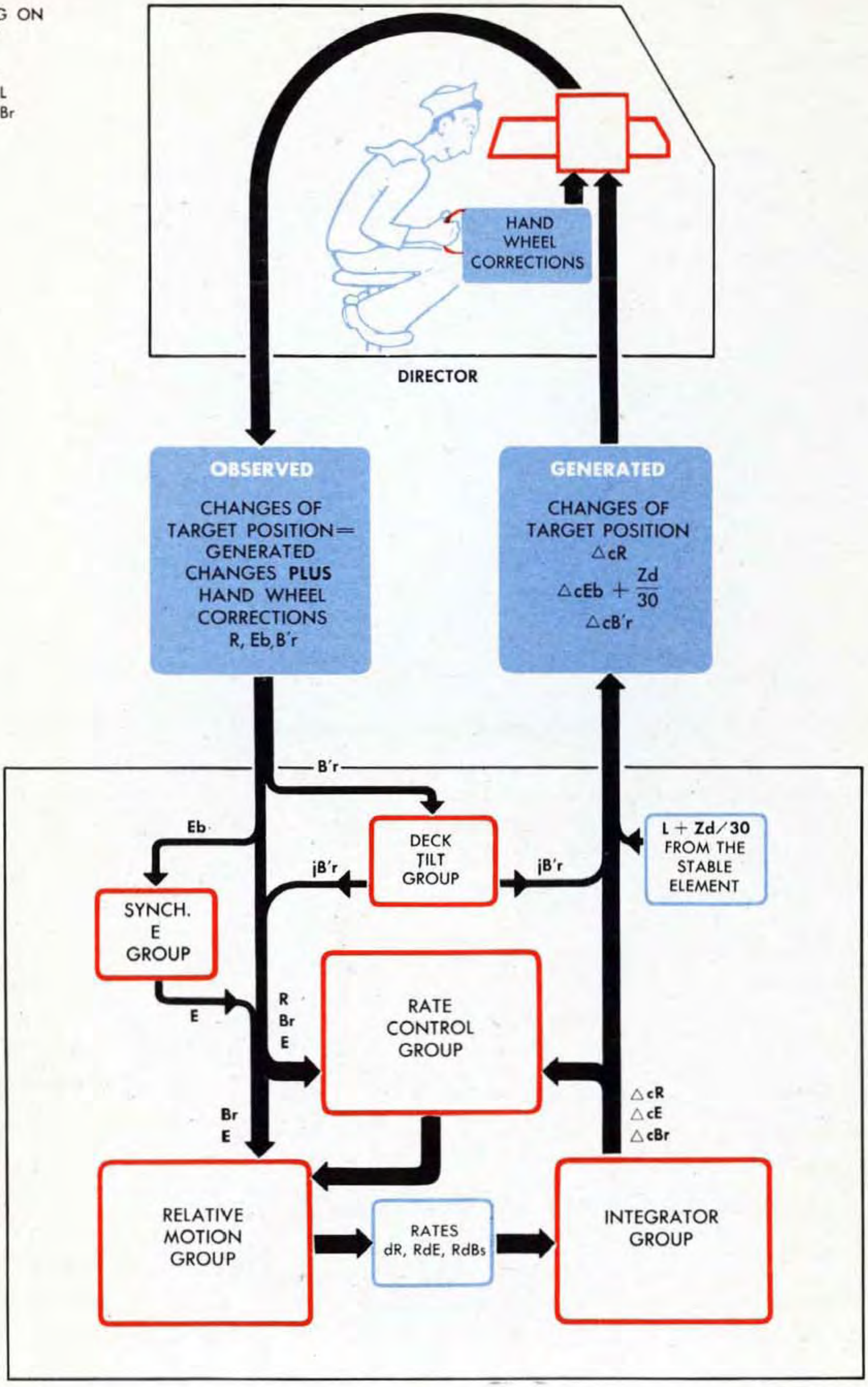
WHEN TRACKING ON A TILTING DECK

$Eb = E + L$

$B'r = Br - jB'r$

$\triangle cEb = \triangle cE + L$

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

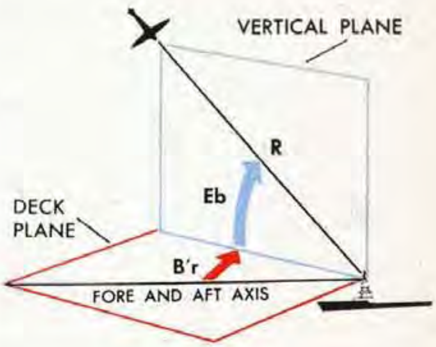


A MORE DETAILED ACCOUNT OF TRACKING, PREDICTION, AND STABILIZATION

In the simplified account of tracking, prediction, and stabilization, the mechanisms were handled in groups and only the quantities comprising the inputs and outputs of the sections and groups were discussed.

In the more detailed account which follows, each mechanism is shown separately and most of the intermediate quantities computed inside the sections are introduced.

The quantities not covered in this account are included in the Detailed Description of the Computer Mark 1 in Part 3 of this OP.



The inputs to the tracking section

When a target is sighted, the Director Crew puts the telescopes and Range Finder on it, and the values of Range, *R,* Director Train in the deck plane, *B'r,* and Director Elevation above the deck plane, *Eb,* are transmitted automatically to the Computer.

Observed Range, *R,* goes to the Range Receiver in the Rate Control Group and will be discussed later.

Director Train, *B'r,* is transmitted to the *B'r* Receiver in the Computer. Director Train is needed in the Relative Motion Group, but first it must be converted to the horizontal plane. *B'r* therefore goes from the *B'r* Receiver to the Deck Tilt Group.

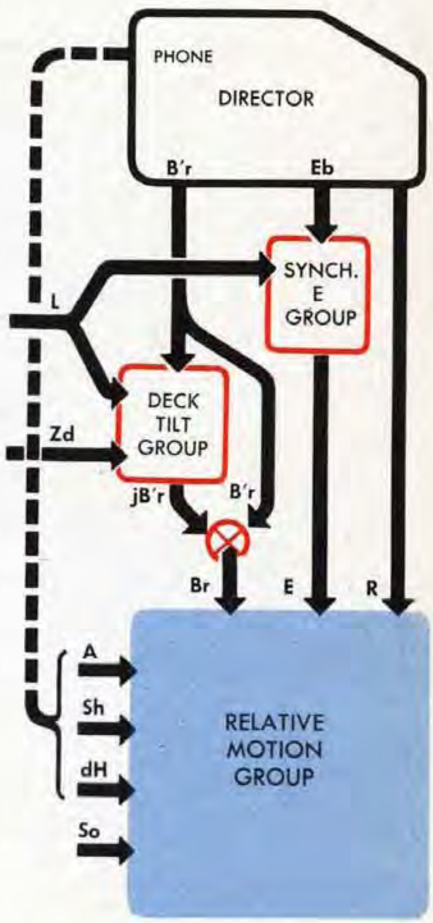
In the Deck Tilt Group, *B'r, L,* and *Zd* are used to compute the Deck Tilt Correction, *jB'r.* The Deck Tilt Group consists of a component solver and two multipliers. These three mechanisms are needed to produce the one output, *jB'r,* which is added to *B'r* to obtain *Br,* Relative Target Bearing in the horizontal plane.

Br then goes to the Relative Motion Group.

Eb from the Director goes to the *Eb* Receiver in the Computer, and from there to the Synchronize Elevation Group, where *L* is subtracted from *Eb,* giving *E.* The Synchronize Elevation Group, which consists of an arrangement of differentials and brakes, sends the value *E* to the Relative Motion Group, and also to other sections of the Computer.

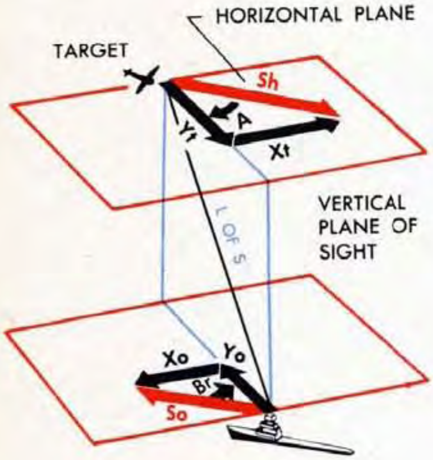
The values of Target Speed, *Sh,* Target Course, *Ct,* and Rate of Climb, *dH,* are estimated by the Control Officer in the Director, phoned down to the plotting room and cranked into the Relative Motion Group as *Sh, A,* and *dH.*

The remaining inputs to the Tracking Section are Ship Speed, *So,* and Ship Course, *Co.* *So* is transmitted electrically from the Pitometer Log to the *So* Receiver in the Relative Motion Group. *Co* is transmitted electrically from the Gyro Compass to the *Co* Receiver.



Computing RELATIVE MOTION rates

The Relative Motion Group contains a bank of four component solvers.

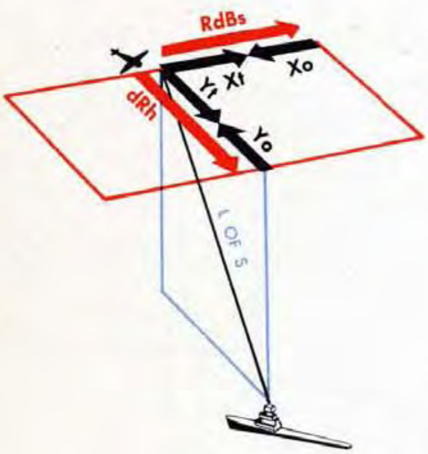


The Ship Component Solver takes Ship Speed, *So*, and Relative Bearing, *Br*, and computes the horizontal components of Ship Motion in and at right angles to the plane of sight.

The components are called *Xo* and *Yo*.

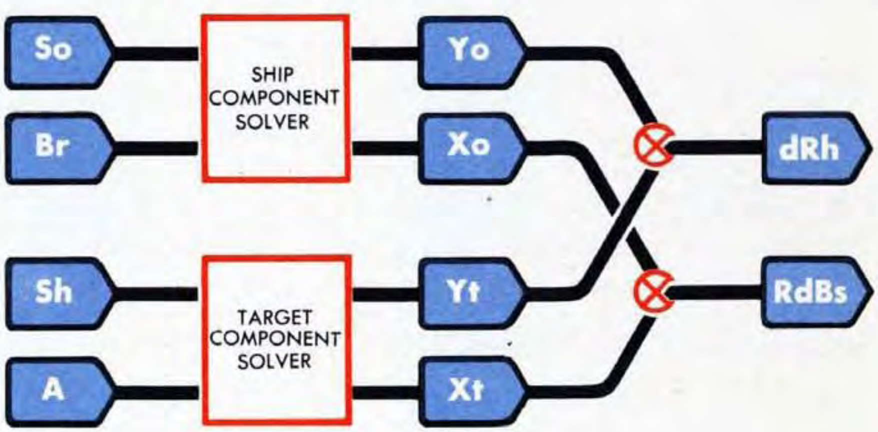
The Target Component Solver breaks down Target Speed, *Sh*, using Target Angle, *A*.

The Target Motion components are called *Xt* and *Yt*.



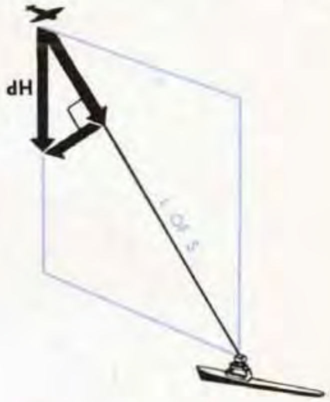
The Component of Ship Motion, *Yo*, is added to the Component of Target Motion, *Yt*, to give the linear Horizontal Range Rate, *dRh*. *dRh* is the combined motion of Ship and Target along a horizontal projection of the Line of Sight.

The two horizontal components, *Xo* and *Xt*, at right angles to the vertical plane through the Line of Sight are added to give total linear Deflection Rate, *RdBs*.

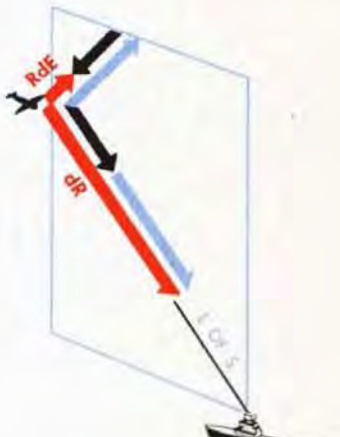


Direct Range Rate, *dR,* and Linear Elevation Rate, *RdE,* are computed from components of Horizontal Range Rate, *dRh,* and Rate of Climb, *dH.*

dRh and Target Elevation, *E,* go into the *dRh* Component Solver. The outputs of this solver are the components of *dRh* along and at right angles to the Line of Sight in the vertical plane through the Line of Sight.



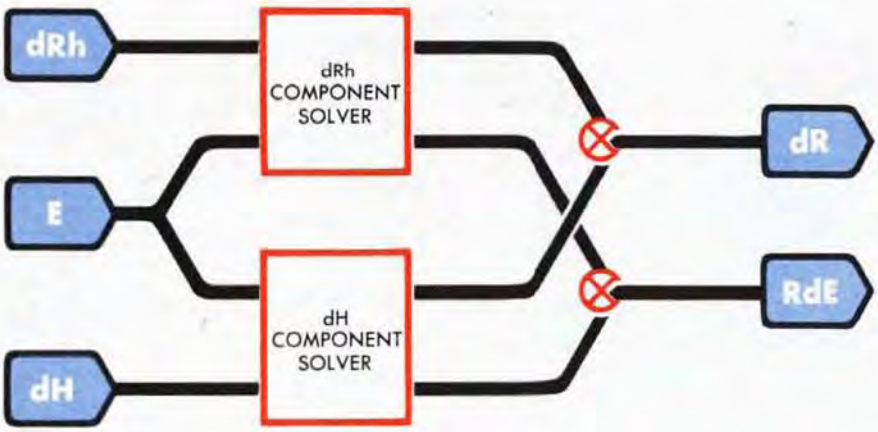
The *dH* Component Solver breaks up *dH* and angle *E* into components, also along and at right angles to the Line of Sight in the vertical plane through the Line of Sight.



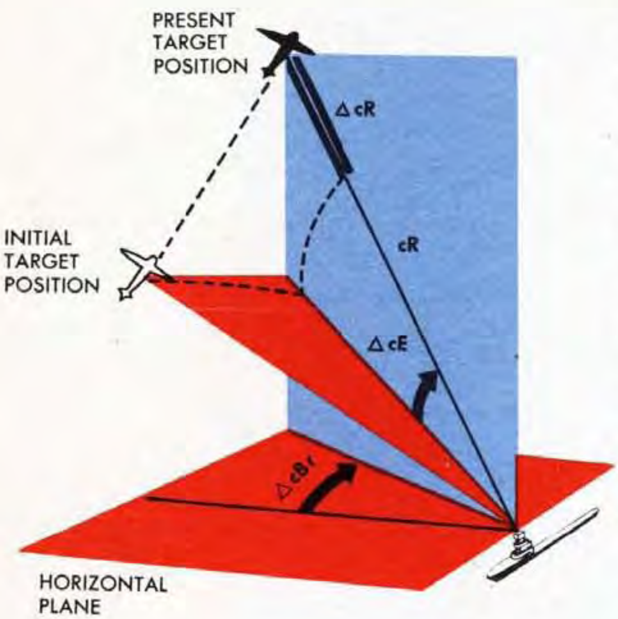
The components from each of these solvers lying along the Line of Sight are then added to give Direct Range Rate, *dR.* Direct Range Rate, *dR,* is the rate at which the Ship and Target are approaching or going apart from each other along the Line of Sight. It is the rate at which the Range is changing.

The two components at right angles to the Line of Sight make up Linear Elevation Rate, *RdE,* the combined Ship and Target speed at right angles to the Line of Sight in the vertical plane.

The Relative Motion Group computes these three Relative Motion Rates: *dR, RdE,* and *RdBs.*



THE INTEGRATOR GROUP



The Integrator Group has the job of generating continuous changes of Target Position. It computes Generated Changes of Range, $\triangle cR$, to drive the Generated Range Dials in the Computer and the Range Finder in the Director.

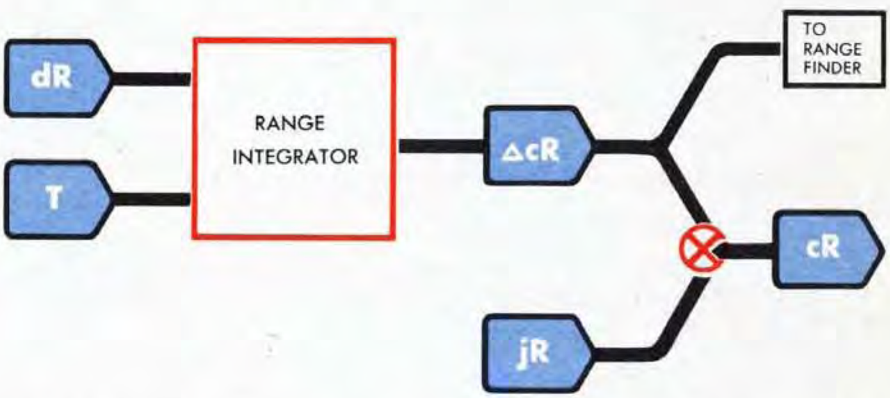
To drive the Generated Elevation and Bearing Dials the Integrator Group computes the Generated Changes of Target Elevation, $\triangle cE$, and Generated Changes of Relative Target Bearing, $\triangle cBr$.

To position the Director sights the Group also computes Generated Changes of Director Elevation, $\triangle cEb + Zd/30$, and Generated Changes of Director Train, $\triangle cB'r$.

The Integrator Group contains five disk integrators and two computing cam units.

Generating changes of range

The calculation of Range changes is fairly simple and is explained in detail in OP 1140.



The Range Integrator continuously multiplies the Range Rate, dR, by Time, T, to produce a continuous flow of increases or decreases in Range during the periods of Time, T. These changes in Range, $\triangle cR$, are continuously added to the Initial Range Setting, jR, to produce the Present Generated Range, cR, at any moment.

$\triangle cR$ positions the Range Finder in the Director.

Generating changes of elevation

Generating changes of Elevation and Bearing is a little more complicated than generating changes of Range, because the changes of Elevation and Bearing are ANGULAR changes. They are the changes that the sights must make in Elevation and Train to stay on the Target.

The Generated Changes of Elevation, $\triangle cE$, are calculated as follows:

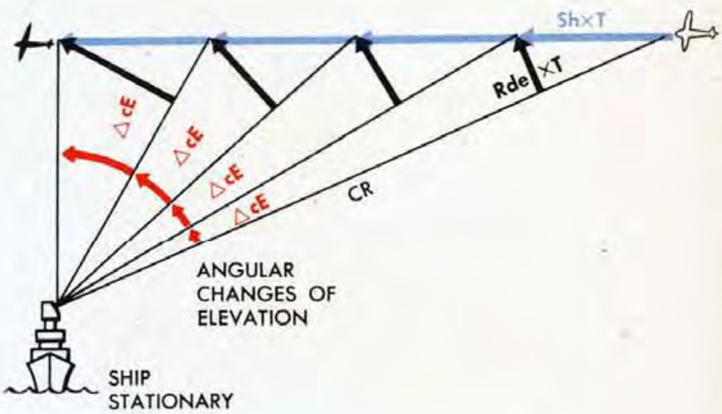
Elevation Rate, RdE, multiplied by Time, T, gives the linear Elevation change during the Time, T. $RdE \times T$ divided by the Range, cR, gives angular change in Elevation in radians.

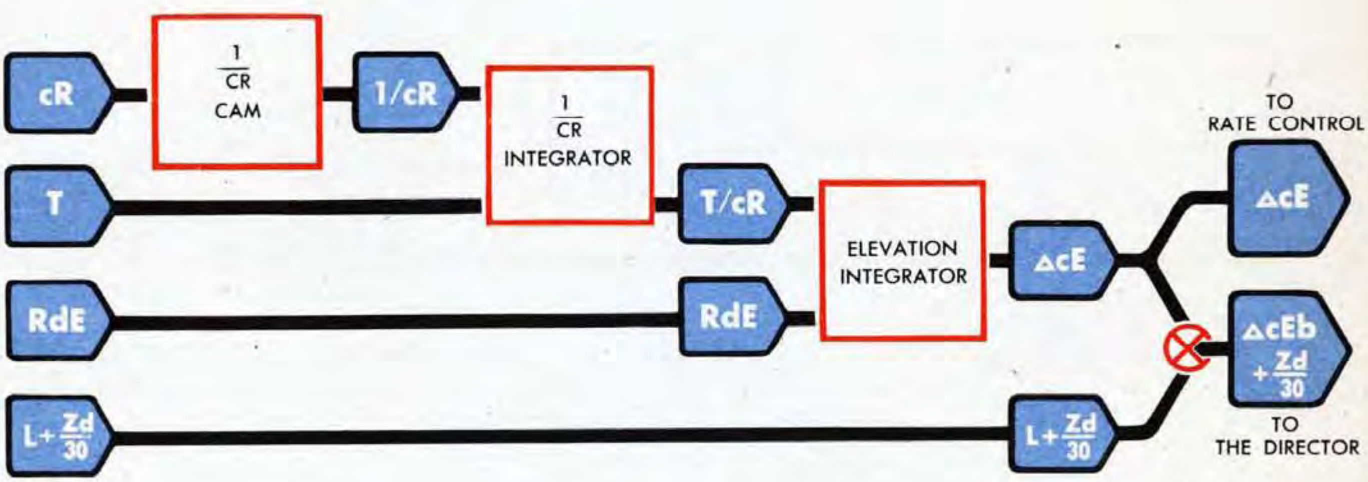
The Generated Angular Elevation Change, $\triangle cE$, is therefore computed for each successive instant of Time as $RdE \times T/cR$

$\triangle cE$ is computed in three mechanisms.

A reciprocal cam computes continuous values of $1/cR$. The changing values of $1/cR$ are multiplied by Time, T, in the $1/cR$ Integrator to give continuous values of T/cR. Then the values of T/cR are multiplied by the Elevation Rate, RdE, in the Elevation Integrator, to give continuous values of $RdE \times T/cR$, which are the Generated Changes of Elevation, $\triangle cE$.

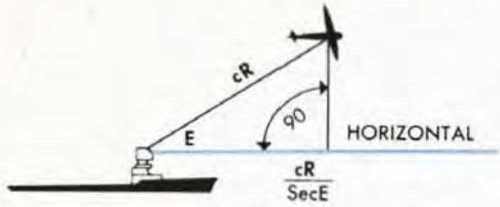
$\triangle cE$ continuously positions the Generated Elevation Dials in the Rate Control Group.



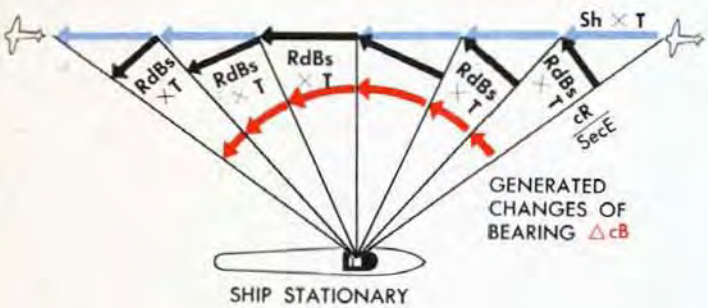


$L + Zd/30$ is added to $\triangle cE$, giving $\triangle cEb + Zd/30$. $\triangle cEb + Zd/30$ is continuously transmitted to the Director sights. The value of L compensates the sights for the effect of Level. The value $Zd/30$ permits Cross-level Corrections to be made at the Director without affecting Director Elevation.

Generating changes of director train



Computing the Generated Changes of Director Train requires more mechanisms than computing Generated Changes of Elevation. These Director Train increments must not only be ANGULAR increments but they must also be converted to the deck plane. Since the Director trains in the deck plane, Generated Changes of True Bearing in the horizontal plane, $\triangle cB$, are computed and then converted, first to Generated Changes of Relative Bearing, $\triangle cBr$, and then to Generated Changes of Director Train, $\triangle cB'r$.

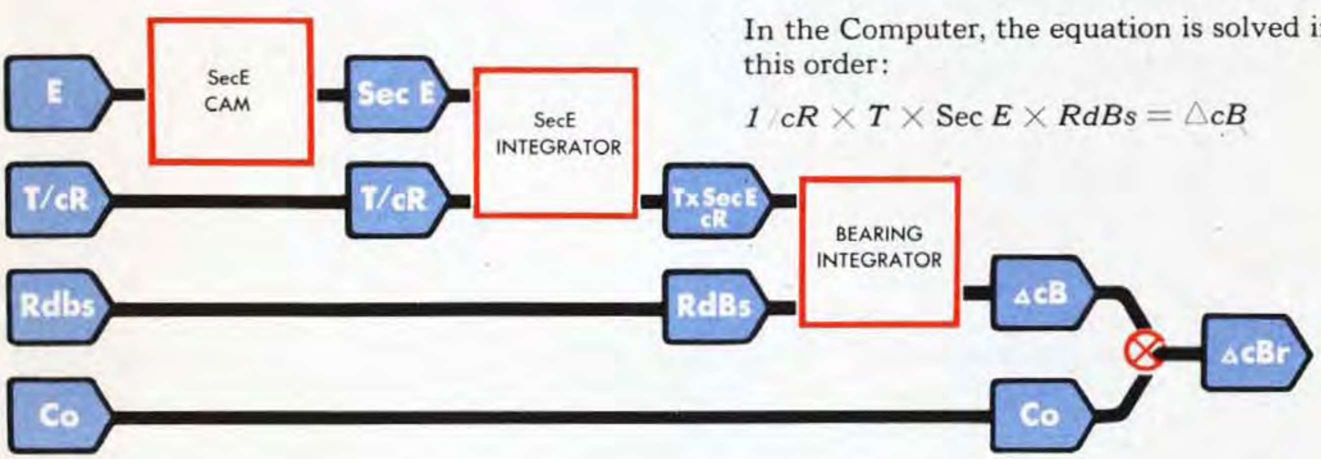


The Generated Angular Changes of True Bearing in the horizontal plane, $\triangle cB$, are computed like $\triangle cE$ except that $cR/\text{Sec } E$ is used instead of cR. This is necessary to convert from the slant plane of the Line of Sight to the horizontal plane.

$$\triangle cB = \frac{RdBs \times T}{\text{Horizontal Range}} = \frac{RdBs \times T}{cR/\text{Sec } E} = \frac{RdBs \times T \times \text{Sec } E}{cR}$$

In the Computer, the equation is solved in this order:

$$1/cR \times T \times \text{Sec } E \times RdBs = \triangle cB$$

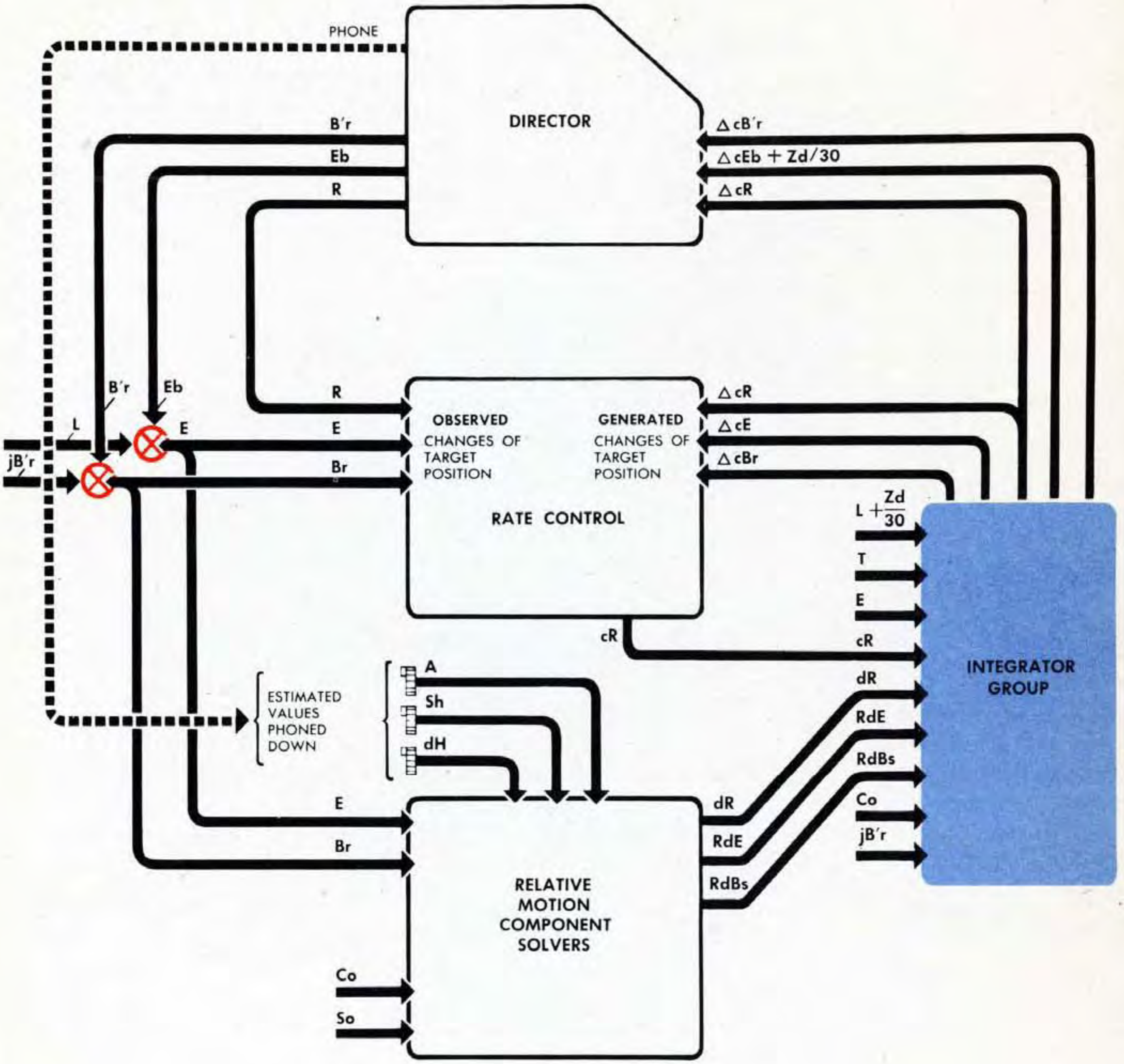


Own Ship Course, Co, is subtracted from $\triangle cB$ to take out the effect of a change in Own Ship Course. The new quantity obtained is the Generated Changes of Relative Bearing in the horizontal plane, $\triangle cBr$.

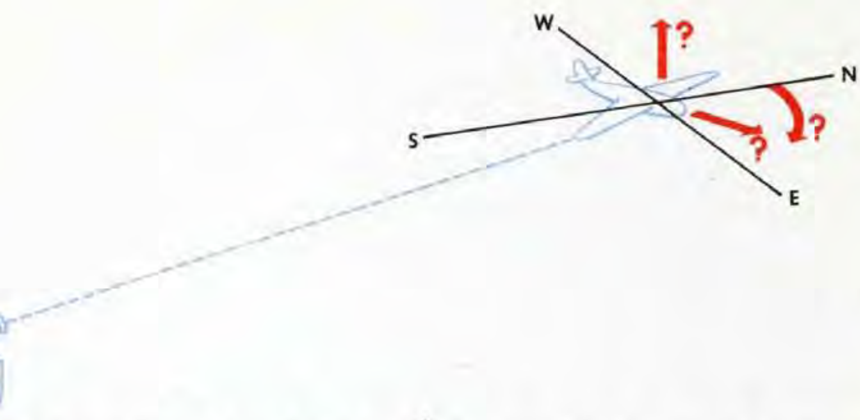
$$\triangle cB - Co = \triangle cBr$$

Deck Tilt Correction, $jB'r$, is subtracted from $\triangle cBr$ to correct it for the effect of deck inclination. The new quantity is the Generated Changes of Director Train, $\triangle cB'r$. $\triangle cB'r$ keeps the Director sights on Target in train regardless of changes in Own Ship Course and deck inclination.

Here are all the inputs and outputs of the integrator group



The RATE CONTROL GROUP



The function of the Rate Control Group is to correct the estimated values of *Sh, dH,* and *A*.

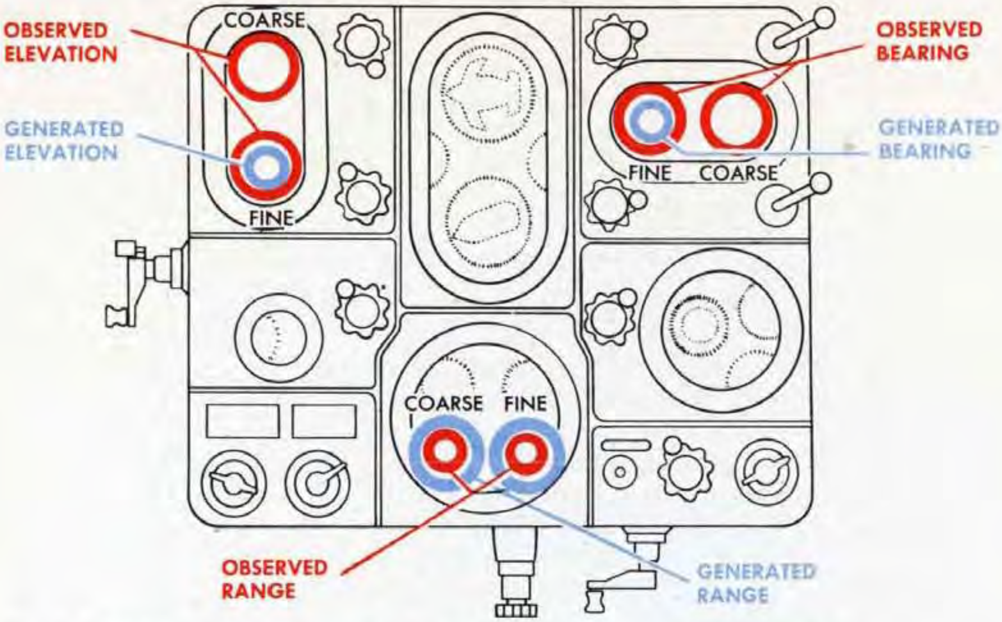
All the values needed by the Computer in tracking and in computing Gun Orders are available, except the values of Target Speed, Target Angle, and Rate of Climb. Target Position can be continuously measured; Own Ship Speed and Course are known; wind, deck inclination, and all the other necessary quantities can be measured. But Target Motion has to be *estimated*.

Even a very experienced man cannot make accurate estimates at long ranges, and the estimates, therefore, always have to be checked and corrected.

The Relative Motion Rates are computed from known values of Own Ship Motion, known values of Target Position, and *estimates* of Target Motion. When the Target Motion estimates are correct, the Relative Motion *Rates* will also be correct. The process of correcting Target Speed, Target Angle and Rate of Climb is therefore called *"Rate Control."*

The method of correcting the Target Motion estimates is this: First the Relative Motion Group computes Relative Motion Rates based on the estimates. Then the Integrator Group uses these rates to generate continuous changes of Target Position. These generated changes are compared with observed changes, and the differences between generated and observed changes are used to correct the estimates.

The job of the Rate Control Computing Mechanism is to analyze the differences between Observed Range and Generated Range, between Observed Elevation and Generated Elevation, and between Observed Target Bearing and Generated Target Bearing, to determine what errors in Target Speed, *Sh*, Target Angle, *A*, and Rate of Climb, *dH*, were responsible for the differences, and to correct these errors.



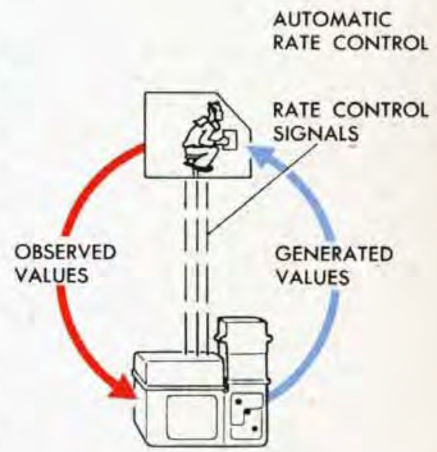
Both GENERATED and OBSERVED changes of Range, Bearing and Elevation show on dials on the top front section of the Computer Mark 1.

In Elevation and Bearing, the outer dials, fine and coarse, are positioned by the observed quantities in the horizontal plane, *E* and *Br*. The inner fine dials are positioned by the generated values, $\triangle cE$ and $\triangle cBr$.

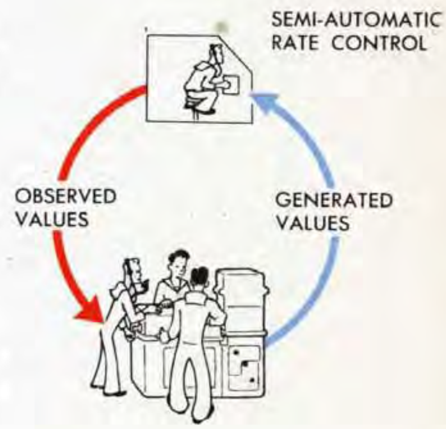
In Range the dials are arranged in the opposite way. The INNER dials are positioned by Observed Range, *R*, the outer dials by Generated Range, *cR*.

The Rate Control Group consists of the Range, Elevation, and Bearing Dials, a system of locks, clutches, and follow-ups, and the Rate Control Computing Mechanism. The Rate Control Computing Mechanism consists of four component integrators and a vector solver.

There are several ways of rate-controlling. The two methods which make use of the Rate Control Computing Mechanism are Automatic and Semi-automatic Rate Control.



In Automatic Rate Control, corrections are put into the Rate Control Computing Mechanism automatically on signals from the Director.



In Semi-automatic Rate Control, corrections are put into the Rate Control Computing Mechanism by handcranks at the Computer.

AUTOMATIC and SEMI-AUTOMATIC RATE CONTROL

Since Elevation and Bearing Rate Control are identical, and Range Rate Control is similar to these two, an error in just ONE of these quantities will serve to show how a Rate Control correction is put into the Rate Control Computing Mechanism.

Suppose the sights begin to move off in elevation. The Pointer turns his handwheels to bring them on. By turning his handwheels, he changes the value of Observed Elevation, *E*, in the Computer. The introduction of this change throws the Observed and Generated Dials out of synchronism.

What happens after this depends on the type of operation being used.

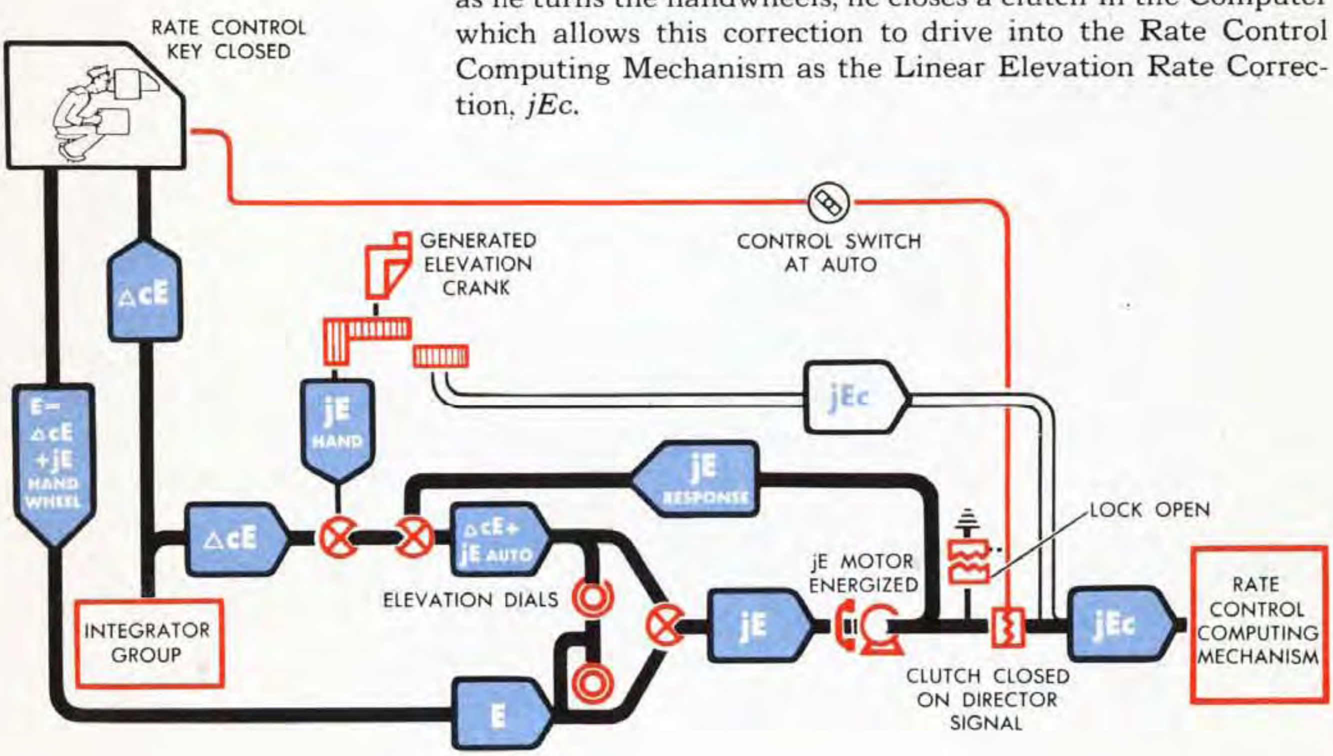
In Automatic Operation, the Generated and Observed Changes of Elevation are continuously fed into a differential which compares them.

As long as the Generated Changes equal the Observed Changes, the output of the differential is at zero.

When the Pointer turns his handwheels, making a change in Observed Elevation, the two sides of the differential no longer match. The difference between the two sides, *jE*, controls a follow-up motor which drives the Generated Elevation line until it matches the value on the Observed Elevation line.

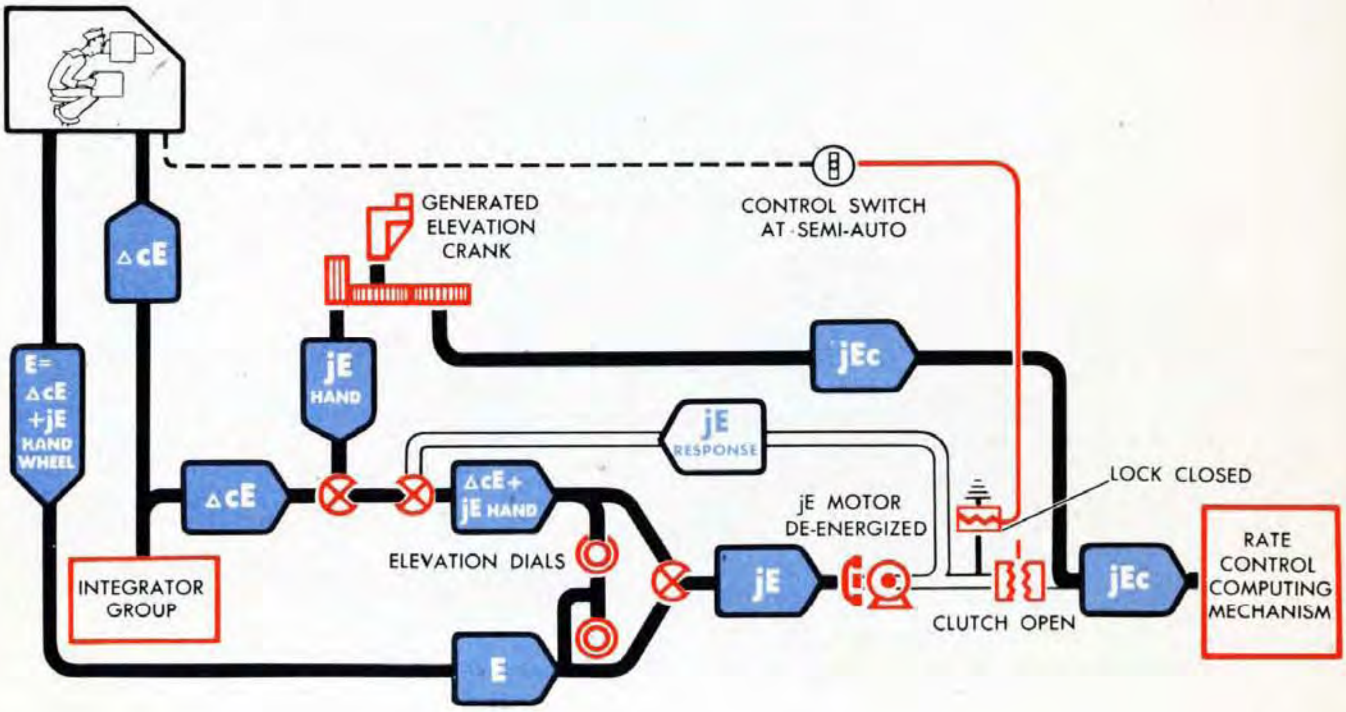
The amount the follow-up drives represents the Angular Correction in Elevation, *jE*.

If the Pointer in the Director has his Rate Control Key closed as he turns the handwheels, he closes a clutch in the Computer which allows this correction to drive into the Rate Control Computing Mechanism as the Linear Elevation Rate Correction, *jEc*.



In Semi-automatic Operation, the Pointer in the Director does not control the Elevation Rate Correction input line to the Rate Control Computing Mechanism. This line is controlled by the Elevation Operator at the Computer. The Elevation Operator watches the Elevation Dials, and as soon as he sees that the Generated Elevation Dial is turning faster or slower than the Observed Elevation Dial, he turns the Generated Elevation Crank in its IN position until the dials turn together. By turning the crank in the IN position he is not only matching the Elevation Dials but is also putting Elevation Rate Correction, *jEc*, into the Rate Control Computing Mechanism.

NOTE: In describing Rate Control, the quantities coming from and going to the Director have been referred to the horizontal plane. The stabilizing quantities, *L* and *Zd*/*30*, have been omitted.



Putting in range rate control corrections

Deflection Rate Control Corrections are put into the Rate Control Computing Mechanism in exactly the same way as Elevation Rate Control Corrections.

Range Rate Control Corrections are put in a little differently. All Elevation and Bearing lines in the Computer are driven by OBSERVED Elevation and Bearing, but the Range lines in the Computer are driven by GENERATED Range. The reason for this is that while Elevation and Bearing can be measured continuously, the Range Finder can only be focused intermittently. Generated Range is therefore a more smoothly and continuously changing quantity than Observed Range.

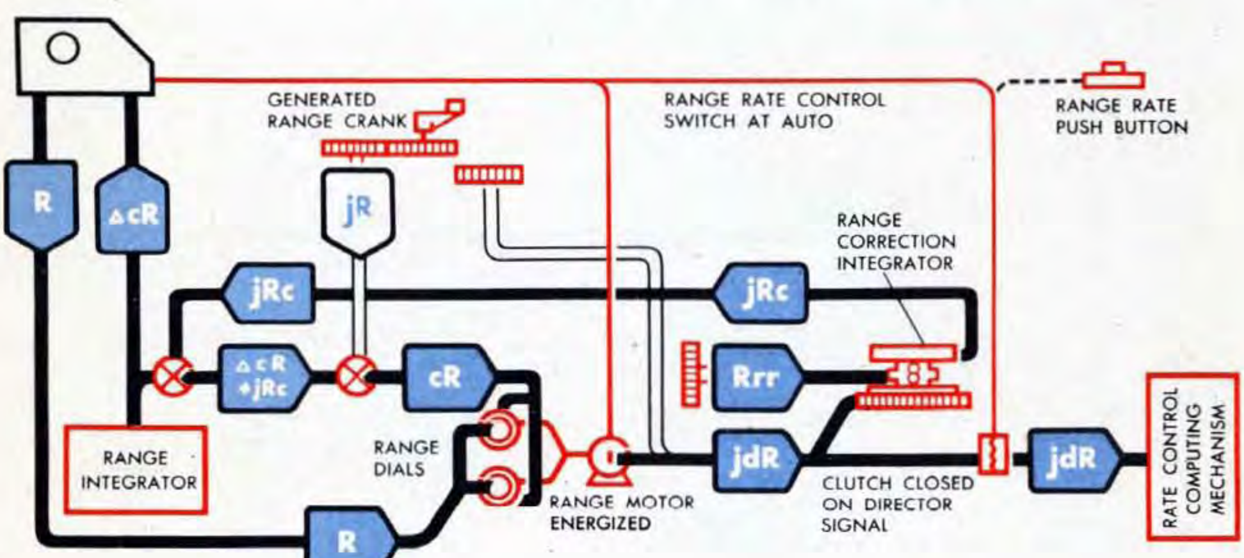
Because it positions all the Range lines, *cR* has to be very accurate. Generated Elevation and Bearing must change at the same rates as Observed Elevation and Bearing. *cR* must not only change at the same rate as *R*, *but also must be exactly equal to R whenever R is correct.*

When Generated Range, *cR*, changes at a different rate from Observed Range, *R*, Range Rate Control is needed.

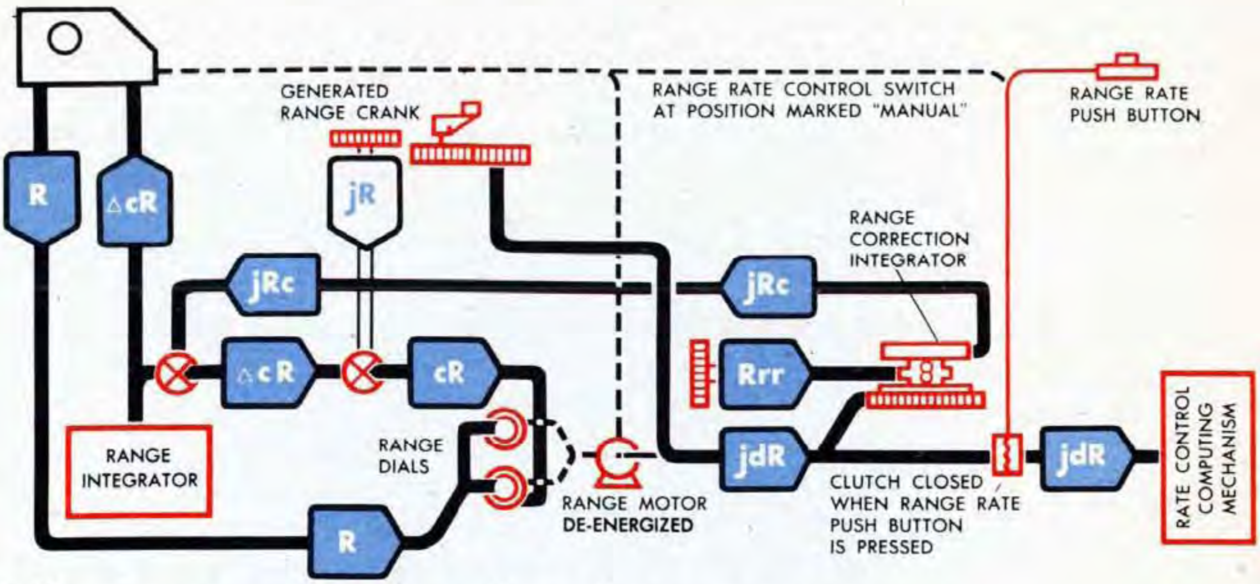
Range Rate Corrections going into the Rate Control Computing Mechanism are controlled through a mechanism called the Range Correction Integrator.

In Automatic Operation, *R* and *cR* are compared at the Range Dials. A special contact arrangement between the dials controls a motor which drives the difference between *R* and *cR* through the Range Correction Integrator into the *cR* line whenever the Signal Key in the Director is closed. This linear correction to *cR* is called *jRc*.

On the same signal from the Range Operator in the Director, a value proportional to the difference between *R* and *cR* is also driven through a clutch into the Rate Control Computing Mechanism, as Range Rate Correction, *jdR*.



In Semi-automatic Operation both the Linear Range Correction, *jRc*, and the Range Rate Correction, *jdR*, are put in manually by the Generated Range Crank in its IN position. The clutch through which *jdR* goes to the Rate Control Computing Mechanism is controlled by the Range Rate Manual Push-button.

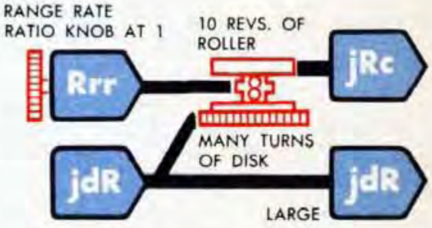


The range correction integrator

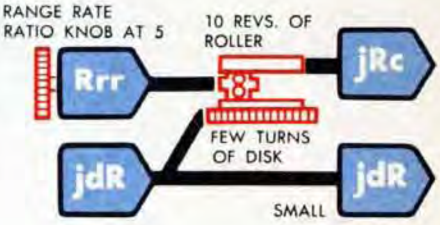
The function of the Range Correction Integrator is to control the amount of Range Rate Correction going into the Rate Control Computing Mechanism for any given amount of linear Range Correction.

The disk of the Range Rate Integrator is turned by Range Rate Correction, *jdR*. The carriage is positioned directly by the Range Rate Ratio Knob on the front of the Computer. The roller drives Linear Range Correction, *jRc*, into the Generated Range Line.

The Range Rate Ratio Knob has a drum numbered from 1 to 5. The setting of this knob determines the amount of Range Rate Correction introduced for each linear correction to Generated Range.

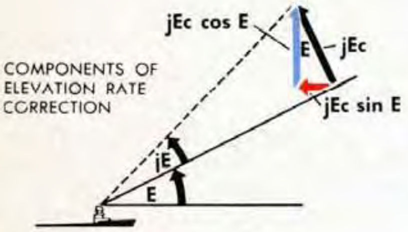


Suppose Generated Range needs a correction *jRc* which requires ten turns of the integrator roller. If the Range Rate Ratio Knob is at 1, a relatively large Range Rate Correction, *jdR*, goes into the Rate Control Computing Mechanism for each Range Correction, *jRc*, because the integrator carriage is positioned near the center of the disk. With the carriage near the center, relatively many turns of the disk are needed to turn the roller ten revolutions. A relatively large *jdR* is therefore put in for the *jRc* needed to match the Range Dials.



With the Range Rate Ratio Knob positioned near 5, a small Range Rate Correction, *jdR*, goes in for each Range Correction, *jRc*, because the carriage is positioned near the edge of the disk. With the carriage near the edge, fewer turns of the disk will produce the ten revolutions of the roller needed to match *cR* and *R*. *jdR* will be relatively small.

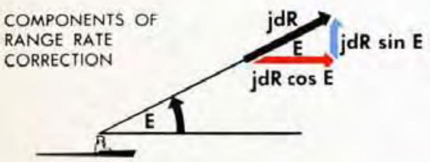
How rate control corrects RATE OF CLIMB TARGET SPEED and TARGET ANGLE



So far, the method has been shown by which the three Rate Control Corrections, Range Rate Control Correction, *jdR*, Elevation Rate Control Correction, *jEc*, and Bearing Rate Control Correction, *jBc*, go into the Rate Control Computing Mechanism.

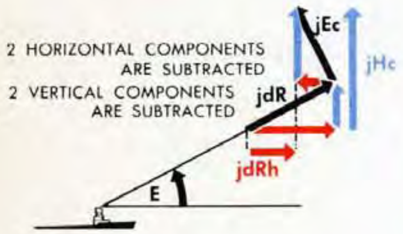
Inside that mechanism, four Component Integrators and the Vector Solver use these corrections to correct the Target Motion values, *dH*, *Sh*, and *A*.

The Elevation Rate Correction, *jEc*, and Target Elevation, *E*, are the inputs to the first component integrator. The outputs are the horizontal and vertical components of *jEc*: *jEc* sin *E* and *jEc* cos *E*.

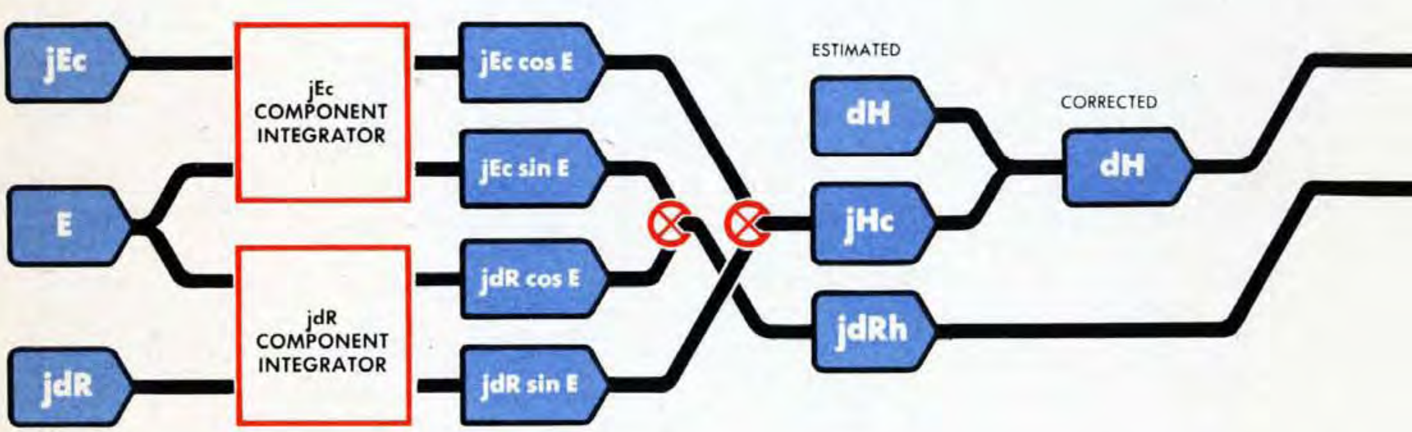


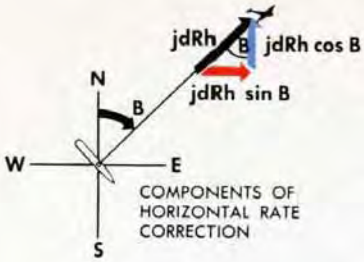
The inputs to the second component integrator are the Range Rate Correction, *jdR*, and Target Elevation, *E*.

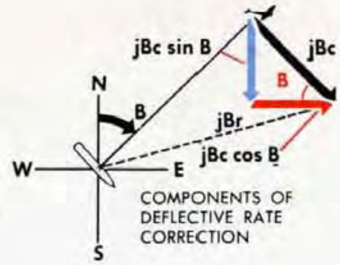
The outputs are the horizontal and vertical components of *jdR*: *jdR* cos *E* and *jdR* sin *E*.



The *horizontal* components from the two integrators are subtracted to obtain the Horizontal Range Rate Correction, *jdRh*. The *vertical* components from the two integrators are added to give the total vertical correction, *jHc*. *jHc* is used to correct Target Rate of Climb, *dH*.



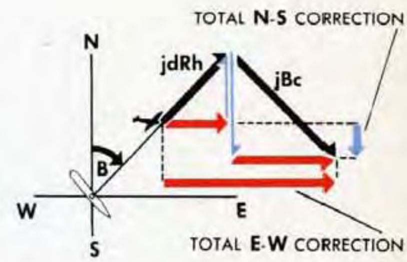




Two more component integrators break up the Horizontal Range Rate Correction, *jdRh*, and the Deflection Rate Correction, *jBc*, into their components along a North-South and East-West axis. The angular input to each of these component integrators is Target Bearing, *B*.

The N-S component of *jBc* is subtracted from the N-S component of *jdRh* to give the total N-S Horizontal Rate Correction.

The two E-W components are added to give the total E-W Horizontal Rate Correction.



The Vector Solver corrects Sh and Ct

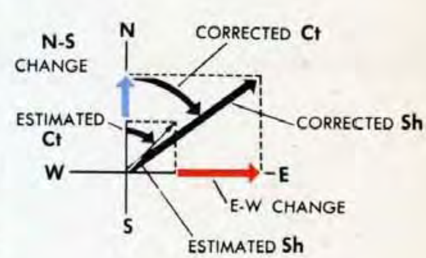
The N-S and the E-W Horizontal Rate Corrections go to the Vector Solver.

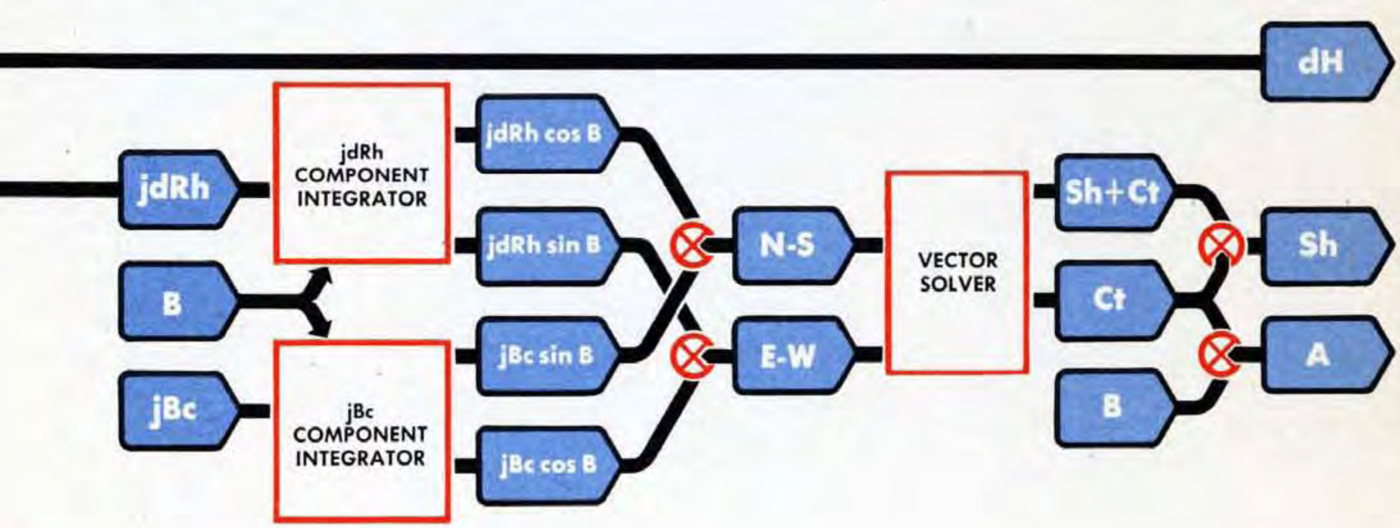
The Vector Solver was previously positioned by the estimated values of Target Speed, *Sh*, and Target Course, *Ct*. The corrections from the Rate Control Component Integrators are added to the values of *Sh* and *Ct* already in the Vector Solver.

The Vector Solver's outputs are therefore *corrected values* of Target Speed and Target Course.

For mechanical reasons the two outputs of the Vector Solver are *(Sh + Ct)* and *Ct*. The *Ct* output is subtracted from the *Sh + Ct* output to obtain the corrected value of *Sh*. The *Ct* output is also subtracted from True Bearing, *B*, to obtain the corrected value of Target Angle, *A*.

The new values of *Sh* and *A* go to the Target Component Solver in the Relative Motion Group.

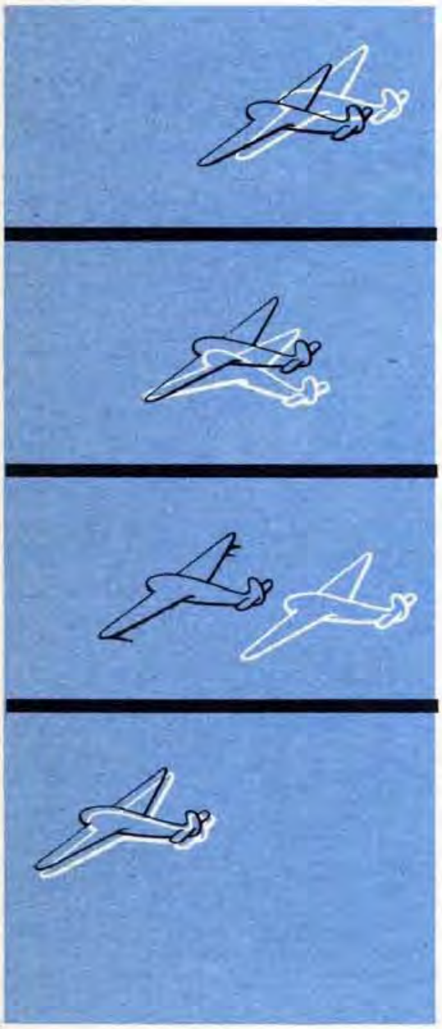




Another way to think about rate control

Suppose that the Control Officer can visualize his guesses of Target Motion by having a "ghost" plane that will fly according to his estimates.

Imagine that the ghost pilot will fly his ghost plane to any desired position in the sky and then fly at any speed and in any direction he is told. His plane will be visible to the Director Operators, but not to the enemy. The ghost pilot will agree not to be disturbed by anti-aircraft fire that hits his plane instead of the enemy plane. The obedient ghost is now ready to obey orders.



The ghost plane could be ordered to go to the target plane and then to fly according to the Control Officer's initial estimates of Target Angle, Target Speed, and Rate of Climb.

Suppose the ghost plane should drop below the target and fly off to its right. This would tell the Control Officer that his guesses were wrong. It would also help him correct them.

He would make corrections to his guesses of Target Course and Rate of Climb and order the ghost plane back to the target.

Suppose now that the ghost plane, flying according to these corrected values, remains on about the same course and level as the target but falls behind it.

The Control Officer would correct his Target Speed guess, order the ghost plane back to the target plane, and again instruct it to proceed at the corrected rates.

With each correction the Control Officer makes, the ghost plane flies closer and closer to the course and speed of the target.

Finally, when all three Target Motion values are corrected, the ghost plane flies right along with the target plane.

Parallel between the ghost plane story and rate control

The ghost plane represents in a general way what the Computer is thinking about the Target. More specifically, the movement of the ghost plane corresponds to the changes of Target position generated by the Computer.

1 Ordering the ghost plane initially to go up to the target corresponds to setting into the Computer the initial observed Target position inputs of Range, Elevation, and Relative Bearing.

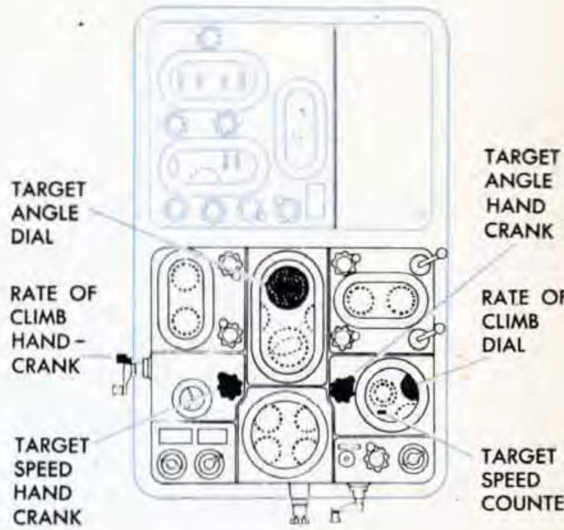
2 Ordering the ghost plane to fly at an estimated speed and direction corresponds to putting into the Computer the initial estimates of Target Speed, Target Angle, and Rate of Climb.

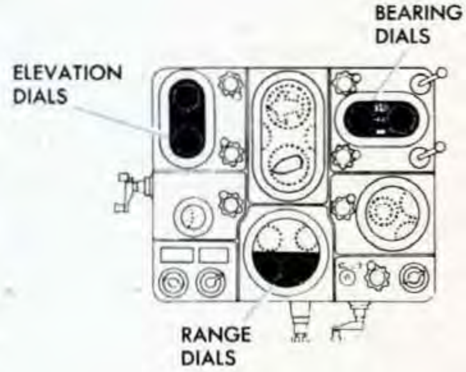
3 Watching the flight of the ghost plane vary from that of the real plane represents the comparison of the movements of the "generated dials" with the "observed dials." The movements of the Generated Elevation and Bearing Inner Dials, and the Generated Range Outer Dials, represent the behavior of the *ghost* plane. The movements of the Observed Elevation and Bearing Outer Dials, and the Observed Range Inner Dials, represent the observed movement of the *real* plane.

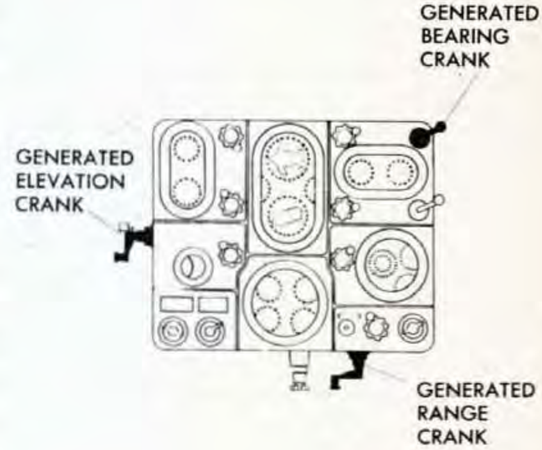
4 Ordering the ghost plane back to the Target corresponds to matching the Generated Range Dials with the Observed Range Dials. (This is not done with the Generated Elevation and Bearing Dials in the Computer Mark 1.)

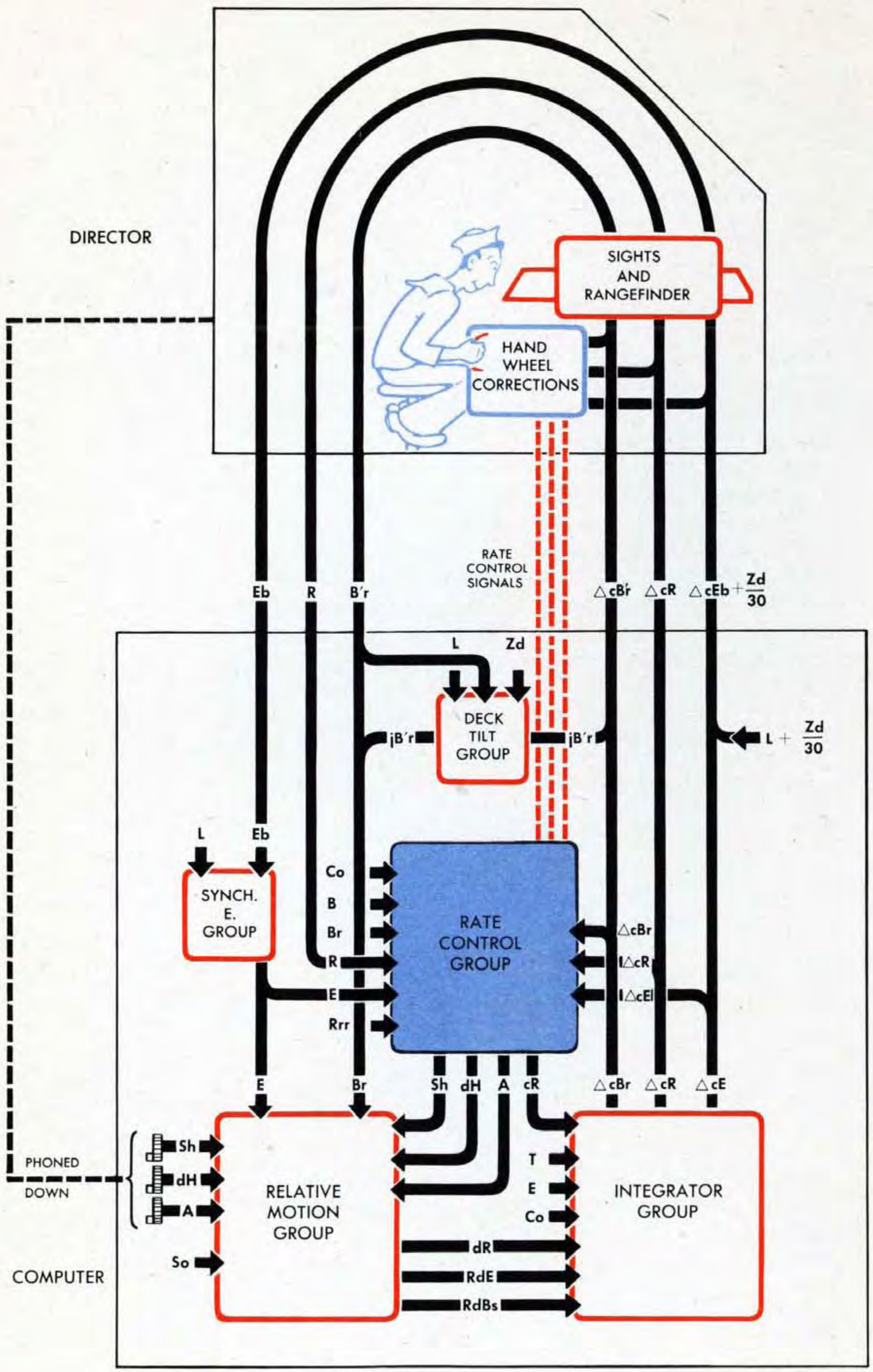
5 Ordering the ghost plane to fly at a corrected speed and direction corresponds to putting in *corrections* to Target Speed, Target Angle, and Rate of Climb. These corrections might be estimated and put in by hand, or they could be computed in the Rate Control Mechanism.

6 When the Target Motion values are correct, the ghost plane flies wing to wing with the Target and the generated dials will turn exactly with the observed dials. This is the same as saying that when the Target Motion estimates are correct, the Relative Motion Rates are correct, and the Generated Changes of Range, Elevation, and Bearing are correct. Since the generated changes continuously position the Director sights, the sights will now stay on the Target. The Relative Motion Rates on which predictions are based will be correct.








DIRECTOR
SIGHTS AND RANGEFINDER
HAND WHEEL CORRECTIONS
RATE CONTROL SIGNALS
Eb
R
B'r
△cBr
△cR
△cEb + Zd/30
L
Zd
DECK TILT GROUP
jB'r
jB'r
L + Zd/30
L
Eb
SYNCH. E. GROUP
Co
B
Br
R
E
Rrr
RATE CONTROL GROUP
△cBr
△cR
△cE
E
Br
Sh
dH
A
cR
△cBr
△cR
△cE
PHONED DOWN
Sh
dH
A
So
RELATIVE MOTION GROUP
T
E
Co
INTEGRATOR GROUP
dR
RdE
RdBs
COMPUTER

The RATE CONTROL GROUP completes the tracking section

Here is the whole Tracking Section of the Computer Mark 1, showing how the Rate Control Group fits in, how the corrected Target values go to the Relative Motion Group, and how the Relative Motion Rates are corrected.

Rate Control is a continuous process. One set of Rate Control corrections will not completely correct the Target values, but each time a set of corrections is put into the Rate Control group, the Target values become more nearly correct.

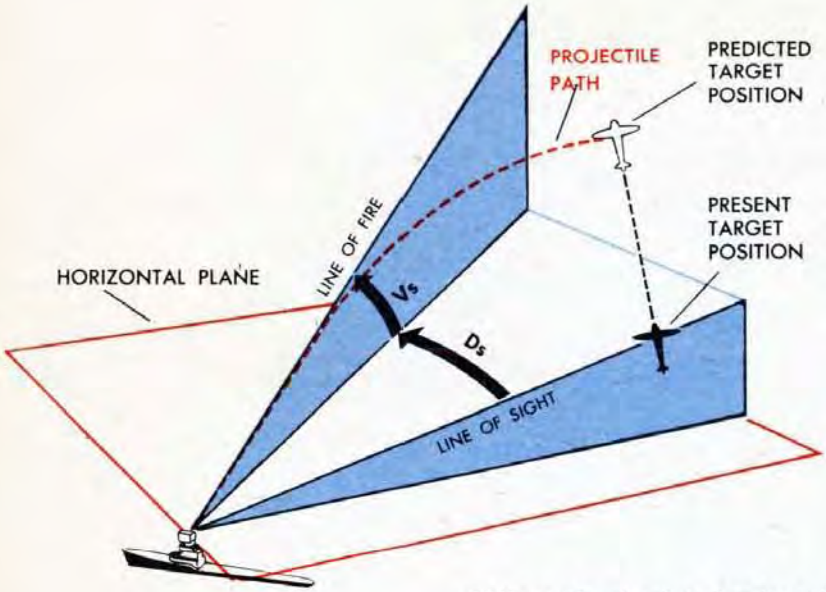
The corrected Target values are used to generate a new set of changes in Target Position which are continuously compared with the Observed Changes. The differences are again used for new Rate Control corrections, and so on, in a continuous regenerative cycle.

When the changes of Target Position generated by the Computer are equal to the Observed Changes of Target Position, a tracking solution is reached and no more Rate Control is necessary as long as the Target continues at the same speed and in the same direction.

Small variations in Target Speed and Direction can be put into the Computer by means of the Rate Control mechanism alone, but where the changes of Target Speed and Direction are large and sudden, the corrections to *Sh, A,* and *dH,* can be put into the Computer much faster by direct hand correction at the Target Speed, Target Angle, and Rate of Climb Knobs.

The new Target values are estimated at the Director and phoned down to the Computer. Then the Rate Control process starts all over again to correct these new estimates.

THE PREDICTION SECTION



The Prediction Section establishes the Line of Fire by computing two lead angles:

1 Sight Angle, *Vs*
2 Sight Deflection, *Ds*

When the deck is horizontal the two lead angles, *Vs* and *Ds*, are: the angle in Elevation, and the Deflection in the slant plane between the Line of Sight and the Line of Fire.

To aid in computing these two lead angles, two other prediction quantities must be computed:

1 Advance Range, *R2*
2 Predicted Elevation, *E2*

R2 and *E2* are also needed for computing quantities in other sections of the Computer.

The whole Prediction Section is based on calculations from a horizontal plane. Any corrections to the Line of Fire made necessary by tilting of the deck are computed in the Trunnion Tilt Section.

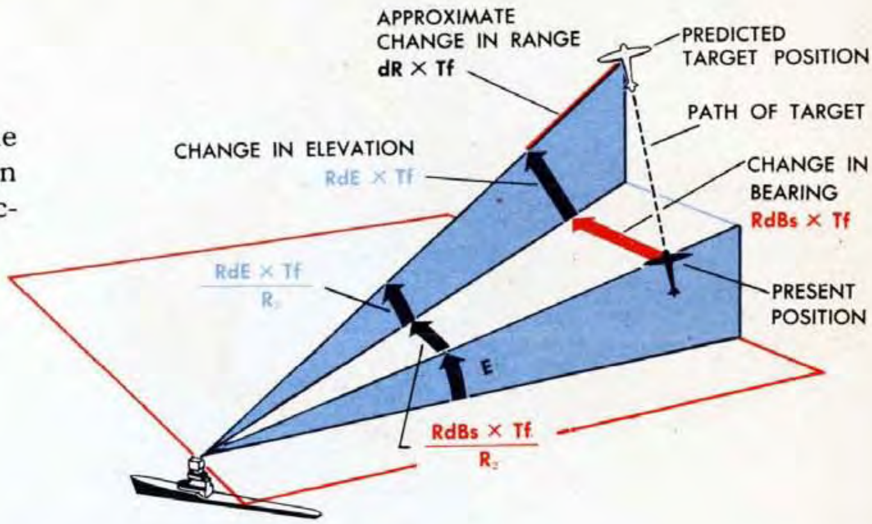
In establishing the Line of Fire, the Prediction Section makes two types of computations:

1 It computes the position of the Target at the end of the Time of Flight, allowing for the effect of Relative Motion during the time the projectile is in the air.

2 It computes how far away from this Predicted Target Position the guns must be positioned to allow for the curvature of the projectile path. Allowances are made for the effect of wind, drop of the projectile due to gravity, drift due to projectile rotation and changes in initial projectile velocity.

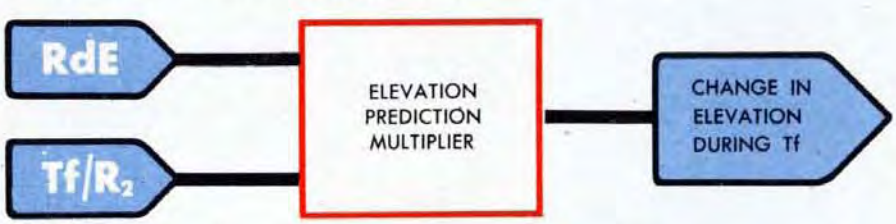
The prediction multipliers

Target Position at the end of the Time of Flight is predicted in Range, in Elevation, and in Deflection.

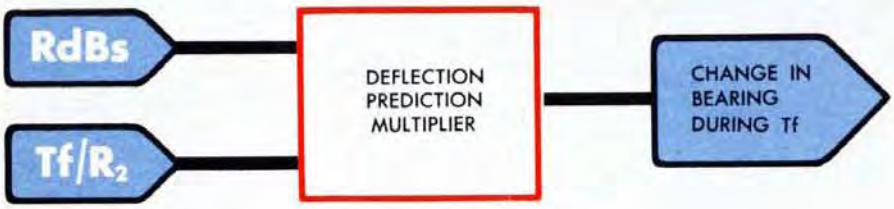


The approximate change of Range during the Time of Flight is computed by multiplying Range Rate, *dR*, by Time of Flight, *Tf*, in the Range Prediction Multiplier.

The change of Elevation during the Time of Flight is an ANGULAR quantity; therefore Elevation Rate, *RdE*, must be multiplied by *Tf* and then divided by *R2* to obtain the approximate angular Elevation changes. *RdE* is multiplied by *Tf/R2* in the Elevation Prediction Multiplier.

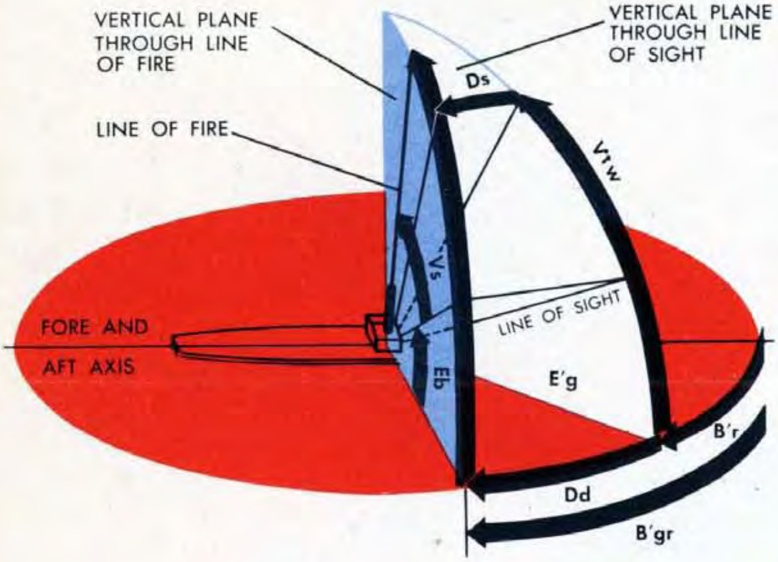


The change of Bearing during *Tf* is also an angular quantity, Deflection Rate, *RdBs*, is therefore multiplied by *Tf/R2* in the Deflection Prediction Multiplier.



NOTE:
Calculations needed to allow for curvature of the projectile path are more complex. They are explained in the Detailed Description chapter on *Prediction*.

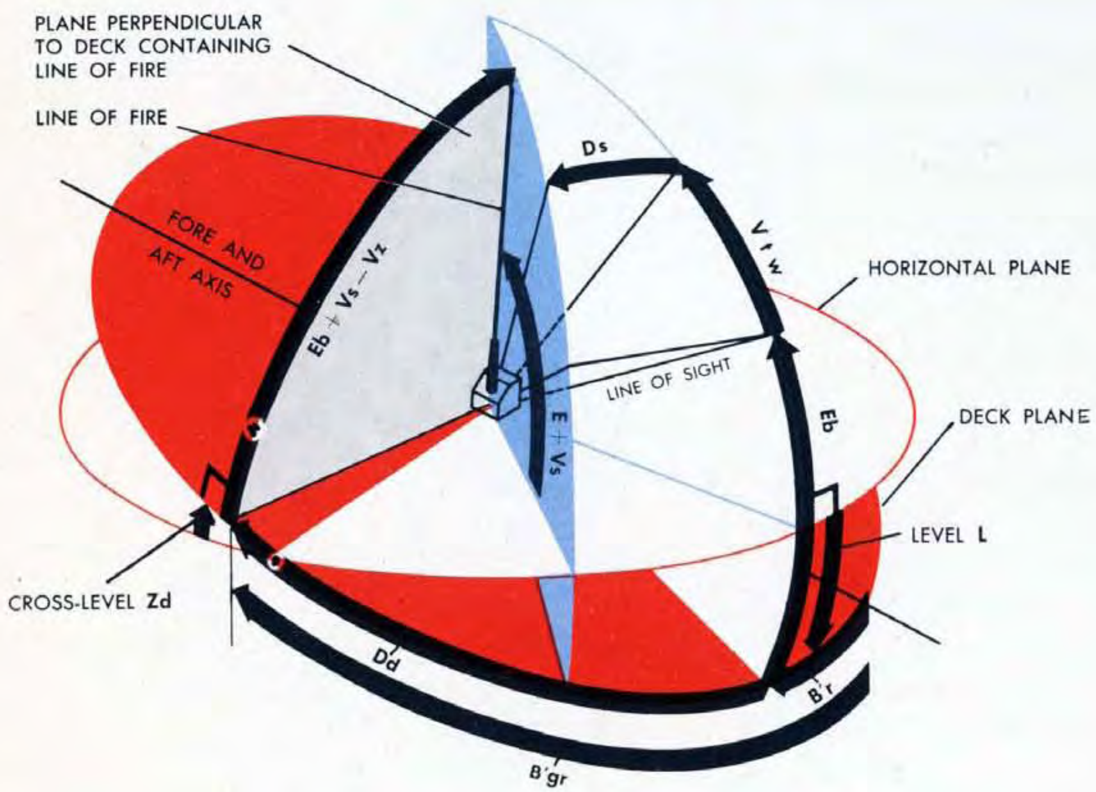
THE TRUNNION TILT SECTION



THIS IS HOW THE LINE OF FIRE IS ESTABLISHED ON A HORIZONTAL DECK

The Trunnion Tilt Section has two outputs. One is *Vz*, a correction to gun elevation to compensate for the effect on gun elevation of the tilting of the gun trunnions. The second output is Deck Deflection, *Dd*, which consists of *Ds* referred to the deck plane plus a train correction to compensate for the effect on gun train of the tilting of the gun trunnions.

The values of *Vz* and *Dd* increase and decrease continuously as Own Ship pitches and rolls. The function of these two corrections is to keep the gun aim steady in spite of the continuous tilting of the gun trunnions due to pitch and roll of the deck.



THIS IS HOW THE LINE OF FIRE IS ESTABLISHED ON A TILTED DECK

The Trunnion Tilt Elevation Correction, *Vz,* is computed in two multipliers. The values used to compute *Vz* are *Zd, Vs, Ds,* and *Eb.*

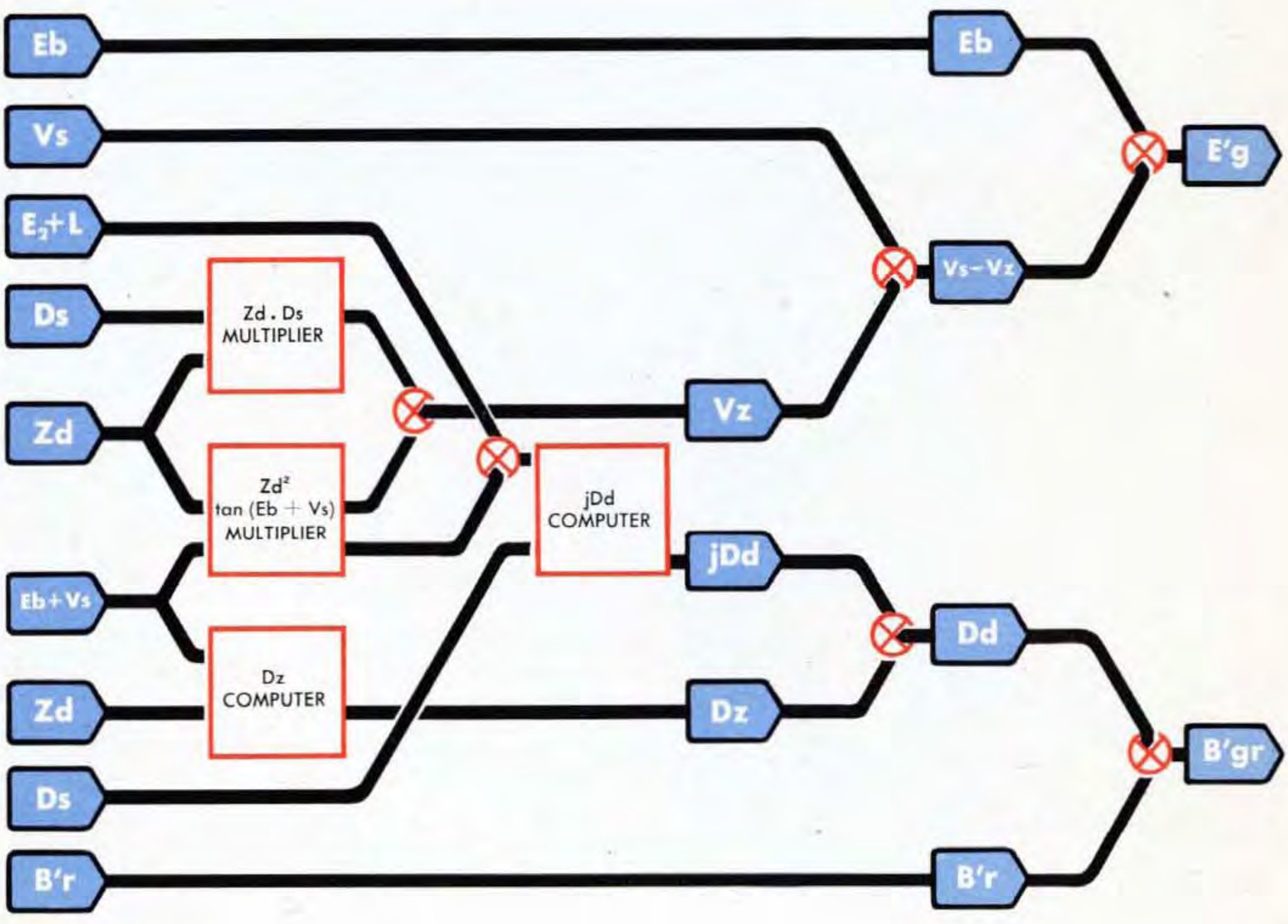
Vz is subtracted from *Eb* + *Vs* to produce the Gun Elevation Order, *E′g.*

The Trunnion Tilt Train Correction, *Dd,* consists of two quantities, *jDd* and *Dz. jDd* is roughly Sight Deflection, *Ds,* corrected to the deck plane and for the effect of Level. *Dz* is approximately the part of the Train Correction needed to compensate for the effect of Cross-level.

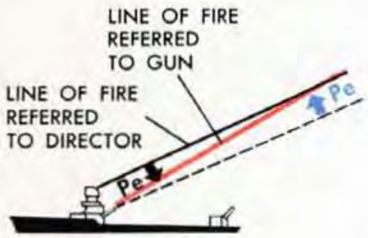
jDd and *Dz* are each computed in a special computer. The inputs are the same values as those used for *Vz* with the addition of *E2* + *L.* The outputs of the two computers are added to give Deck Deflection, *Dd.*

Deck Deflection, *Dd,* is added to *B′r* to give the Gun Train Order, *B′gr.*

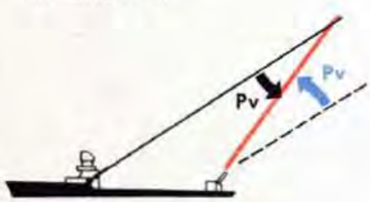
Both gun orders, *E′g* and *B′gr,* are continuously and automatically transmitted to the gun mounts to operate the machinery controlling the actual pointing and training of the guns.



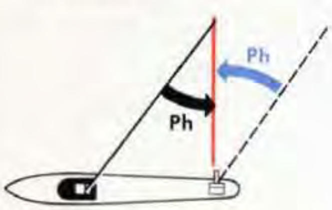
PARALLAX CORRECTIONS



REFERENCE POINT
AT DIRECTOR



REFERENCE POINT
AT DIRECTOR



REFERENCE POINT
AT DIRECTOR

The Line of Fire is established by the Computer from a certain reference point. The reference point is usually the Director when there is only one Director on board; if there are several Directors, the reference point may be either one of the Directors or a point chosen arbitrarily.

If a gun is at the reference point, it can use the Gun Orders without further correction. If a gun is anywhere else on the deck, its aim must be corrected to compensate for the horizontal distance between the reference point and that particular gun.

The corrections to compensate for this difference in location are the Parallax Corrections. The Parallax Section of the Computer Mark 1 computes two Parallax Corrections, one to Gun Elevation, called *Pv*, and one to Gun Train, called *Ph*. A third Parallax Correction, *Pe*, is computed on a ballistic cam along with Superelevation, *Vf*.

Pe compensates for the difference in height between the guns and reference point and is included in the Gun Elevation Order.

Both *Pv* and *Ph* are corrections to compensate for a 100-yard horizontal distance between the guns or Director and the reference point.

The Parallax Elevation Correction, *Pv*, is largest when the Target is straight ahead or astern of Own Ship.

The Parallax Train Correction, *Ph*, is largest when the Target is abeam of Own Ship.

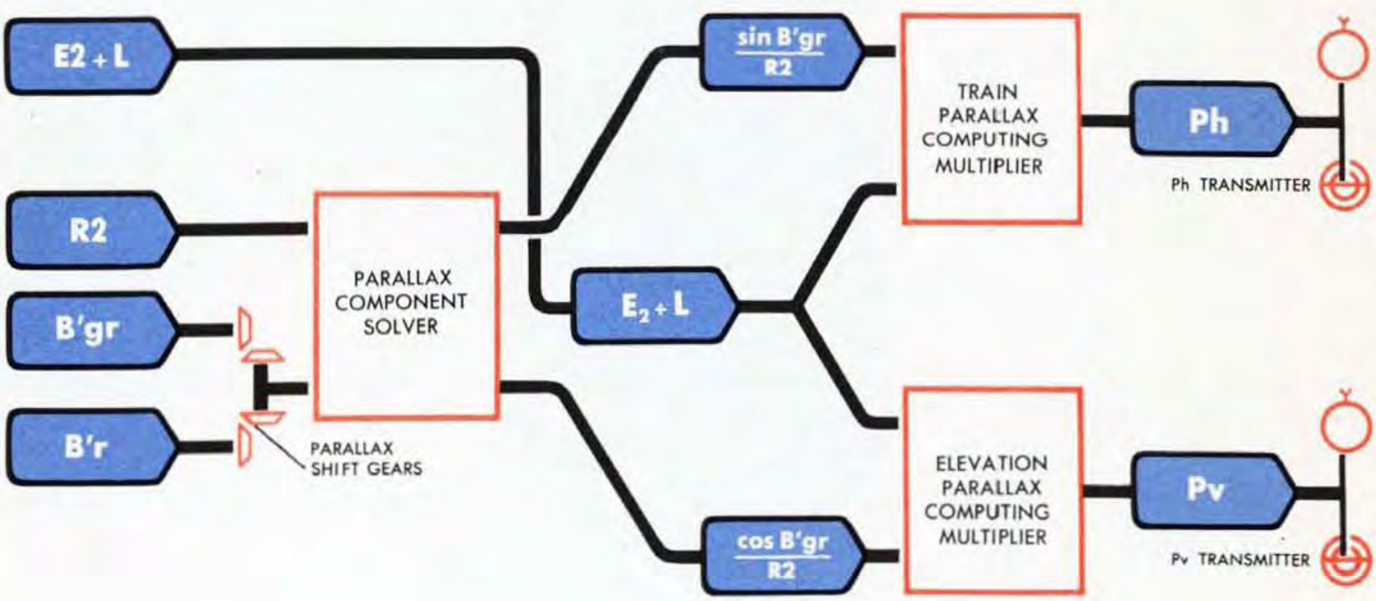
Pv and *Ph* are transmitted to the gun mounts separately from the Gun Orders. Each gun uses a fraction of each correction proportional to its own distance from the reference point. For example, a gun 50 yards from the reference point would use half of *Pv* and half of *Ph*. A gun 20 yards from the reference point would use one fifth of each correction, and so on.

The Parallax Section of the Computer Mark 1 contains a component solver, two single-cam computing multipliers, and two single-speed transmitters.

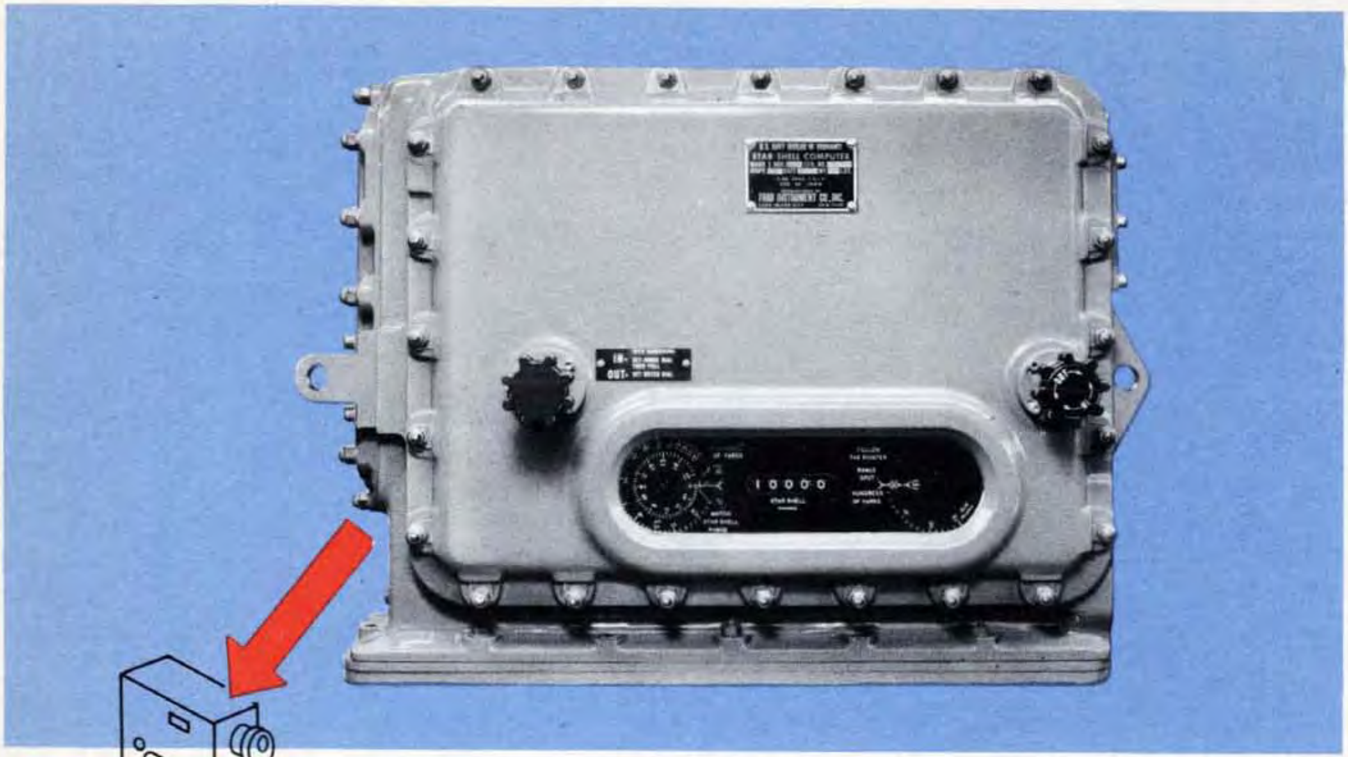
The values used in computing the Parallax Corrections are *E2 +L*, *R2*, and either *B′r* or *B′gr*. *B′r* is used on BB's, CA's, CV's, CBB's, and some CL's; *B′gr* is used on DD's, some AD's, AV's, and all ships having only one Director.

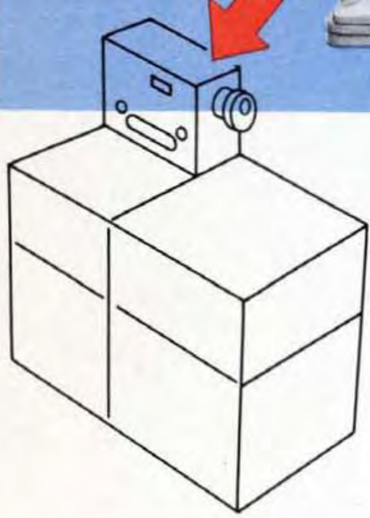
The outputs of the Parallax Section are *Pv* and *Ph*, which are transmitted electrically to the gun mounts. *Ph* is also transmitted to all Directors except those being used as a reference point. In the Directors, *Ph* is used to correct Director Train, *B′r*.

By correcting the Director Train for parallax, the values of *B′r* coming from all Directors on one ship are made uniform and the observations from any Director can be used for any or all guns aboard.



THE STAR SHELL COMPUTER MARK 1





This is the Star Shell Computer. Its job is to compute Gun and Fuze Orders for a 5″/38 cal. gun firing star shells to illuminate surface targets.

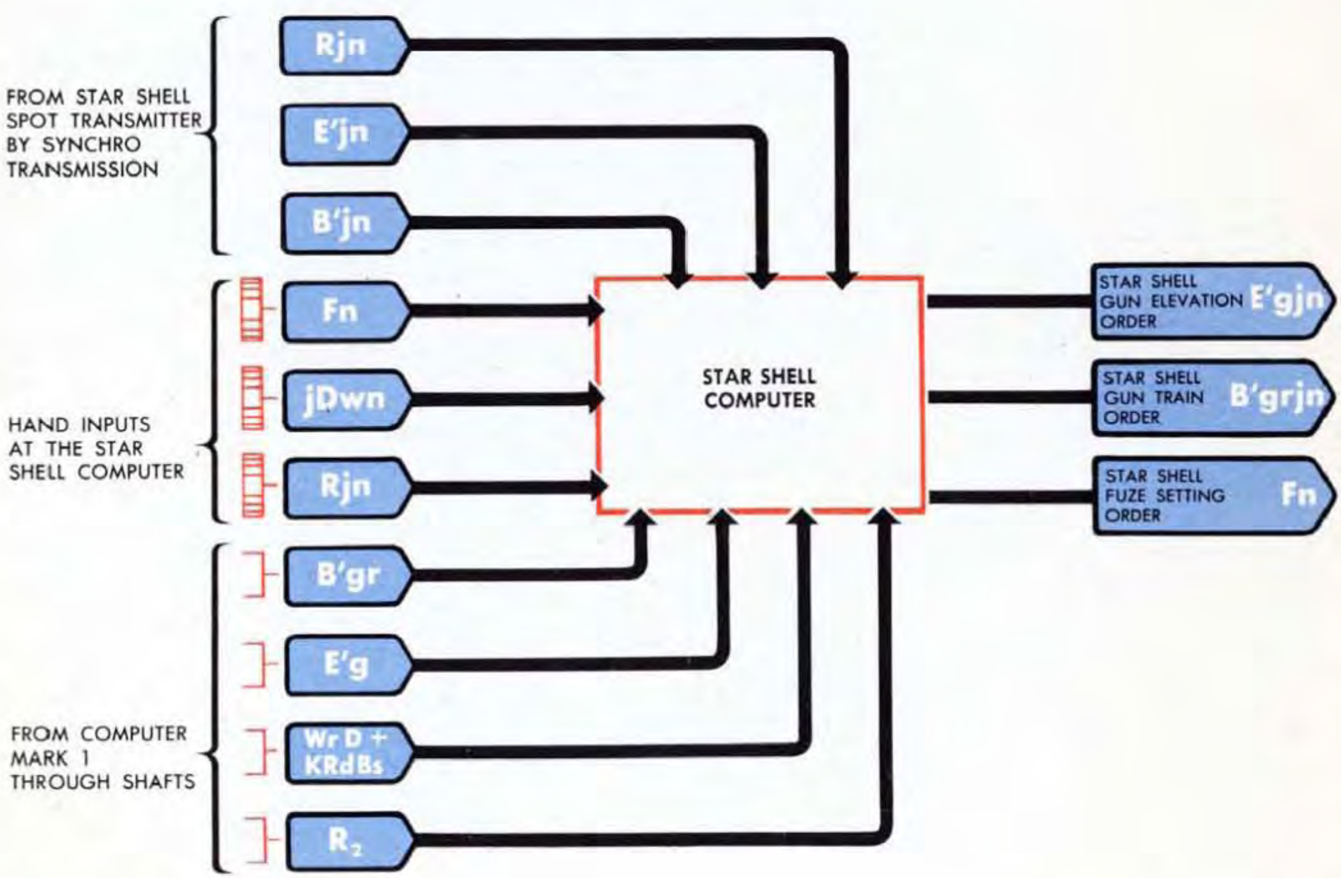
Star shells are projectiles containing a flare attached to a parachute. When the star shell bursts, the flare lights up and burns for about one minute as it floats down.

The star shells are fired at night to illuminate a given surface target or to search an area for possible targets.

When star shells are used for searching an area, the Star Shell Computer Mark 1 is NOT used. The guns are pointed according to ship's doctrine. Later mods of the Star Shell Computer provide for star shell search fire.

The Star Shell Computer receives the Gun Orders from the Computer Mark 1. These Gun Orders point the guns to HIT a given target. The Star Shell Computer adds corrections to these Gun Orders which point a gun to ILLUMINATE that same target. The Gun and Fuze Orders from the Star Shell Computer place a star 1000 yards beyond the target, 1500 feet above the target, and with a deflection such that it is directly beyond the moving target after it has been burning 30 seconds (half its life).

The inputs and outputs of the Star Shell Computer are shown in the schematic. The hand inputs need some explanation. Fuze Setting Order, *Fn*, and Angular Deflection, *jDwn*, are put in by matching the readings of the two Star Shell Range Dials with the reading on the Star Shell Range Counter. The matching is done with a two-position knob. *Rjn* is a hand input based on information received by synchro transmission. Star Shell Range Spot, *Rjn*, is sent by synchro transmission from the Star Shell Spot Transmitter to a synchro motor and dial in the Star Shell Computer. The value of *Rjn* which shows on the dial must be put into the Star Shell Computer mechanisms by hand. By turning a knob, the index on the Range Spot Ring Dial can be matched with the pointer on the receiver dial, thus putting in the value of *Rjn*



INPUTS and OUTPUTS of the COMPUTER MARK 1 and the

INPUTS

1 Inputs from the Director

Observed Target Position (By synchro transmission)	*R* *Eb* *B'r*	Observed Range Director Elevation Director Train
Estimated Target Motion (By phone to the Computer Operators, and initially set in manually)	*Sh* *dH* *A* *Ct*	Horizontal Target Speed Rate of Climb Target Angle, or Target Course
Rate Control Signals (By electrical signal)	*jdR* *jE* *jBr*	Range Rate Control Correction Elevation Rate Control Correction Bearing Rate Control Correction
Spot Correction to the Computer Mark 1 (By synchro transmission)	*Rj* *Vj* *Dj*	Range Spot Elevation Spot Deflection Spot
Spot Corrections to the Star Shell Computer (By synchro transmission)	*Rjn* *E'jn* *B'jn*	Star Shell Range Spot Star Shell Elevation Spot Star Shell Deflection Spot

2 Inputs from the Stable Element (By shafts)	*L* *Zd* *L+Zd/30*	Level Cross-level Level plus function of Cross-level
3 Inputs from the Gyro Compass (By synchro transmission)	*Co*	Ship Course
4 Inputs from the Pitometer Log (By synchro transmission)	*So*	Ship Speed

5 Hand Inputs

Quantities that can be put in by hand only	*Sw* *Bw* *I.V.* *Tg* *Rrr* *Dip*	Wind Speed Wind Direction Initial Velocity Dead Time Range Rate Ratic Dip Angle
Alternate hand inputs for quantities normally received electrically	*cR* *E* *Br* *Rj* *Vj* *Dj* *Co* *So*	Range (Alternate input for *R*) Elevation (Alternate input for *Eb*) Relative Bearing (Alternate input for *B'r*) Range Spot Elevation Spot Deflection Spot Ship Course Ship Speed

STAR SHELL COMPUTER MARK 1

Hand inputs that may be used during Rate Control	jdR	Rate Control Correction through Generated Range Crank
	jE	Rate Control Correction through Generated Elevation Crank
	jBr	Rate Control Correction through Generated Bearing Crank
	Sh	Horizontal Target Speed
	dH	Rate of Climb
	Ct	Target Course
	A	Target Angle
Hand inputs to the Star Shell Computer	Rjn	Star Shell Range Spot
	Fn	Star Shell Fuze Setting Order
	jDwn	Angular Deflection of Star

OUTPUTS

1 To the Gun Mounts (By synchro transmission)

To the Train Indicator Regulator	B'gr	Gun Train Order
	B'grjn	Star Shell Gun Train Order
	Ph	Train Parallax Correction (also goes to some Directors)
To the Elevation Indicator Regulator	E'g	Gun Elevation Order
	E'gjn	Star Shell Gun Elevation Order
	Pv	Elevation Parallax Correction (also goes to some Directors)
To the Sights	Vs	Sight Angle
	Ds	Sight Deflection
To the Fuze Setting Indicator Regulator	F	Fuze Order

2 To the Director (By synchro transmission)

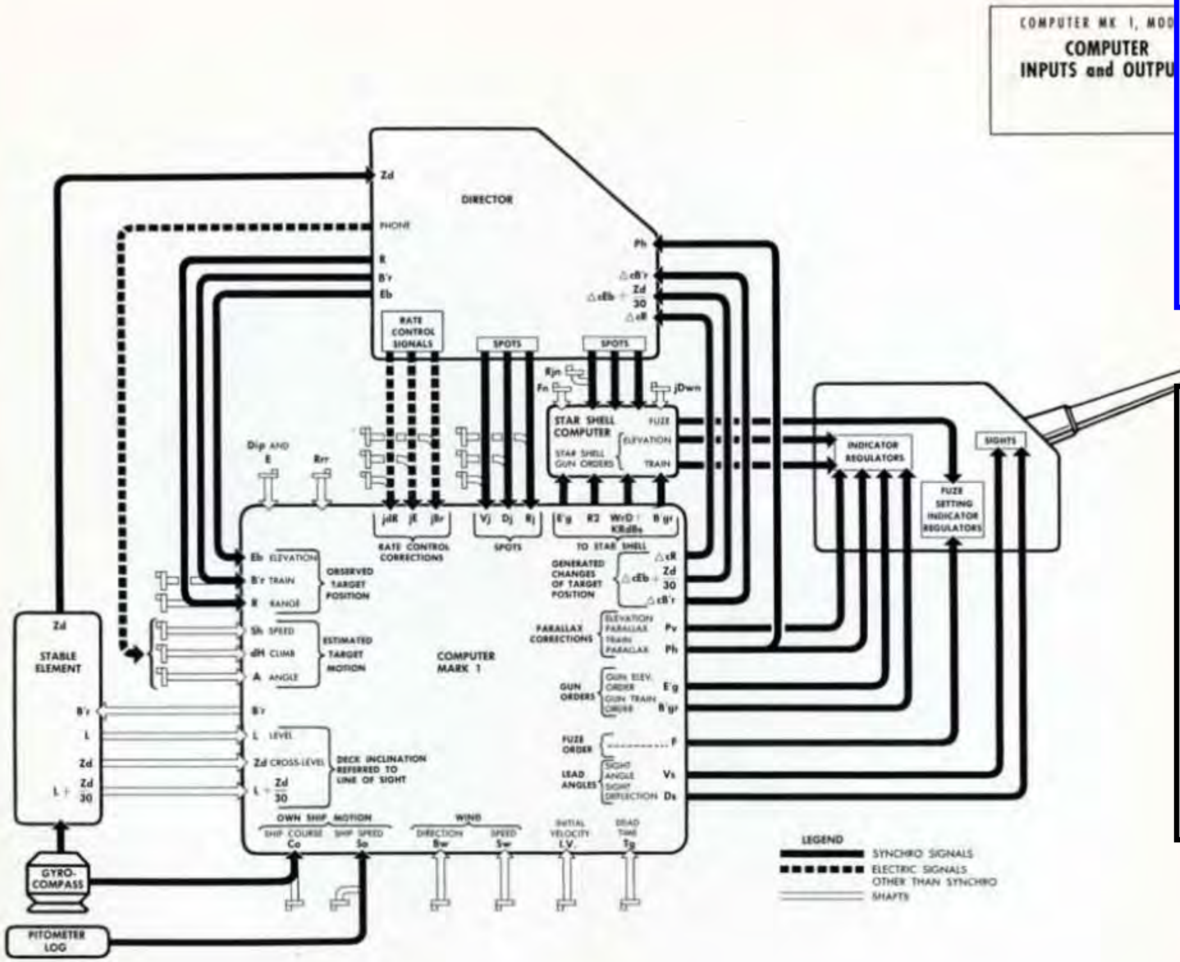
To the Change of Range Receiver at the Range Finder	ΔcR	Generated Changes of Range
To the Elevation Receiver	$\Delta cEb + \frac{Zd}{30}$	Generated Changes of Director Elevation plus Function of Cross-level
To the Train Receiver	$\Delta cB'r$	Generated Changes of Director Train

3 To the Stable Element (By shaft)

	B'r	Director Train

4 To the Star Shell Computer (By shafts)

	E'g	Gun Elevation Order
	B'gr	Gun Train Order
	R2	Advance Range
	Wrd + KRdBs	Deflection Wind plus Function of Deflection Rate



Summary of COMPUTER MARK 1 DATA

Size

Without handcranks the Computer Mark 1 measures approximately:

62 inches long
38 inches wide
45 inches high

With the Star Shell Computer Mark 1 in place the all-over height is 65 inches. The exact dimensions are shown below.

Weight

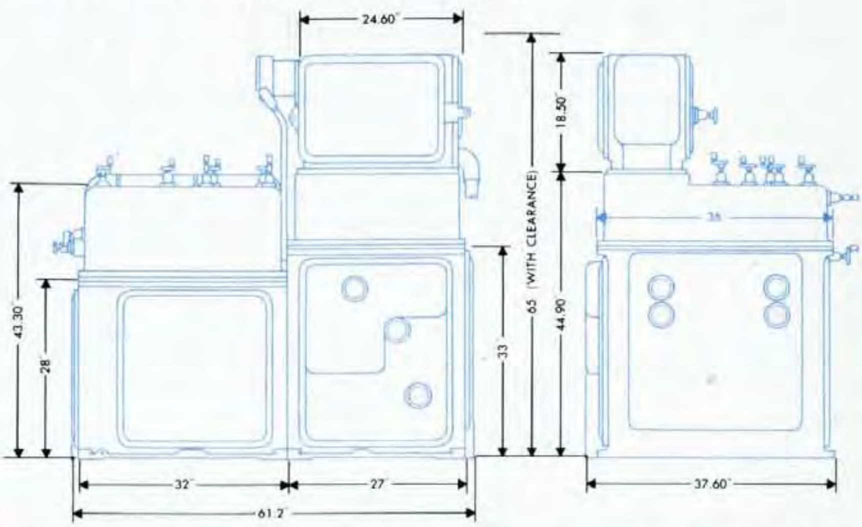
The Computer Mark 1 weighs about 3125 lbs.
The Star Shell Computer Mark 1 weighs about 215 lbs.

Power Supply

The Computer Mark 1 and the Star Shell Computer operate on 115-volt, 60-cycle, single-phase, alternating current.

The normal current, including excitation of the transmitters, is about 57½ amperes.

The maximum current, assuming the extremes in synchronization, could be as much as 140 amperes.



LIMITS OF OPERATION

INTERMITTENT DRIVES

COMPUTER MARK 1

Symbol	Lower Limit	Upper Limit
Ds	320 MILS	680 MILS
Vs	2,000′	3,800′
E2	0°	90°
Eb + Vs	1,640′	7,160′
dRs	− 450 KNOTS	+ 450 KNOTS
cR	750 YARDS	22,500 YARDS
E	− 2°	+ 85°

LIMIT STOPS

COMPUTER MARK 1

Stop No.	Symbol	Lower Limit	Upper Limit	
L-1	So	0 KNOTS	45 KNOTS	
L-2	Sh	0 KNOTS	400 KNOTS	
L-3	Sw	0 KNOTS	60 KNOTS	
L-4	dH	−250 KNOTS	+150 KNOTS	
L-5	dRh	−440 KNOTS	+440 KNOTS	
L-6	RdBs	−400 KNOTS	+400 KNOTS	
L-7	RdE	−400 KNOTS	+400 KNOTS	
L-8	dR	−450 KNOTS	+450 KNOTS	
L-9	Ywgr	−100 KNOTS	+100 KNOTS	
L-10	cR	0 YARDS	35,000 YARDS	
L-11	Eb	500′	8,600′	
L-12	E	−5°	+85°	Serial Numbers below 390
		−25°	+85°	Serial Numbers above 389
L-13	Rrr	1	5	
L-14	Tg	0 SECONDS	6 SECONDS	Serial Numbers below 781
	Tg + F − Tf	0 SECONDS	50 SECONDS	Serial Numbers above 780
L-15	I.V.	2,350 f.s.	2,600 f.s.	
L-16	L	480′	3,520′	
L-17	Zd	480′	3,520′	
L-18	jB′r	348° 20′	11° 40′	
L-19	R2	500 YARDS	18,000 YARDS	
L-20	Tf/R2	0.00122	0.00336	
L-21	R2	*300 YARDS	*18,200 YARDS	
L-22	Vf + Pe	0′	2,500′	
L-23	R2	*300 YARDS	*18,200 YARDS	
L-24	Tf	0.6 SECONDS	60.6 SECONDS	
L-25	R2	*300 YARDS	*18,200 YARDS	
L-27	R3	*−1,250 YARDS	*+19,750 YARDS	
L-28	Dtwj	−518 MILS	+518 MILS	
L-29	Rj	IN 12,000 YARDS	OUT 1,800 YARDS	
L-30	Dj	LEFT 180 MILS	RIGHT 180 MILS	
L-31	Vj	DOWN 180 MILS	UP 180 MILS	
L-32	Dd	−120°	+120°	
L-34	Vz	−2,940′	+1,860′	
L-35	F	0.6 SECONDS	55.0 SECONDS	
L-36	R3	*−1,250 YARDS	*+19,750 YARDS	
L-37	V	200′	3,800′	
L-38	Tg	0 SECONDS	6 SECONDS	Serial Numbers above 780

STAR SHELL COMPUTER

L-1	WrD + KRdBs	−60 KNOTS (Read as 940 Knots on counter)	+60 KNOTS
L-2	Rjn	IN 1,500 YARDS	OUT 1,500 YARDS
L-3	Fn	8.20 SECONDS	41.55 SECONDS
L-4	jDwn	4,000 YARDS	15,000 YARDS

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

Name		Location Section	Location Cover	Value per rev.	Size	Mods
Range Correction Transmitter		Control	1	1000 yds	5 G	All
Range Receiver	Coarse	Control	1	72,000 yds	5 F	
	Fine	Control	1	2000 yds	5 F	All
Target Course Transmitter		Control	1	360°	5 G	Except Mods 0, 1, 2, 9
Elevation Correction Transmitter		Computer	3	5°	6 DG	Mod 0
Bearing Correction Transmitter		Computer	3	5°	6 G	Mod 0
Elevation Correction Ind. Transmitter		Computer	3	10°	5 G	Except Mod 0
Elevation Correction Auto Transmitter		Computer	3	5°	6 G	Except Mod 0
Bearing Correction Ind. Transmitter		Computer	3	10°	5 G	Except Mod 0
Bearing Correction Auto Transmitter		Computer	3	5°	6 G	Except Mod 0
Ship Course Receiver	Coarse	Computer	5	360°	5 B	All
	Fine	Computer	5	10°	5 F	All
Deflection Spot Receiver		Indicator	2	360 mils	5 B	All
Elevation Spot Receiver		Indicator	2	360 mils	5 B	All
Range Spot Receiver		Indicator	2	4000 yds	5 B	All
Ship Speed Receiver		Indicator	2	Various	5 B	Except Mod 0
Fuze Setting Order Transmitter	Coarse	Indicator	2	100 sec	6 G	Mods 0, 1, 2, 9
					7 G	Except Mods 0, 1, 2, 9
	Fine	Indicator	2	2 sec	6 G	Mods 0, 1, 2, 9
					7 G	Except Mods 0, 1, 2, 9
Single Mount Sight Angle Transmitter		Indicator	2	2400 min	6 G	Mods 0, 2, 7, 11, 13
					7 G	Mods 9, 10, 5, 6
Single Mount Sight Deflection Transmitter		Indicator	2	442.24 mils	6 G	Mods 0, 2, 7, 11, 13
					7 G	Mods 9, 10, 5, 6
Twin Mount Sight Angle Transmitter	Coarse	Indicator	2	7200 min	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12

Quick Reference Index

Twin Mount Sight Angle Transmitter	Fine	Indicator	2	200 min	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12
Twin Mount Sight Deflection Transmitter	Coarse	Indicator	2	4000 mils	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12
	Fine	Indicator	2	100 mils	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12
Gun Train Order Ind. Transmitter (No. 1)	Coarse	Corrector	8	360°	7 G	All
	Fine	Corrector	8	10°	7 G	All
Gun Train Order Auto Transmitter (No. 2)	Coarse	Corrector	8	360°	7 G	All
	Fine	Corrector	8	10°	7 G	All
Director Train Receiver	Coarse	Corrector	8	360°	5 B	All
	Fine	Corrector	8	10°	5 F	All
Gun Elev. Order Ind. Transmitter (No. 1)	Coarse	Corrector	6	10,800 min	7 G	All
	Fine	Corrector	6	600 min	7 G	All
Gun Elev. Order Auto Transmitter (No. 2)	Coarse	Corrector	6	10,800 min	7 G	All
	Fine	Corrector	6	600 min	7 G	All
Director Sight Elev. Receiver	Coarse	Corrector	6	180°	5 B	All
	Fine	Corrector	6	10°	5 F	All
Train Parallax Transmitter		Corrector	6	30°/100 yds	6 G	Mods 0, 1, 2, 9
					7 G	Except Mods 0, 1, 2, 9
Elevation Parallax		Corrector	6	10°/100 yds	7 G	Mods 5, 7, 11, 13, 8, 12
Star Shell Fuze Setting Order Transmitter	Coarse	Star Shell		100 sec	6 G	All
	Fine	Star Shell		2 sec	6 G	All
Star Shell Gun Elev. Order Transmitter	Coarse	Star Shell		10,800 min	6 DG	All
	Fine	Star Shell		600 min	6 DG	All
Star Shell Gun Train Order Transmitter	Coarse	Star Shell		360°	6 DG	All
	Fine	Star Shell		10°	6 DG	All
Star Shell Range Spot Receiver		Star Shell		4000 yds	1 F	All

DESIGN FEATURES OF THE COMPUTER MARK 1

There are several important features of the Computer Mark 1 which must be grasped before the details of the Computer can be fully understood.

1 The Computer Mark 1 is designed to compute for a Target moving in a straight line at a constant speed.

The Rate Control Mechanism corrects the estimates of Target Motion set into the Computer. Once these have been corrected, the Computer will continue to compute correct Gun and Fuze Orders as long as the course and speed of the Target remain unchanged.

2 The inputs of Target Speed are Target Horizontal Speed, *Sh*, and Rate of Climb, *dH*. The air speed of the Target is NOT an input. Target Horizontal Speed, *Sh*, is the horizontal component of the Target's speed with respect to the ground. Rate of Climb, *dH*, is the vertical component of the Target's speed with respect to the ground.

Since both *Sh* and *dH* are measured with respect to the ground and not to the air, the effect of wind on the Target is already included in these speeds and need not be computed separately. For this reason the wind computations in the Computer Mark 1 are concerned only with the effect of wind on the projectiles.

3 The Range shaft lines in the Computer Mark 1 are positioned by Generated Range while the Elevation and Bearing shaft lines are positioned by Observed Elevation and Observed Bearing. One reason for this is that Elevation and Bearing are observed continuously in the Director, while Range if observed optically cannot be measured continuously.

Since Observed Range can be measured only intermittently, the motion of the Observed Range shaft line is not smooth. The Generated Range line on the other hand, moves smoothly since it is positioned by the Increments of Range from the Range Integrator. Using Generated Range to position the Range lines in the Computer therefore makes for smoother operation of all the mechanisms on this line.

Since Elevation and Bearing can be observed continuously, these observed quantities can be used to position the mechanisms in the Computer. Generated Elevation and Bearing could be used to position the mechanisms. However, the observed quantities are used in the Computer Mark 1 because they are more accurate than the generated quantities at the beginning of tracking, before the Rate Control Computing Mechanism has corrected the rates of change of the generated quantities.

4 The information stored on the ballistic cams in the Computer Mark 1 is based on trajectories which the projectile will follow when the Initial Velocity is 2550 feet per second and there is no Wind.

It is a feature of the Computer Mark 1 that it uses hand inputs of Wind Speed, Wind Direction, and actual Initial Velocity to alter the Advance Range and Advance Elevation inputs to these cams in such a way that the outputs from the cams include alterations for the effects of Wind and of variations in the Initial Velocity of the projectile.

Here is a table showing which of the variable factors in the fire control problem affect each of the outputs from the Computer Mark 1.

COMPUTED OUTPUTS

VARIABLES that affect the computed outputs	LEAD ANGLES		GUN ORDERS		FUZE SETTING ORDER
	GUN SIGHT POSITION		GUN POSITION		FUZE TIME
	Vs	Ds	E'g	B'gr	F
RELATIVE MOTION RATES	X	X	X	X	X
RANGE	X	X	X	X	X
ELEVATION	X	X	X	X	X
ROLL AND PITCH	—	—	X	X	—
DROP OF PROJECTILE	X	X	X	X	X
DRIFT OF PROJECTILE	X	X	X	X	X
TIME OF FLIGHT	X	X	X	X	X
INITIAL VELOCITY	X	X	X	X	X
WIND RANGE WIND ELEVATION WIND DEFLECTION WIND	X	X	X	X	X
DEAD TIME	—	—	—	—	X
SPOTS RANGE SPOT ELEVATION SPOT DEFLECTION SPOT	X	X	X	X	X

LEGEND: X indicates the output is affected by variable
— indicates the output is not affected by variable

PART 2

OPERATION

Part 2 identifies the operating controls, explains how the operating controls are used in various types of Computer operations, and traces through a typical operating cycle.

No explanations are given for the operating instructions. The reasons behind the operating instructions are supplied by Part 1, the *General Description*, and Part 3, the *Detailed Description*. Operation of the Computer Mark 1 is largely rate-controlling. For this reason, the chapters in the Detailed Description dealing with Relative Motion, Integrators, and Rate Control will be very useful to operators.

Part 2 is not intended to specify or supersede any *ship's doctrine*. It is not intended to imply when any particular type of operation is to be used. The four chapters in Part 2 will serve as a foundation for operating procedure when combined with the doctrine of a particular combat area and a particular ship.

The chapters in Part 2 are:

OPERATING CONTROLS

This chapter describes all of the dials, counters, handcranks, and switches which are used in operating the Computer Mark 1, the Target Course Indicator Mark 1, and the Star Shell Computer Mark 1. Dials and counters which are used only during tests are described in OP 1064A.

The dials and counters show the values of the various quantities on the Computer shaft lines. Some dials indicate the values of the quantities set in by handcranks or by automatic transmission. Other dials show the values of computed quantities. A knowledge of the location of all the dials and the quantities that can be read on them must be acquired in order to operate the Computer.

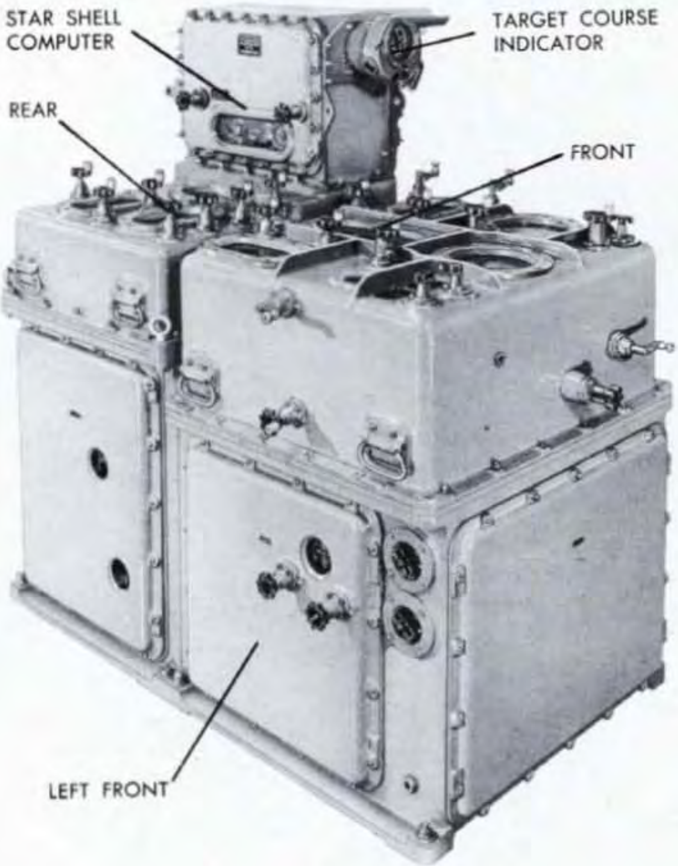
The handcranks provide a means of putting values into the Computer. In some cases a handcrank is the *only* means of putting a value into the Computer. More often the handcrank provides an *alternate* means of introducing a value when the normal automatic receivers fail. Such handcranks have a shift mechanism which allows them to be connected to or disconnected from the shaft lines, and to actuate switches to disconnect or connect the automatic receivers. A few of the handcranks are used only in the event of casualties in the fire control system.

The switches control electrical circuits in the Computer. Some of the switches are used to select a type of Computer operation, such as AUTO or SEMI-AUTO. The switches which are used for this purpose are especially important to identify because their several positions determine the ways in which various handcranks and dials are to be used.

The controls divide into five groups: the controls on the

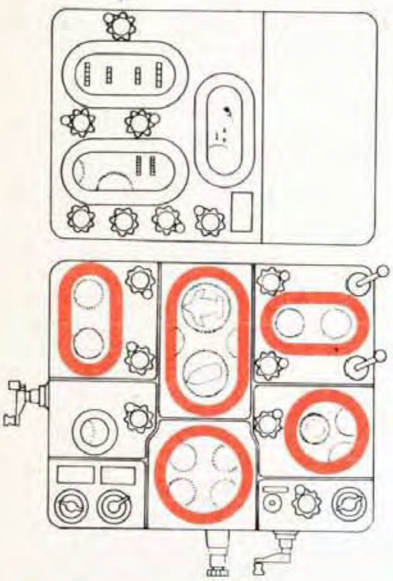
1 FRONT
2 LEFT FRONT
3 REAR
4 Target Course Indicator
5 Star Shell Computer

The front contains most of the controls used in operating the Computer and is therefore described first.



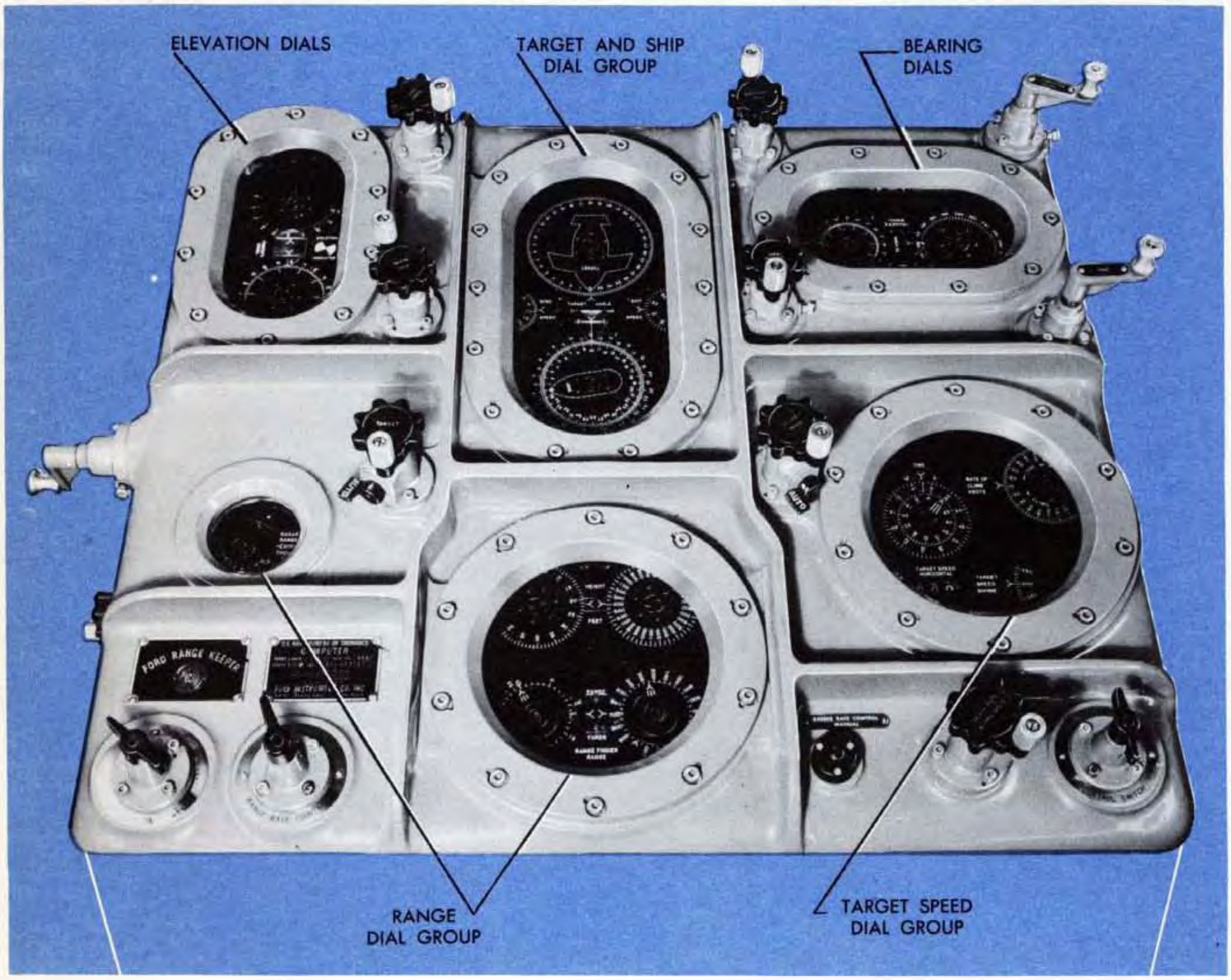
A large diagram of the Computer showing the locations and names of all the controls appears on page 109.

THE DIALS ON THE FRONT OF



The front of the Computer Mark 1 divides itself into five dial groups.

1 The TARGET AND SHIP Dial Group
2 The TARGET SPEED Dial Group
3 The RANGE Dial Group
4 The BEARING Dials
5 The ELEVATION Dials



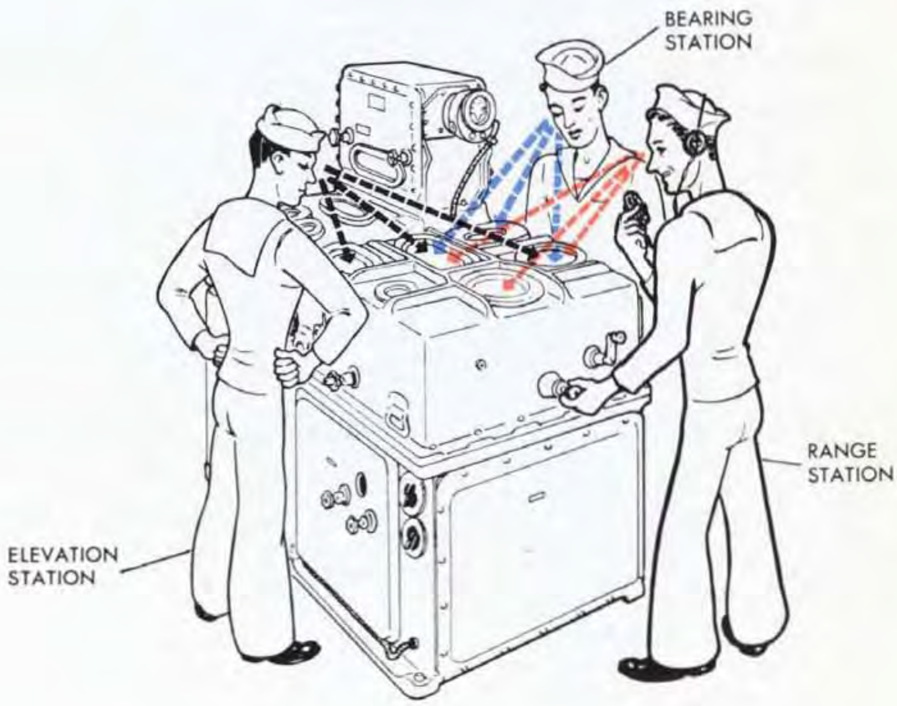
THE COMPUTER MARK 1

The five dial groups on the front of the Computer are used continuously in tracking a target. The front is operated from three operating stations: the Range Station in front of the Computer, the Bearing Station on the right side of the Computer, and the Elevation Station on the left side of the Computer. Each station may be manned by one or more operators, according to ship's doctrine.

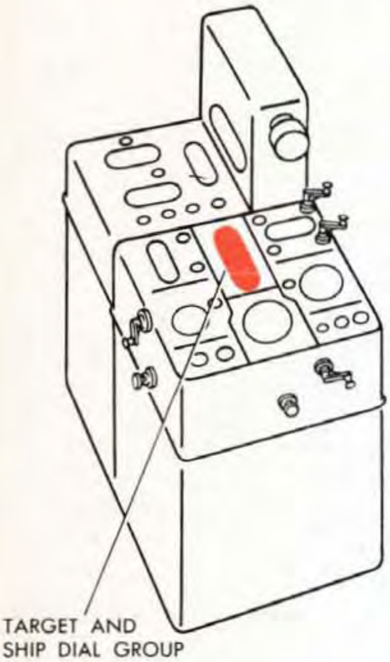
The Target and Ship Dial Group is watched by the men at all three operating stations. It is one of the most important sources of information for the operation of the Computer.

The Target Speed Dial Group is also watched by the men at all three operating stations.

Besides watching the Target and Ship Dial Group and the Target Speed Dial Group, the Range Station Operators watch the Range Dials, the Bearing Station Operators watch the Bearing Dials, and the Elevation Station Operators watch the Elevation Dials.

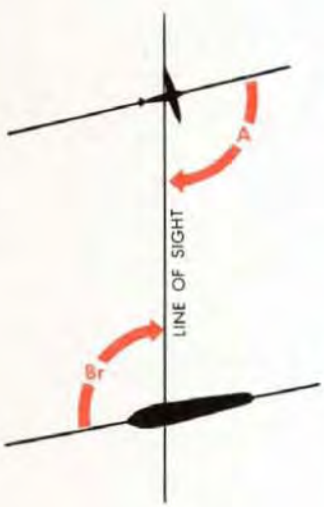


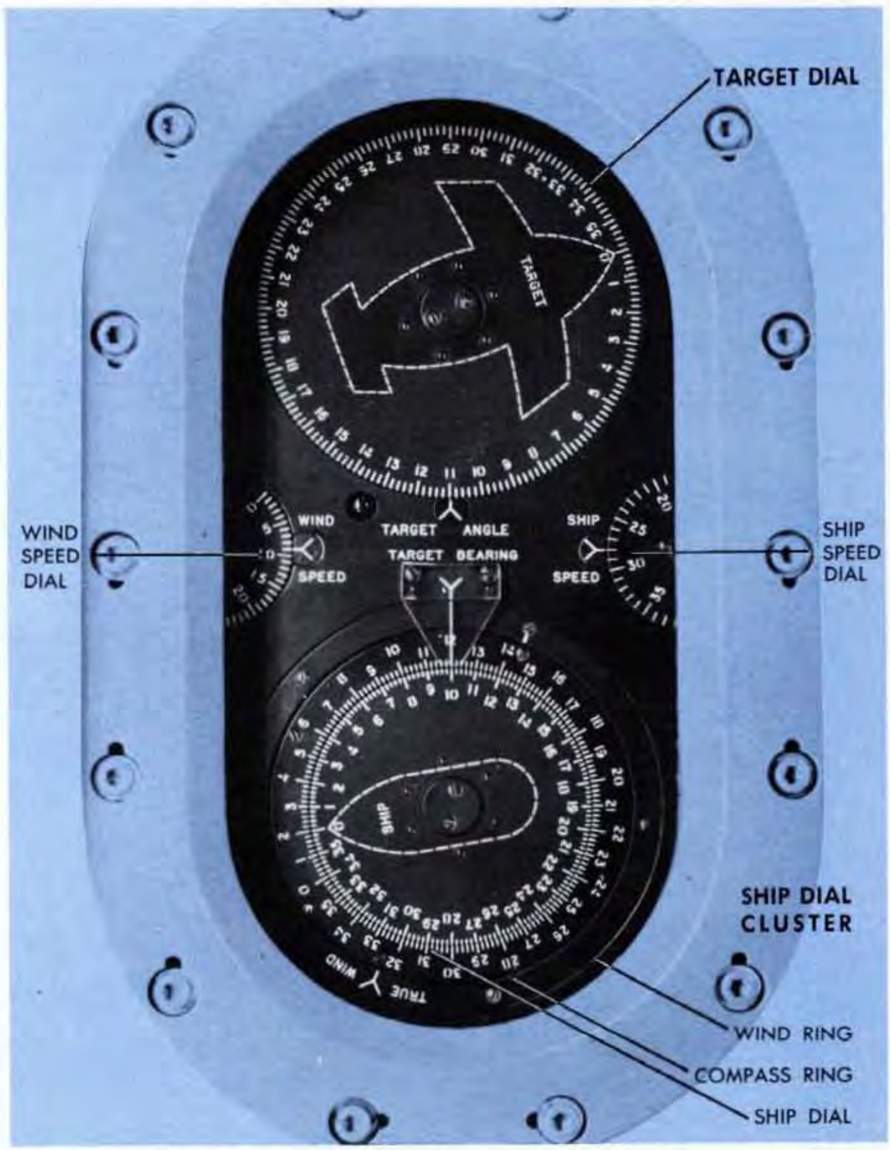
The TARGET and SHIP dial group



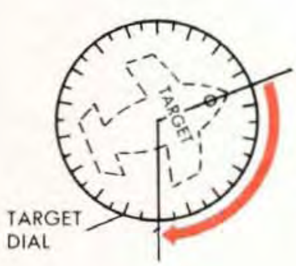
The Target and Ship Dial Group contains the Target Dial, the Ship Dial Cluster, the Wind Speed Dial, and the Ship Speed Dial.

The Target Dials and the dials in the Ship Dial Cluster indicate angles measured in the horizontal plane. A line drawn through the fixed indexes between the Target Dial and the Ship Dial Cluster represents the horizontal projection of the Line of Sight.





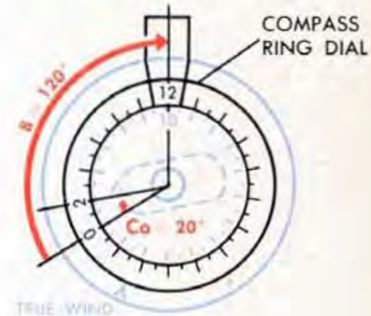
THE TARGET DIAL shows Target Angle, *A*. It is graduated every 2 degrees and numbered every 10 degrees from 0 to 360 degrees. One zero is omitted from each number to allow use of larger figures.



Target Angle is measured clockwise from the bow of the Target and is read at the fixed index representing the Line of Sight.

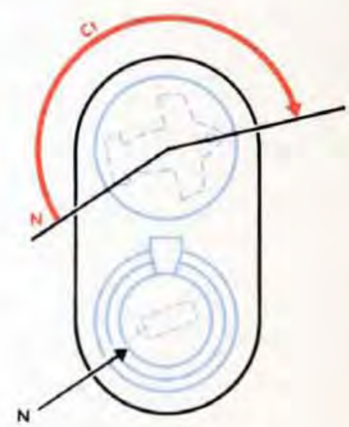
THE SHIP DIAL CLUSTER consists of three dials mounted one outside the other: the Ship Dial, the Compass Ring Dial, and the True Wind Ring Dial.

THE SHIP DIAL shows Relative Target Bearing, *Br*. *Br* is measured clockwise from the bow of the Ship and is read at the fixed index representing the Line of Sight.



THE COMPASS RING DIAL shows Ship Course, *Co*. The zero on this dial represents *North*. *Co* is measured clockwise from *North* and is read on the Compass Ring against the bow of the Ship. Changes in *Co* are recorded by movement of the Compass Dial around the Ship Dial.

The Compass Dial also shows True Target Bearing, *B*, the angle between *North* and the Line of Sight, measured clockwise from *North*. *B* is read on the Compass Ring against the fixed index. Both the Ship Dial and the Compass Ring are graduated every 2 degrees and numbered every 10 degrees from 0 to 360 degrees. The zeros are omitted to allow use of larger figures.

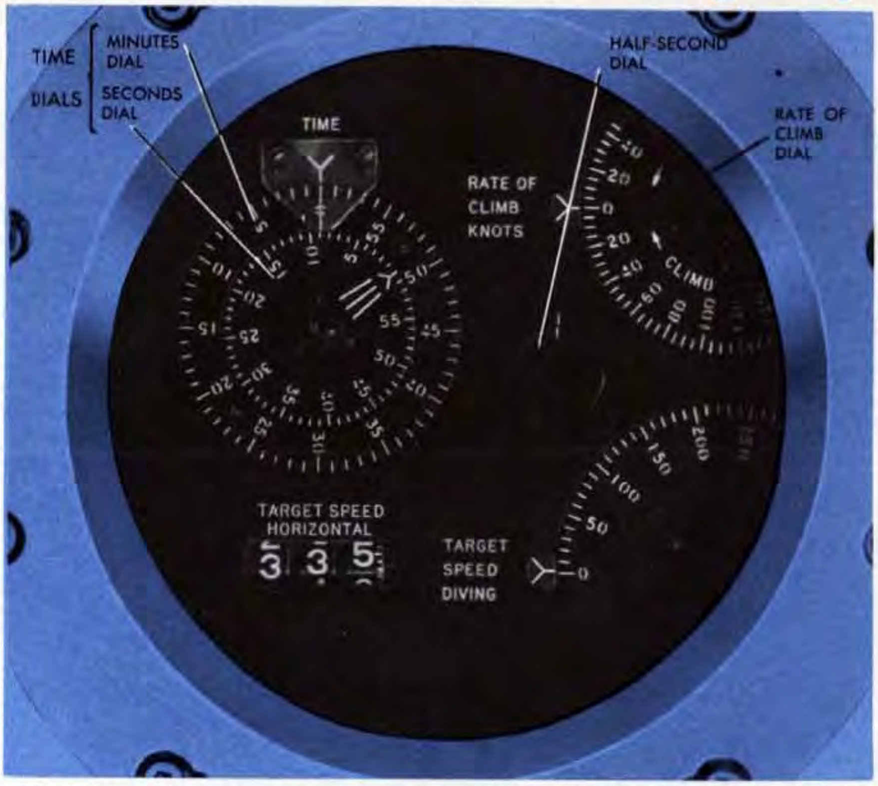


Target Course, *Ct*, is the angle measured clockwise from *North* to the bow of the Target. On the Target Dial it is possible to approximate *Ct* by observing the angle from *North*, as shown on the Compass Ring, clockwise to the bow of the Target. To obtain the exact value of *Ct*, read the value of *B* on the Compass Ring, add 180° and subtract the value of *A* as shown on the Target Dial. $Ct = B + 180° - A$.

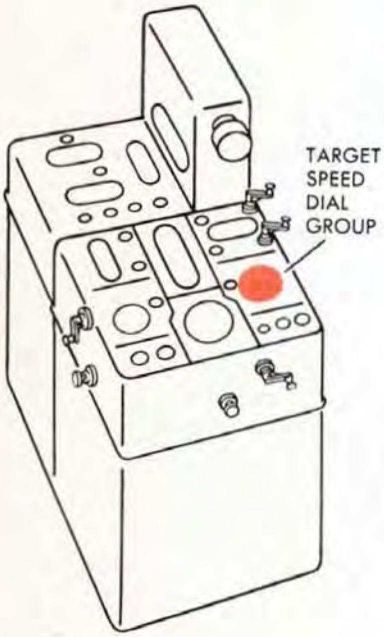
THE TRUE WIND RING DIAL has no graduations. Instead it has an index indicating the direction from which the wind is blowing. Wind Direction, *Bw*, is the angle between *North* and the direction from which the wind is blowing, measured clockwise from *North*. It is read on the Compass Ring against the True Wind Index. Wind Angle, *Bws*, is the angle between the direction from which the wind is blowing and the Line of Sight, measured clockwise on the Compass Ring from the True Wind Index to the fixed index. $Bws = B - Bw$.

The small dials on the Target and Ship Group show WIND SPEED, *Sw*, and SHIP SPEED, *So*. Each dial is read against its fixed index. The Wind Speed Dial is graduated from 0 to 60 knots, with numbers every 5 knots. The Ship Speed Dial is graduated from 0 to 45 knots, with numbers every 5 knots.

The TARGET SPEED dial group



The Target Speed Dial Group consists of the TARGET SPEED Counter, the TIME Dials, the RATE OF CLIMB Dial, and the TARGET SPEED DIVING Dial.



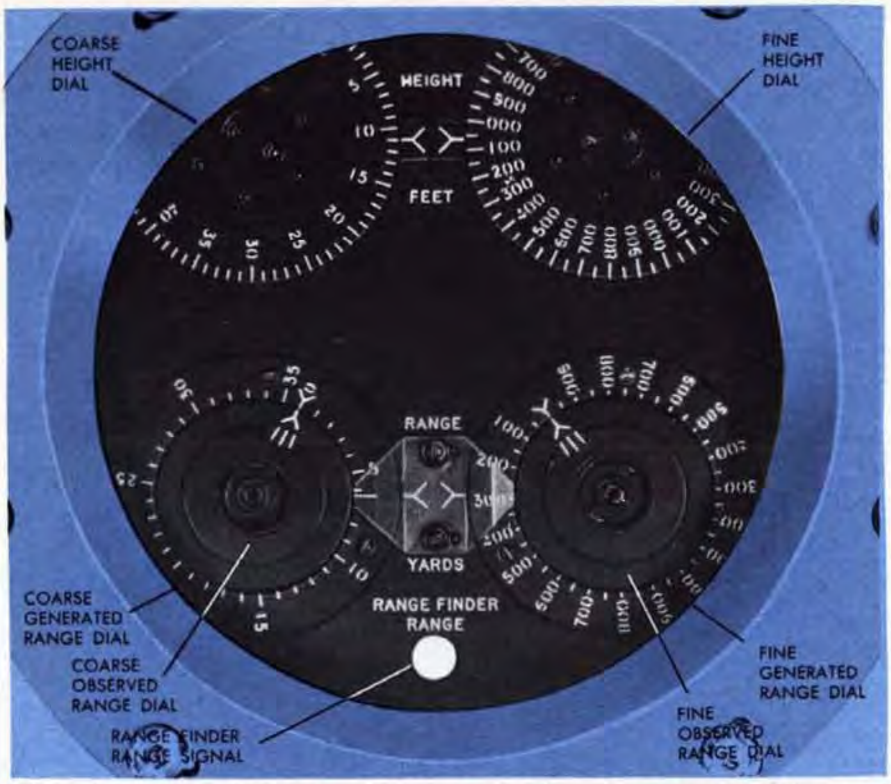
THE TARGET SPEED COUNTER shows Horizontal Ground Speed of Target, *Sh,* in knots, from 0 to 400 knots.

THE TIME DIALS are used principally in running tests. The ring dial is the Minutes Dial. It is graduated in minutes from 0 to 60, with numbers every 5 minutes. The inner dial is the Seconds Dial. It is graduated in seconds from 0 to 60, with numbers every 5 seconds. Both dials are read against the fixed index. The small dial is the Half-second Dial. It has one graduation and makes one revolution every half-second.

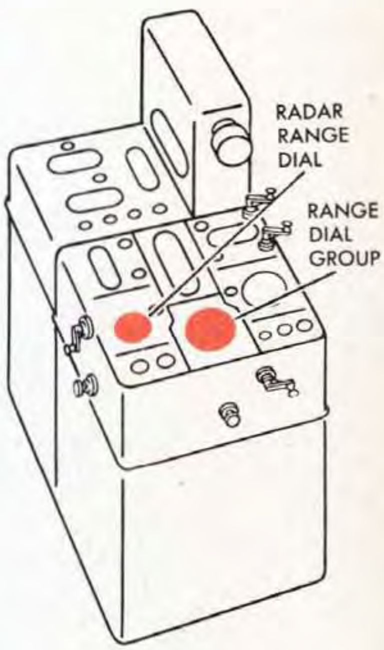
THE RATE OF CLIMB DIAL shows Rate of Climb, *dH,* in knots. It is graduated every 5 knots and numbered every 20 knots from 0 to CLIMB (plus) 150 knots, and from 0 to DIVE (minus) 250 knots.

THE TARGET SPEED DIVING DIAL is used only during certain dive attacks against Own Ship. It shows a substitute Range Rate, *dR,* for use when a special dive attack setup is ordered. This dial turns from minus 450 to plus 450 knots. It is graduated every 10 knots, numbered every 50 knots, and is read against the fixed index. To avoid confusion, only the DIVE (minus) side is graduated and numbered.

The RANGE dial group



The Range Dial Group contains the Generated and Observed Range Dials and the Height Dials. The coarse dials are on the left, and the fine dials are on the right.



GENERATED RANGE, *cR*, is shown on two ring dials, coarse and fine. The coarse *cR* Dial is graduated every 1,000 and numbered every 5,000 yards up to 35,000. Each dial has an index at its zero. The fine *cR* Dial is graduated every 50 and numbered every 100 yards. One revolution of the fine dial represents 2,000 yards. Each *cR* Dial is read against its fixed index.

OBSERVED RANGE, *R*, is indicated on two inner dials, coarse and fine. These inner dials have no graduations. When the indexes of the outer, *cR*, Range Dials are matched with the indexes on the inner, *R*, Range Dials, *R* equals *cR*. *R* can then be read indirectly by reading *cR* against the fixed index.

THE RANGE FINDER RANGE SIGNAL is in front of the Range Dials. A white signal appears here when the Range Operator in the Director presses his key to signal that Observed Range is correct. Otherwise this signal is black.

THE HEIGHT DIALS show the vertical height, *H*, of the Target. The coarse dial at the left is graduated every 1,000 feet and numbered every 5,000 feet up to 50,000. The fine dial is graduated every 50 feet and numbered every 100 feet. The Height Dials are read at their fixed indexes.

THE RADAR RANGE DIAL shows Radar Range. This dial is used chiefly to let the Range Operator follow the Radar tracking of a target before it comes within the operating limits of the Computer Tracking Section. The Radar Range Dial is graduated and numbered every 5,000 yards from 0 to 100,000 yards, and is read at the fixed index.

The BEARING dials

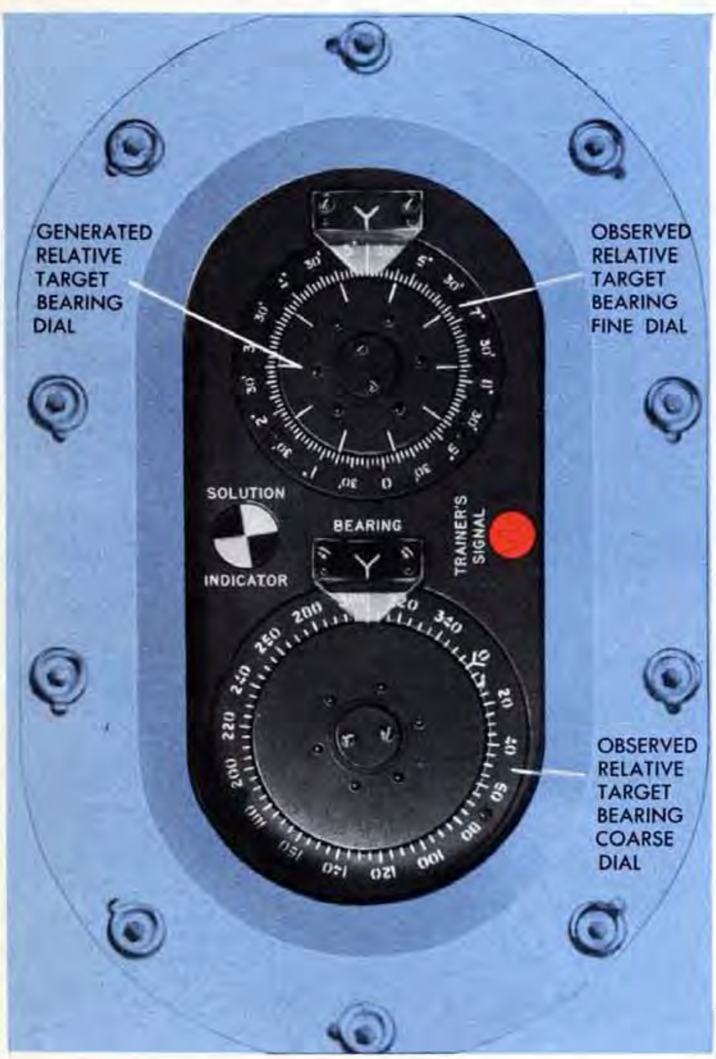
The Bearing Dials consist of a fine and a coarse ring dial, and an inner fine dial.

OBSERVED RELATIVE TARGET BEARING, *Br*, is shown on the two ring dials. Notice that the arrangement of the Bearing Dials is opposite to that of the Range Dials. In the Bearing Dial Group, the observed value is shown on the two *outer* dials. Generated Changes of Relative Target Bearing, $\triangle cBr$, turn only the fine *inner* dial.

The coarse ring dial is graduated every 5 degrees and numbered every 20 degrees from 0 to 360 degrees.

The fine ring dial is graduated every 5 minutes and numbered every 30 minutes. One revolution represents 10 degrees.

Both ring dials are read at their fixed indexes.



THE GENERATED BEARING DIAL is not numbered but has ten equally spaced graduations. These graduations are used to show whether Generated Bearing is changing at the same RATE as Observed Bearing. When the inner and outer fine dials turn together, the Generated Bearing Rate is correct. The position of these graduations relative to the ring dial is immaterial.

THE TRAINER'S SIGNAL shows red when the Trainer in the Director has his signal key closed. Otherwise the signal is black.

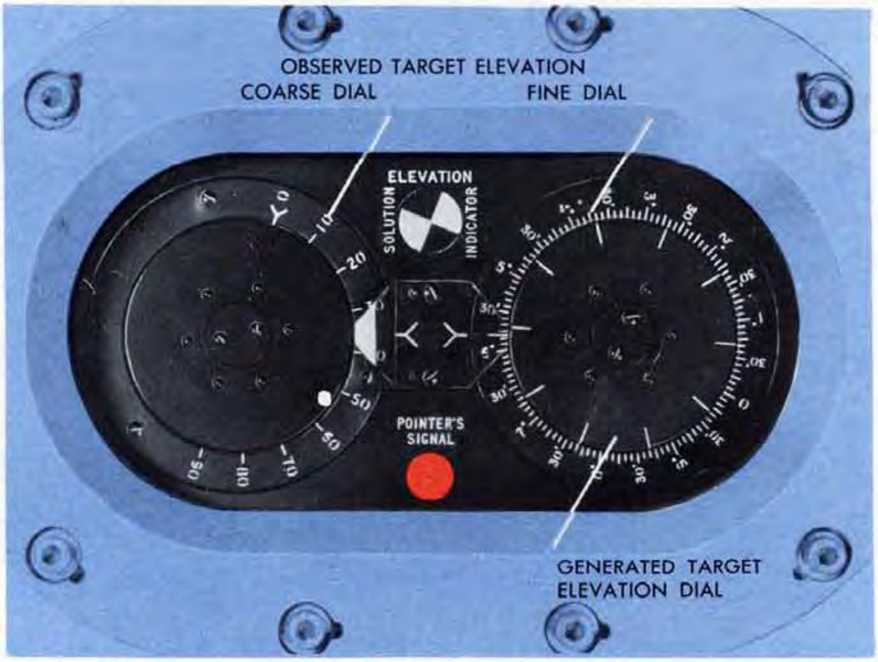
THE SOLUTION INDICATOR operates in Automatic Control only. It revolves when the Trainer in the Director is turning his handwheels.

If the Trainer's Signal shows red while the Solution Indicator turns, Bearing Rate Corrections are being put into the Rate Control Computing Mechanism automatically.

The ELEVATION dials

The Elevation Dials, like the Bearing Dials, consist of a fine and a coarse ring dial and a fine inner dial.

OBSERVED TARGET ELEVATION, E is shown on the two outer ring dials. Generated Changes of Target Elevation, $\triangle cE$, turn the fine inner dial.



The coarse ring dial is graduated and numbered every 10 degrees, from 0 to 90 degrees.

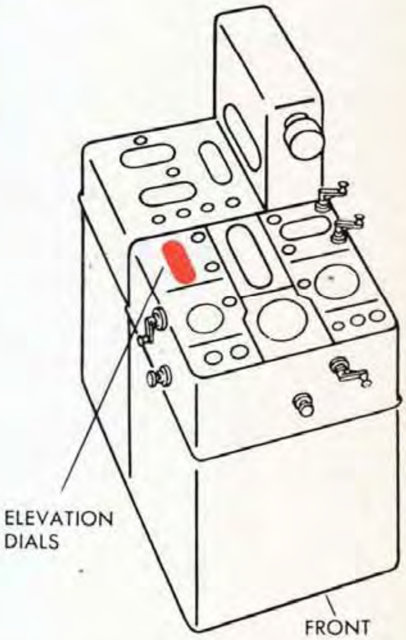
The fine ring dial is graduated every 5 minutes and numbered every 30 minutes. One revolution of this dial represents 10 degrees.

Both ring dials are read at their fixed indexes.

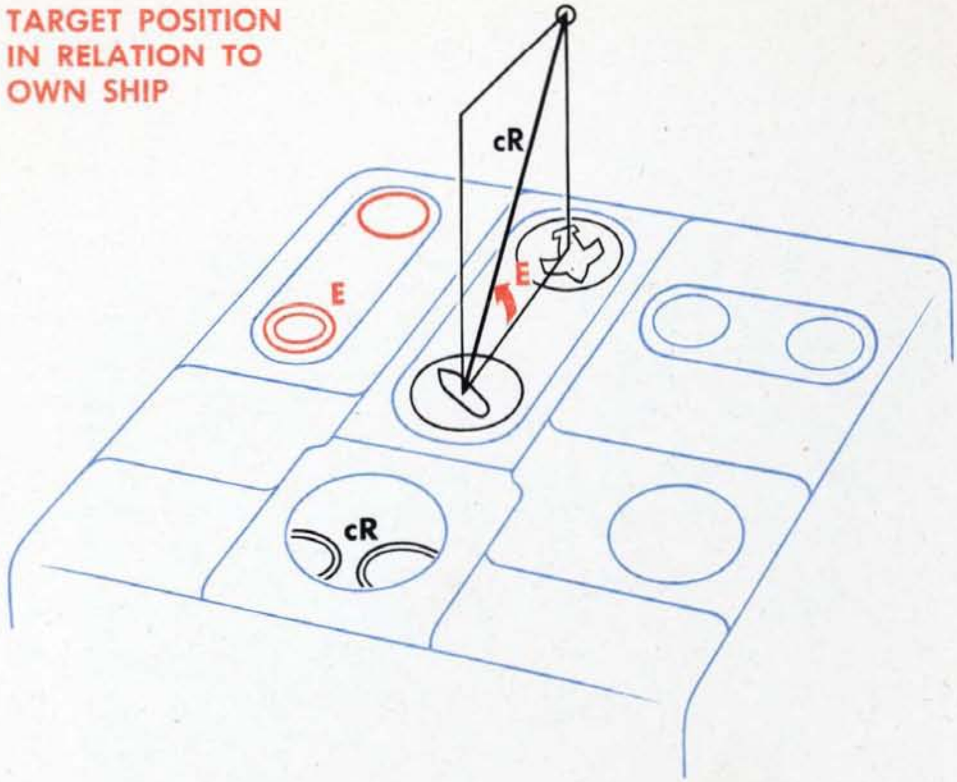
THE GENERATED ELEVATION DIAL has ten equally spaced graduations which are used to show whether Generated and Observed Elevation are changing at the same rate. The position of these graduations relative to the ring dial is immaterial.

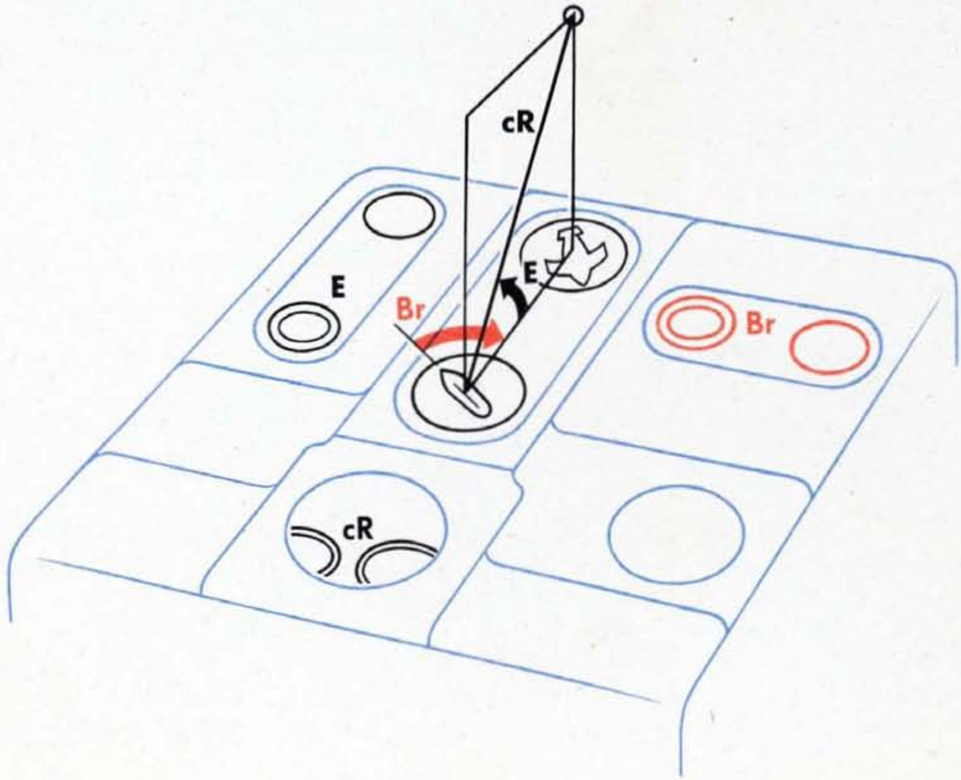
THE POINTER'S SIGNAL AND THE SOLUTION INDICATOR in the Elevation Dial Group work in exactly the same way as those in the Bearing Group.

The Pointer's Signal is red when the Pointer in the Director closes his key. Otherwise the signal is black. When the signal is red and the Solution Indicator turns, Elevation Rate Corrections are being put into the Rate Control Computing Mechanism automatically.



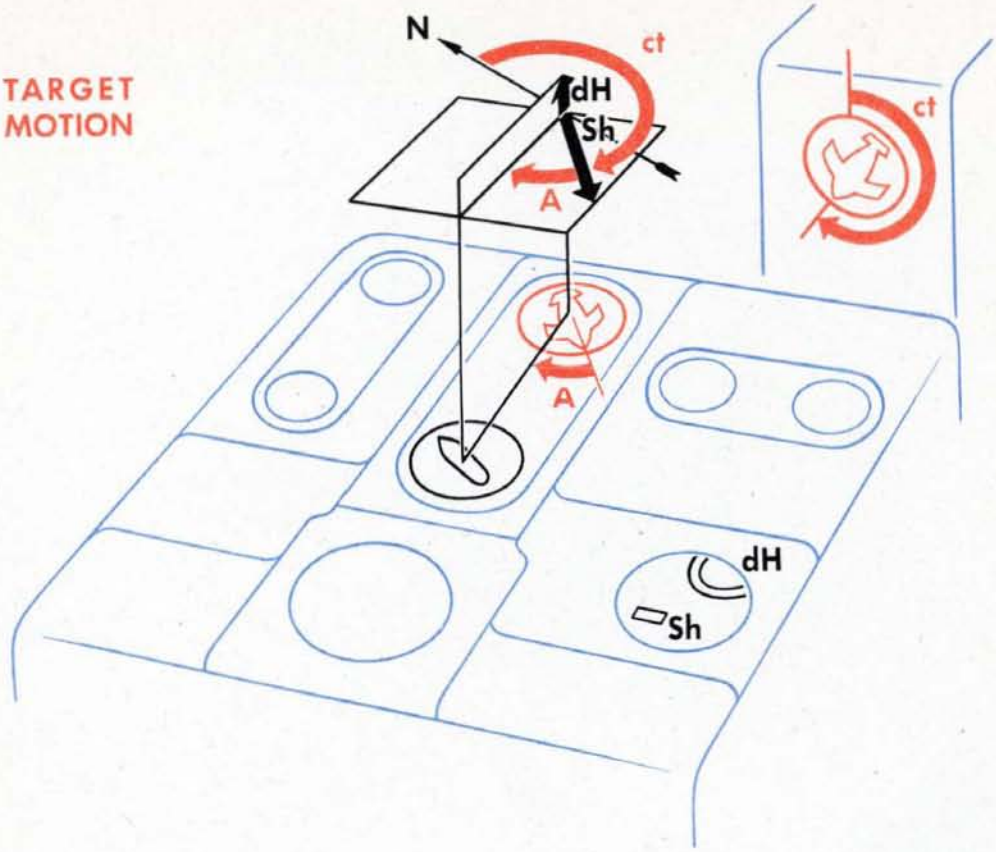
How the DIALS picture the



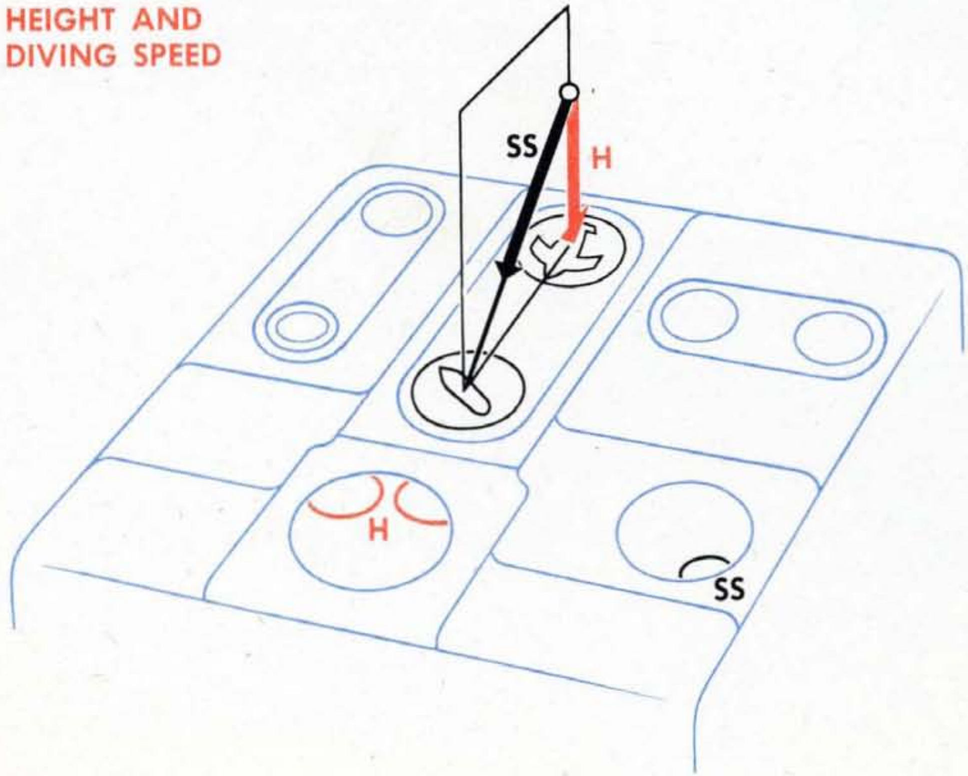


FIRE CONTROL PROBLEM

TARGET MOTION

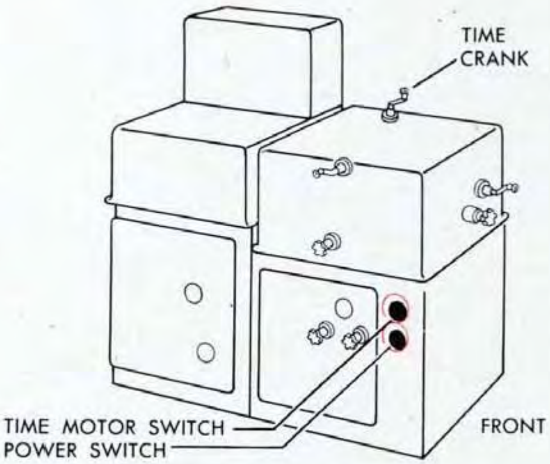


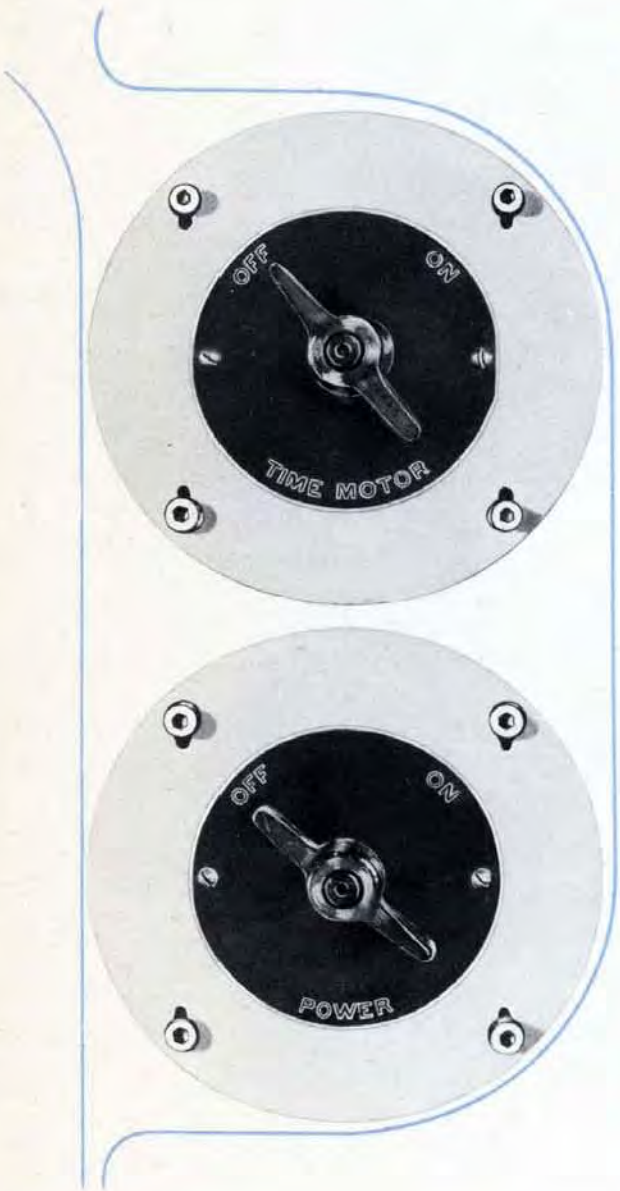
HEIGHT AND DIVING SPEED



The TIME MOTOR and POWER switches

The Time Motor and Power Switches are located on the lower left side of the Computer near the front. The station from which these switches are operated depends on ship's doctrine.





The TIME MOTOR SWITCH is the upper of the two switches. It has two positions: OFF and ON. Turning this switch to the ON position puts the Time Motor in operation when the Power Switch is ON.

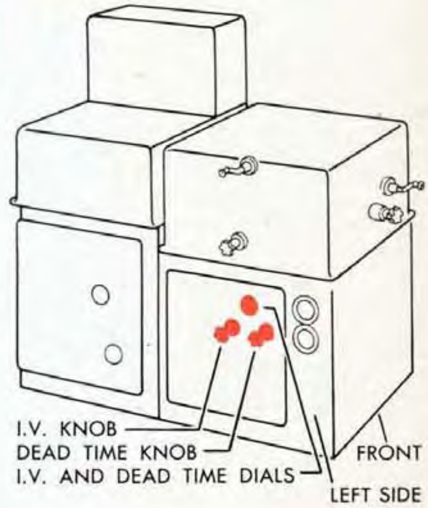
NOTE:
In the event that the Time Motor does not start, pull the Time Crank OUT and turn it clockwise.

The POWER SWITCH is the lower of the two switches. It has two positions: OFF and ON. Turning it to the ON position energizes the Computer.

CAUTION:
The Power Switch should be ON before any operating handcranks are turned.

INITIAL VELOCITY and DEAD TIME

The Initial Velocity and Dead Time Dials and Knobs are on the lower left side of the Computer, near the front and to the left of the Time Motor and Power Switches. The station from which these controls are operated depends on ship's doctrine.



The INITIAL VELOCITY DIAL shows Initial Velocity, *I.V.*, in feet per second. It is graduated every 5 feet per second and numbered every 50 feet per second from 2350 to 2600 feet per second. Making a setting of this dial puts into the Computer a correction for the difference between the *I.V.* which is ordered and 2550 feet per second. The *I.V.* shaft line is positioned by the Initial Velocity Knob.

The DEAD TIME DIAL shows Dead Time, Tg, the time in seconds between the setting of the fuze and the firing of the projectile. The dial is graduated from 0 to 6 seconds at half-second intervals. The Tg shaft line is positioned by the Dead Time Knob.

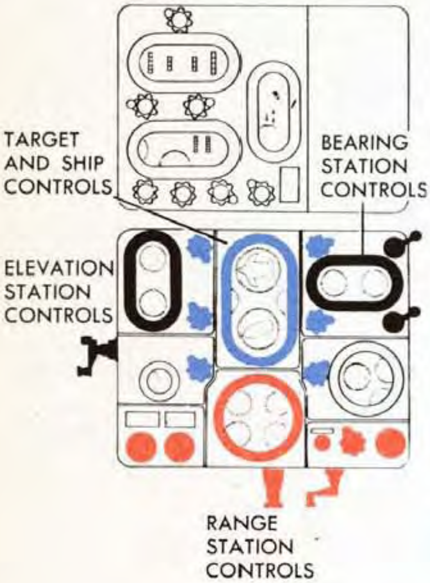
The INITIAL VELOCITY and DEAD TIME KNOBS each have two positions: IN and OUT. A pin holds each knob in the IN position. To make a setting to the dial, the pin must be lifted and the knob pulled OUT. When the knobs are released they spring back to their IN positions.

NOTE:

Set the Initial Velocity Dial at the computed Initial Velocity of the projectiles. For example, if the Initial Velocity for a given battery is determined to be 2590 feet per second, turn the Initial Velocity Knob until the Initial Velocity Dial reads 2590 at the fixed index.

Set the Initial Velocity Dial at 2550 only when the projectiles actually have this Initial Velocity, or when running tests and making settings which require Initial Velocity to be at this value.

THE CONTROLS ON THE FRONT OF THE COMPUTER MARK 1



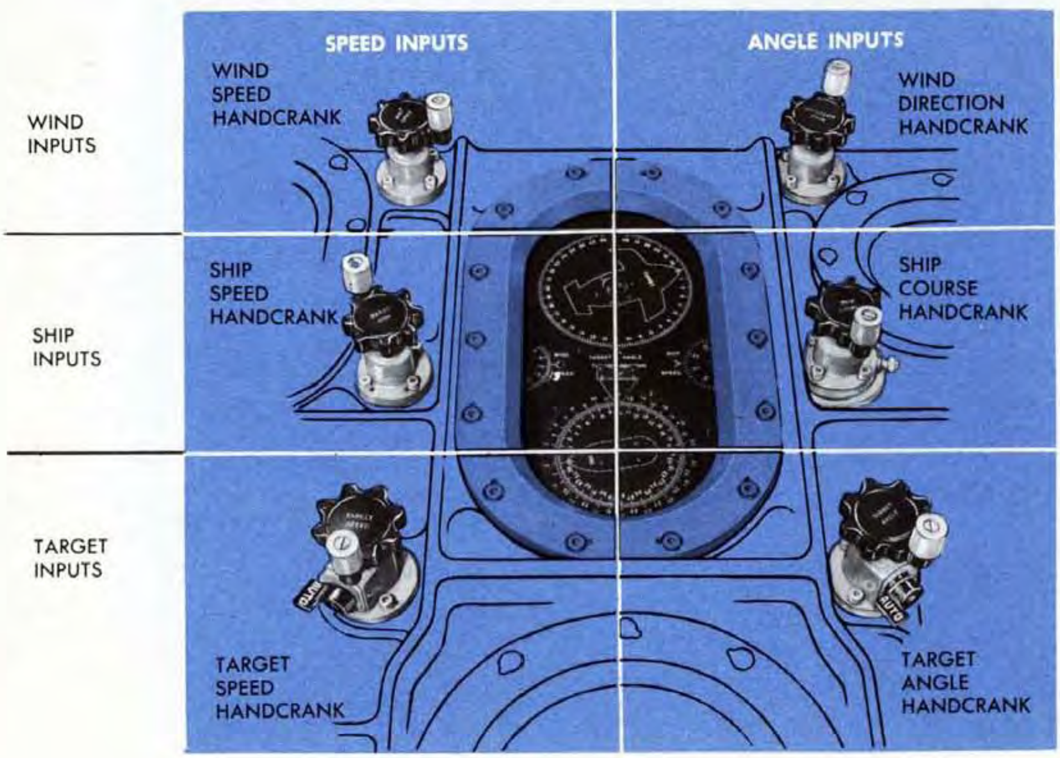
The simplest way to become familiar with the controls on the front of the Computer is to group them by operating stations.

The controls fall into four groups: the Target and Ship Dial Group Controls, the Range Station Controls, the Bearing Station Controls, and the Elevation Station Controls.

Operation of the controls in the Target and Ship Dial Group is divided among the operating stations according to ship's doctrine.

The controls in the target and ship group

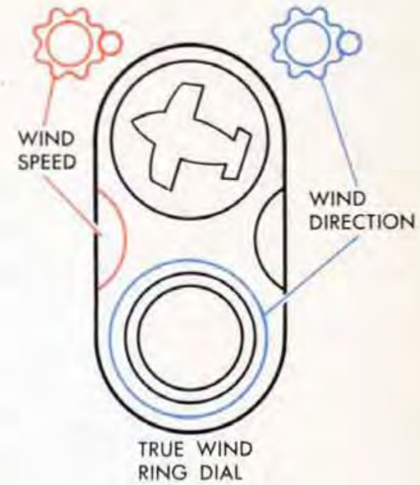
There are six handcranks in this group. The three handcranks to the left of the dials are for SPEED INPUTS. Those on the right are for ANGLE INPUTS.



THE WIND SPEED HANDCRANK puts in values of Wind Speed, *Sw*, which show on the Wind Speed Dial.

THE WIND DIRECTION HANDCRANK puts in values of Wind Direction, *Bw*, which are read on the Wind Ring Dial.

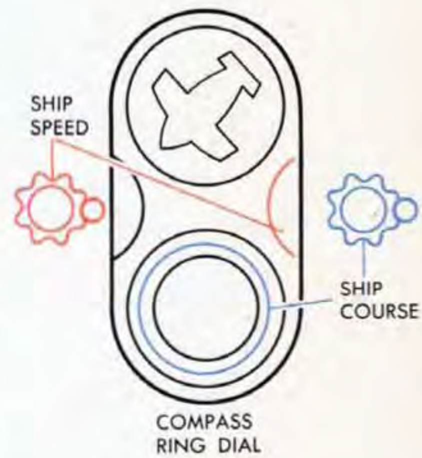
Wind Speed and Wind Direction are always put in by hand, as ordered.



THE SHIP SPEED HANDCRANK has two positions: IN and OUT, with a pin to hold it in either position. When this handcrank is in the IN position, it puts in values of Ship Speed, *So*, which are read on the *So* Dial. When this handcrank is in the OUT position, the *So* Line and Dial are positioned automatically from the Pitometer Log through the Ship Speed Receiver.

When setting the Ship Speed Dial by hand, it is important to remember that 0 and 45 are at the same position on this dial.

When Ship Speed is received by synchro transmission from the Pitometer Log, it is possible for the single-speed Ship Speed Receiver to be out of synchronism with the incoming signal. If the correct value does not appear on the dial, push the handcrank IN, set the dial by hand, and pull the handcrank OUT.

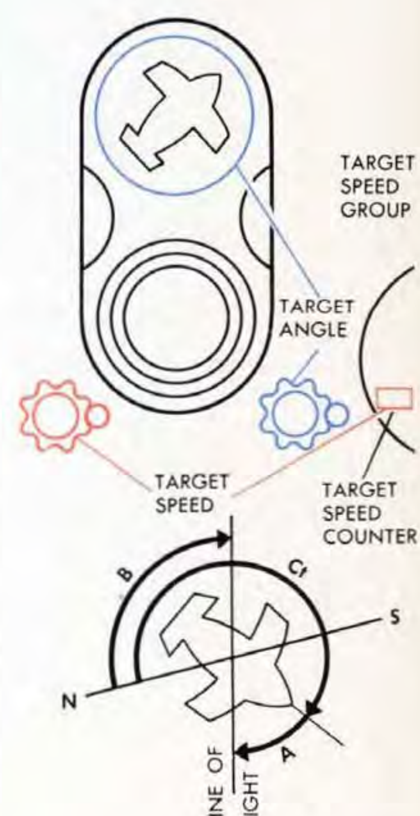


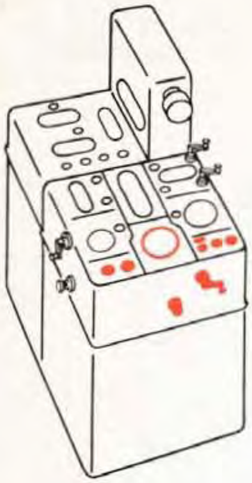
THE SHIP COURSE HANDCRANK has two positions: IN and OUT, with a pin to hold it in either position. When this handcrank is in the IN position, it puts in values of Ship Course, *Co*, which are read on the Compass Ring Dial. When this handcrank is in the OUT position, the *Co* Line and Dial are positioned automatically by the double-speed Ship Course Receiver which receives *Co* from the Gyro Compass.

THE TARGET SPEED HANDCRANK puts in Target Horizontal Ground Speed, *Sh*, which shows on the Target Speed Counter in the Target Speed Dial Group.

THE TARGET ANGLE HANDCRANK positions the Target Course, *Ct*, shaft line and the Target Course Indicator Dial. *Ct* is subtracted from True Bearing, *B*, in the Computer, producing Target Angle, *A*, which appears on the Target Dial. $A = 180° + B - Ct$.

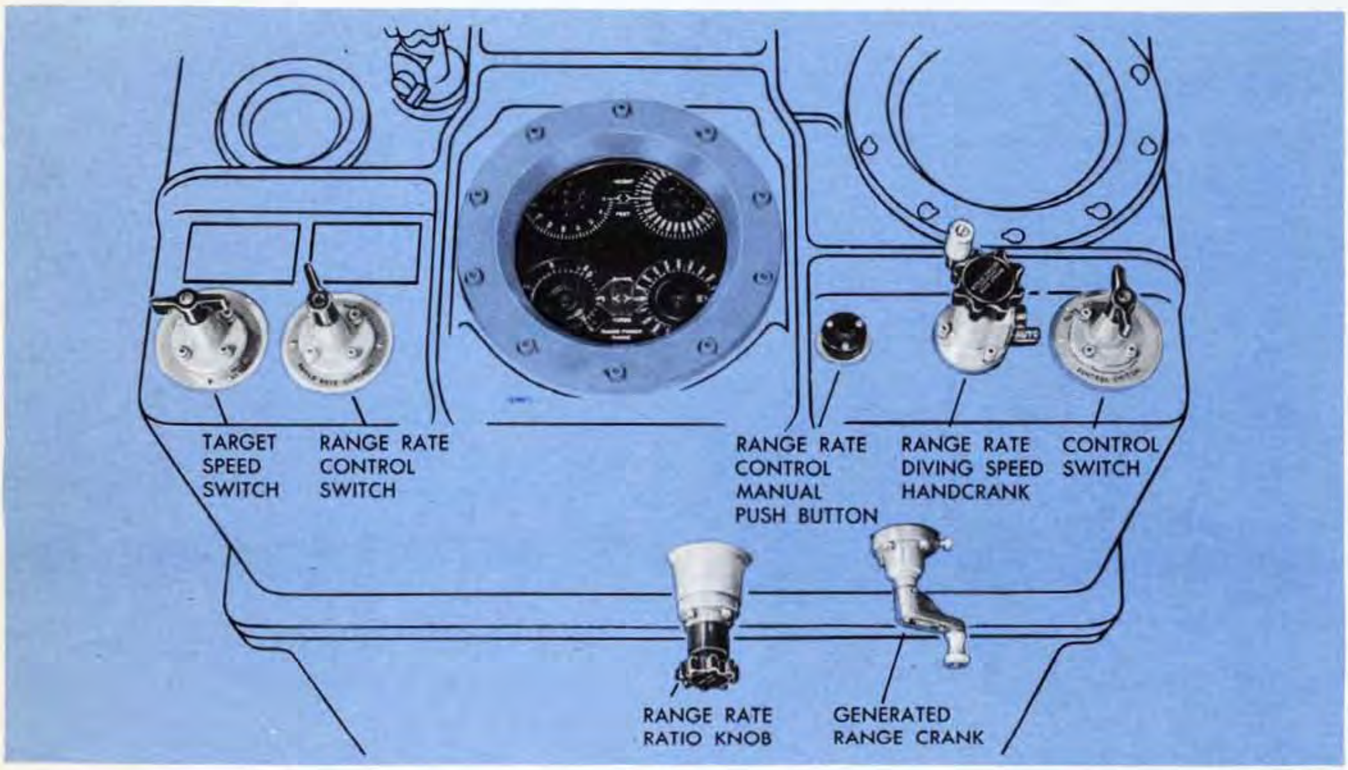
The Target Speed and Target Angle Handcranks have two positions: HAND and AUTO. Shift levers move them from one position to the other. With the levers at HAND position, these handcranks are connected to their shaft lines. With the levers at AUTO, the handcranks are disconnected, and the *Sh* and *Ct* shaft lines are positioned by the Rate Control Mechanism.





The controls at the range station

In addition to the dials, the controls at the Range Station include three switches: the Control Switch, the Range Rate Control Switch, and the Target Speed Switch. The controls also include the Generated Range Crank, the Range Rate Ratio Knob, the Range Rate/Diving Speed Handcrank, and the Range Rate Control Manual Push Button.

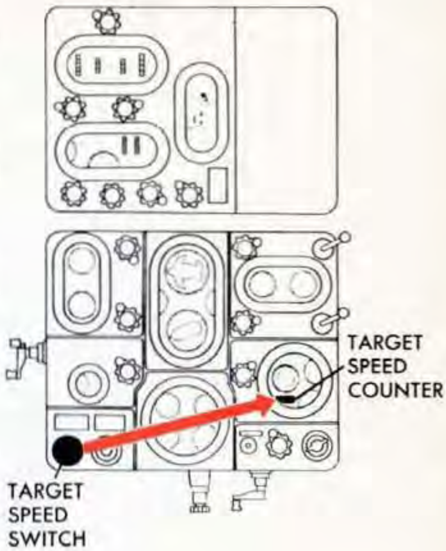


THE CONTROL SWITCH is on the right side of the top of the Computer near the front. This switch determines the method of rate-controlling Bearing and Elevation. The Control Switch has three positions: AUTO, SEMI-AUTO, and LOCAL.

With the Control Switch at AUTO, Bearing and Elevation Corrections are made automatically on signal from the Trainer and Pointer in the Director.

With the Control Switch at SEMI-AUTO, Bearing and Elevation Corrections are put into the Computer by the Computer Crew.

With the Control Switch at LOCAL, the Rate Control Mechanism is inoperative. This type of operation is used against surface targets when the Director is not operating.



THE TARGET SPEED SWITCH is connected to the Target Speed, *Sh*, Servo Motor. This switch has three positions: NORMAL, INCREASE, and DIVE ATTACK.

When the Target Speed Switch is at NORMAL, the *Sh* Follow-up controls the *Sh* Motor. This allows normal operation of the Rate Control Mechanism.

When the Target Speed Switch is at INCREASE, the "increase" side of the *Sh* Servo Motor is energized. This causes the *Sh* shaft line and counter to turn rapidly in an increasing direction. The switch has to be held at INCREASE since it springs back to NORMAL when released.

When the Target Speed Switch is at DIVE ATTACK, the "decrease" side of the *Sh* Servo Motor is energized. This causes the value on the Target Speed shaft line to decrease rapidly, running the Target Speed counter to zero. The switch stays at DIVE ATTACK until moved to another position.

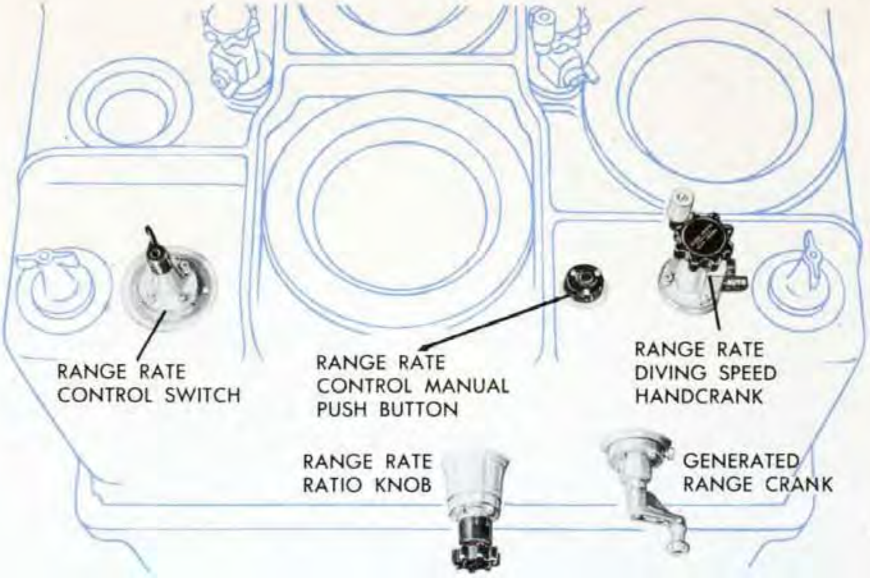
The Target Speed Switch functions only when the Target Speed and Target Angle Handcranks are at AUTO.

THE RANGE RATE CONTROL SWITCH is at the left side of the Computer, near the front. It has a one-wing handle. This switch controls the method by which Range Rate Corrections are put into the Rate Control Mechanism. The switch has two positions: AUTO and MANUAL.

With the Range Rate Control Switch at AUTO, Range and Range Rate Corrections are put in automatically on signal from the Range Operator in the Director or the Radar Operator.

With the Range Rate Control Switch at MANUAL, these corrections are put in bv a member of the Computer Crew.

The position of the Range Rate Control Switch is independent of the position of the Control Switch. RANGE MAY BE RATE-CONTROLLED EITHER AUTOMATICALLY OR SEMI-AUTOMATICALLY DURING AUTOMATIC OR SEMI-AUTOMATIC RATE CONTROL OF ELEVATION AND BEARING.

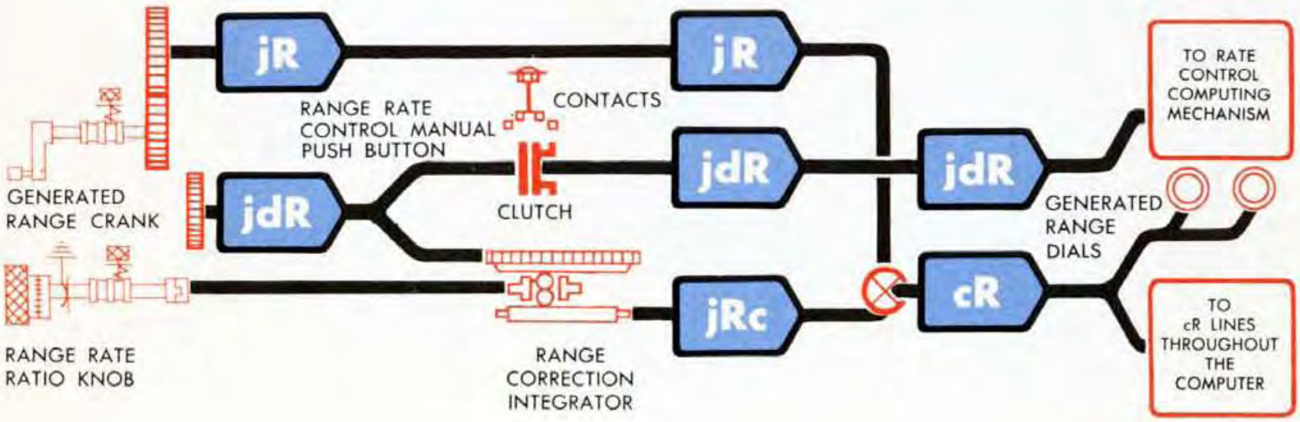


THE GENERATED RANGE CRANK turns the Generated Range line. It has two positions, IN and OUT, with a pin to hold it in the OUT position.

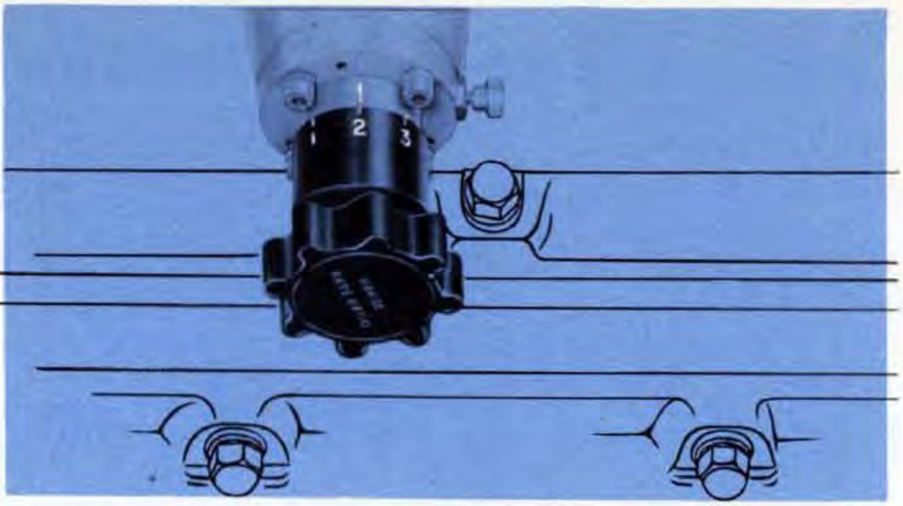
When the Range Rate Control Switch is at AUTO, Range Rate Control is handled automatically on signal from the Range Operator in the Director. The Generated Range Crank must be in its OUT position.

When the Range Rate Control Switch is at MANUAL, Range Rate Control is handled through the Generated Range Crank. In its OUT position the crank puts in linear Range Correction, *jR*, to match the indexes on the Generated Range Dials to the indexes on the Observed Range Dials. In its IN position the Generated Range Crank can make two kinds of corrections. It puts in linear Range Correction, *jRc*, to match *cR* to *R*, and if the Range Rate Control Manual Push Button is depressed, it also puts Range Rate Correction, *jdR*, into the Rate Control Computing Mechanism.

THE RANGE RATE CONTROL MANUAL PUSH BUTTON is located above the Generated Range Crank. When the Range Rate Control Switch is at MANUAL, pressing this push button closes a solenoid clutch which allows Range Rate Corrections to drive into the Rate Control Computing Mechanism.

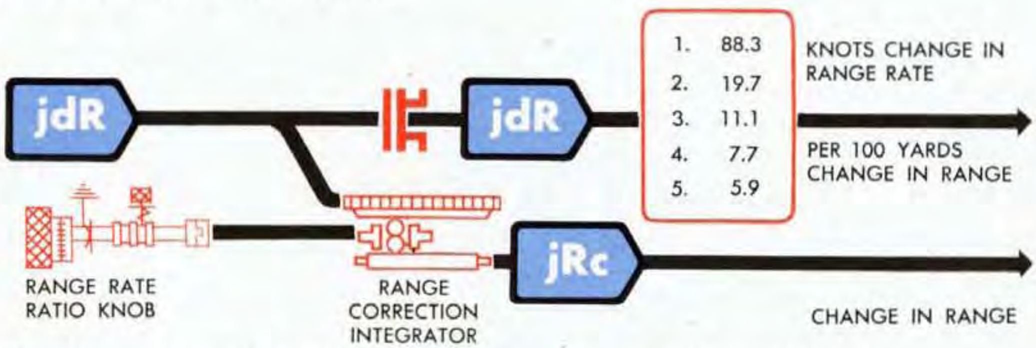


Quick Reference Index



THE RANGE RATE RATIO KNOB positions the carriage of the Range Correction Integrator. This integrator controls the ratio between linear Range Correction and the Range Rate Correction put into the Rate Control Computing Mechanism during Range Rate Control.

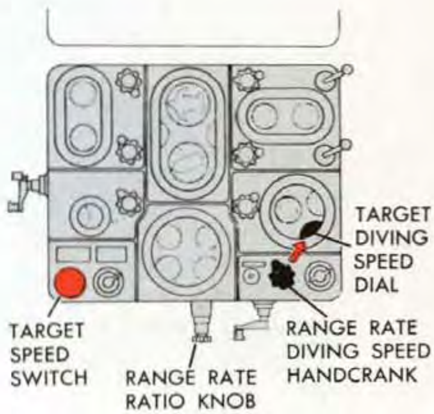
The sleeve of the Range Rate Ratio Knob is calibrated from 1 to 5. The largest Range Rate Correction for each linear Range Correction is made with the knob set at 1. As the knob is turned toward 5, the Range Rate Correction for each linear Range Correction becomes smaller. With the knob set at 1, a few revolutions of the Generated Range line will put in a large amount of Range Rate Correction. With the knob set at 5, an equal number of revolutions of the line results in a much smaller amount of Rate Correction.



The Range Rate Ratio Knob has two positions: IN and OUT. It is always operated in the IN position. The OUT position is provided only to permit removal of the cover of the Computer for adjustment or repair.

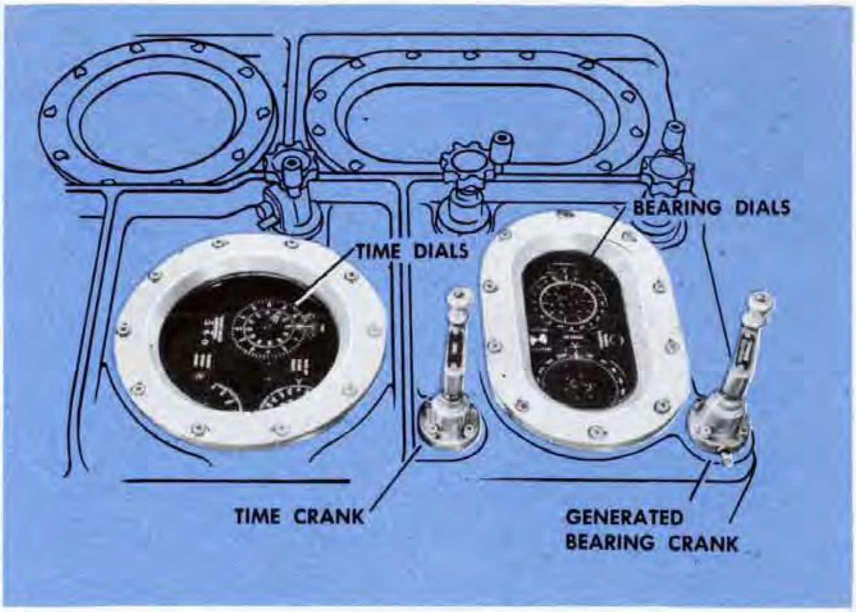
The RANGE RATE DIVING SPEED HANDCRANK has two positions: HAND and AUTO. At HAND it positions the Target Diving Speed Dial and the *dR* shaft line .When this handcrank is at AUTO, it is disengaged, and the *dR* shaft line is positioned automatically by *dR* from the Relative Motion Group.

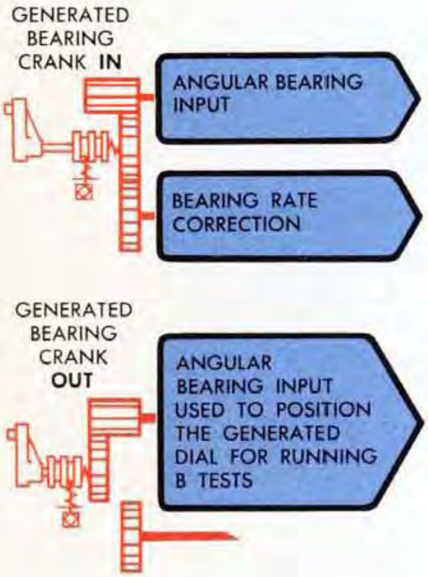
The Range Rate/Diving Speed Handcrank is used only when a DIVE ATTACK order is given and when the Target Speed Switch is at DIVE ATTACK. This handcrank must never be used when the Target is diving at other ships.



The controls at the bearing station

The controls at the Bearing Station consist of the Generated Bearing Crank and the Time Crank.





THE GENERATED BEARING CRANK has two positions: IN and OUT, with a pin to hold it in the OUT position.

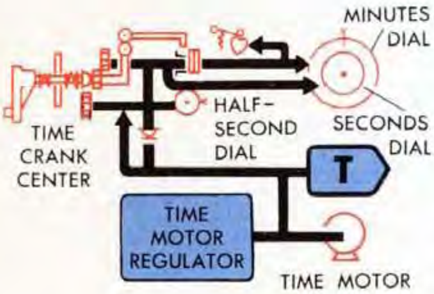
In Automatic Control, Bearing Rate Control is handled automatically on signal from the Trainer in the Director. The Generated Bearing Crank must be in its OUT position.

In Semi-automatic Control, the Generated Bearing Crank is put in its IN position to make Bearing Rate Control Corrections.

In its IN position, the Generated Bearing Crank puts in both angular inputs to Generated Bearing and *Bearing Rate Corrections* to keep the Generated Bearing Dial rotating at the same speed and in the same direction as the Observed Bearing Dial.

In its OUT position, the crank can be used to position the Generated Bearing Dial for running B Tests.

In Local Control, the Generated Bearing Crank in its OUT position is used to set the Relative Target Bearing Ring Dials to read the initial value of Generated Relative Target Bearing. Subsequent corrections to Generated Relative Target Bearing can also be introduced with this crank.

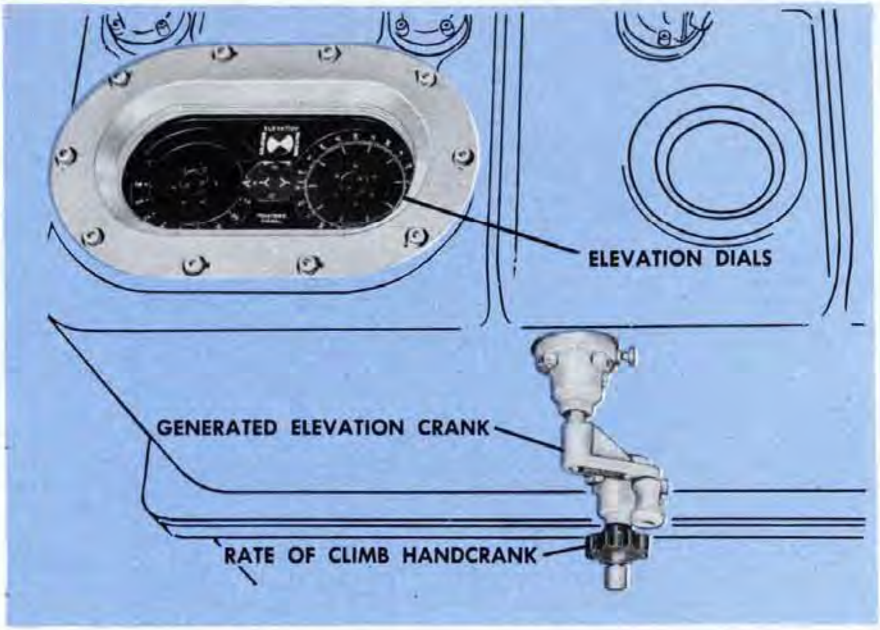


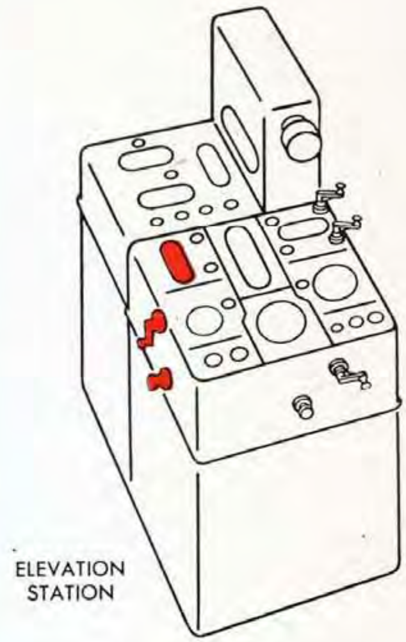
THE TIME CRANK has three positions: IN, CENTER, and OUT. It has to be held in the IN or OUT position, since it springs to CENTER when released. It is normally in the CENTER position, allowing the Time shaft line and dials to be positioned by the Time Motor. When the Time Crank is pushed IN, it zeros the Minute ring of the Time Dials. When turned in the IN position, this crank turns the Seconds Dial.

In its OUT position, the Time Crank is connected to the Time shafting. With the Time Motor Switch OFF, the Time shaft line may be rotated by the Time Crank for test purposes.

The controls at the elevation station

The controls at the Elevation Station consist of the Generated Elevation Crank and the Rate of Climb Handcrank.



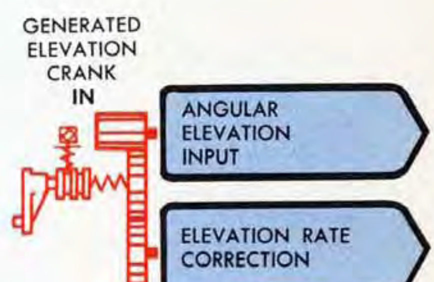


THE GENERATED ELEVATION CRANK has two positions: IN and OUT, with a pin to hold it in the OUT position.

In Automatic Control, Elevation Rate Control is handled automatically on signal from the Pointer in the Director. The Generated Elevation Crank must be in its OUT position.

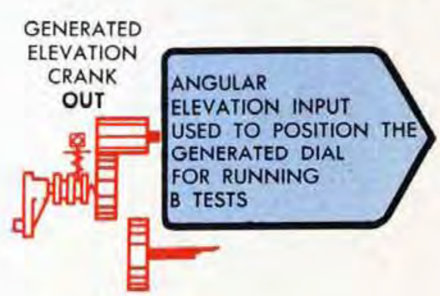
In Semi-automatic Control, Elevation Rate Control Corrections are put in through the Generated Elevation Crank. The Generated Elevation Crank must be in its IN position.

In its IN position the Generated Elevation Crank puts in both angular inputs to Generated Elevation and Elevation Rate Corrections, to keep the Generated Elevation Dial rotating at the same speed and in the same direction as the Observed Elevation Dial.



In its OUT position the crank can be used to position the Generated Elevation Dial for running B Tests.

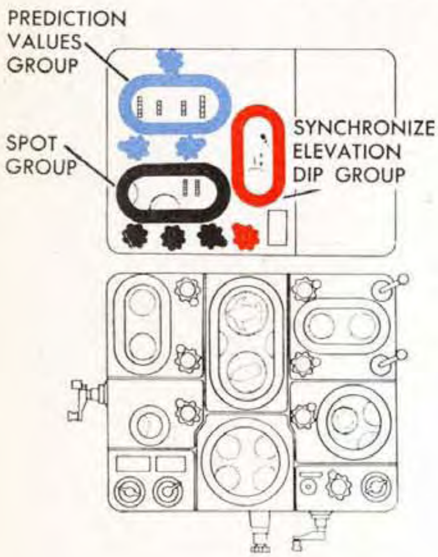
In Local Control, the Generated Elevation Crank is pulled OUT, since it is not used.



THE RATE OF CLIMB HANDCRANK is located below the Generated Elevation Crank. It has two positions: IN and OUT. In its IN position, it sets values of Rate of Climb, *dH*, into the Rate of Climb shaft line. The value on this shaft line can be read on the Rate of Climb Dial in the Target Speed Group.

When the Rate of Climb Handcrank is OUT, it is disconnected and the Rate Control Mechanism positions the *dH* shaft line automatically.

HANDCRANKS and DIALS on the REAR TOP of the COMPUTER

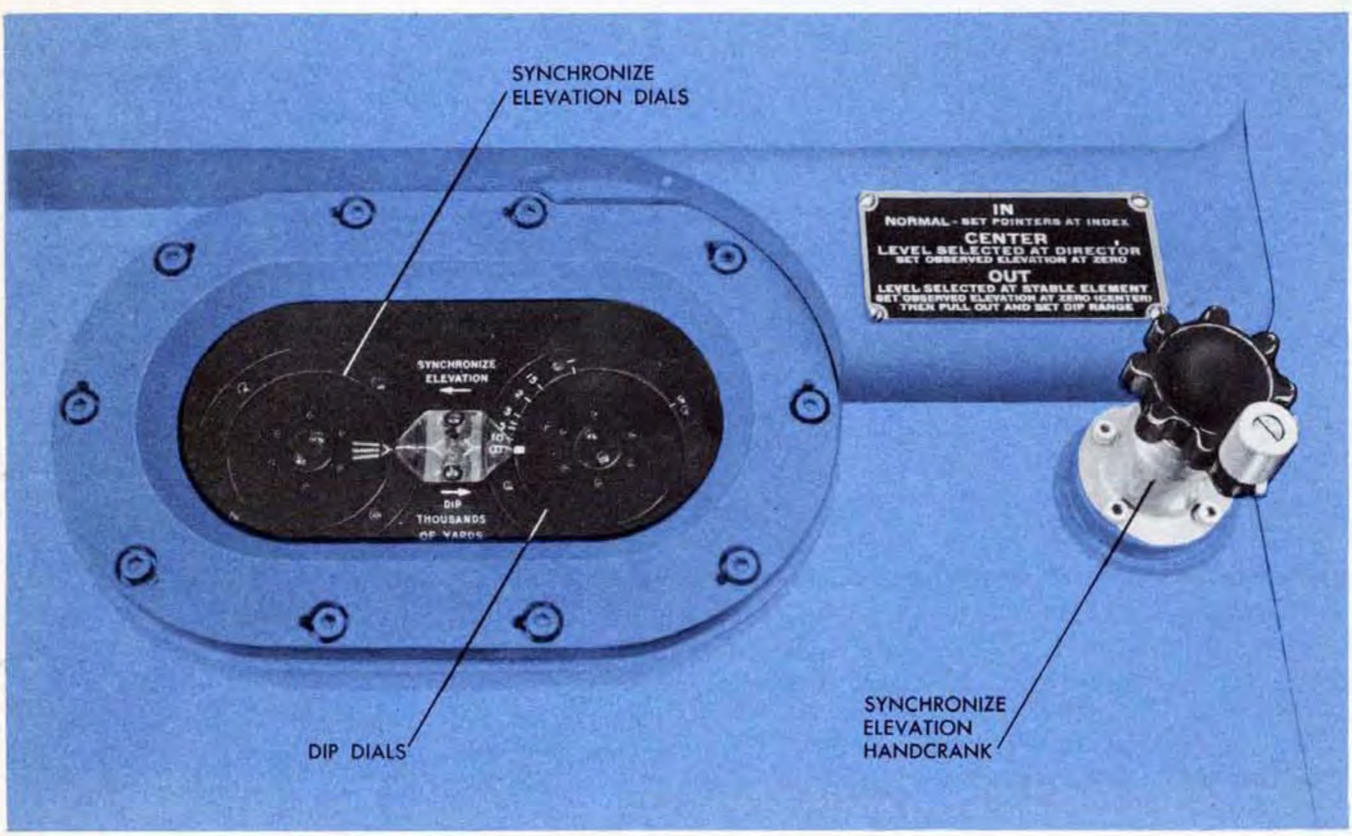


The rear top of the Computer Mark 1 is divided into three control groups:

The Synchronize Elevation and Dip Group
The Spot Group
The Prediction Values Group

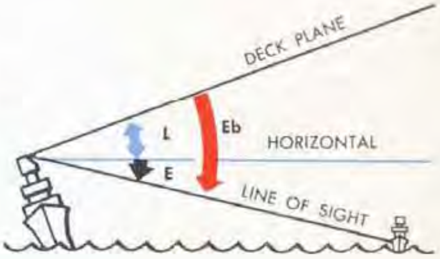
The synchronize elevation and dip dial group

This group consists of the Synchronize Elevation and Dip Dials and the Synchronize Elevation Handcrank.



THE SYNCHRONIZE ELEVATION DIALS consist of an inner dial and a ring dial. The index on the ring dial is a broken line. The index on the inner dial is an arrow. These markings are matched at the fixed index for Continuous Aim.

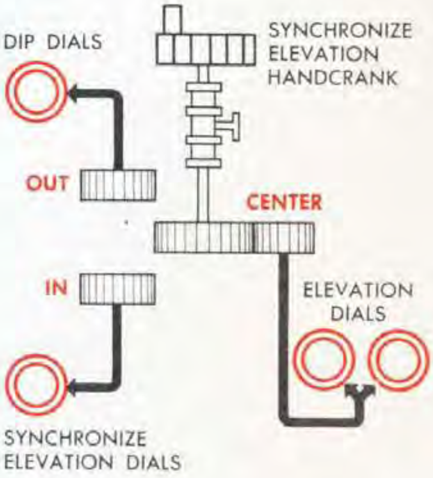
THE DIP DIALS consist of an inner dial with a wide index mark, and an outer ring with uneven graduations and numbers from 0.5 to infinity. The graduations on the outer dial represent thousands of yards of Range. The Dip Dials are used to obtain a substitute value for Target Elevation, *E*, when the Computer is operated without the Director. This substitute *E* is combined with Level Angle, *L*, to obtain a substitute value of Director Elevation, *Eb*, a value normally received from the Director.



THE SYNCHRONIZE ELEVATION HANDCRANK has three positions: IN, CENTER, and OUT, with a pin to lock it in each position.

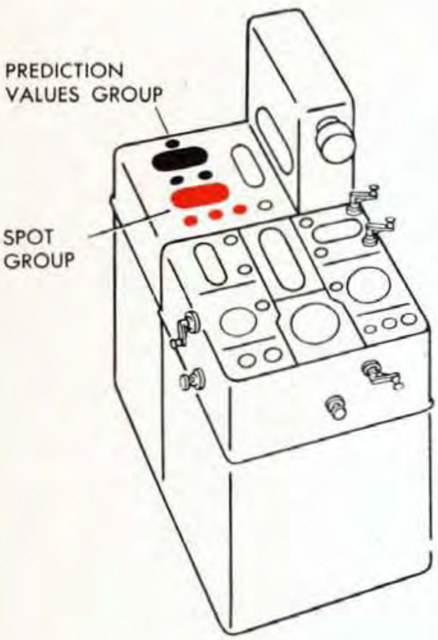
In the IN position, the handcrank is connected to the Synchronize Elevation Dials. In preparing for Continuous Aim, this handcrank is turned in the IN position to match the Synchronize Elevation Dials at their fixed index.

In the CENTER position, the Synchronize Elevation Handcrank is connected to the Observed Elevation shaft line and the Elevation Dials on the front of the Computer. When the Computer is being set up for Selected Level Fire, with Level Angle selected at the Director, against a surface target, this handcrank is turned in the CENTER position to zero the Elevation Dials. It should be left in the CENTER position.



In the OUT position the Synchronize Elevation Handcrank is connected to the Dip Dials. When the Computer is being set up to fire against a surface target without the Director Elevation input, that is, in Indirect Fire from the Stable Element, this handcrank is turned in the OUT position to put in a Dip value. The Dip value is set by matching the index on the inner Dip Dial to the fixed index and then setting the value of Advance Range on the ring dial to the same fixed index. Dip is set in after the Elevation Dials have been zeroed with the handcrank in the CENTER position. The graduations on the Dip Dial actually represent thousands of yards of Present Range. Advance Range is used to set the dials, however, because it is easily read on the adjacent *R2* Counter and is sufficiently accurate for this purpose.

When the handcrank is in the IN position, ignore any motion of the Dip Dials. When the handcrank is in the CENTER position, ignore any motion of both the Dip Dials and the Synchronize Elevation Dials. When the handcrank is in the OUT position, ignore any motion of the Synchronize Elevation Dials.



The spot group

The Spot Group consists of two Range Spot Counters, the Elevation Spot Dial, the Deflection Spot Dial, the Range Spot Handcrank, the Elevation Spot Knob, and the Deflection Spot Knob.

THE TWO RANGE SPOT COUNTERS show Range Spot, Rj, in yards. The upper counter reads from zero to 1,800 OUT. The lower counter reads from zero to 12,000 IN. One counter is always masked while the other shows a value of Range Spot. Both counters are uncovered at the zero position.

THE ELEVATION SPOT DIAL shows Elevation Spot, Vj, in mils from DOWN 180 mils to UP 180 mils. The dial is graduated every 5 mils, numbered every 20 mils, and read against its fixed index.

THE DEFLECTION SPOT DIAL shows Deflection Spot, Dj, in mils from RIGHT 180 mils to LEFT 180 mils. The dial is graduated every 5 mils, numbered every 20 mils, and read against its fixed index.

THE RANGE SPOT HANDCRANK puts Range Spot, Rj, into the Range Spot Counters and the Rj shaft line.

THE ELEVATION SPOT KNOB puts Elevation Spot, Vj, into the Elevation Spot Dial and the Vj shaft line.

THE DEFLECTION SPOT KNOB puts Deflection Spot, Dj, into the Deflection Spot Dial and the Dj shaft line.

The two knobs and the handcrank each have two positions: IN and OUT, with pins to hold them in either position. To introduce a spot manually, the knobs and handcrank must be in their IN positions. For automatic reception of spots from the Director, the knobs and handcrank must be OUT.

CAUTION:
The Rj, Vj, and Dj Receivers can get out of synchronism with the incoming signals. To prevent this, see that the Spot Dials indicate the correct value of the spot before pulling the handcranks OUT.

The prediction values group

The Prediction Values Group consists of the Sight Angle Counter and Handcrank, the Sight Deflection Counter and Handcrank, the Fuze Counter and Handcrank, and the Advance Range Counter.

THE SIGHT ANGLE COUNTER shows the computed value of Sight Angle, *Vs*, in minutes, with 2,000 minutes as the zero value.

THE SIGHT DEFLECTION COUNTER shows the computed value of Sight Deflection, *Ds*, in mils, with 500 mils as the zero value.

THE FUZE COUNTER shows the computed value of Fuze Setting Order, *F*, in seconds.

THE ADVANCE RANGE COUNTER shows the computed value of Advance Range, *R2*, in yards. There is no *R2* handcrank.

The handcranks in this group have two positions: IN and OUT, and each has a pin to hold it in either position.

THE SIGHT ANGLE HANDCRANK in its IN position is connected to the *Vs* shaft line and counter. When this knob is OUT, the *Vs* line is positioned by the Prediction Section of the Computer.

THE FUZE COUNTER

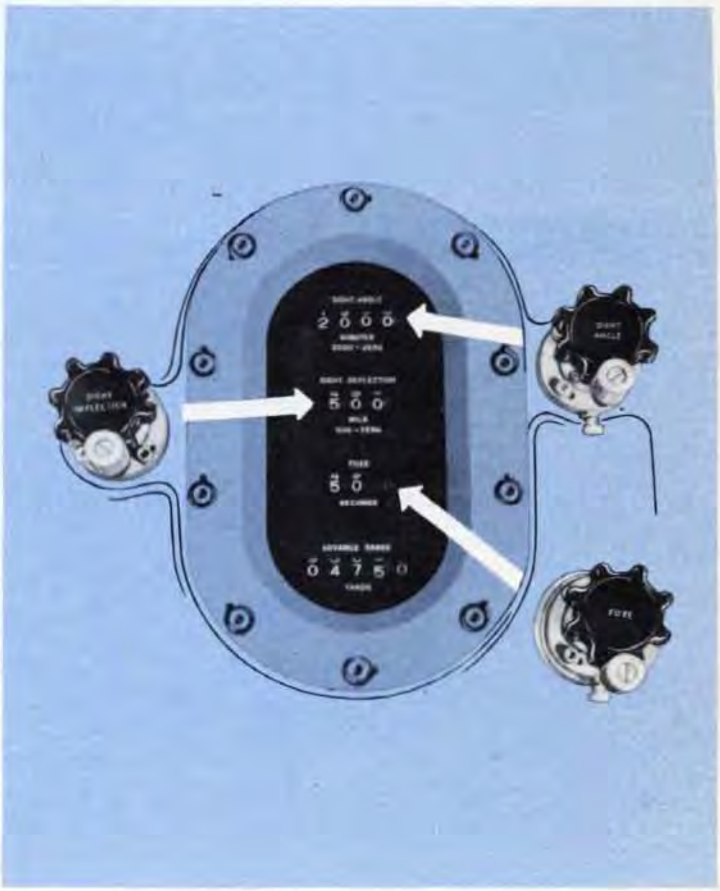
Read the white figures to obtain the number of whole seconds. Read the red figure and graduations to obtain the tenths of a second. Only the numbers 0 and 5 appear on the tenth-seconds drum. Hundredths of a second can be approximated by observing the relation of the tenth-seconds graduations to the fixed index. The counter reading above is 14.65 seconds.

THE SIGHT DEFLECTION HANDCRANK in its IN position is connected to the *Ds* shaft line and counter. When this knob is OUT, the *Ds* line is positioned by the Prediction Section of the Computer.

THE FUZE HANDCRANK in its IN position is connected to the *F* shaft line and counter. When this knob is OUT, the *F* line is positioned by the Prediction Section of the Computer.

If some of the power circuits should fail leaving the Sight Angle, Sight Deflection, and Fuze Transmitters energized, these transmitters can be set by hand through the handcranks to send values of *Vs*, *Ds* and *F* to the guns.

When no Star Shell Computer is supplied, the Fuze and Sight Angle Handcranks can be used in transmitting these values to the gun firing the star shells. The values to be used are obtained from a Star Shell Legend Plate.



THE TARGET COURSE INDICATOR

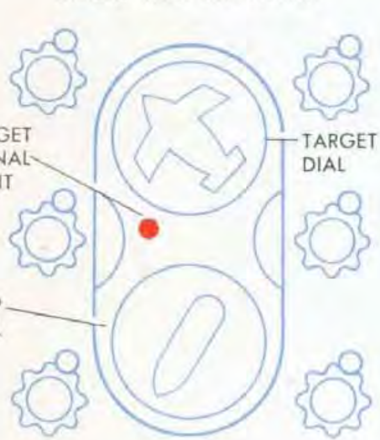
The Target Course Indicator is mounted on the Star Shell Computer. It has a Target Course Dial, an INCREASE Button, and a DECREASE Button.

THE TARGET COURSE DIAL shows Target Course, *Ct*, which is the horizontal angle between *North* and the bow of the Target, measured clockwise from *North*.

An index plate around the dial is graduated in degrees from 0°, which represents *North*, to 360°, with graduations every 2 degrees and numbers every 10 degrees. Zeros are omitted so that the figures can be read more easily.

The dial has an airplane engraved on it. The bow of the Target is read against the index plate.

The dial is positioned by synchro transmission from the *Ct* Transmitter in the Computer.



THE INCREASE AND DECREASE BUTTONS

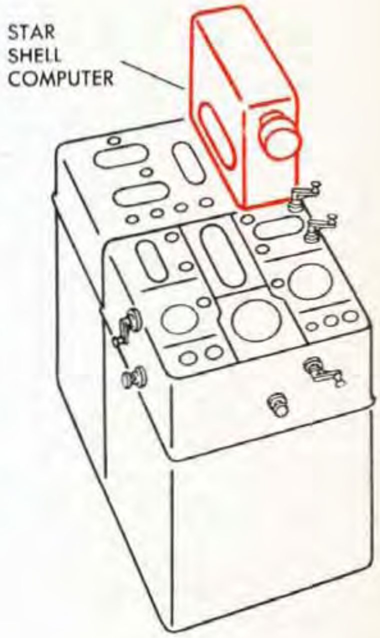
The *Ct* shaft line in the Computer may also be positioned manually by the push buttons on the Target Course Indicator. When the DECREASE Button is pressed, the value of *Ct* in the Computer decreases; when the INCREASE Button is pressed, the value of *Ct* in the Computer increases. The Target Course Indicator Dial shows the value of *Ct* in the Computer at all times. To make inputs at the Target Course Indicator, the Target Angle *and* Target Speed Handcranks must be positioned at AUTO.

THE TARGET SIGNAL LIGHT

On early modifications of the Computer Mark 1 there was a red signal light below the Target Dial. This signal light was ON only when a change in Target Angle was being put into the Computer through the Target Angle Repeater in the Director. This signal has been eliminated from later modifications of the Computer Mark 1.

THE STAR SHELL COMPUTER

The controls on the Star Shell Computer consist of the Star Shell Range Counter, the Star Shell Range Spot Dials and Knob, and the Star Shell Range Dials and Knob.

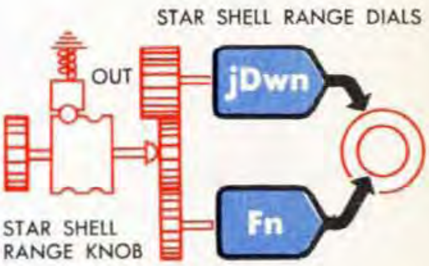


THE STAR SHELL RANGE COUNTER shows Star Shell Range, *R2n*. The reading of this counter, except as it may be modified by Star Shell Range Spot, *Rjn*, is 1000 yards higher than Advance Range, *R2*, which it receives from the Prediction Section of the Computer Mark 1. The 1000-yard offset, which is introduced at the time of adjustment, serves to cause star shells to burst beyond the Target.

THE STAR SHELL RANGE SPOT DIALS consist of an inner and an outer dial. The inner dial has an index on it and is positioned automatically by the Star Shell Spot Transmitter. The outer dial is graduated and numbered in hundreds of yards of Star Shell Range Spot, *Rjn*, from 1500 OUT to 1500 IN. The figures on the IN side are printed in red. This dial is positioned by the Star Shell Range Spot Knob.

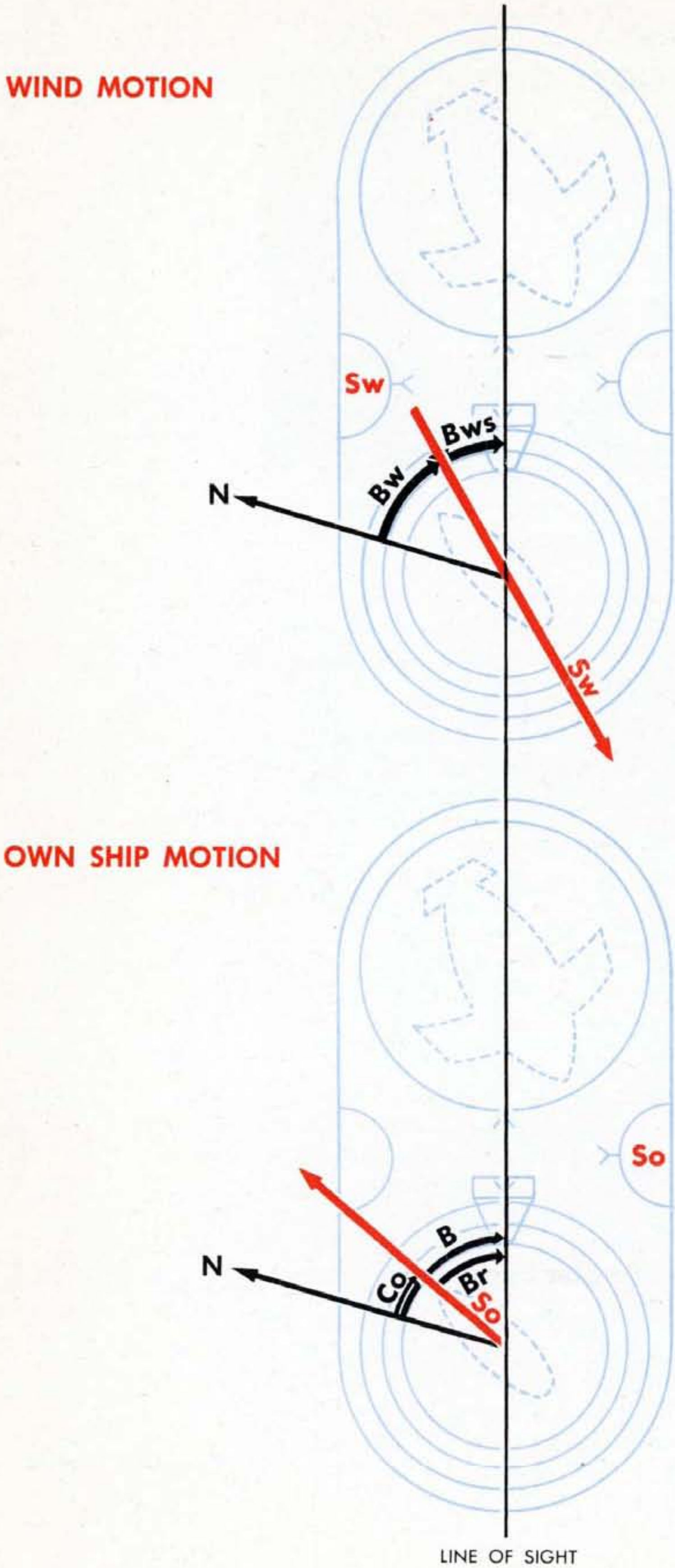
THE STAR SHELL RANGE SPOT KNOB sets Star Shell Range Spot, *Rjn*, into the outer Star Shell Range Spot Dial and the *Rjn* shaft line, when the outer *Rjn* Dial is matched to the inner *Rjn* Dial.

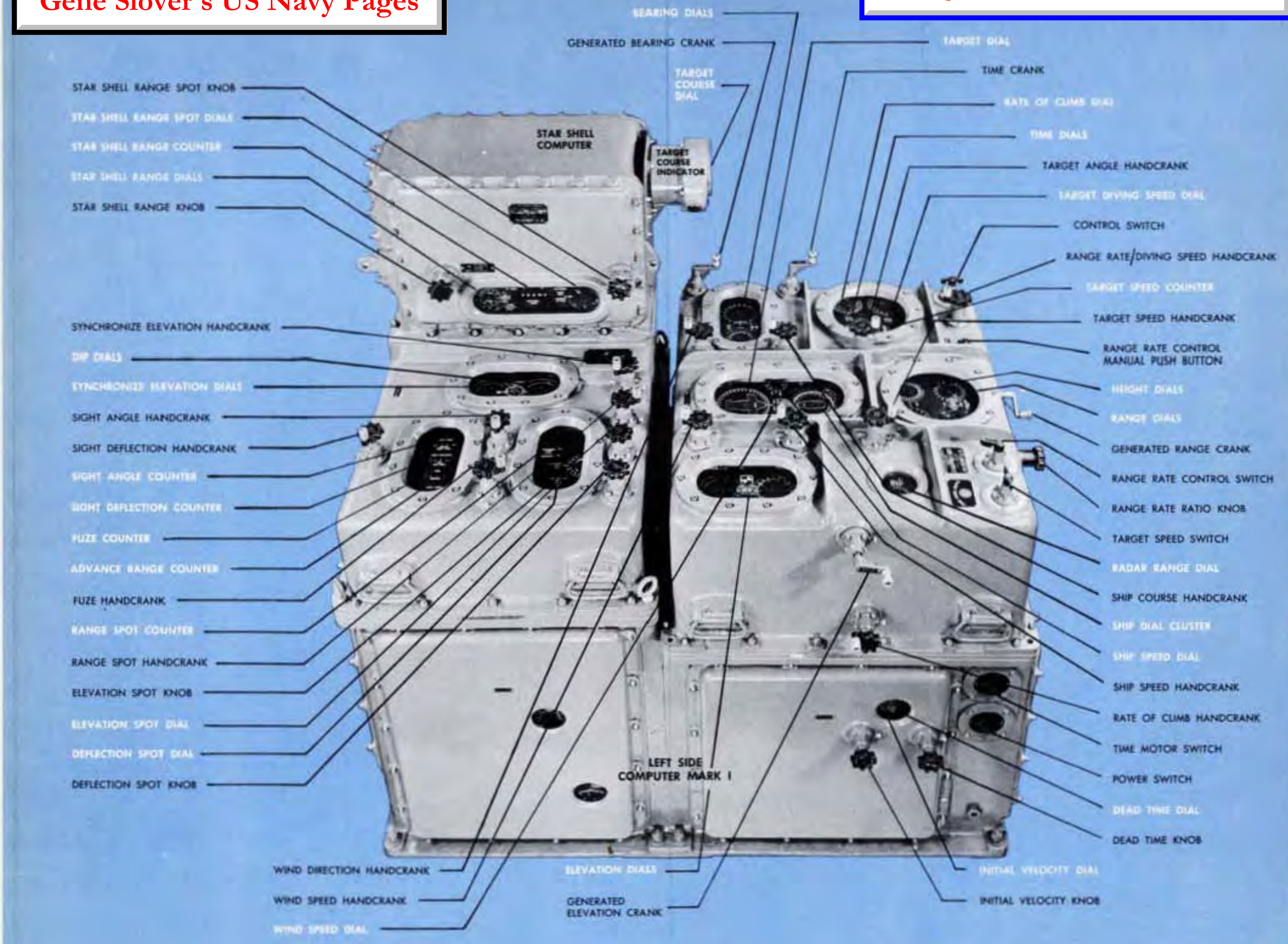
THE STAR SHELL RANGE DIALS consist of an inner and an outer dial. The inner Star Shell Range Dial is called the *Fn* Dial; the outer Star Shell Range Dial is called the *jDwn* Dial. Both dials have unevenly spaced graduations and are numbered in thousands of yards. These dials must be positioned by the Star Shell Range Knob so that the reading across their fixed index matches the reading on the Star Shell Range Counter.



THE STAR SHELL RANGE KNOB has two positions: IN and OUT, with a ball detent to hold it in either position. This knob is turned in its IN position to match the inner *Fn* Dial approximately to the Star Shell Range Counter reading. Then in its OUT position this knob is turned to move the outer *jDwn* Dial until the reading across the fixed index agrees exactly with the counter reading. In its IN position, the Star Shell Range Knob sets Star Shell Fuze Setting Order, *Fn*, into the Star Shell Computer. In its OUT position it sets in *jDwn*.

THE SHIP DIAL CLUSTER




BEARING DIALS
GENERATED BEARING CRANK
TARGET COURSE DIAL
TARGET DIAL
TIME CRANK
RATE OF CLIMB DIAL
TIME DIALS
TARGET ANGLE HANDCRANK
TARGET DIVING SPEED DIAL
CONTROL SWITCH
RANGE RATE/DIVING SPEED HANDCRANK
TARGET SPEED COUNTER
TARGET SPEED HANDCRANK
RANGE RATE CONTROL MANUAL PUSH BUTTON
HEIGHT DIALS
RANGE DIALS
GENERATED RANGE CRANK
RANGE RATE CONTROL SWITCH
RANGE RATE RATIO KNOB
TARGET SPEED SWITCH
RADAR RANGE DIAL
SHIP COURSE HANDCRANK
SHIP DIAL CLUSTER
SHIP SPEED DIAL
SHIP SPEED HANDCRANK
RATE OF CLIMB HANDCRANK
TIME MOTOR SWITCH
POWER SWITCH
DEAD TIME DIAL
DEAD TIME KNOB
INITIAL VELOCITY DIAL
INITIAL VELOCITY KNOB
STAR SHELL RANGE SPOT KNOB
STAR SHELL RANGE SPOT DIALS
STAR SHELL RANGE COUNTER
STAR SHELL RANGE DIALS
STAR SHELL RANGE KNOB
STAR SHELL COMPUTER
TARGET COURSE INDICATOR
SYNCHRONIZE ELEVATION HANDCRANK
DIP DIALS
SYNCHRONIZE ELEVATION DIALS
SIGHT ANGLE HANDCRANK
SIGHT DEFLECTION HANDCRANK
SIGHT ANGLE COUNTER
SIGHT DEFLECTION COUNTER
FUZE COUNTER
ADVANCE RANGE COUNTER
FUZE HANDCRANK
RANGE SPOT COUNTER
RANGE SPOT HANDCRANK
ELEVATION SPOT KNOB
ELEVATION SPOT DIAL
DEFLECTION SPOT DIAL
DEFLECTION SPOT KNOB
LEFT SIDE
COMPUTER MARK I
WIND DIRECTION HANDCRANK
WIND SPEED HANDCRANK
WIND SPEED DIAL
ELEVATION DIALS
GENERATED ELEVATION CRANK

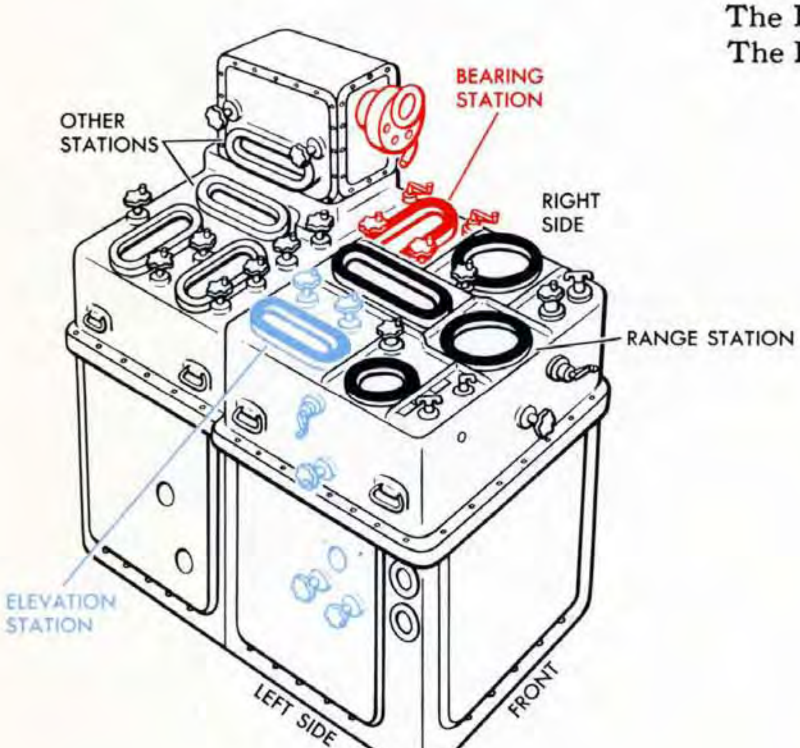
OPERATING INSTRUCTIONS

Operating Stations

The number of men operating the Computer Mark 1 and the duties assigned to each man are determined by ship's doctrine.

For convenience in describing operating procedures in this chapter, the principal controls of the Computer are divided among three operating stations:

The Range Station at the front
The Elevation Station at the left side
The Bearing Station at the right side



Each of these stations may be manned by one or more operators. If necessary one operator can man more than one station. For convenience it is assumed here that there is one operator at each of the three stations.

In the operating instructions that follow, the duties of the men at the three main stations are always given first. Additional duties are grouped under "Other Stations."

The Conditions of the Computer

The Computer controls must always be set in such a way that the Computer can be put into operation quickly. When no action is expected, the controls should be positioned to avoid needless wear of the Computer parts. The suggested settings for the Computer when it is not in use are grouped under the title, *Secured Condition of the Computer.*

When a search for a target begins, several changes may be made to these settings to prepare for action. When the type of target is not known, the Computer is put into the *Standby for Search* condition. When the type of target is known, the Computer may be put into *Standby for an Air Target* or *Standby for a Surface Target.*

When tracking a target, the Computer may be operated in several different ways. There are four basic types of operation: Automatic, Semi-automatic, Manual, and Local (without Director). In actual practice, features of two or more of these types are often combined.

The instructions which follow describe the steps required to change the Computer:

1 From *Secured* to *Standby for Search*

2 From *Standby for Search* to *Standby for an Air Target*

3 From *Standby for an Air Target* to each of the basic types of operation used for air targets. The basic types of operation for an air target are: Auto, Semi-auto, and Manual.

4 From *Standby for Search* to *Standby for a Surface Target.*

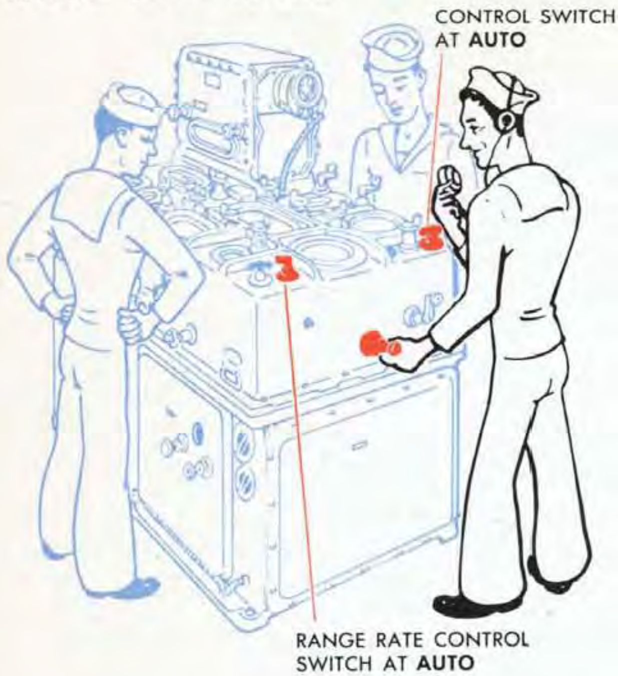
5 From *Standby for a Surface Target* to each of the basic types of operation used for surface targets. The basic types of operation for a surface target are: Manual and Local.

Operators who are familiar with these procedures will be able to change from any condition or type of operation to any other condition or type of operation

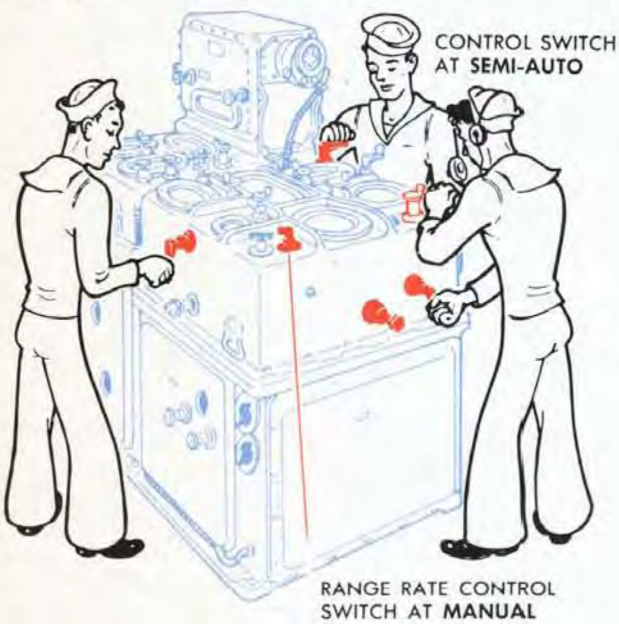
The Standby Conditions discussed on pages 116, 118, and 132, are a compromise between *speed* in shifting to full operation, and *prevention of wear.* There are other Standby setups which put greater emphasis on *speed* and less emphasis on *prevention of wear.* Samples of these faster setups are included on pages 146-147.

The FOUR TYPES of OPERATION

COMPUTER CREW WATCH DIALS



COMPUTER CREW TURN GENERATED RANGE, ELEVATION, AND BEARING CRANKS



NOTE:
Range can be rate-controlled semi-automatically while Elevation and Bearing are being rate-controlled automatically. Likewise, Range can be rate-controlled automatically while Elevation and Bearing are being rate-controlled semi-automatically.

In Automatic and Semi-automatic Operation, the Rate Control Group computes corrected values of *Sh, dH*, and *A*.

AUTOMATIC OPERATION

In Automatic Operation the Rate Control Group computes the corrected values of *Sh, dH*, and *A*, on signal from the Director. When the Pointer and Trainer press their signal keys as they turn their handwheels, Elevation and Bearing Rate Control Corrections automatically feed into the Rate Control Group. When the Range Operator presses his Range Signal Button as he turns his Range Knob, Range Rate Control Corrections enter the Rate Control Group. The amount of Range Rate Control Correction is controlled manually by the Range Rate Ratio Knob at the Computer. A solution is reached when the Elevation and Bearing Solution Indicators cease turning.

Switch Positions:

Control Switch at AUTO
Range Rate Control Switch at AUTO

SEMI-AUTOMATIC OPERATION

In Semi-automatic Operation the Rate Control Group computes the corrected values of *Sh, dH*, and *A*, using Rate Control Corrections put in by hand by the Computer Crew. The Computer Crew makes rate corrections by turning the Generated Range, Generated Elevation, and Generated Bearing Cranks. These cranks are turned in their IN positions when the signals from the Director show that Observed Range, Observed Elevation, and Observed Bearing are correct. A solution is reached when sufficient corrections have been put in to keep the Generated Range, Generated Elevation, and Generated Bearing Dials rotating in the same directions and at the same rates as the Observed Range, Observed Elevation, and Observed Bearing Dials.

Switch Positions:

Control Switch at SEMI-AUTO
Range Rate Control Switch at MANUAL

In Manual and Local Operation, the Rate Control Group is not used. Instead, the operators correct *Sh*, *dH*, and *A* directly by means of the *Sh*, *dH*, and *A* Handcranks.

MANUAL OPERATION

In Manual Operation the Computer Crew makes rate corrections through the *Sh*, *dH*, and *A* Handcranks. A solution is reached when sufficient corrections have been made to the Target Motion values to keep the Generated Range, Generated Elevation, and Generated Bearing Dials rotating in the same directions and at the same rates as the Observed Range, Observed Elevation, and Observed Bearing Dials.

Switch Positions:

Control Switch at SEMI-AUTO
Range Rate Control Switch at MANUAL

LOCAL OPERATION

Local Operation is a type of operation used when Target Position is not being completely determined by the Gun Director Mark 37. Observed Range, *R*, Relative Target Bearing, *Br*, Target Angle, *A*, and Target Speed, *Sh*, are observed from some aloft station and continually phoned to the plotting room. The Computer Crew puts the values of these quantities into the Computer by hand at the Generated Range, Generated Bearing, Target Angle, and Target Speed Handcranks. The crew then corrects the values of *Sh* and *A* through the Target Speed and Target Angle Handcranks. The solution of the problem is reached when the readings on the Range and Bearing Dials stay in agreement with the phoned values.

Switch Positions:

Control Switch at LOCAL
Range Rate Control Switch at MANUAL

SECURED CONDITION

Securing the COMPUTER MARK 1

At the Range Station:
1 Turn the Time Motor Switch OFF.

At the Other Stations:
1 Set Level at a selected value of 2000 minutes at the Stable Element.
2 Disconnect Cross-level and set it at a selected value of 2000 minutes. On some ships this is done at the Selector Drive; on other ships it is done at the Stable Element.

Setting the handcranks and dials in Secured Condition

All handcranks, switches, and dials should be set at definite positions whenever the Computer is secured. Knowing the settings makes it possible to go into operation fast. If the same settings are used consistently, any changes from them can be recognized as evidence of tampering.

The settings used may vary according to ship's doctrine. The following settings are suggested:

At the Range Station:
1 Turn the Control Switch to LOCAL.
2 Put the Range Rate Diving Speed Handcrank to AUTO.
3 Turn the Range Rate Control Switch to MANUAL.
4 Turn the Target Speed Switch to NORMAL.
5 With the Target Speed Handcrank at HAND, set *Sh* at zero. Leave the handcrank at HAND.
6 Set the Range Rate Ratio Knob at 1.
7 With the Generated Range Crank OUT, set the Range Dials at 30,000 yards. Leave the crank OUT.

At the Elevation Station:
1 With the Rate of Climb Handcrank IN, set *dH* at zero. Leave the handcrank IN.
2 Set the Generated Elevation Crank at the OUT position.
3 With the Ship Speed Handcrank IN, set *So* at zero. Leave the handcrank IN.
4 With the Wind Speed Handcrank, set *Sw* at zero.
5 With the Synchronize Elevation Handcrank at CENTER, set *E* at zero. Leave the handcrank at CENTER.
6 Pull the Initial Velocity Knob OUT and set *I.V.* at 2600 f.s.
7 Pull the Dead Time Knob OUT and set *Tg* at the established value.

The Initial Velocity and Dead Time Knobs return to their IN positions when released.

At the Bearing Station:

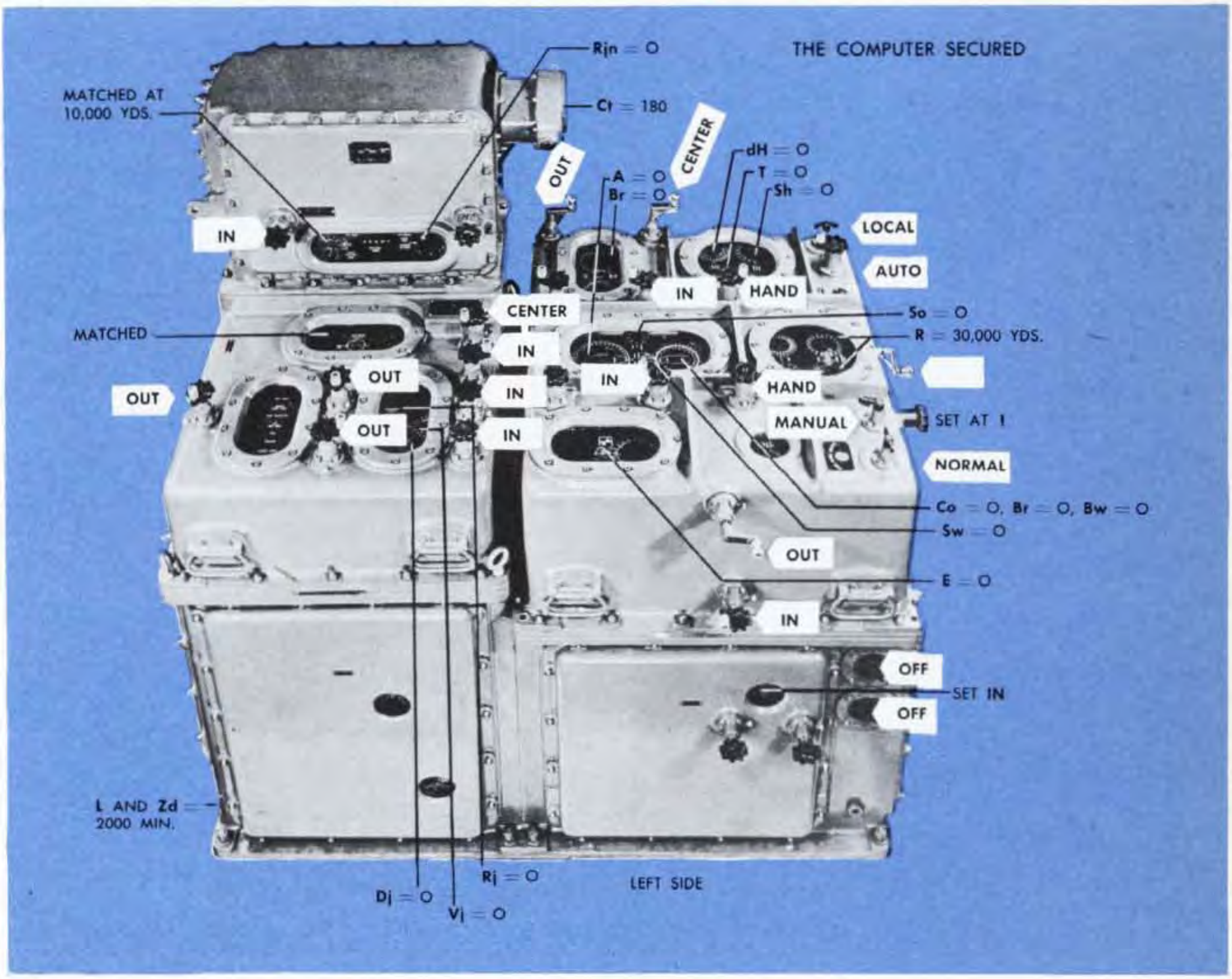
1 With the Ship Course Handcrank IN, set *Co* at zero. Leave the handcrank IN.
2 With the Wind Direction Handcrank, set *Bw* at zero.
3 With the Generated Bearing Crank OUT, set *Br* at zero. Leave the crank OUT.
4 With the Target Angle Handcrank at HAND, set *A* a zero. Leave the handcrank at HAND.
5 Push the Time Crank IN and zero the Time Dials. When the crank is released it returns to the CENTER position.

At the Other Stations:

1 With the Range Spot Handcrank and the Elevation and Deflection Spot Knobs IN, set *Rj*, *Vj*, and *Dj* at zero.
2 Leave the Sight Angle, Sight Deflection and Fuze Handcranks OUT.
3 With the Star Shell Range Spot Knob, set *Rjn* at zero.
4 With the Star Shell Range Knob IN, set the inner dial at 10,000 yards. Pull the knob OUT and set the outer dial at 10,000 yards. Push the knob IN.

After all settings are made:

1 Turn the Power Switch OFF.
2 Turn the Computer Power Supply Switch OFF at the Switchboard.



STANDBY CONDITION

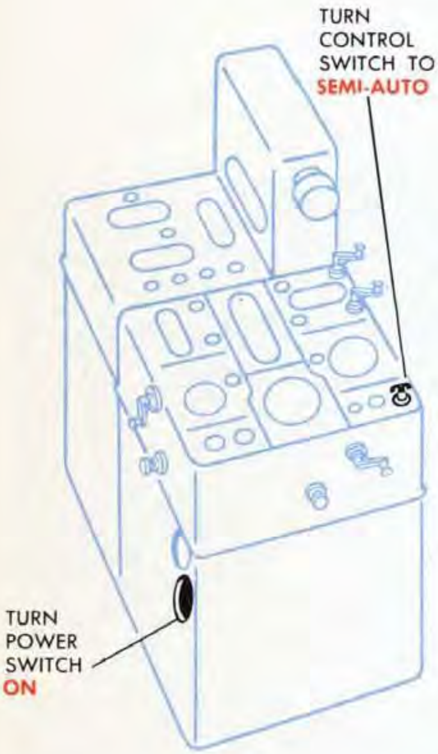
There are several Standby Conditions for the Gun Director Mark 37 System. These Standby Conditions and their names are determined by ship's doctrine. The Computer will be in one of the three following Standby Conditions, depending upon the System Standby Condition ordered.

Initial standby

Initial Standby is used only when there is little possibility of action.
The Computer is in *Secured* Condition.
Only the Stable Element gyro is energized.
The Computer circuits and all other circuits are de-energized.
This condition keeps wear of the Computer at a minimum.

Standby for search

The Stable Element gyro and follow-ups are energized.
Level and Cross-level are set at selected values.
The Computer power circuit is energized.
The synchro circuits are not energized.
The *Standby for Search* Condition keeps the system in instant readiness to begin searching without causing needless wear of the Computer parts.



Standby during search

All circuits in the Stable Element and Computer are energized except the Director Elevation Transmission circuit to the *Eb* Receiver.
Level and Cross-level are set at selected values.

Changing from secured to standby for search and standby during search

At the Range Station:

1 Turn the Power Switch ON.
2 Turn the Control Switch to SEMI-AUTO.
3 Pull the Ship Course Handcrank OUT.
4 Set in ordered value of *I.V.*

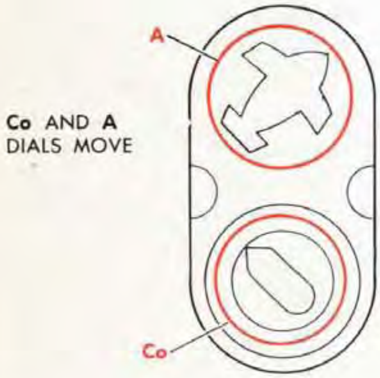
The other Computer settings remain the same as for *Secured* Condition.

The Computer Dials During Search

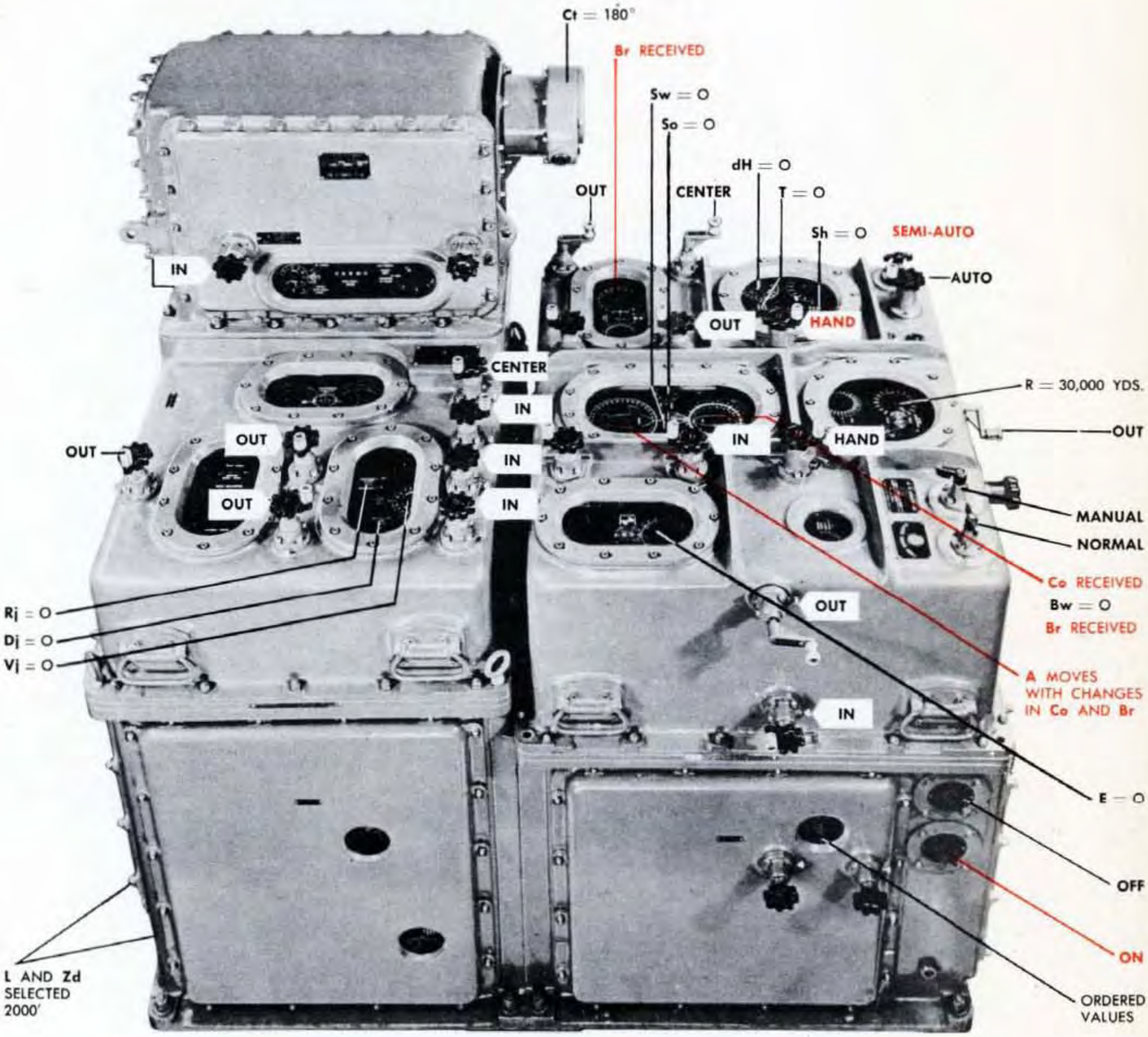
With the Power Switch ON, and the Switchboard positioned so that the Computer is in *Standby during Search*, the following dials move:

1 The Compass Ring Dial shows Ship Course, *Co*. This value is received from the Gyro Compass because the Ship Course Handcrank is OUT.
2 The Ship Dial turns and Relative Target Bearing, *Br*, changes as the Director trains in search of the target.
3 The Target Dial turns as Own Ship changes course and as Relative Target Bearing changes.

As soon as the type of target is known, additional settings may be made.



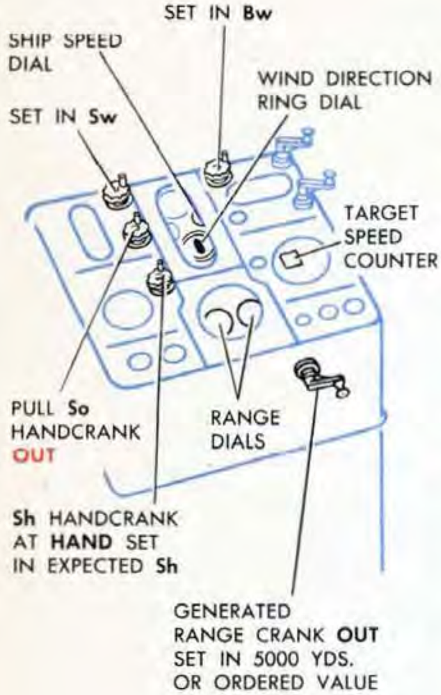
THE COMPUTER IN STANDBY DURING SEARCH



CHANGES FROM SECURED SHOWN IN RED

STANDBY FOR AN AIR TARGET

Changing from standby during search to standby for air target



At the Range Station:

1 With the Generated Range Crank OUT, match the "Y" indexes on the ring dials to the pointers on the inner dials. Set the ring dials at 5000 yards until an accurate range can be determined. Leave the crank OUT.

2 With the Target Speed Handcrank at HAND, set the estimated Target Speed into the Target Speed Counter. Leave the Handcrank at HAND.

At the Elevation Station:

1 With the Ship Speed Handcrank IN, set in the approximate *So;* then pull the handcrank OUT.

2 With the Wind Speed Handcrank, set in Wind Speed, *Sw*.

At the Bearing Station:

1 With the Wind Direction Handcrank, set in Wind Direction, *Bw*.

At the Other Stations:

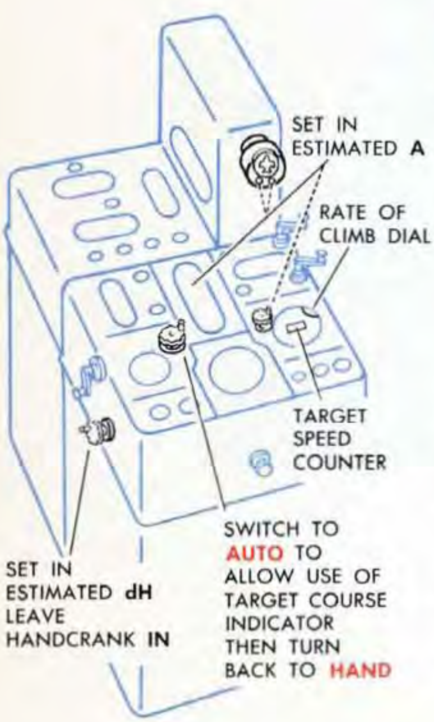
1 Put the Stable Element at Continuous Aim.

2 Connect, synchronize, and lock the Selector Drive.

3 Make sure that all the switches connecting the Director, the Computer, the Stable Element, and the guns are ON at the Fire Control Switchboard.

4 Pull Spot Knobs OUT, noting that correct values of *Rj*, *Vj*, and *Dj* are indicated.

Setting in estimates of A, Sh, and dH



At the Range Station:

1 With the Target Angle Handcrank at HAND, set the estimated value of Target Angle, *A*, into the Target Dial. Leave the handcrank at HAND.

OR

Switch the Target Speed and Target Angle Handcrank to AUTO. At the Target Course Indicator press the INCREASE or DECREASE push-button until the estimated *A* is read on the Target Angle Dial. Return the handcranks to HAND position.

2 With the Target Speed Handcrank at HAND, set the estimated *Sh* into the Target Speed Counter.

3 With the Rate of Climb Handcrank in the IN position, set the estimated *dH* into the Rate of Climb Dial. Leave the handcrank IN.

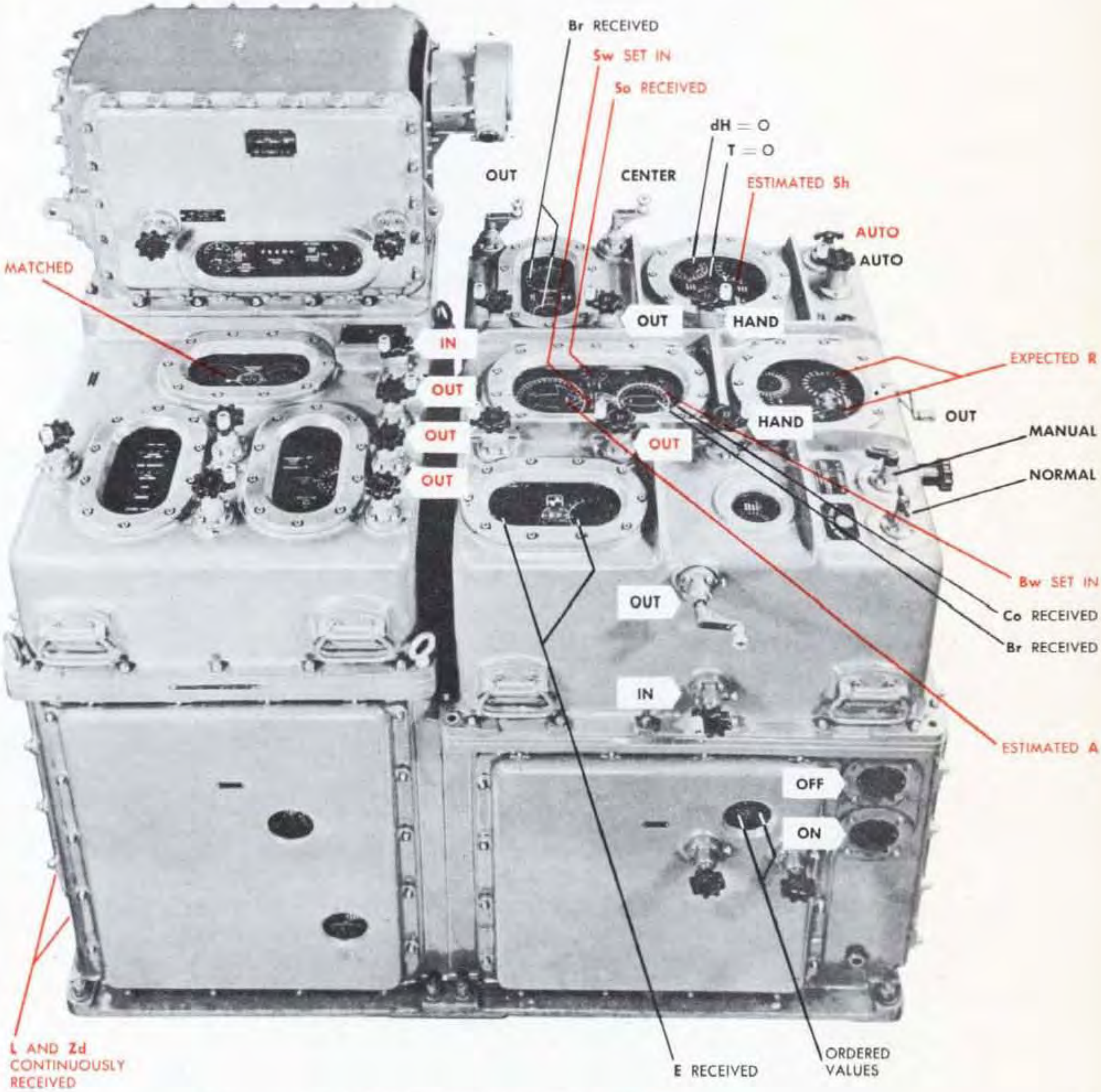
4 Turn the Control Switch to AUTO.

At the Elevation Station:

1 When the Director Sights are on the Target, push the Synchronize Elevation Handcrank IN and match the Synchronize Elevation Dials at the index.

2 See that Dead Time, *Tg*, and Initial Velocity, *I.V.*, are set at their ordered values.

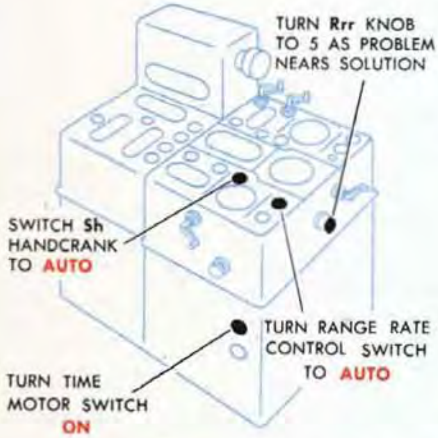
THE COMPUTER IN STANDBY FOR AN AIR TARGET

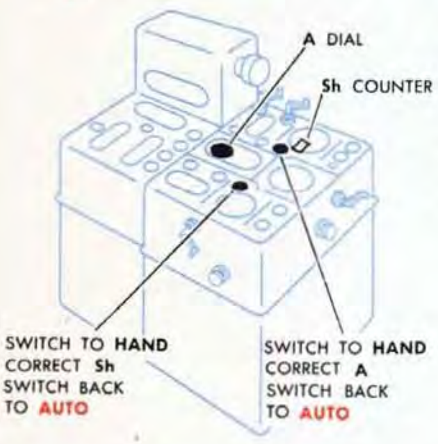


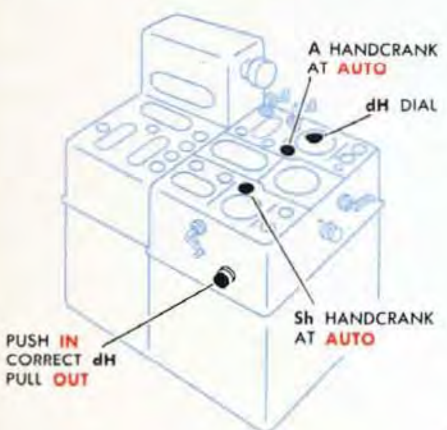
CHANGES FROM STANDBY SHOWN IN RED

When the Director Sights are positioned on the Target, the Pointer, Trainer and Range Finder Operator in the Director indicate they are ready to start tracking by closing their signal keys. When the signal keys are closed, the Range Finder Signal on the Computer turns to white, and the Pointer's and Trainer's Signals turn to red.

NOTE:
Range Rate should be controlled in AUTO only when the Range input from the Director is smooth and accurate. Even when receiving Radar Range it is advisable to rate-control manually until the ranges smooth out. With optical ranging, Automatic Rate Control should not be used unless at least 40 accurate ranges per minute are received.







AUTOMATIC OPERATION

Changing from standby for an air target to automatic operation

At the Range Station:

1. Turn the Range Rate Control Switch to AUTO.
2. Turn the Time Motor Switch ON.
3. Shift the Target Speed and Target Angle Handcranks to AUTO.

At the Elevation Station:

1. Pull the Rate of Climb Handcrank OUT.

Tracking in automatic operation

At the Range Station:

1. Turn the Range Rate Ratio Knob toward 5 as the problem nears solution. When the rate corrections become small, the Generated Range Dials will oscillate if the Range Rate Ratio Knob is positioned at too low a figure.

Making target corrections during automatic operation

If a large correction to a Target value is needed, it is always advisable to assist the Rate Control Mechanism by quickly setting in the new value by hand.

At the Range Station:

1. When ordered, correct Target Speed with the lever on the handcrank at HAND. Switch the lever back to AUTO as soon as the correction has been made.

   OR

   Leave the Target Speed and Target Angle Handcranks at AUTO. Correct Target Speed by holding the Target Speed Switch at either INCREASE or DIVE ATTACK until the new value is read on the Target Speed Counter.
2. When ordered, correct Target Angle with the lever on the handcrank at HAND. Switch the lever back to AUTO as soon as the correction has been made.

   OR

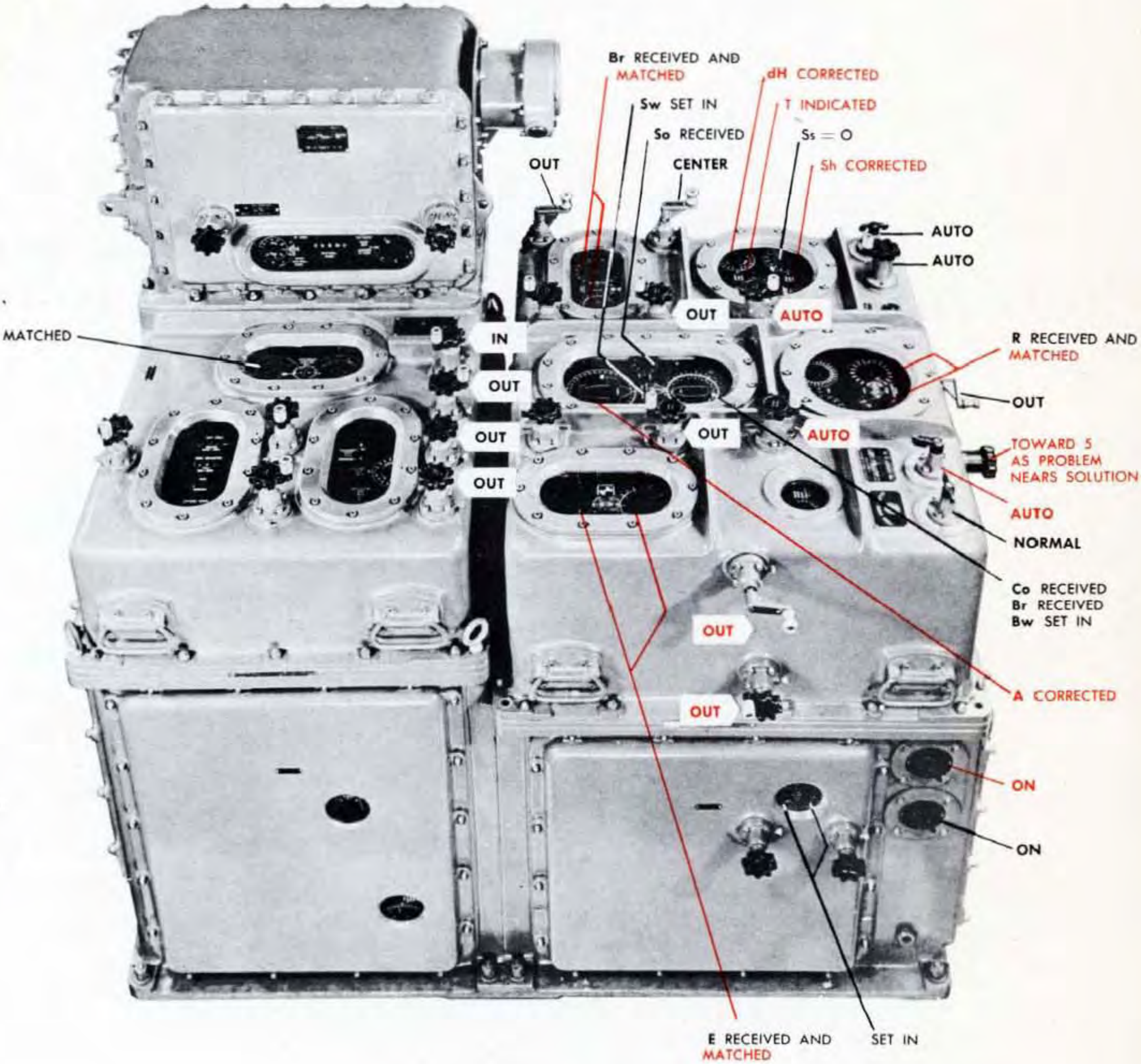
   Leave the Target Angle and Target Speed Handcranks at AUTO. Correct Target Angle by pressing one of the push buttons on the Target Course Indicator until the new value is read on the *A* Dial.

At the Elevation Station:

1. When ordered, make corrections to Rate of Climb with the *dH* Handcrank IN. Pull the handcrank OUT as soon as the correction has been made.

The Computer Crew now watches the Ship, Target, and Generated Dials, and stands ready either to make hand corrections, to change the method of operation, or to cease tracking.

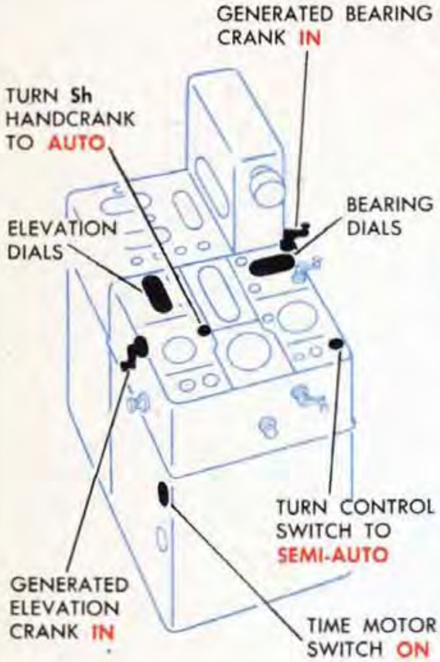
THE COMPUTER IN AUTOMATIC OPERATION



CHANGES FROM STANDBY FOR AN AIR TARGET SHOWN IN RED.

SEMI-AUTOMATIC OPERATION

Changing from standby for an air target to semi-automatic operation



At the Range Station:

1 Turn the Control Switch to SEMI-AUTO.

2 Turn the Time Motor Switch ON.

3 Shift the lever on the Target Speed Handcrank to AUTO.

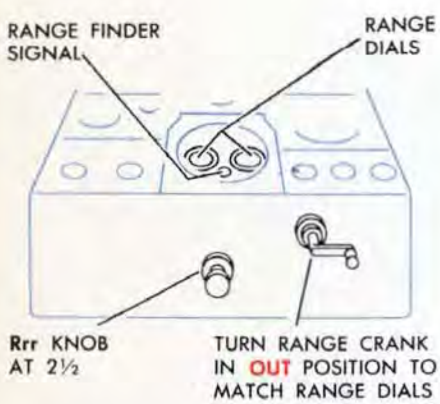
At the Elevation Station:

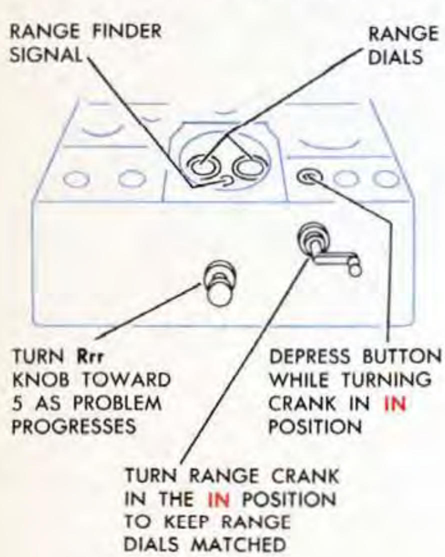
1 Put the Generated Elevation Crank IN.

At the Bearing Station:

1 Put the Generated Bearing Crank IN.

Rate control in semi-automatic operation





In Semi-automatic Operation, rate-controlling should be done at all stations at the same time.

At the Range Station:

1 Match the Range Dials.

To do this, put the Generated Range Crank in its IN position. When the Range Finder Signal shows white, pull the crank OUT against spring pressure and turn it until the indexes on the Generated Range Dials match the indexes on the Observed Range Dials. The dials may also be matched with the crank in its IN position. When the crank is turned in its IN position, the amount of dial change for a given crank rotation depends on the position of the Range Rate Ratio Knob. With this knob at 1, a large crank movement makes a small dial change. With the knob at 5, the same crank movement causes a much greater dial change. A good Range Rate Ratio Knob setting for beginners is 2½. Experienced operators will sense the proper setting.

2 Keep the Generated Range Dials rotating at such a rate and in such a direction that they match the Observed Range Dials whenever the Range Finder Signal is white.

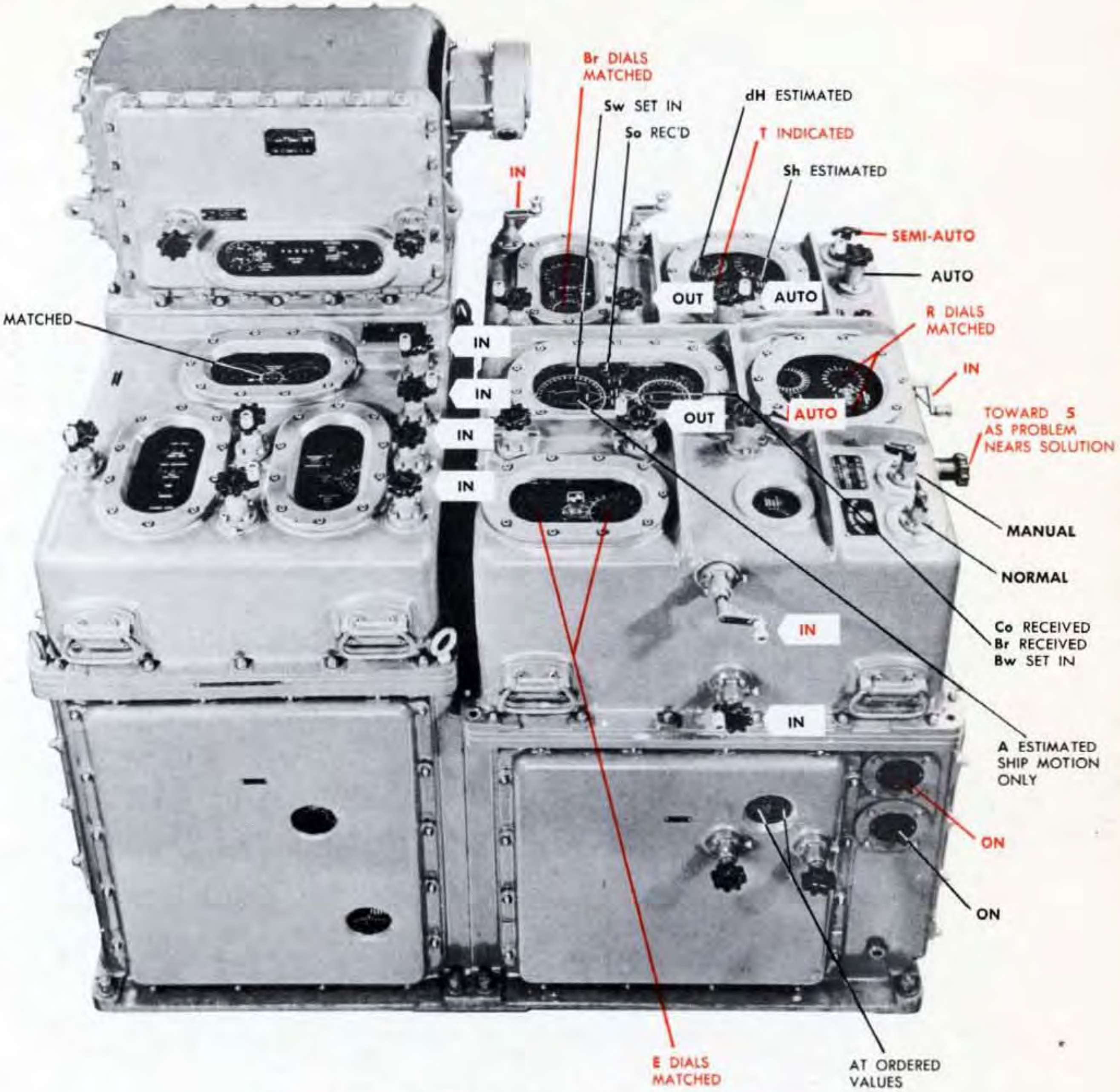
To do this, depress the Range Rate Control Manual Push-button and turn the Generated Range Crank in its IN position while the Range Finder Signal is white. Turn the crank until the dials match. Turning the crank in its IN position with the push-button depressed puts Range *Rate* Corrections into the Rate Control Mechanism.

The ratio of the *Rate* Corrections to the *Linear* Corrections is determined by the position of the Range Rate Ratio Knob.

If there is a great difference in rate of rotation between the Generated and Observed Range Dials, it is advisable to over-correct. To over-correct, depress the Range Rate Control Manual Push-button and turn the Generated Range Crank in its IN position until the index on the fine outer dial passes the index on the fine inner dial. Then release the push-button and turn the crank back to match the indexes on the dials.

THE COMPUTER IN SEMI-AUTOMATIC OPERATION

SETTINGS AT THE MOMENT THAT THE TIME MOTOR IS TURNED ON

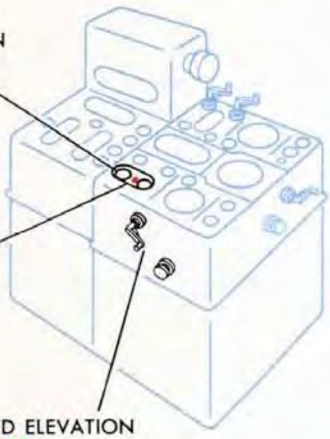


CHANGES FROM STANDBY FOR AN AIR TARGET SHOWN IN RED

The Range Rate Ratio Knob should be at the 1 position at the beginning of a problem or whenever large rate corrections are required. This knob should be turned to its next higher-numbered position whenever there is any oscillation of the Target Speed, *Sh*, Counter. As the problem progresses and the rate of rotation of the Generated Dials nears the rate of rotation of the Observed Dials, turn the Range Rate Ratio Knob toward its 5 position.

When the Generated Dials match the Observed Dials each time the Range Signal turns white, Generated Range and Range Rate are correct.

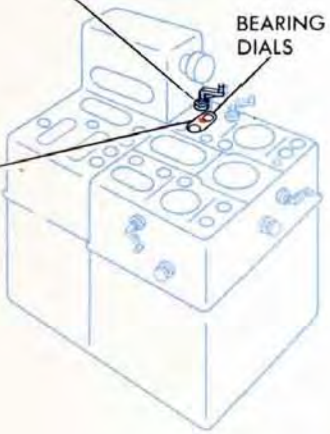
Rate-controlling at the elevation and bearing stations



At the Elevation Station:

1 With the Generated Elevation Crank in the IN position, turn it until the Generated Elevation Dial rotates with the fine Observed Elevation Dial. Over-correcting Elevation will cause false values of Rate of Climb and Range Rate to be computed.

When the Generated Elevation Dial and the fine Observed Elevation Dial rotate together, the Elevation Rate is correct.



At the Bearing Station:

1 With the Generated Bearing Crank in the IN position turn it until the Generated Bearing Dial rotates with the fine Observed Bearing Dial.

When the Generated Bearing Dial and the fine Observed Bearing Dial rotate together, the Bearing Rate is correct.

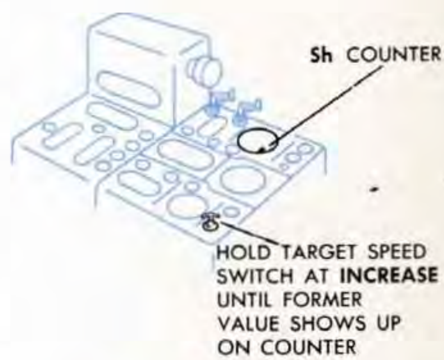
NOTE:
The speed with which rate corrections can be made will be determined by the skill of the operators. With experience the operators can judge the amount of crank rotation needed for any correction and make the whole correction quickly.

TARGET ANGLE

In Automatic or Semi-automatic Operation, a large fast change in Target Angle may cause the Rate Control Mechanism to compute a solution based on an incorrect Target Angle. Whenever this occurs, the reading on the Target Speed Counter drops rapidly to below 80 knots and all the dials showing generated values slow down. In Semi-automatic Operation, the Generated Bearing Dials rotate in the opposite direction to the Observed Bearing Dials. Finally the Target Angle Dial starts to vibrate.

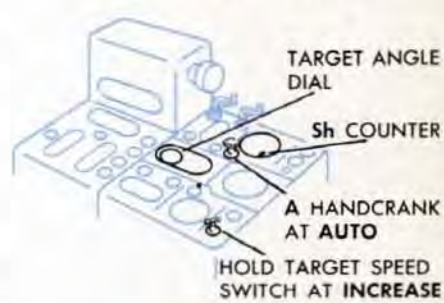
To avoid a false solution, watch the Target Speed Counter. As soon as the reading on this counter drops below 80 knots:

1 Hold the Target Speed Switch at INCREASE until the former value of Target Speed shows up on the counter. Let the switch spring back to NORMAL. The Computer will then compute the correct Target Angle.



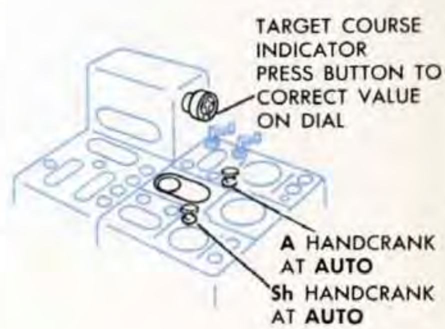
OR

2 When the report of a large change of Target Angle is received, switch the Target Angle Handcrank to HAND and make the correction to Target Angle while holding the Target Speed Switch at INCREASE. Hold the switch at INCREASE until the former value of Target Speed shows up on the counter. Switch the Target Angle Handcrank back to AUTO.



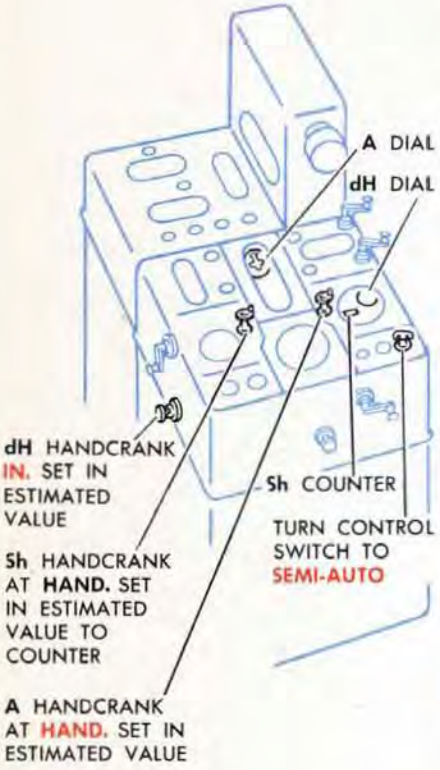
OR

3 When a report of a large change of Target Course is received, leave the Target Angle Handcrank at AUTO. Press one of the buttons on the Target Course Indicator. It is not necessary to hold the Target Speed Switch at INCREASE, but a quicker solution will be obtained if this is done.



If the Target Angle Dial is vibrating, the Target Speed Switch must be held at INCREASE while the Target Angle is being corrected at the Target Course Indicator or after Target Angle is corrected by the Target Angle Handcrank.

MANUAL OPERATION against an Air Target



Changing from standby for an air target to manual operation against an air target

At the Range Station:

1 Turn the Control Switch to SEMI-AUTO.
2 With the Target Speed Handcrank at HAND, set the estimated Target Speed.

At the Elevation Station:

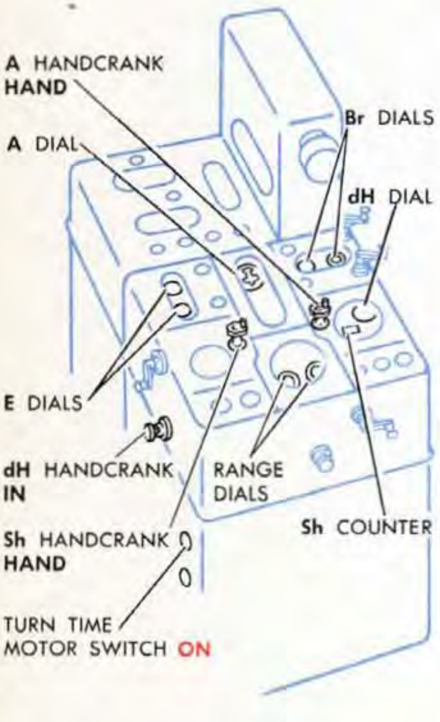
1 With the Rate of Climb Handcrank IN, set the estimated value for *dH* into the Rate of Climb Dial. Leave the handcrank IN.

At the Bearing Station:

1 With the Target Angle Handcrank at HAND, set the estimated Target Angle on the Target Dial. Leave the handcrank at HAND.

Manual control of rates against an air target

In Manual Operation for an air target, the Rate Control Mechanism is not used. Control of rates is handled from the Range and Elevation Stations. The Target Speed, Target Angle, and Rate of Climb Handcranks are used to correct the speed and direction of rotation of the Generated Dials.



At the Range Station:

1 Turn the Time Motor Switch ON.
2 With the Target Angle and Target Speed Handcranks at HAND, make corrections to these values until the Generated Range, Generated Elevation, and Generated Bearing Dials rotate at the same rates and in the same directions as the Observed Range, Observed Elevation, and Observed Bearing Dials.

At the Elevation Station:

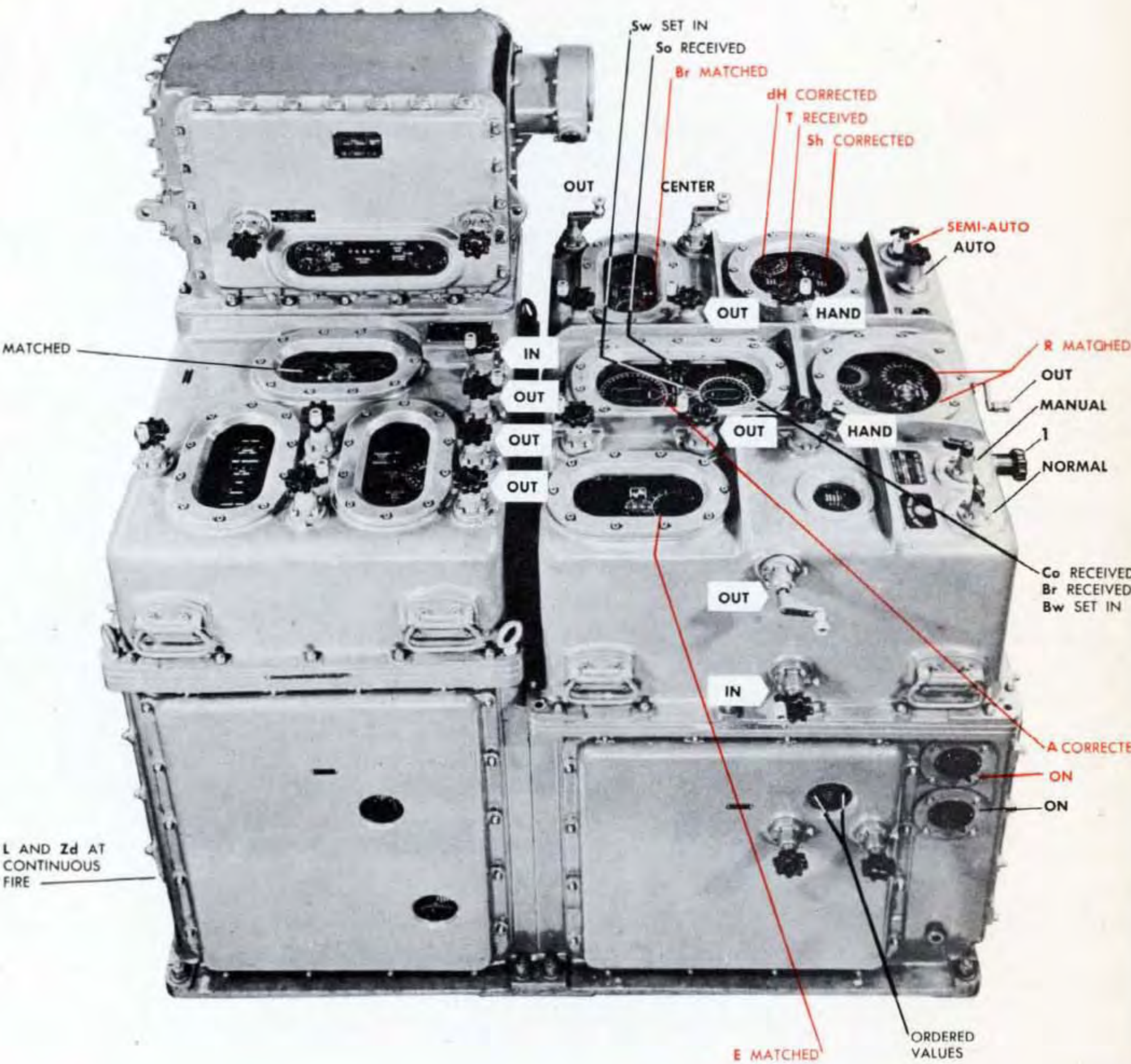
1 With the Rate of Climb Handcrank IN, make corrections to *dH* until the Generated Range and Generated Elevation Dials rotate at the same rates and in the same directions as the Observed Range and Observed Elevation Dials. Corrections to Rate of Climb have little effect on the Bearing Dials.

At the Bearing Station:

1 Stand by for instructions.

Target Elevation, *E*, and Target Angle, *A*, are used to determine which one of the three target values (*Sh*, *A*, or *dH*) to correct.

THE COMPUTER IN MANUAL OPERATION AGAINST AN AIR TARGET



CHANGES FROM STANDBY FOR AN AIR TARGET SHOWN IN RED

CONTROLLING THE GENERATED DIALS IN MANUAL OPERATION

In general, Manual Control of rates against fast-moving air targets is difficult. Knowledge of the fire control problem and practice in Computer operation are necessary because any correction to *Sh, dH* or *A*, usually affects more than one of the generated quantities.

While practicing, skill can be acquired by correcting each generated dial in turn, starting with the one showing the most error. In operation, a skilled operator can often correct two or more of the generated quantities at once.

The information which follows describes the correction of each generated quantity separately, by showing the changes in *Sh, dH* or *A* that will have the *greatest* effect on that quantity.

The effect of a change in *Sh, dH* or *A* on the generated dials depends on two things:

1. Target Elevation, *E*, the vertical angle between the Horizontal and the Line of Sight.
2. Target Angle, *A*, the horizontal angle between the direction in which the Target is moving and the Line of Sight.

The Target Elevation Dial is divided by an imaginary line into two sections: one section containing values from zero to 45°, and the other section containing values from 45° to 90 degrees.

On the window of the Target Angle Dial, an imaginary line representing the Line of Sight is extended across the dial through the fixed index. Another imaginary line known as the Cross Line is drawn at right angles to the Line of Sight through the center of the Target.

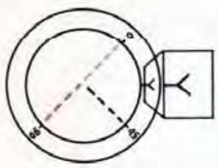
The Target is said to be toward the Line of Sight when the bow of the Target is nearer the Line of Sight.

The Target is said to be toward the Cross Line when the bow of the Target is nearer the Cross Line.

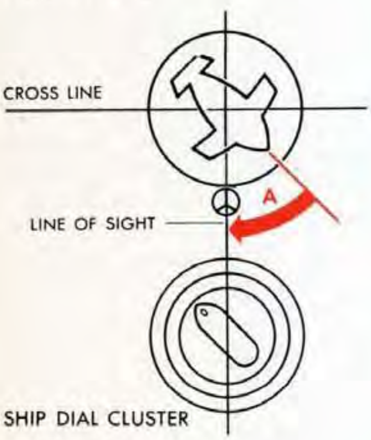
The position of the Target on the Target Dial in relation to the Line of Sight and the Cross Line, together with the value of Target Elevation, determines which Target value has to be changed to control the generated dials in Manual Operation.

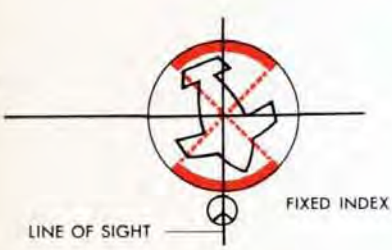
A generated dial may be turning in the same direction as the corresponding observed dial, but at a faster or slower speed, or it may be turning in the opposite direction to the observed dial. The instructions which follow give the correction for each of these conditions.

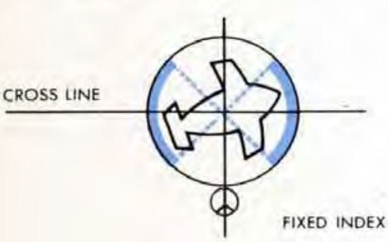
ELEVATION DIAL



TARGET DIAL







Controlling the generated range dials

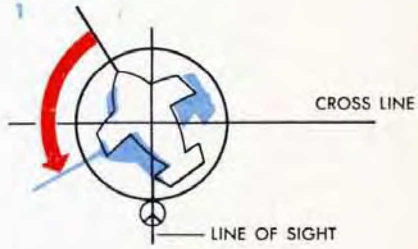
When target elevation is below 45° and the target is toward the line of sight

To increase the speed of the Generated Range Dials, increase *Sh*.

To decrease the speed of the Generated Range Dials, decrease *Sh*.

1 To reverse the direction of rotation of the Generated Range Dials, change *A* until the Target is on the other side of the Cross Line.

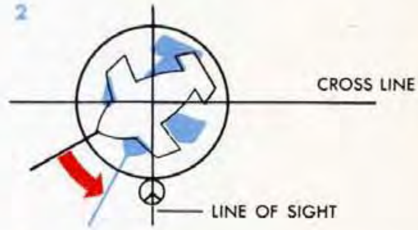
1



When target elevation is below 45° and the target is toward the cross line

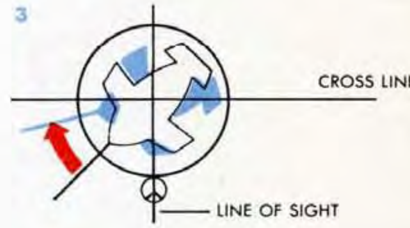
2 To increase the speed of the Generated Range Dials, move the Target away from the Cross Line.

2



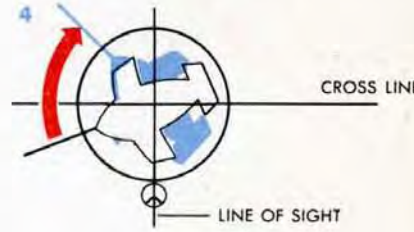
3 To decrease the speed of the Generated Range Dials, move the Target closer to the Cross Line.

3



4 To reverse the direction of rotation of the Generated Range Dials, change *A* until the Target is on the other side of the Cross Line.

4



When target elevation is above 45°

To increase the speed of the Generated Range Dials, increase the numerical value of *dH*.

To decrease the speed of the Generated Range Dials, decrease the numerical value of *dH*.

To reverse the direction of rotation of the Generated Range Dials, change *dH* from a positive to a negative, or a negative to a positive value.

Controlling the generated elevation dial in manual operation

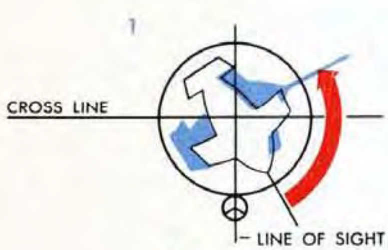
When target elevation is below 45°

To increase the speed of the Generated Elevation Dial, increase the numerical value of *dH*.

To decrease the speed of the Generated Elevation Dial, decrease the numerical value of *dH*.

To reverse the direction of rotation of the Generated Elevation Dial, change *dH* from a positive to a negative, or a negative to a positive value.

When target elevation is above 45° and the target is toward the line of sight

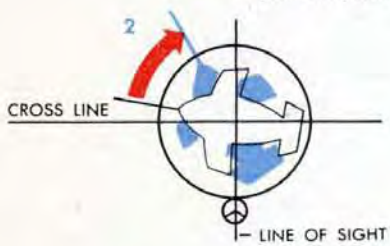


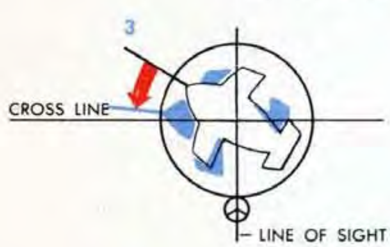
To increase the speed of the Generated Elevation Dial, increase *Sh*.

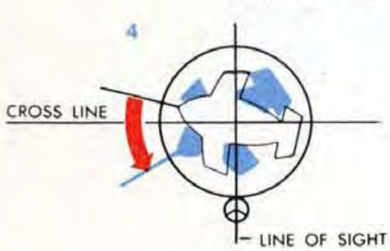
To decrease the speed of the Generated Elevation Dial, decrease *Sh*.

1 To reverse the direction of rotation of the Generated Elevation Dial, change *A* until the Target is on the other side of the Cross Line.

When target elevation is above 45° and the target is toward the cross line







2 To increase the speed of the Generated Elevation Dial, change *A* to move the Target farther away from the Cross Line.

3 To decrease the speed of the Generated Elevation Dial, change *A* to move the Target closer to the Cross Line.

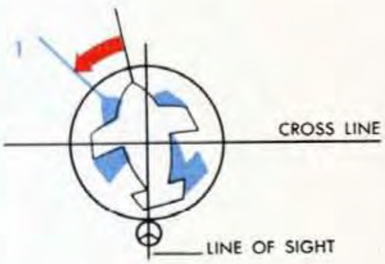
4 To reverse the direction of rotation of the Generated Elevation Dial, change *A* until the Target is on the other side of the Cross Line.

Controlling the generated bearing dial in manual operation

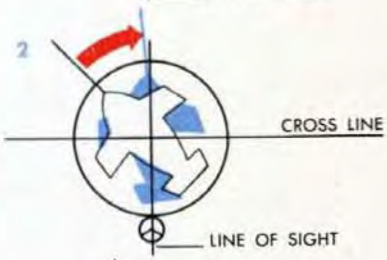
In making corrections to the Generated Bearing Dial, the value of Target Elevation may be disregarded.

When the target is toward the line of sight

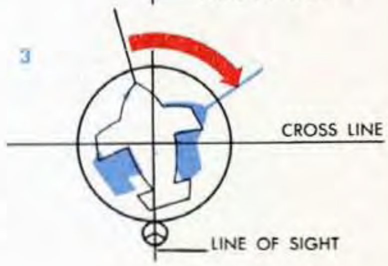
1 To increase the speed of the Generated Bearing Dial, change *A* to move the Target farther away from the Line of Sight.

1


2 To decrease the speed of tne Generated Bearing Dial, change *A* to move the Target closer to the Line of Sight.

2


3 To reverse the direction of rotation of the Generated Bear-ing Dial, change *A* to move the Target to the other side of the Line of Sight.

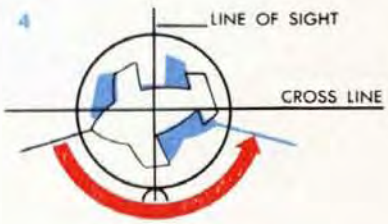
3


When the target is toward the cross line

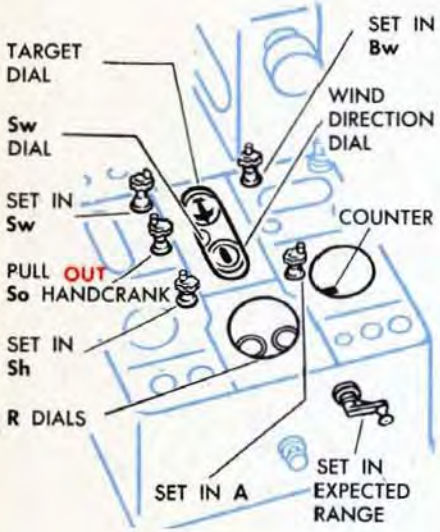
To increase the speed of the Generated Bearing Dial, in-crease *Sh*.

To decrease the speed of the Generated Bearing Dial, de-crease *Sh*.

4 To reverse the direction of rotation of the Generated Bear-ing Dial, change *A* to move the Target to the other side of the Line of Sight.

4


STANDBY FOR A SURFACE TARGET



Changing from standby during search to standby for a surface target

At the Range Station:

1 With the Generated Range Crank OUT, set the expected Range into the Range Dials. Leave the crank OUT.

2 With the Target Speed Handcrank at HAND, set the estimated *Sh* into the Target Speed Counter. Leave the handcrank at HAND.

At the Elevation Station:

1 With the Rate of Climb Handcrank IN, check that the Rate of Climb Dial is at zero.

2 Set in Wind Speed by turning the Wind Speed Handcrank.

3 With the Ship Speed Handcrank IN, set the approximate speed; then pull the handcrank OUT.

At the Bearing Station:

1 Switch the Target Angle Handcrank to HAND and set in the estimated Target Course or Angle. Leave the handcrank at HAND.

2 Set in Wind Direction by turning the Wind Direction Handcrank.

At the Other Stations:

1 Put the Synchronize Elevation Handcrank IN and match the Synchronize Elevation Dials at the fixed index.

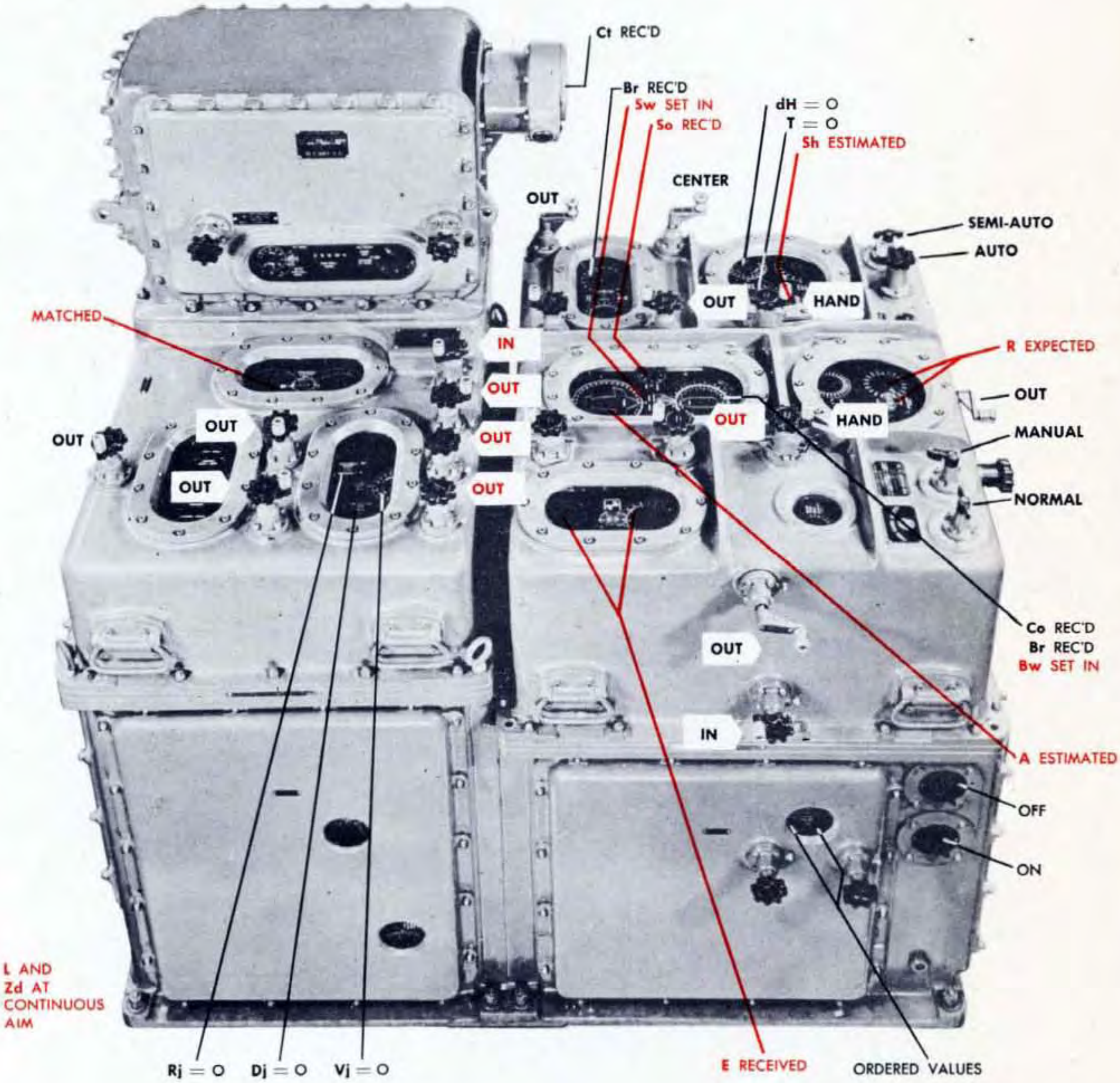
2 Pull the Spot Knobs OUT, noting that correct values of *Rj*, *Vj*, and *Dj* are indicated.

3 Put the Stable Element at Continuous Aim.

4 Make sure that all the switches connecting the Director, the Computer, the Stable Element, and the 5" guns are ON at the Fire Control Switchboard.

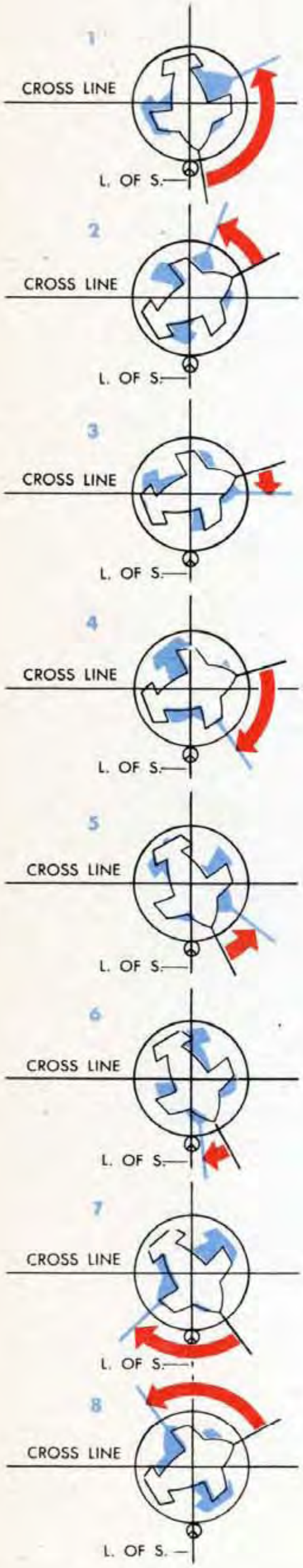
When the Range Finder, Pointer's, and Trainer's Signals indicate that the Director is tracking the Target, and the Target comes within tracking range, the Time Motor Switch is turned ON to commence tracking in Manual Operation.

COMPUTER IN STANDBY FOR A SURFACE TARGET



CHANGES FROM STANDBY SHOWN IN RED

MANUAL OPERATION AGAINST A SURFACE TARGET



Changing from standby for a surface target to manual operation against a surface target

At the Range Station:

1 Turn the Time Motor Switch ON.

Rate-controlling in manual operation against a surface target

When Observed Range is correct, the Generated Range Dials must be matched and kept rotating at the same speed. The Generated Bearing Dials must rotate at the same speed as the Observed Dials.

At the Range Station:

1 Use the Target Speed and Target Angle Handcranks to keep the Generated Range and Generated Bearing Dials rotating at the same rates and in the same directions as the Observed Range and Observed Bearing Dials.

Controlling the generated range dials

When the Target is toward the Line of Sight

To increase the speed of the dials, increase *Sh*.
To decrease the speed of the dials, decrease *Sh*.

1 To reverse the direction of rotation of the dials, move the Target to the other side of the Cross Line.

When the Target is toward the Cross Line

2 To increase the speed of the dials, move the Target farther from the Cross Line.

3 To decrease the speed of the dials, move the Target closer to the Cross Line.

4 To reverse the direction of rotation of the dials, move the Target to the other side of the Cross Line.

Controlling the generated bearing dial

When the Target is toward the Line of Sight

5 To increase the speed of the dial, move the Target away from the Line of Sight.

6 To decrease the speed of the dial, move the Target closer to the Line of Sight.

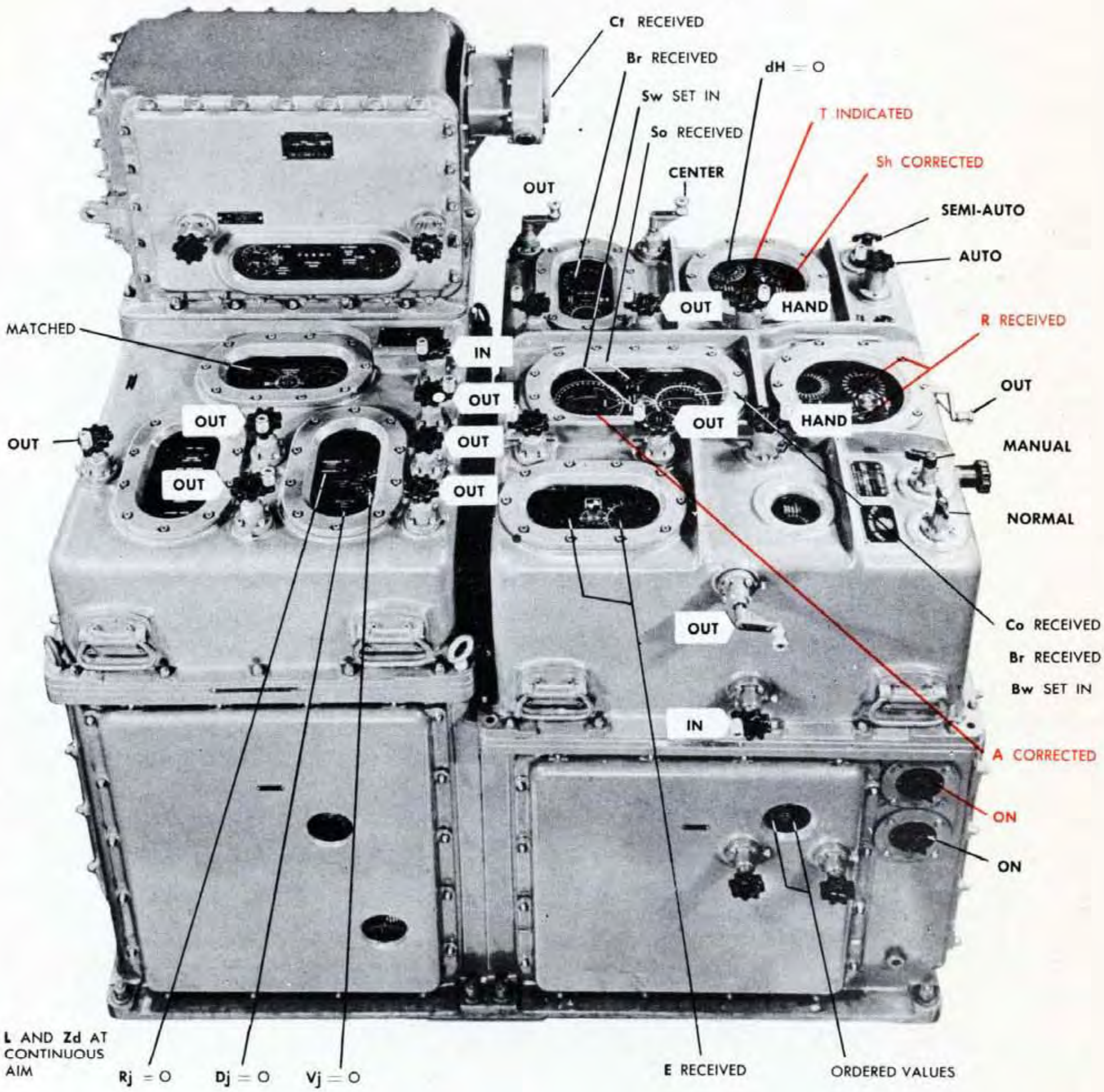
7 To reverse the direction of rotation of the dial, move the Target to the other side of the Line of Sight.

When the Target is toward the Cross Line

To increase the speed of the dial, increase *Sh*.
To decrease the speed of the dial, decrease *Sh*.

8 To reverse the direction of rotation of the dial, move the Target to the other side of the Line of Sight.

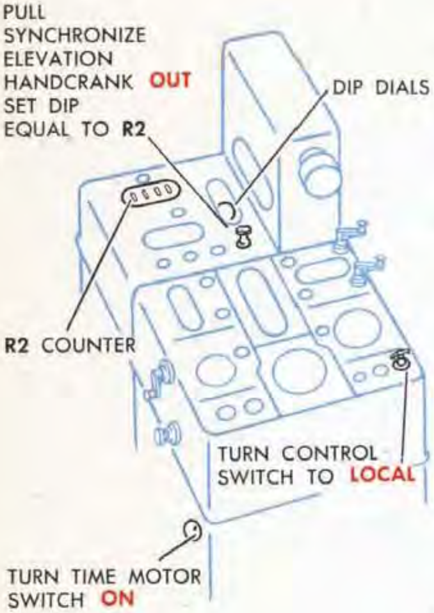
MANUAL OPERATION AGAINST A SURFACE TARGET



CHANGES FROM STANDBY FOR A SURFACE TARGET SHOWN IN RED

LOCAL OPERATION

Local Operation is used against surface targets only, when the Director is not operating, or when specified by ship's doctrine.



Changing from standby for a surface target to local operation

At the Range Station:

1 Turn the Control Switch to LOCAL.

At the Other Stations:

1 Put the Synchronize Elevation Handcrank at CENTER, set the *E* Dials at zero; then pull the Synchronize Elevation Handcrank OUT and set Dip Range into the Dip Dials.

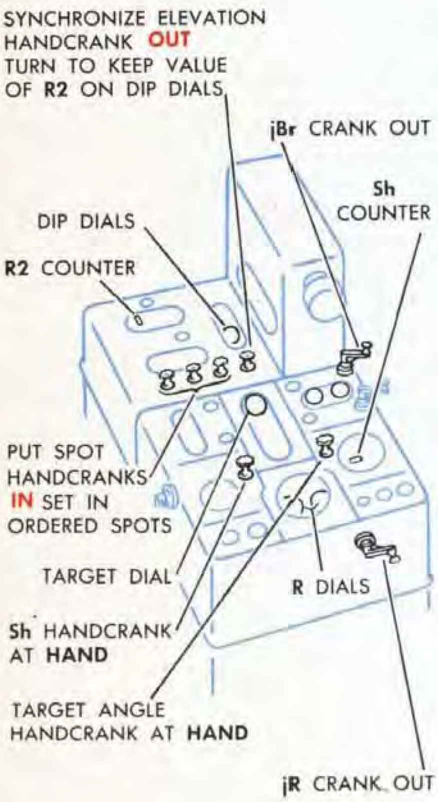
CAUTION: In setting Dip Range into the Dip Dials, be sure that the wide index on the coarse dial is set at the fixed index.

2 Put the Spot Handcranks IN.

To start tracking turn the Time Motor Switch ON.

Tracking in local operation

Range, *R*, Relative Target Bearing, *Br*, Target Angle, *A*, and Target Speed, *Sh*, are continually observed from some point on deck and phoned to the plotting room. The Computer Crew puts these values into the Computer. The Crew then corrects the Target estimates until no further corrections are needed to keep the computed values of Generated Range and Bearing shown on the dials equal to the phoned values of Range and Bearing.



At the Range Station:

1 With the Generated Range Crank OUT, set the phoned values of Range into the Generated Range Dials.

2 With the Target Speed and Target Angle Handcranks at HAND, correct *Sh* and *A* until the Range and Bearing Dials turn in agreement with the phoned values.

At the Bearing Station:

1 With the Generated Bearing Crank OUT, set the phoned values of Bearing into the Bearing Dials.

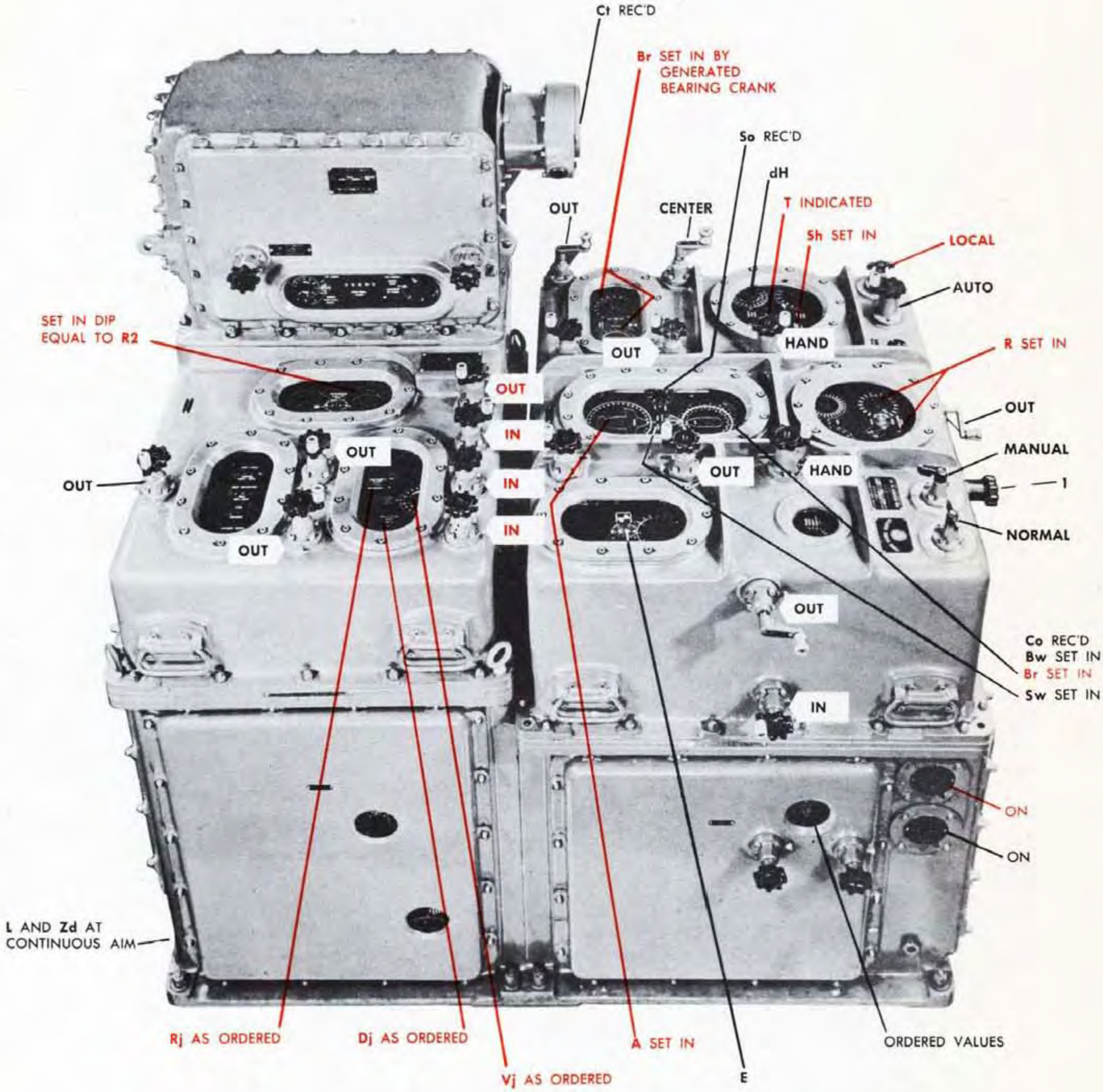
At the Other Stations:

1 Turn the Synchronize Elevation Handcrank in the OUT position to keep the value of Dip Range on the Dip Dials in agreement with the Advance Range reading on the *R2* Counter. (*R2* is used instead of *cR* for convenience in setting the Dip Range.)

2 With the Spot Handcranks IN, set in any Spot Corrections that are ordered.

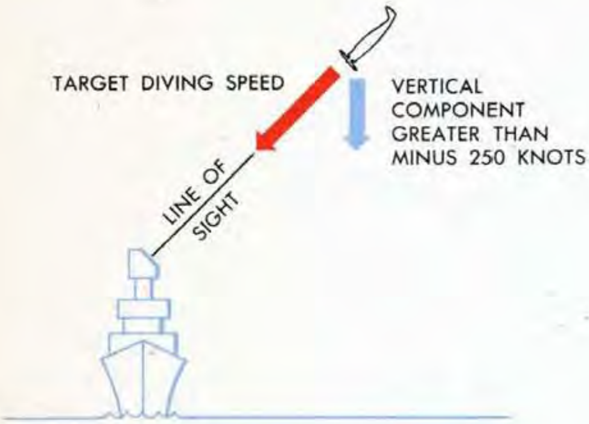
The problem is solved when no further Target value corrections are necessary to keep the values of Range and Bearing shown on the dials in agreement with the phoned values.

THE COMPUTER IN LOCAL OPERATION



CHANGES FROM STANDBY FOR A SURFACE TARGET SHOWN IN RED

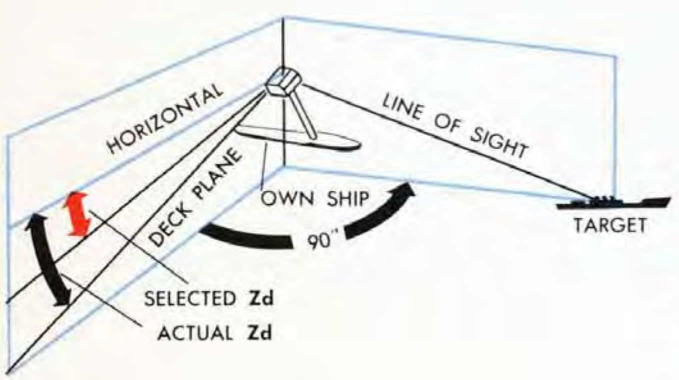
Summary of SPECIAL TYPES OF OPERATION

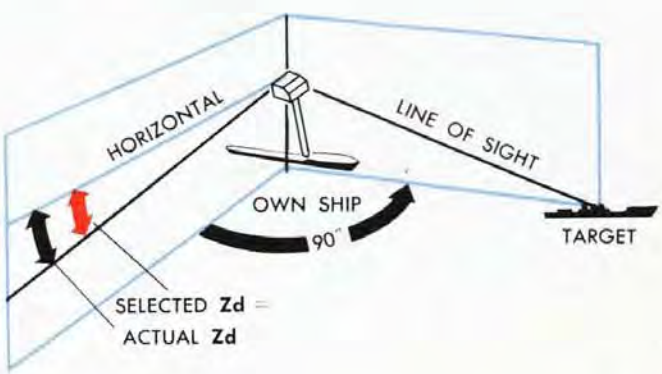


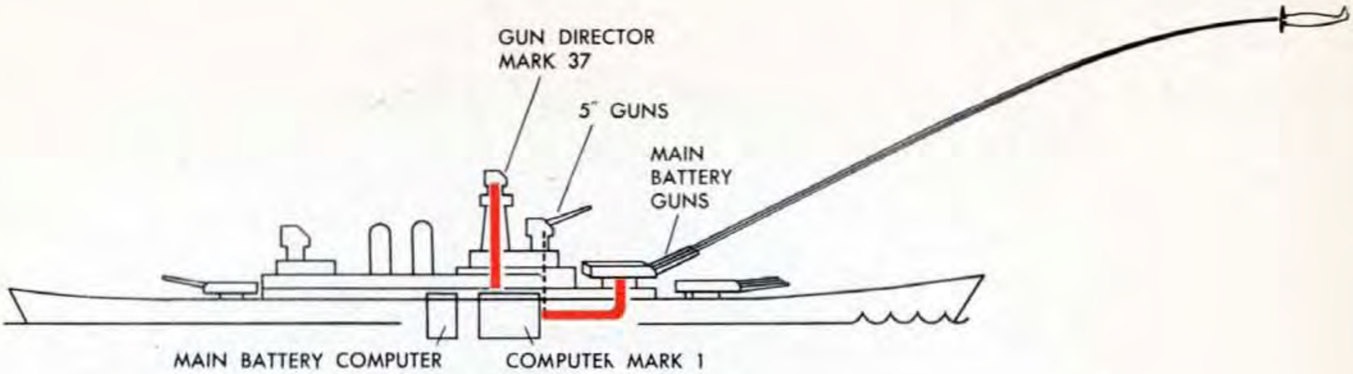
Special Dive Attack Procedure is a special type of operation used against air targets diving at Own Ship along the Line of Sight. Special Dive Attack Procedure is necessary only when the vertical component of dive is greater than −250 knots.

Selected Level Fire, Level Angle selected at the Director, is a method of operation used against surface targets when Continuous Aim cannot be used. The Pointer in the Director selects a fixed value of Level and fires the guns when actual Level equals the Selected Level. If the Director is not operating, the Selected Level is set at the Stable Element, and the firing of the guns is handled by the Stable Element Crew.

Selected Cross-level Fire also is used only against surface targets when Continuous Aim cannot be used. Selected Cross-level is always set at the Stable Element, and the firing of the guns is handled by the Stable Element Crew.







Main Battery Barrage Fire is a method of operation that permits the use of the main battery guns against on-coming aircraft. The normal outputs of the Computer Mark 1 are corrected by spots to compensate for the difference in ballistics between the 5" guns and the guns in the main battery.

Star Shell Fire is used at night to illuminate surface targets. A star shell bursts 1500 feet above and 1000 yards beyond the Target. When the shell bursts, it releases a parachute flare that burns for sixty seconds. A deflection correction is required to place the flare directly on the Line of Sight behind the Target after the flare has burned for thirty seconds.

A Star Shell Computer is mounted on the right side of the top of the Computer Mark 1. The Star Shell Computer receives data from the Computer and adds the corrections that are needed to place the star shell above and beyond the Target. The Star Shell Computer outputs are electrically transmitted to any one gun used to fire the star shells. The firing of the star shells does not interfere with the firing of service shells by the other guns. When a Star Shell Computer is not supplied, a Star Shell Legend Plate is mounted in its place. This legend plate gives the values of Sight Angle and Fuze Setting Order required for different values of Advance Range. These values are phoned to the gun used to fire the star shell.

DIVE ANGLE	DIVING SPEED FOR MAX. dH OF 250 KNOTS
90°	250
80°	254
70°	266
60°	289
50°	326
40°	389

DIVE ATTACK AGAINST OWN SHIP

The type of Computer operation used against diving aircraft depends on the nature of the dive attack.

In Auto or Semi-auto Operation

When Vertical Target Speed, *dH*, is numerically less than −250 knots, dive attacks against Own Ship can be handled by the Computer in Automatic or Semi-automatic Operation.

SPECIAL DIVE ATTACK PROCEDURE

When the *dH* Dial reaches −250 knots, SPECIAL DIVE ATTACK PROCEDURE must be used against Targets diving at Own Ship.

Changing to Special Dive Attack Procedure

At the Range Station:

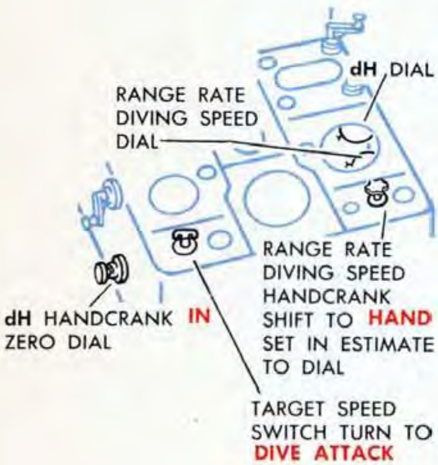
1 Turn the Target Speed Switch to DIVE ATTACK and leave it there.

2 Shift the Range Rate/Diving Speed Handcrank to HAND. Set the estimated Diving Speed into the Diving Speed Dial.

At the Elevation Station:

1 Put the Rate of Climb Handcrank IN. Zero the Rate of Climb Dial. Leave the handcrank IN.

Rate-controlling in Special Dive Attack Procedure



At the Range Station:

1 With the Range Rate/Diving Speed Handcrank at HAND, continue correcting the Diving Speed estimated until the Generated Range Dials turn at the same rate as the Observed Range Dials and remain matched at the same value.

At the Elevation Station:

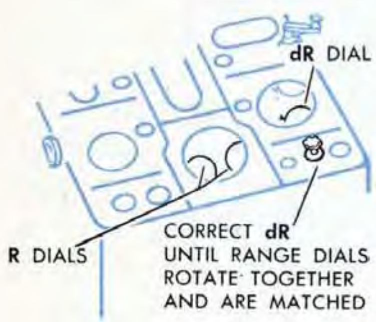
1 The Elevation Dials remain almost stationary because the Target is coming down the Line of Sight.

At the Bearing Station:

1 Any movement of the Bearing Dials is due to motion of Own Ship.

The solution is reached when the Generated Range, Elevation, and Bearing Dials rotate at the same rate as the Observed Range, Elevation, and Bearing Dials.

As soon as the Dive Attack order is over, turning the Target Speed Switch to NORMAL returns the Computer to Automatic Operation. Put the Range Rate/Diving Speed Handcrank at AUTO.



DIVE ATTACK AGAINST OTHER SHIPS

No special procedure is available for dive attack against other ships, regardless of the diving speed. The Computer should be placed in Automatic or Semi-automatic Operation.

SPECIAL DIVE ATTACK PROCEDURE CANNOT BE USED AGAINST PLANES DIVING AT OTHER SHIPS.

SELECTED LEVEL FIRE

Selected Level Fire is used only against surface targets. The guns can be fired only when the deck has tilted to the Selected Level Angle.

There are two types of Selected Level Fire: one in which the Selected Level is set by the Pointer in the Director, and another in which the Selected Level is set at the Stable Element. The second type is almost always used, and must be used when the Director is not operating.

WHEN LEVEL IS SELECTED AT THE DIRECTOR, the operation of the Computer is exactly the same as for regular Manual Operation against a surface target, except that the Synchronize Elevation Handcrank is put in the CENTER position and the Elevation Dials are set at zero.

The Pointer fires the guns whenever his crosshair is on the Target.

NOTE:

The Director Mark 37 is not well adapted to Selected Level Fire from the Director because the Trainer's and Range Finder Optics and the Radar Antenna cannot be elevated independently of the Pointer's Optics. When the Pointer's Line of Sight swings off the Target the Trainer's and Range Finder Optics and the Radar beams also swing off the Target. This makes ranging and training impossible under most conditions.

WHEN LEVEL IS SELECTED AT THE STABLE ELEMENT, the operation of the Computer is exactly the same as for either regular Manual or Local Operation, except that Dip is set in by the Synchronize Elevation Handcrank in the OUT position.

The Stable Element Crew puts the Stable Element firing selector lever at SELECTED LEVEL position and selects the value of Level desired. Either AUTO or HAND firing can be used. Whenever the deck tilts so that the actual Level equals the Selected Level, the firing contacts complete the firing circuit allowing the guns to be fired.

SELECTED CROSS-LEVEL FIRE

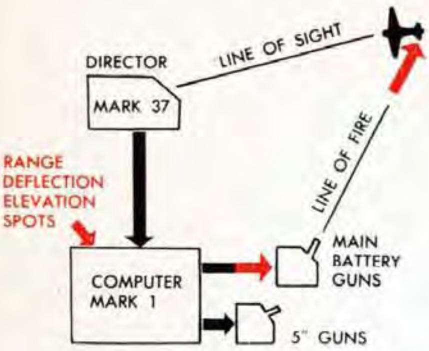
Selected Cross-level Fire is used only against surface targets. The guns can be fired only when the deck has tilted to the selected value of Cross-level.

Selected Cross-level Fire can be used with or without the Director. The Cross-level value is always selected at the Stable Element. The guns can be fired whenever the Stable Element firing contacts complete the firing circuit.

WITH THE DIRECTOR, the Computer is operated for Selected Cross-level Fire in Manual Operation.

WITHOUT THE DIRECTOR, the Computer is operated for Selected Cross-level Fire in Local Operation.

MAIN BATTERY OPERATION



Many of the Directors and Computers controlling main battery guns solve surface problems only. By using the Gun Director Mark 37 and the Computer Mark 1, the main battery guns can be adapted for barrage fire against on-coming aircraft.

The Computer Mark 1 normally computes solutions for the 5″ guns. These solutions can be adapted to main battery guns by the addition of the proper Range, Deflection, and Elevation Spot Corrections for each size of gun and projectile.

The spots that are required are given in a Table of Corrections for each size of gun. A Table of Corrections looks like this:

SAMPLE TABLE OF CORRECTIONS

4000 FEET
TARGET HEIGHT

MIN. OBS. RANGE	FUZE	RANGE SPOT IN	ELEV. SPOT DOWN	DEFL. SPOT RIGHT
12400	15	1080	16	0
12900	16	1140	17	1
13400	17	1190	18	1
13900	18	1250	20	1
14400	19	1310	21	1
14900	20	1370	23	1
15400	21	1421	25	1

OD 5102

This table is a sample and does not apply to any particular combination of gun and computer.

The Director Mark 37 and Computer Mark 1 track the Target by the same methods used when controlling the 5″ guns. The guns are elevated and trained continuously by the Mark 1 Gun Orders. The Parallax Corrections are not used.

When a solution is reached, the Spot Corrections that are shown on the Table are applied. A Fuze Setting Order is selected and phoned to the guns. The guns are fired when the computed Fuze Setting Order equals the Selected Fuze Setting Order.

When the Computer Mark 1 is used for main battery operation, its solution can be used by only one size of gun and projectile at any one firing. If the 5″ guns are to be fired in the same barrage as the main battery guns, a separate Computer Mark 1 is required to operate the 5″ guns, because the Spot Corrections made to suit the main battery guns would place the 5″ gun-bursts short of the Target.

Quick Reference Index

Using a TABLE OF CORRECTIONS

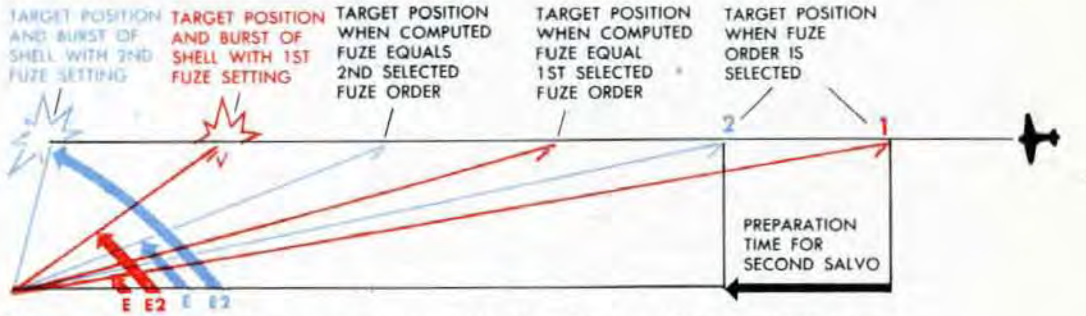
The Table of Corrections is based on one problem: a Target flying at a constant speed, at a constant height, directly toward Own Ship.

The guns are fired at a Selected Fuze Setting Order determined by the Target Height and Range. The Height of the Target is obtained from the Computer Height Dials. The Observed Present Range is obtained from the Generated Range Dials. After the Height and the Present Range are determined, a Minimum Observed Range is obtained from the table that is *less* than the Computer Range Dial reading. This allows for Target Motion between the time of selecting the Fuze Setting Order and the firing of the guns.

The Selected Fuze Setting Order depends on the Minimum Observed Range obtained from the table. In the column headed "Fuze," next to the column headed "Min. Obs. Range," is the value of the Selected Fuze Setting Order for the particular Height and Range of the Target. This Selected Fuze Setting Order is phoned to the guns.

The Range, Deflection, and Elevation Spots given in the table are set into the Computer to adapt its outputs to the ballistics of the main battery guns. With the Spots entered, the guns are fired as soon as the Fuze Setting Order transmitted from the Computer equals the Selected Fuze Setting Order previously phoned.

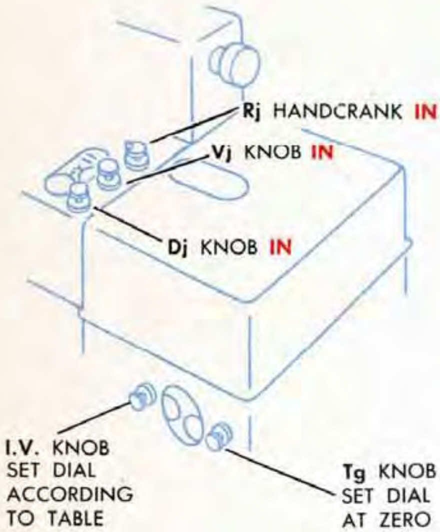
Using alternate tables



Two tables may be used to permit the firing of two salvos in close succession. Using this method, two Fuze Setting Orders are selected for two different ranges. The first range is longer than the second by a time sufficient to allow for the preparation of the guns for the second salvo.

THE MAIN BATTERY CONTROL

Changing from standby for an air target to main battery control



At the Range, Elevation, and Bearing Stations:

1 Make the changes required to go into Automatic, Semi-automatic, or Manual Operation.

At the Other Stations:

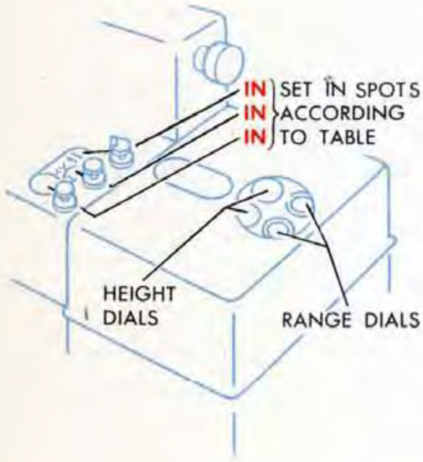
1 At the Fire Control Switchboard, connect the Gun Director Mark 37 and the Computer Mark 1 to the main battery guns.

2 Set the Dead Time Dial at zero.

3 Set the Initial Velocity Dial at a value that is equal to the actual *I.V.* of the main battery guns minus the value given on the Table of Corrections.

4 Put the Range Spot Handcrank and the Deflection and Elevation Spot Knobs IN.

The computer is then operated in automatic, semi-automatic or manual control until a solution is reached



After the solution is reached:

1 Read the Height Dials. Apply this value to the nearest thousand feet on the Table of Corrections.

2 Read the Range Dials. Select a Fuze Setting Order on the Table of Corrections for a shorter Range than is shown on the Range Dials.

3 Phone the Selected Fuze Setting Order to the guns, and at the same time,

4 Set in the Range, Deflection, and Elevation Spots given in the Table of Corrections for the Selected Fuze Setting Order.

At the Computer, the Fuze Setting Order Counter is watched carefully. The instant that the Fuze Setting Order Counter reading equals the phoned Selected Fuze Setting Order, the guns are fired.

STAR SHELL FIRE

Star Shell Fire is controlled in three ways:

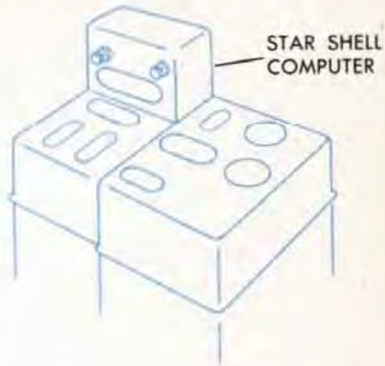
1 By the Star Shell Computer Mark 1.

2 By orders for Fuze and Sight Angle taken from the Star Shell Legend Plate and phoned to the guns.

3 By orders for Fuze and Sight Angle taken from the Star Shell Legend Plate and transmitted to the guns through the Computer Mark 1.

THE STAR SHELL COMPUTER

The Star Shell Computer is mounted on the top of the Computer Mark 1.



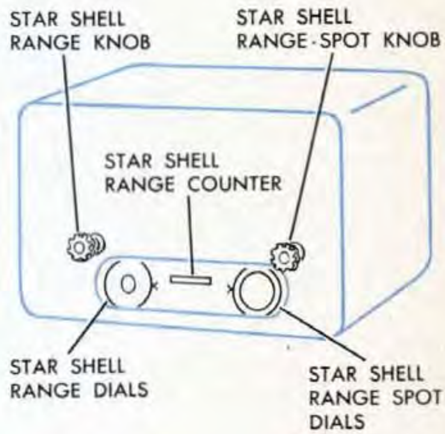
Operating the star shell computer

1 At the Fire Control Switchboard, connect the Star Shell Computer to the gun that is to fire the star shells.

2 Turn the Star Shell Range Spot Knob to match the index on the Range Spot Ring Dial with the arrow on the inner dial.

3 Push the Star Shell Range Knob IN and set the inner Star Shell Range Dial to the Star Shell Counter reading. Pull the knob OUT and set the ring dial to the counter reading. Return the knob to its IN position.

CAUTION: The transmission system of the Star Shell Computer is designed to control only one gun.



THE STAR SHELL LEGEND PLATE

When there is no Star Shell Computer, a Star Shell Legend Plate is attached to the Computer Mark 1 in its place.

The Legend Plate has four columns. The first column shows Advance Range at intervals of 2,000 yards, from 4,000 to 14,000 yards. The next two columns show the Fuze Setting Orders for powder and mechanical fuzes corresponding to the values of Advance Range given in the first column. The last column lists the values of Sight Angle corresponding to the values of Advance Range in the first column.

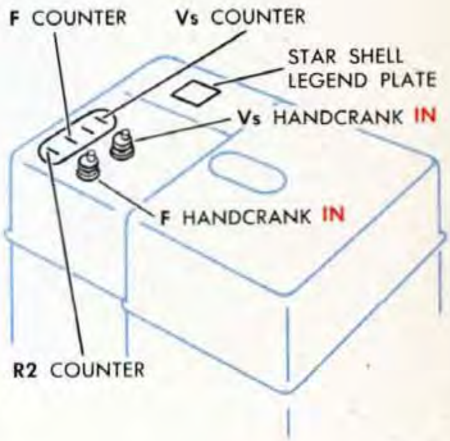
STAR SHELL DATA FOR 2500 F.S. I.V.

ADV. RANGE	FUZE PWDR.	FUZE MECH.	SIGHT ANGLE
4000	11	8	2570
6000	16	13	2630
8000	22	19	2800
10000	29	27	3050
12000	35	35	3400
14000	42	45	3880

Using the legend plate

1 Read the Advance Range Counter on the Computer. Apply this value to the Advance Range Column of the Star Shell Legend Plate.

2 Read the Fuze Setting Order and Sight Angle values appearing opposite the Advance Range selected, and phone these values to the gun firing the star shells, or if the 5″ battery is being used to fire star shells only, send the Fuze and Sight Angle data to the guns by setting the values into the Computer Mark 1. To do this, put the Fuze and Sight Angle Handcranks IN and turn them until the values designated on the Star Shell Legend Plate show on the Fuze and Sight Angle Counters on the Computer.



ALTERNATIVE STANDBY CONDITIONS

The following Standby Conditions may be used when great speed is needed in shifting to full operation.

Standby Condition

All the Computer, Stable Element, Director, and gun transmission circuits are energized.

The Stable Element Level and Cross-level Switches are at MANUAL.

The Selector Drive is in LOCK position.

At the Computer:
1 The Power Switch is ON.
2 The Ship Course Handcrank is IN.
3 The Control Switch is at SEMI-AUTO.
4 The Range Rate Control Switch is at MANUAL.
5 The Ship Speed Handcrank is OUT, with *So* synchronized.
6 The Time Motor is OFF.

NOTE:
To eliminate constant setting of fuzes in the bottom of the projectile hoist, the Fuze Handcrank on the Computer may be locked in its IN position with Fuze set at 2 seconds.

Standby during search

When Search begins, turn the Stable Element Level and Cross-level Switches to AUTO.

At the Computer:
1 Pull the Ship Course Handcrank OUT.
2 Pull the Fuze Handcrank OUT.

NOTE:
The only time the Selector Drive should be unlocked is when the equipment is in a Standby Condition and Own Ship is rolling more than 20 degrees. Under these conditions the Stable Element Level and Cross-level Switches must be at AUTO to prevent tumbling of the gyro. The plotting room crew must be alerted to shift to LOCK when Search begins.

Changing from standby during search to air target expected

At the Range Station:

1 Switch the Target Speed and Target Angle Handcranks to AUTO.
2 With the Target Speed Switch, set *Sh* at approximately 200 knots.
3 With the Generated Range Crank OUT, match Generated Range to Observed Range.
4 Turn the Time Switch ON.
5 Switch the Target Speed Handcrank to HAND.
6 Turn the Control Switch to AUTO.
7 After approximately 2 seconds, switch the Target Speed Handcrank back to AUTO. This may be done by the Elevation Operator while the Range Operator keeps the Range Dials matched.
8 Report "Plot set."
9 Push the Generated Range Crank IN. Press the Range Rate Manual Push-button and keep the Range Dials matched.

At the Elevation Station:

1 Put the Synchronize Elevation Handcrank IN and match the Synchronize Elevation Dials.
2 Set Rate of Climb on zero and pull the Rate of Climb Handcrank OUT.
3 Pull the Spot Knobs OUT.

At the Bearing Station:

1 At the Target Course Indicator, set Target Course as ordered.

A SAMPLE PROBLEM

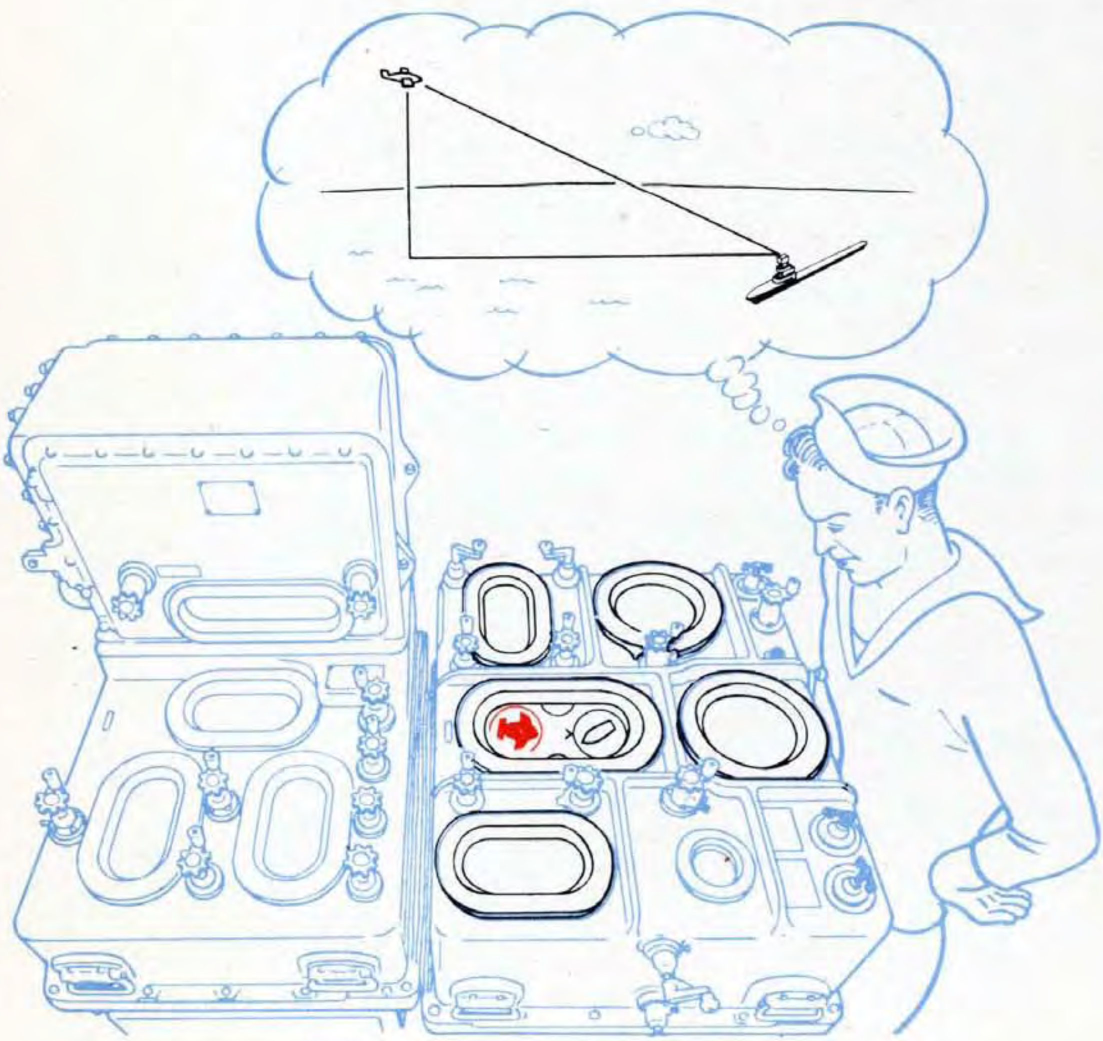
A man standing in the plotting room watching the Fire Control Switchboard and the Computer Mark 1 can obtain a very accurate picture of the fire control problem and of the activity throughout the Gun Director Mark 37 System.

The positions of the switches on the Fire Control Switchboard and the Computer show him the condition of the Computer relative to the other parts of the fire control system.

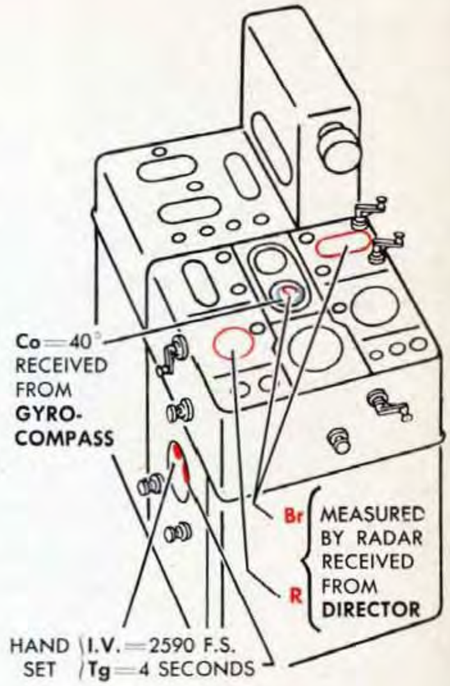
The positions and motion of the Computer dials give a good picture of the actual conditions existing between Own Ship and Target.

Indicating signals from various parts of the system show the action being taken there.

This chapter describes a sample fire control problem. It is not a typical combat problem but is designed to show how the action above deck can be visualized in the plotting room.



Action is expected



At the start of this problem, the switches on the Fire Control Switchboard and the Computer show that the Computer is in *Standby during Search. Standby during Search* usually indicates that action is expected.

At the Computer, Own Ship Course is being received from the Gyro Compass. The Compass Ring Dial reads 40° against the zero index of the Ship Dial. The only other dials showing actual values are the Initial Velocity Dial, which has been set at 2590 f.s., and the Dead Time Dial, which has been set at 4 seconds.

The Radar Range Dial and Relative Target Bearing Dials are moving, showing that the Director is searching for a target.

After a few moments the Radar Range Dial and Relative Target Bearing Dials steady down and move gradually, indicating that radar search has picked up a target. The Radar Range Dial shows a little under 75,000 yards.

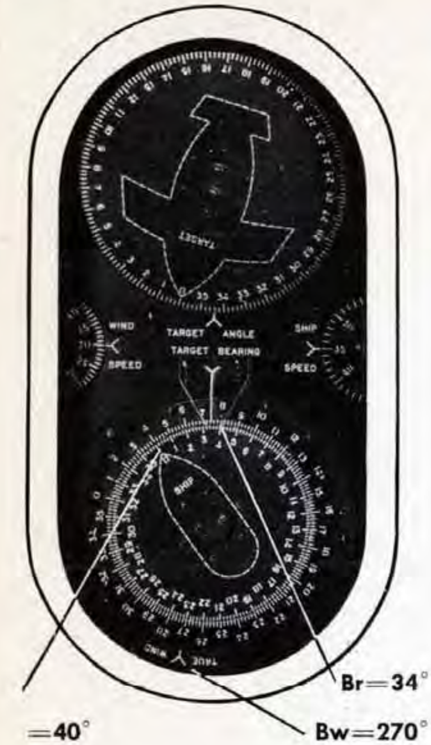
The Bearing Dials steady down around 34 degrees.

There is no reading for Target Elevation because the Director Elevation Receiver is not yet energized at the Fire Control Switchboard.

The reading on the Radar Range Dial is decreasing, showing that the Target is approaching Own Ship. The high rate at which the reading is decreasing indicates an air target.

The problem so far can be visualized like this:

An air target is expected



The Computer is ordered to *Standby for an Air Target*. The Range Dials are set at 35,000 yards, the maximum Range at which the Computer can start tracking.

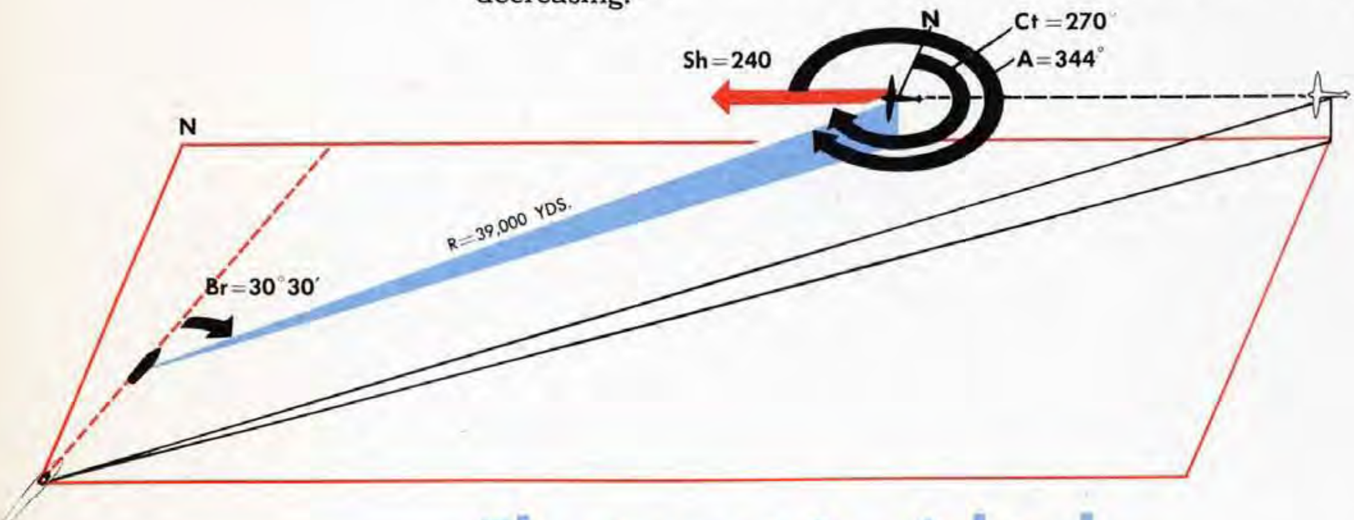
The Ship Speed Dial now shows 35 knots. The value of this quantity is being received from the Pitometer Log. Own Ship Course still reads 40 degrees.

Reports of Wind Direction and Wind Speed are now received. *Bw* is quickly set at 270°, *Sw* at 20 knots.

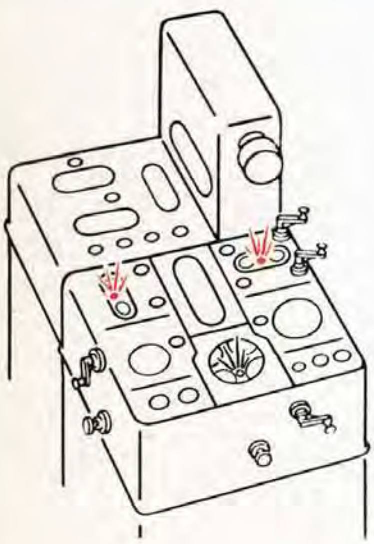
A moment later, estimates of Target Course and Target Speed are received by phone. *Ct* is set at 270° and *Sh* is set at 240 knots. *dH* is set at zero. According to these estimates, the Target is heading due West, flying at a steady altitude. The position of the Target in relation to Own Ship can now be seen on the Ship and Target Dials.

The Director Elevation Receiver is now energized and *E* can be read on the *E* Dials.

The Ship, Compass, and True Wind Dials, and the Observed Relative Target Bearing Dials turn slowly as Relative Target Bearing changes. The Radar Range Dial shows Range steadily decreasing.



The target is sighted



When Range has closed to less than 39,000 yards, and *Br* is 30° 30′, the Trainer's Signal turns to red. The Trainer now has his crosshair on the Target.

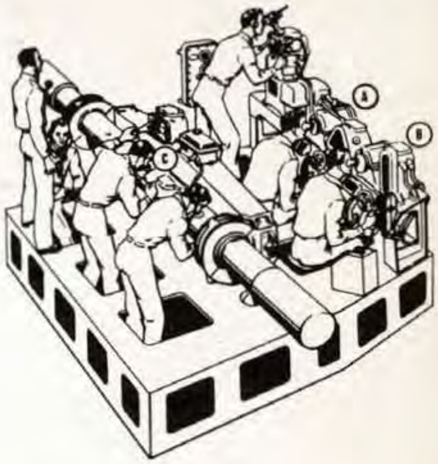
A few seconds later the Pointer's Signal also turns to red. Now the Pointer has his crosshair on the Target.

The Range Finder Signal turns to white, showing that the Range Operator in the Director has the Target in focus.

For a while all three signals from the Director continue to show these colors, indicating that the sights are being held on the Target by the Director Operators.

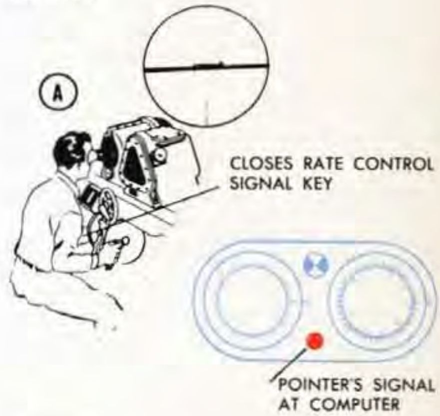
With the Director Sights and Range Finder on the Target, and all the necessary information available, tracking can be started at the Computer the moment that Range reaches 35,000 yards.

Reviewing the signals and indicators in automatic operation



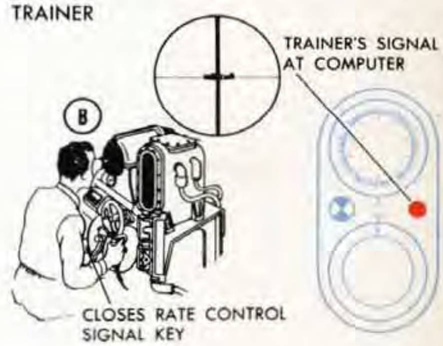
When the Computer is in Automatic Operation, the signals and solution indicators play a large part in visualizing the Gun Director operation. Because the Computer may be ordered into Automatic Operation when the maximum tracking range is reached, it is well to review the function of these controls.

Elevation



The Pointer closes his signal key and causes the Pointer's Signal at the Computer to show red whenever his crosshair is on the Target. If the Elevation Solution Indicator rotates while the Pointer's Signal is red, the Pointer is putting angular and rate corrections to Elevation into the Computer. If the Indicator rotates while the Signal is black, the Pointer is putting in angular corrections only.

Bearing



The Bearing Solution Indicator and the Trainer's Signal have the same relationship to Bearing corrections as the Elevation Solution Indicator and the Pointer's Signal have to Elevation corrections.

Range

The Range Operator depresses his signal button and causes the Range Finder Signal at the Computer to show white whenever the Range is correct. If the indexes on the Generated Range Dials are not matched to those on the Observed Range Dials at the time that the signal turns to white, the Generated Range Dials immediately turn until the indexes match. A linear and a rate correction to Range are made automatically.

If the indexes on the Range Dials are already matched at the time that the Range Finder Signal turns to white, no corrections are made to Range.

TRACKING BEGINS

When the Radar Range Dial reads 35,000 yards and Range is coming in smoothly and accurately, the Computer is ordered into Automatic Operation. The Control Switch and the Range Rate Control Switch are set at AUTO and the Time Switch is turned ON. The Generated Range, Elevation, and Bearing Dials spin and then synchronize with their Observed Dials.

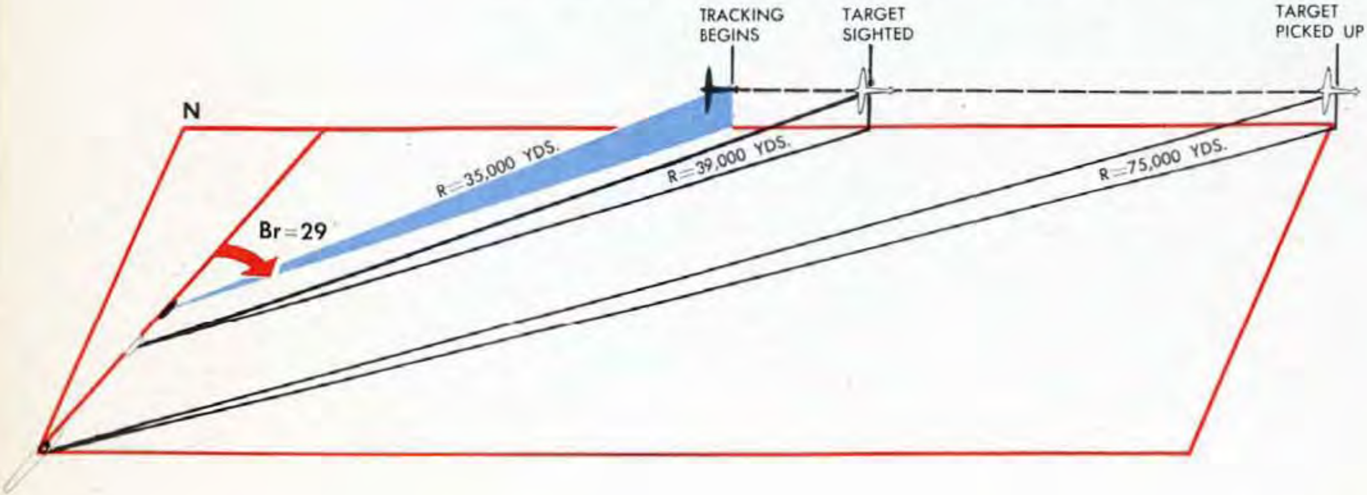
The sights are kept on target

As the Elevation Dials synchronize, the Pointer's Signal turns to black, showing that the Pointer's crosshair has moved off the Target. The Elevation Solution Indicator rotates as the Pointer turns his handwheels and sets in a correction to Elevation. The Pointer's Signal turns to red as the Indicator turns, showing that the Pointer is now setting in both angular and rate corrections to Elevation. After a moment the Indicator stops turning, and the Signal remains red. The Generated Changes of Elevation are now raising the Director sights at the correct rate to keep the Pointer's crosshair on the Target.

The Trainer's Signal remains red as the Computer is put into Automatic Operation. The Bearing Solution Indicator remains stationary, indicating that the Generated Changes of Director Train are training the Director correctly, and no rotation of the Trainer's handwheels is required to keep the Trainer's crosshair on the Target.

With Range just under 35,000 yards, Relative Bearing has decreased to 29°. The Elevation Dials now show less than 1°, Target Course is still 270°, and the Rate of Climb Dial still reads zero.

These dial readings show that the Target is flying low at a constant height and that it will pass ahead of Own Ship if both Ship and Target remain on their present courses.



A SOLUTION IS REACHED

At the time that the Computer is put into Automatic Operation, the Range Finder Signal is white, indicating that the Range Operator has the Target in focus. The Generated and Observed Range Dials turn together as the Generated Changes of Range from the Computer alter the Range Finder focus.

After a few seconds, the Range Finder Signal turns to black. The Target is now out of focus because the Generated Changes of Range are not correct. The Observed Range Dials turn faster than the Generated Range Dials and the indexes are no longer matched as the Range Operator turns his Range Knob to bring the Target into focus.

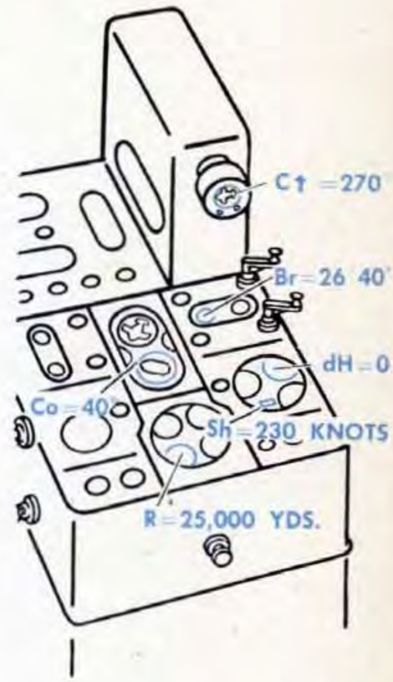
The Range Finder Signal turns to white again, and the dials jump to match at their indexes. The dials turn together as linear and rate corrections to Range are set into the Computer.

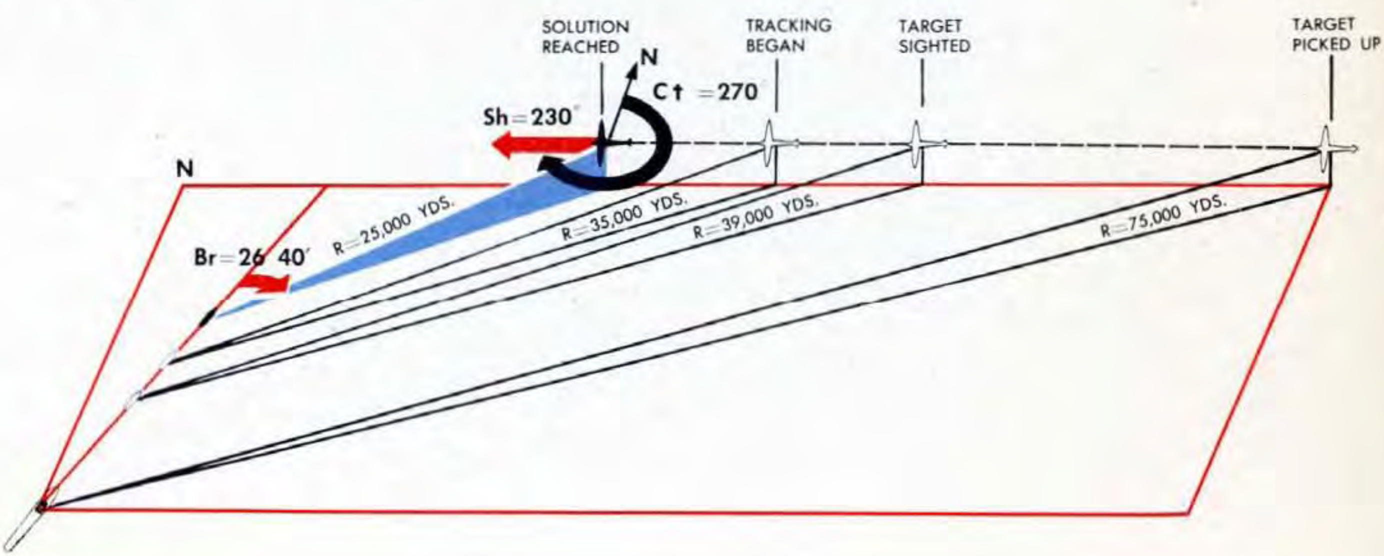
The Range Finder Signal now remains white. The Pointer's and Trainer's Signals remain red. All three operators in the Director are now on Target and the Generated Changes of Range, Elevation, and Bearing are keeping the sights on Target, and the Range Finder in focus. A solution has been reached, and the Computer is transmitting correct orders to the guns. Firing can begin as soon as the Target is within shooting Range.

At the time that the solution is reached, the Range Dials show that the Range has closed to 25,000 yards.

The Relative Target Bearing Dials, which showed 29° at the beginning of tracking, now show 26° 40′.

The Rate Corrections put in by the Trainer and Range Operator have been used by the Computer to correct the estimated value of Target Speed. The Target Speed Counter now reads 230 knots.





The PROBLEM PROGRESSES

The Range Finder Signal remains white and the Pointer's and Trainer's Signals remain red for several minutes after the solution is reached, indicating that the Target is continuing in a straight line at a constant speed.

When the Range Dials read 14,000 yards, the Relative Target Bearing Dials show 20° and Elevation is 2 degrees.

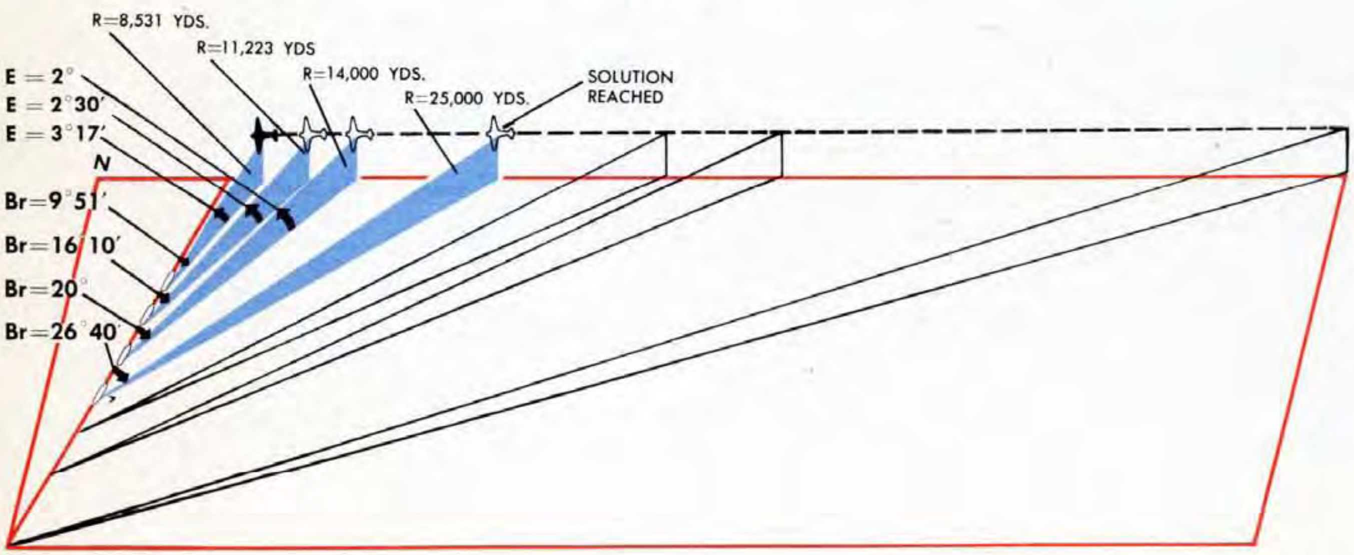
Twenty seconds later the dials are read again to check that the problem is progressing smoothly. At this reading, Range has decreased to 11,223 yards, Relative Target Bearing has decreased to 16° 10′, while Target Elevation has increased to 2° 30′.

The order "*Commence firing*" is given.

The Target is still approaching Own Ship and will cross in front of Own Ship if Target Course does not change. The dial on the Target Course Indicator is at present fairly steady at 220 degrees. The Target Speed Counter shows the Target to be flying at a steady speed of 230 knots.

The Range Finder Signal still remains white and the Pointer's and Trainer's Signals still remain red as the Target approaches, showing that the values generated by the Computer are keeping the Range Finder focused and the sights on the Target. Twenty seconds after the last dial reading, the dials show these new values:

> Range is down to 8 531 yards and Relative Target Bearing is only 9° 51′; Elevation continues to increase slowly and is now 3° 17′.



FIRING CEASES

When Range reaches 6038 yards, an order is received to "*Cease firing*." This is the usual order given when a Target is brought down.The Computer is ordered back to the original *Standby during Search*, indicating that further action is expected.

The moment that the "*Cease firing*" order is received in the Plotting Room, the dials show that the following changes have taken place:

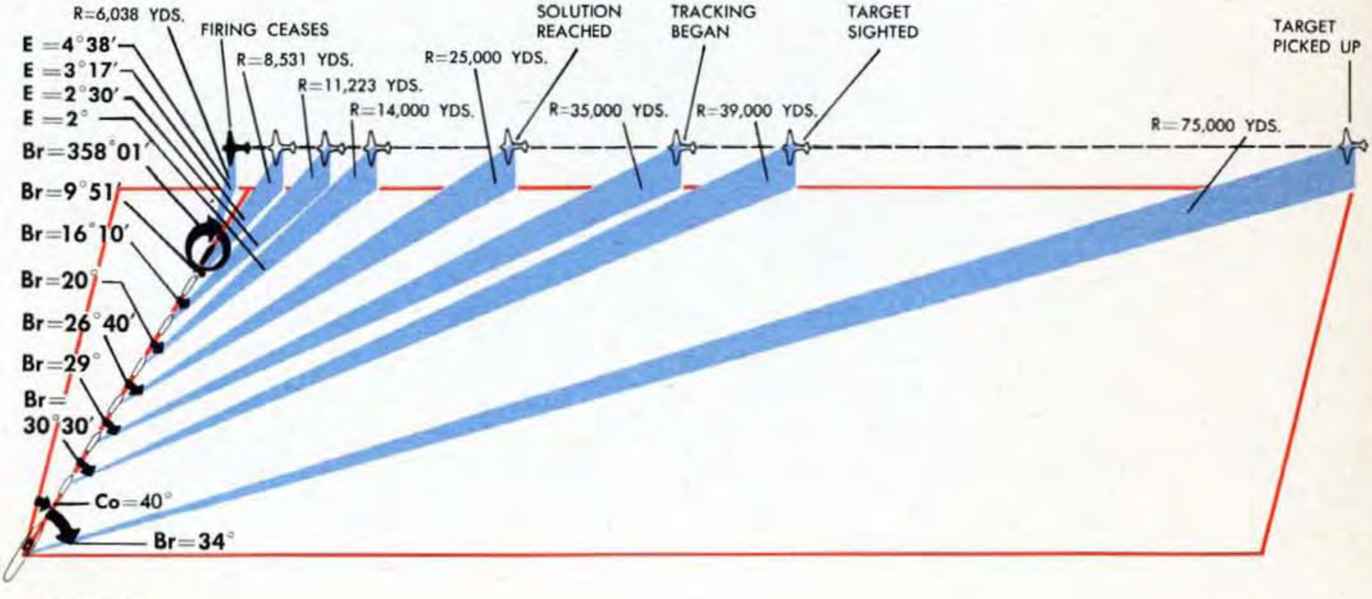
Range has decreased to 6038 yards.

The Target has now crossed in front of Own Ship, causing Relative Target Bearing to move to 358° 01′.

Target Elevation which has been increasing continuously, is now 4° 38′.

A SUMMARY OF THE PROBLEM

Here is a summary of the sample problem as it has been visualized from the Computer Dials:



OPERATING CAUTIONS

To avoid faulty operation of the Computer Mark 1, caution should be used in operating the instrument. Instructions are given here for avoiding some of the most usual sources of damage and faulty operation.

Use of the Time Crank

The Time Crank should never be turned counterclockwise in the OUT position. Although friction drive A-161 is adjusted to slip when the Time line is turned counterclockwise, this friction may be too tight and damage to the Time Motor Regulator may result if the Time line is turned backwards. In the IN position the Time Crank is connected to the Seconds Dial only and may be turned safely in either direction.

Elevation Limit Stops

Various units may slip out of adjustment if the Director Elevation Receiver drives at full speed against the end of the *Eb* limit stop, L-11, or the *E* limit stop, L-12.

Operating instructions are designed to avoid hitting L-11, which may cause clamp A-50 to slip in instruments having serial numbers 1 to 290. In changing from *Standby during Search* to *Standby for An Air or Surface Target,* make sure that the Director Pointer's sights are not at either limit of travel, because the operating limits of *Eb* in the Computer are narrower than in the Director. Then, when the *Eb* transmission circuit is completed, the servo motors will not drive into L-11.

One possible result of hitting the end of L-12 is slippage at assembly clamps A-56 and A-59 in instruments having serial numbers 1 to 290. Such slippage usually occurs when the Director Pointer's sights are slewed beyond the limits of the Computer, or while the Synch *E* Handcrank is being returned from the OUT position to the normal operating position at IN. Slippage due to the latter cause may be avoided by synchronizing as follows:

1. See that the correct value of Level is being received.
2. Put the Synch *E* Handcrank in the CENTER position. Wait until the *Eb* Receiver has synchronized on the signal.
3. Put the Synch *E* Handcrank IN and match the Synch *E* Dials.

Preventing faulty synchronization of Receivers

Due to the heart-shaped relief cams, synchro-receiver units will run toward synchronization in the direction of shorter travel. Under certain conditions, instead of driving to the desired synchronization point, certain receiver units may drive into the end of a limit stop in the opposite direction.

These units are:

The Range Spot Receiver (4000 yards per revolution)
The Elevation Spot Receiver (360 mils per revolution)
The Deflection Spot Receiver (360 mils per revolution)
The Ship Speed Receiver (40 knots per revolution, usually)
The Director Elevation Receiver (180° per revolution)

For an example of a condition under which a unit may drive into the end of a limit stop, consider the Elevation Spot Receiver. The limit stop travel is ± 180 mils, totaling 360 mils. This value, 360 mils, is equal to the value per revolution of the synchro motor. If the instrument setting were UP 150 mils and the transmitted value were DOWN 150 mils when the circuit was energized to receive the signal, the receiver unit would run into the UP 180 mils limit instead of driving back through zero to the desired DOWN 150 mils position.

The Ship Speed and Range Spot Receivers may synchronize a full revolution out. On most installations the *So* limit is 0 to 45 knots and the *So* Synchro has a value of 40 knots per revolution. When the Pitometer Log is on 0 knots, the *So* line in the instrument may therefore drive either to 0 or to 40 knots. In the same way, on modifications of the Computer Mark 1 having the IN 12,000-yard limit, when the Range Spot Transmitter is on 0, the Range Spot Receiver may synchronize on 0, IN 4000, IN 8000, or IN 12,000.

To prevent both faulty synchronization and running into limit stops, the units should be set at the approximate transmitted values, or held at zero position until after the transmission circuits have been completely energized.

Setting I.V.

The *I.V.* correction is actually three corrections: a powder temperature correction based on average magazine temperature, an erosion correction based on average erosion, and an air density correction based on air temperature and barometric pressure.

The standard *I.V.* value of 2550 f.s. for which zero correction is put into the Computer Mark 1 for 5"/38 cal. guns, is taken as an average *I.V.* for a rifle of average age and for average atmospheric conditions. It has no relationship to the standard *I.V.* of the particular ammunition being used. The *I.V.* setting, however, must allow for the standard *I.V.* of the projectile. For example, suppose the ammunition has a standard *I.V.* of 2600 f.s. If powder temperature and barometric pressure are such as to necessitate a +10 correction, and erosion necessitates a −20 correction, the *I.V.* setting will be 2600 + 10 − 20 = 2590. The Computer dial (or dials on Serial Nos. 811 up) must be set at 2590, NOT at 2550 + 10 − 20 = 2540.

The Range Rate/Diving Speed Handcrank

The handcrank labeled *Range Rate/Diving Speed* should be set at AUTO during normal operation of the Computer. It is used at HAND only during certain DIVE ATTACK problems. Since this handcrank is often set at HAND during testing, the operator should check to make sure that it is at AUTO during normal operation.

The Rrr Knob

The Range Rate Ratio Knob engages at only one position. To make sure that the knob is engaged, turn the knob in a decreasing direction to Ratio 1, and check that the limit of travel is reached.

Shifting from Semi-automatic Operation to Automatic or Local Operation

It is sometimes desirable to shift to Automatic Operation after reaching a solution of an air problem in Semi-automatic Operation. Since there is no definite matching point between Observed and Generated values of Bearing and Elevation in SEMI-AUTO, as there is in AUTO and LOCAL, the solution can easily be upset by shifting to AUTO without special care. If the Computer operator shifts to AUTO while the Pointer and Trainer have their signal keys closed, the *jE* and *jBr* Motors will drive the inner Elevation and Bearing Dials up to as much as 20° travel and will put in corresponding amounts of rate corrections. The solution will be considerably upset. If the Generated Elevation and Generated Bearing Cranks are left in the IN position when control is shifted to AUTO, the solution will be even more upset.

If a solution has been reached or even partially reached in SEMI-AUTO and it is desired to shift to AUTO, the following procedure should be followed:

1. Set the Generated Elevation and Generated Bearing Cranks in the OUT position.
2. Shift the Target Speed Handcrank to HAND.
3. Turn the Control Switch to AUTO.
4. Wait until the *jE* and *jBr* Motors drive the inner dials to synchronization; then shift the Target Speed Handcrank back to AUTO to resume Rate Control.

If it is desired to shift to LOCAL while tracking a surface target in SEMI-AUTO, synchronize Generated Bearing with Observed Bearing before making the shift to LOCAL.

Synchronize Generated Bearing with Observed Bearing as follows:

1. Shift to AUTO until the dials are synchronized.
2. Shift back through SEMI-AUTO to LOCAL.

If this is not done, Observed Bearing will run off the correct value by some amount up to 20 degrees.