COMPUTER MARK 48 MOD 1

DESCRIPTION, OPERATION, INSTALLATION, AND MAINTENANCE

CONFIDENTIAL

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ORDNANCE PAMPHLET 2074

COMPUTER MARK 48 MOD 1 - DESCRIPTION, OPERATION, AND MAINTENANCE

1. Ordnance Pamphlet 2074 contains the description and instructions for operation and maintenance of Computer Mark 48 Mod 1.

2. This publication is intended for use by all personnel concerned with operation and maintenance of the subject computer.

3. This publication does not supersede any existing publication.

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~~F. S. WITHINGTON~~

Paul D. Stroop

PAUL D. STROOP
Rear Admiral, U. S. Navy
Deputy Chief, Bureau of Ordnance

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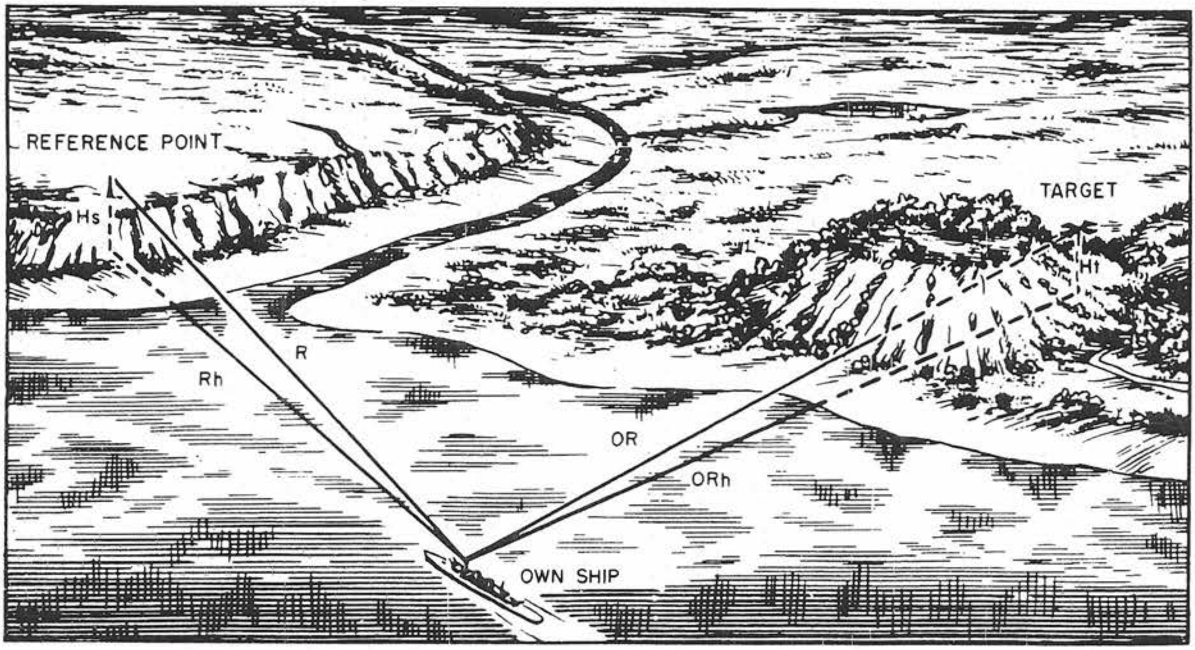

Figure 1. Fire at an Obscured Target

Chapter 1

INTRODUCTION

PURPOSE

Computer Mk 48 Mod 1 operates in conjunction with the gun order computer, stable element, and director to provide an accurate solution to the problem of shore bombardment by indirect fire. It is designed to operate with the main and secondary batteries of cruisers and battleships, and may be used with anti-aircraft or surface fire directors and computers or range keepers.

FUNCTION

Computer Mk 48 Mod 1 primarily is designed to solve a fire control problem by using a visible reference point to direct fire at an obscured target whose map location with respect to the reference point is known, figure 1. This computer translates data that describe reference point position with respect to the ship into data that describe actual target position with respect to the ship. Figure 2 shows the data flow for direct and for indirect fire control. The data that describe target position with respect to the ship then are transmitted to the gun order computer for computation of firing data.

In indirect fire, Computer Mk 48 Mod 1 computes the quantities involved in target location by combining three sets of data:

Location of the reference point with respect to the ship. The reference point, at which the director is continuously aimed, is located by its relative bearing, range, and height.

Location of the target with respect to the reference point. This is established by X-Y map coordinates, reference point height, and target height.

Level and cross level referenced to the target line-of-sight.

By combining these three sets of data, Computer Mk 48 Mod 1 furnishes to the gun order computer the following quantities:

Offset relative target bearing (director train to target)

Target slant range

Target elevation

In addition to transmitting target data to the gun order computer, Computer Mk 48 Mod 1 transmits data to the gun director to keep it aimed at the reference point. To achieve this, the following quantities are transmitted:

Changes in slant range to reference point

Unit parallax computation (Gun Director Mk 37)

Reference point bearing corrections

Level (with respect to reference point line of sight) to main battery directors

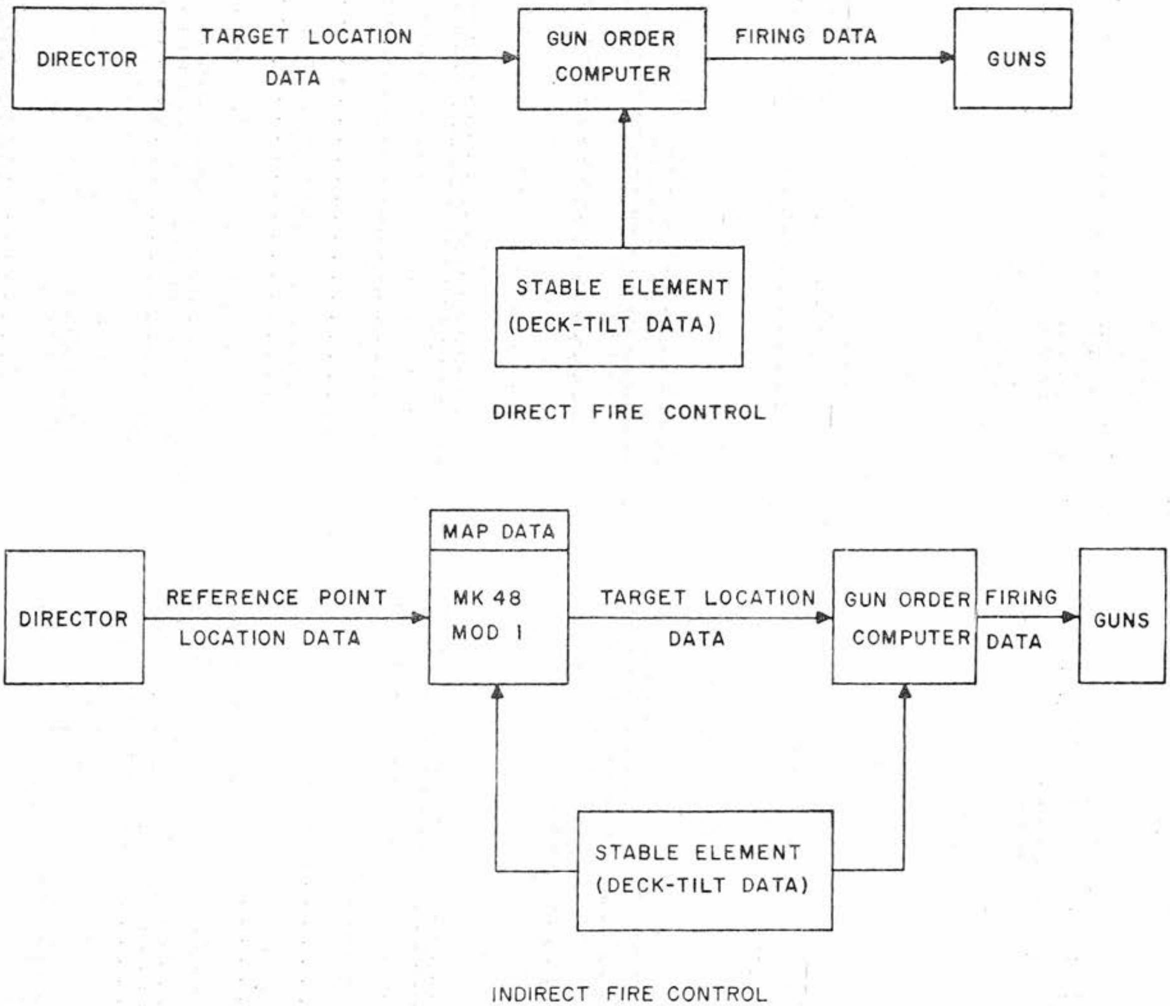

Figure 2. Direct and Indirect Fire Control

Cross level and level plus a function of cross level (with respect to reference point director line of sight) to Gun Director Mk 37

These quantities are described in chapter 4.

Computer Mk 48 Mod 1 also can perform the following functions:

Local control when director information is not available

Dead reckoning navigation

Determine set and drift by plotting successive target positions

Since an antiaircraft, AA, fire control system, generally used with the secondary batteries, is a three-axis system, and the main battery, MB, system generally used for surface fire is a two-axis system, differences exist between the systems in the method of measuring some angles involved in the fire control problem. This necessitates two solutions for some of the quantities computed by Computer Mk 48 Mod 1, one solution for MB and one for AA. For simplicity, fire control symbols for a two-axis system are used throughout this publication and, where necessary for clarity, equivalent three-axis symbols are included in parentheses. The method by which Computer Mk 48 Mod 1 computes for the two types of systems is described in chapter 4.

ASSOCIATED FIRE CONTROL SYSTEMS

Computer Mk 48 Mod 1 is designed to function with Gun Directors Mk 34, Mk 37, Mk 38, and Mk 54; Stable Vertical Mk 41 and Stable Element Mk 6; Range Keeper Mk 8 with Target Elevation Indicator Mk 66; and Computer Mk 1A (figures 3 and 4).

REFERENCES

Gun Director Mk 34:	OP 1057
Gun Director Mk 37:	OP 1060
Gun Director Mk 38:	OP 810
Gun Director Mk 54:	OP 1352
Stable Vertical Mk 41:	OP 1170
Stable Element Mk 6:	OP 1063
Range Keeper Mk 8:	OP 1068
Computer Mk 1A:	OP 1064

SCOPE

This publication contains operating, maintenance, and installation instructions for Computer Mk 48 Mod 1. Physical and functional descriptions of the instrument also are given. Maintenance procedures contained in chapter 5 include instructions for using the special portable test unit supplied with the instrument.

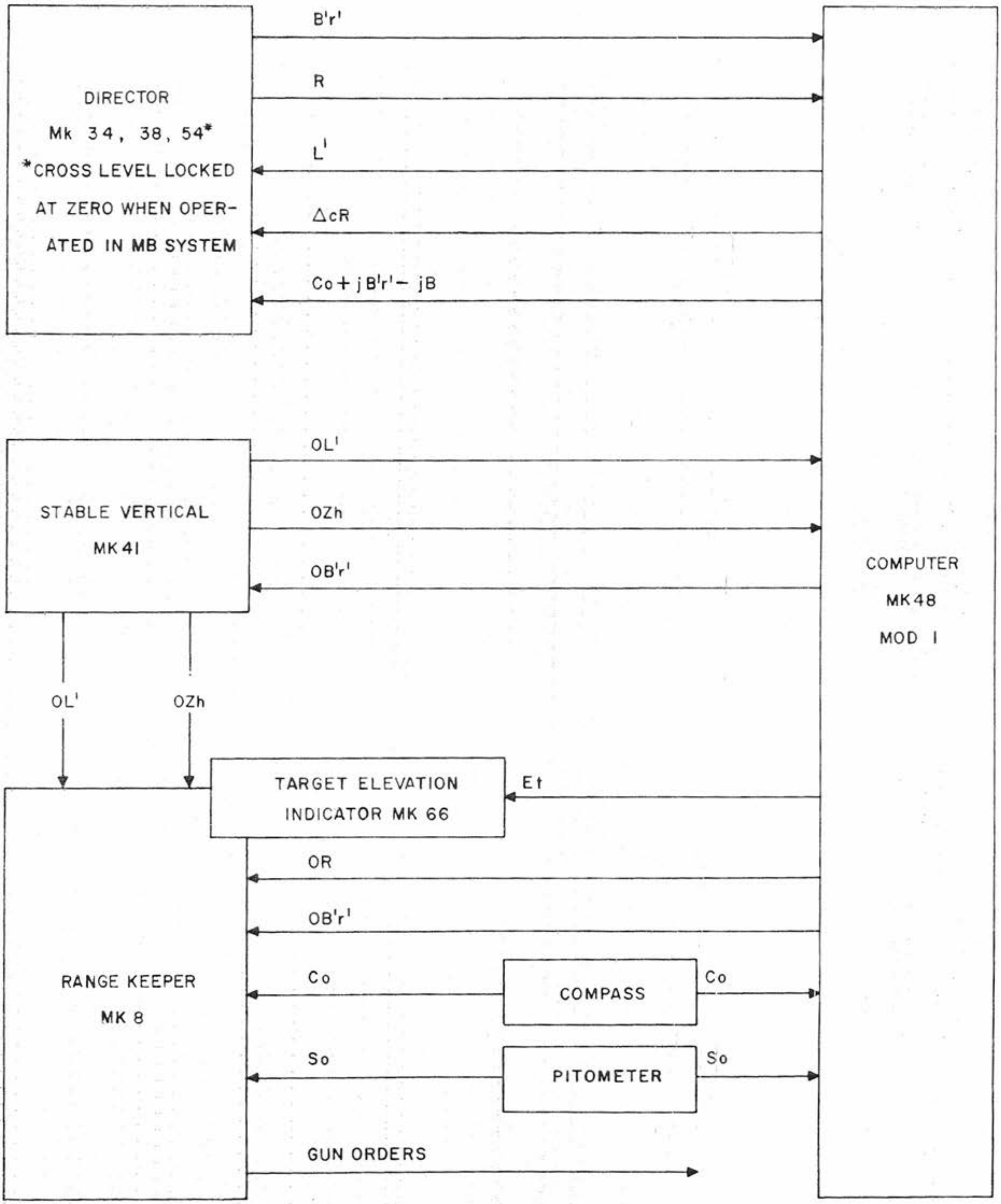

Figure 3. Two-Axis (MB) Indirect Fire Control Systems

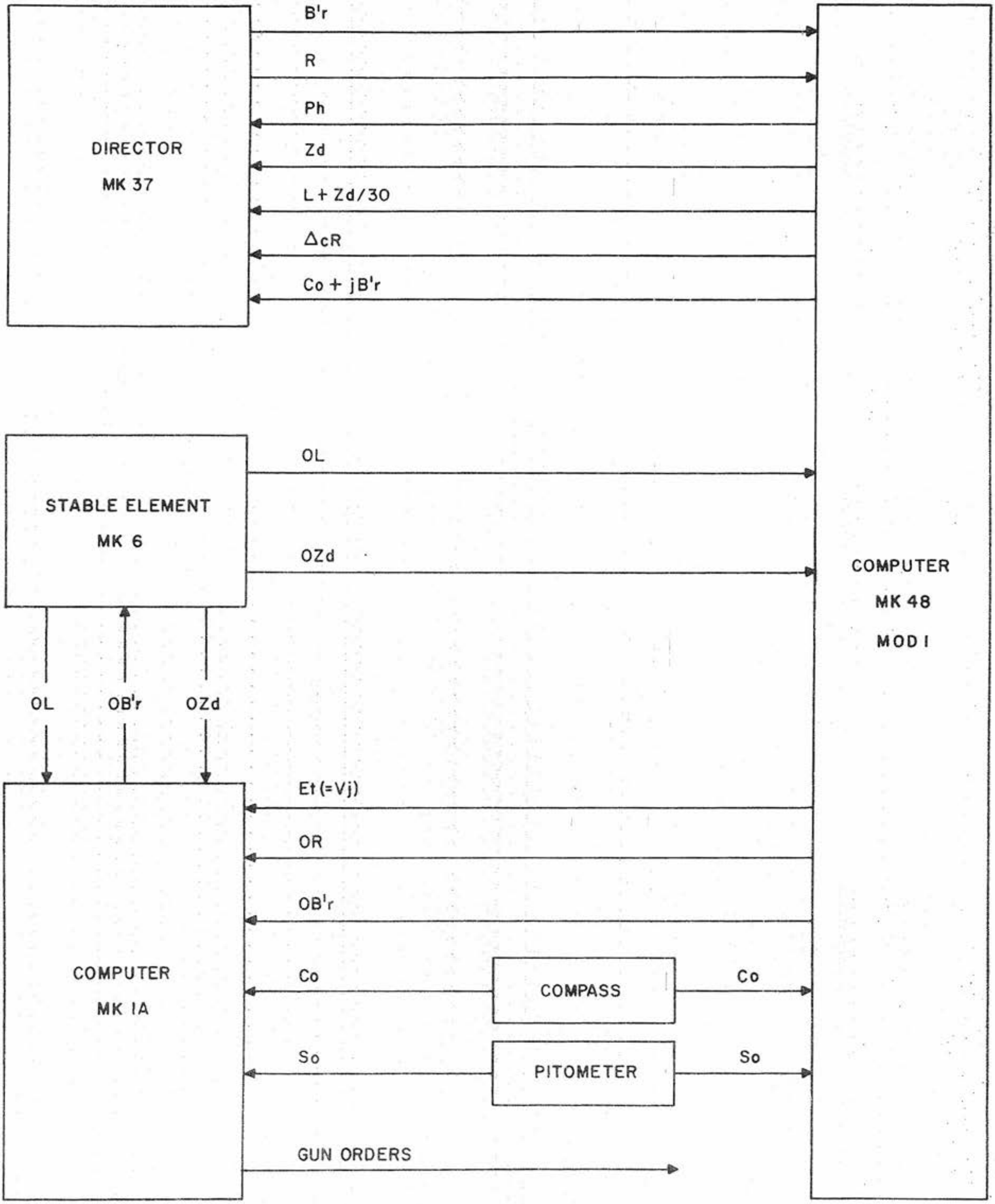

Figure 4. Three-Axis (AA) Indirect Fire Control Systems

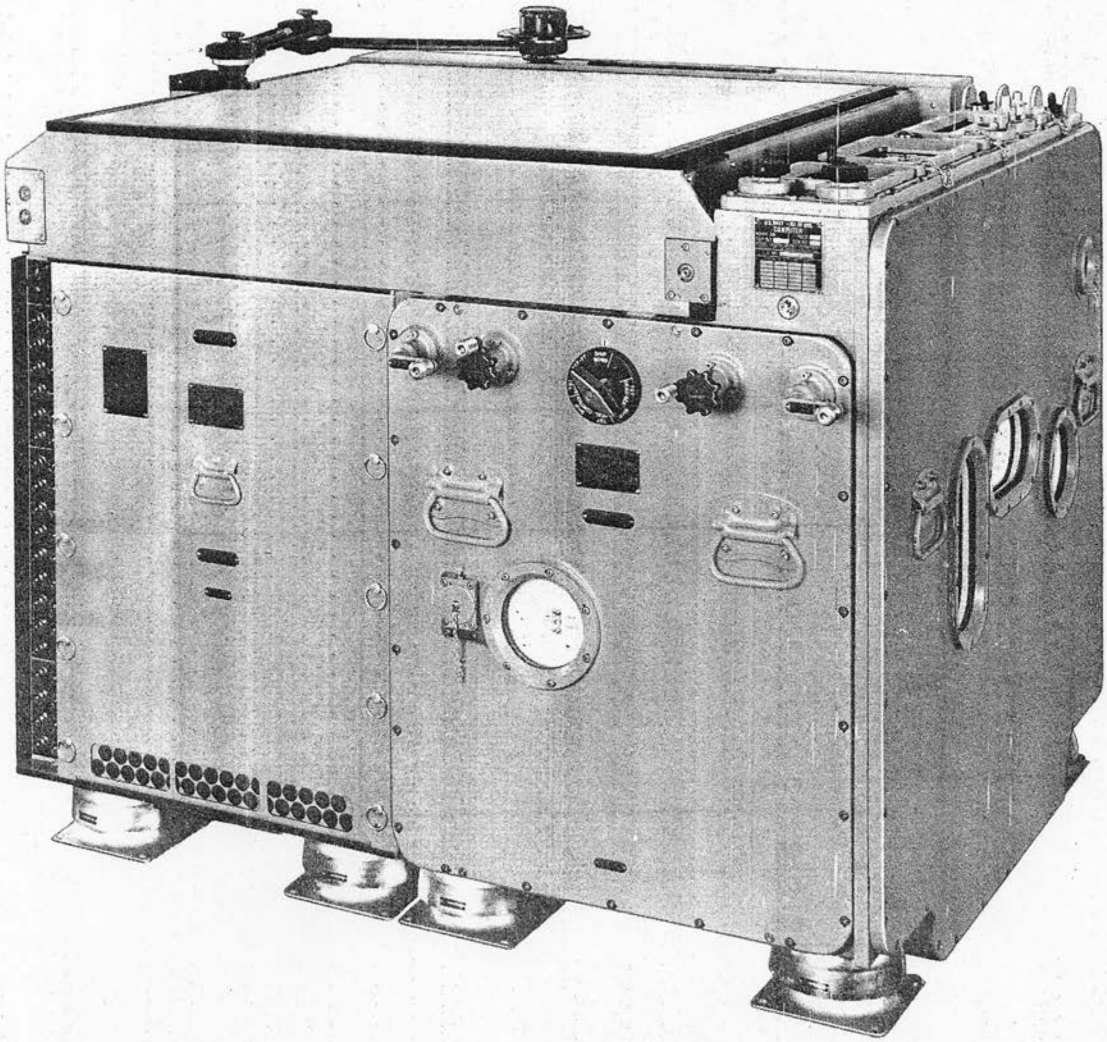

Figure 5. Computer Mk 48 Mod 1

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Chapter 2

PHYSICAL DESCRIPTION

Computer Mk 48 Mod 1 contains electro-mechanical and electronic devices arranged as a mechanical section, an electronic section, and a plotter assembled together as shown in figure 5. A separate motor-generator set with controls supplies 350-volts DC to the computer. This set is not part of the computer and is maintained by a different activity. A portable test unit, figure 6, for measuring the value of computed voltages is furnished with the equipment. The computer weighs 2136 pounds and is shock-mounted on the deck. The portable test unit weighs about 75 pounds.

MECHANICAL SECTION AND PLOTTER

The plotter covers the top of the mechanical and electronic sections, except for a narrow strip on the mechanical section that carries operating controls, figure 7. A parallel motion protractor is attached to the plotter. The protractor is not used for indirect fire control, but is furnished for auxiliary functions described in chapter 3.

Additional operating controls are on the front of the mechanical section, figure 8. On the right side of this section are transmitter check dials and the radar beacon delay spot, Rj, dial, figure 9. The SCALE FACTOR counter and handcrank are on the rear panel of the mechanical section, figure 10. Within the mechanical section are all the receivers, computing and generating mechanisms, and transmitters of Computer Mk 48 Mod 1.

ELECTRONIC SECTION

The electronic section houses the network boxes, amplifiers, servo controls, and switching circuitry. On the front panel of the electronic section are the lights and switches of the neon monitoring system. Test-unit connectors, voltmeters, and fuses are on panels at the rear, figure 11.

INPUTS AND OUTPUTS

The manual inputs are set into the plotter with a knob or crank either by positioning a dial or counter or by positioning the plotter index light. The automatic inputs are received by synchro transmission. However, to test the computer, some normally automatic inputs (ship speed, ship course, range, and director train) may be set manually. Outputs are by synchro transmission. The inputs and outputs of Computer Mk 48 Mod 1 are:

Manual Inputs

Height of reference point, Hs

Height of target, Ht

East-west position of own ship, Xo

North-south position of own ship, Yo

East-west position of reference point, Xa

North-south position of reference point, Ya

East-west position of target, Xt

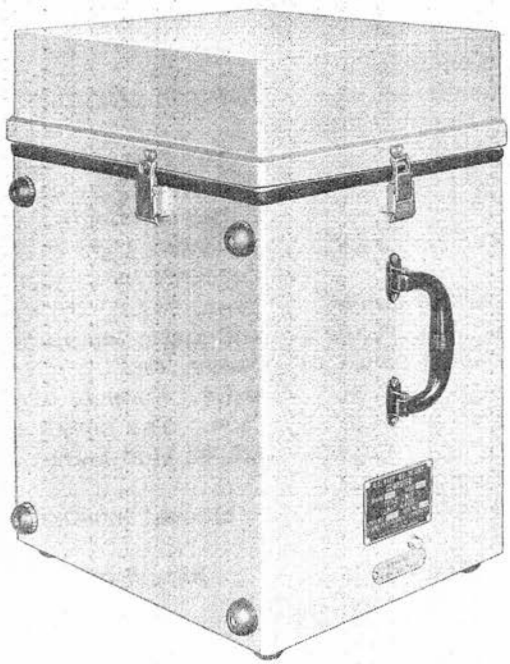

Figure 6. Test Unit

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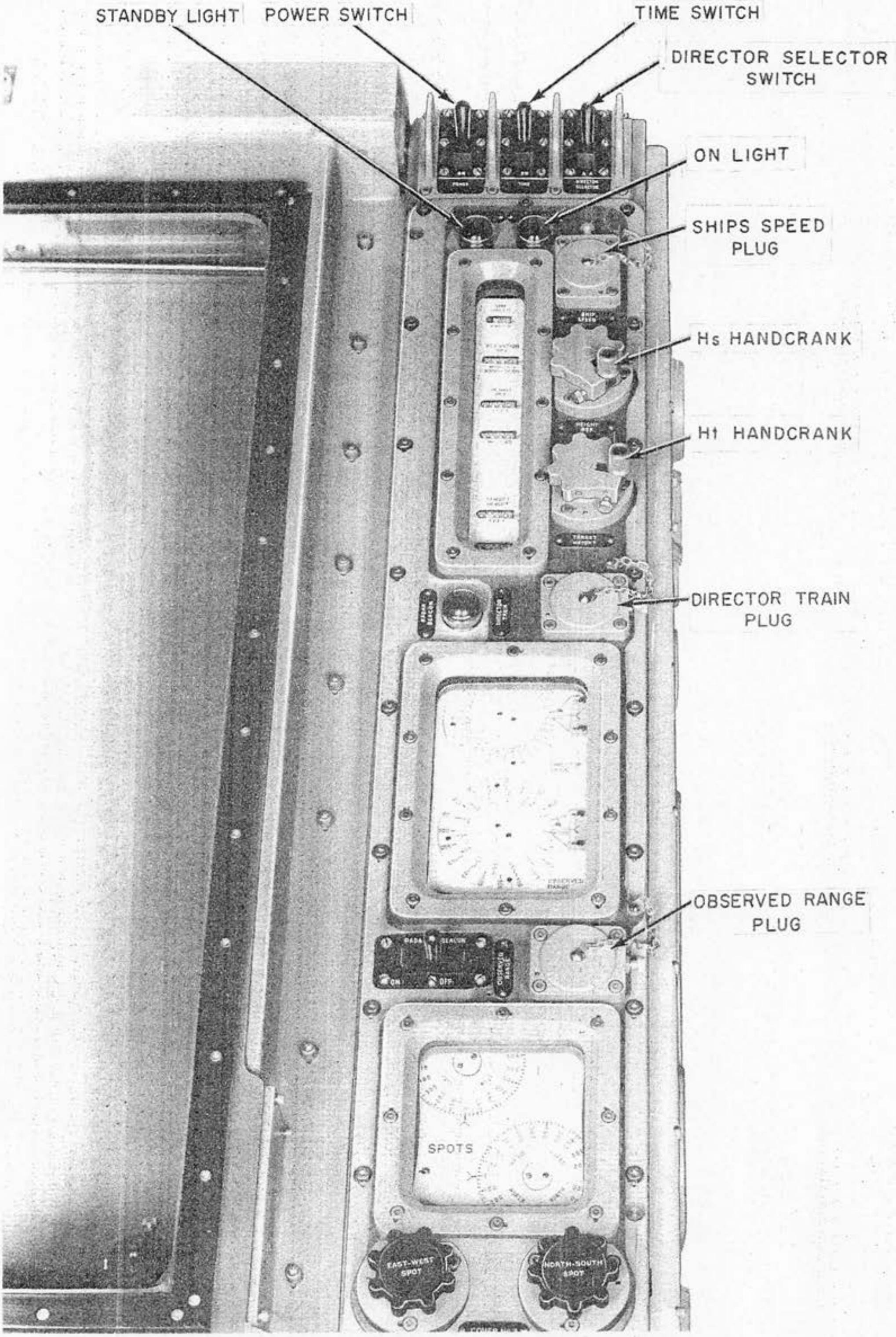

Figure 7. Controls on Top of Computer Mk 48 Mod 1

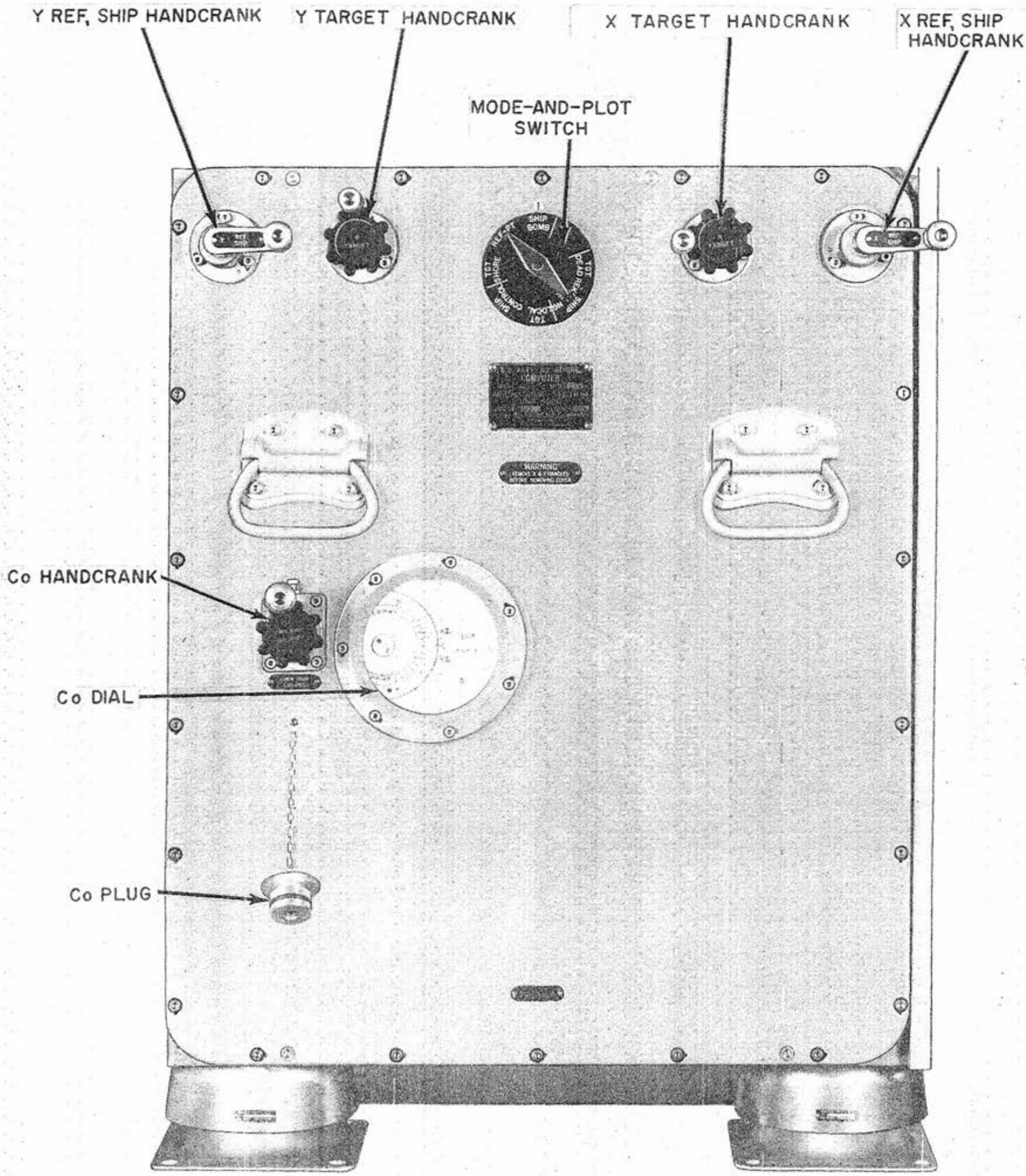

Figure 8. Controls on Front of Computer Mk 48 Mod 1

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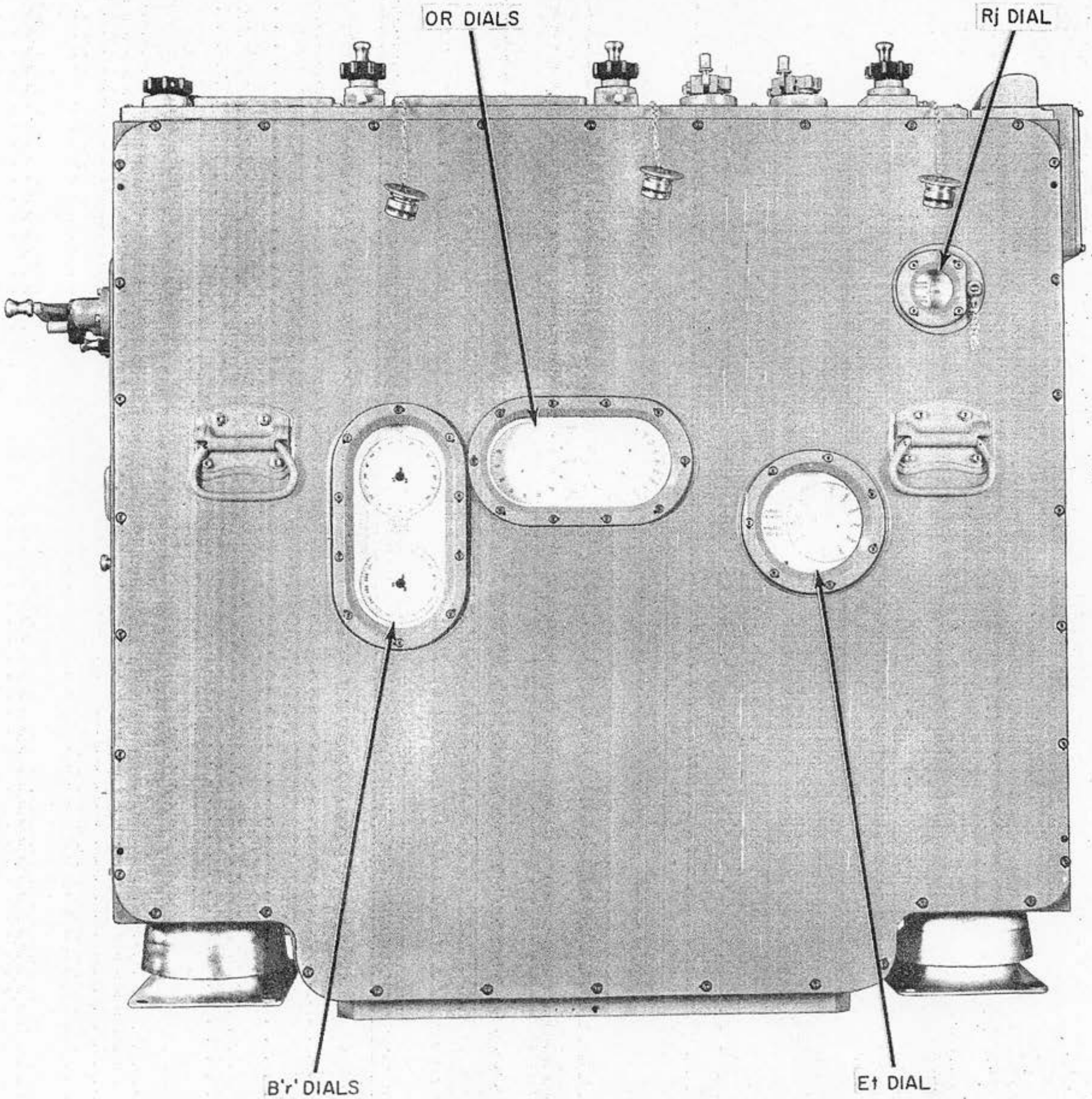

Figure 9. Dials on Right Side of Computer Mk 48 Mod 1

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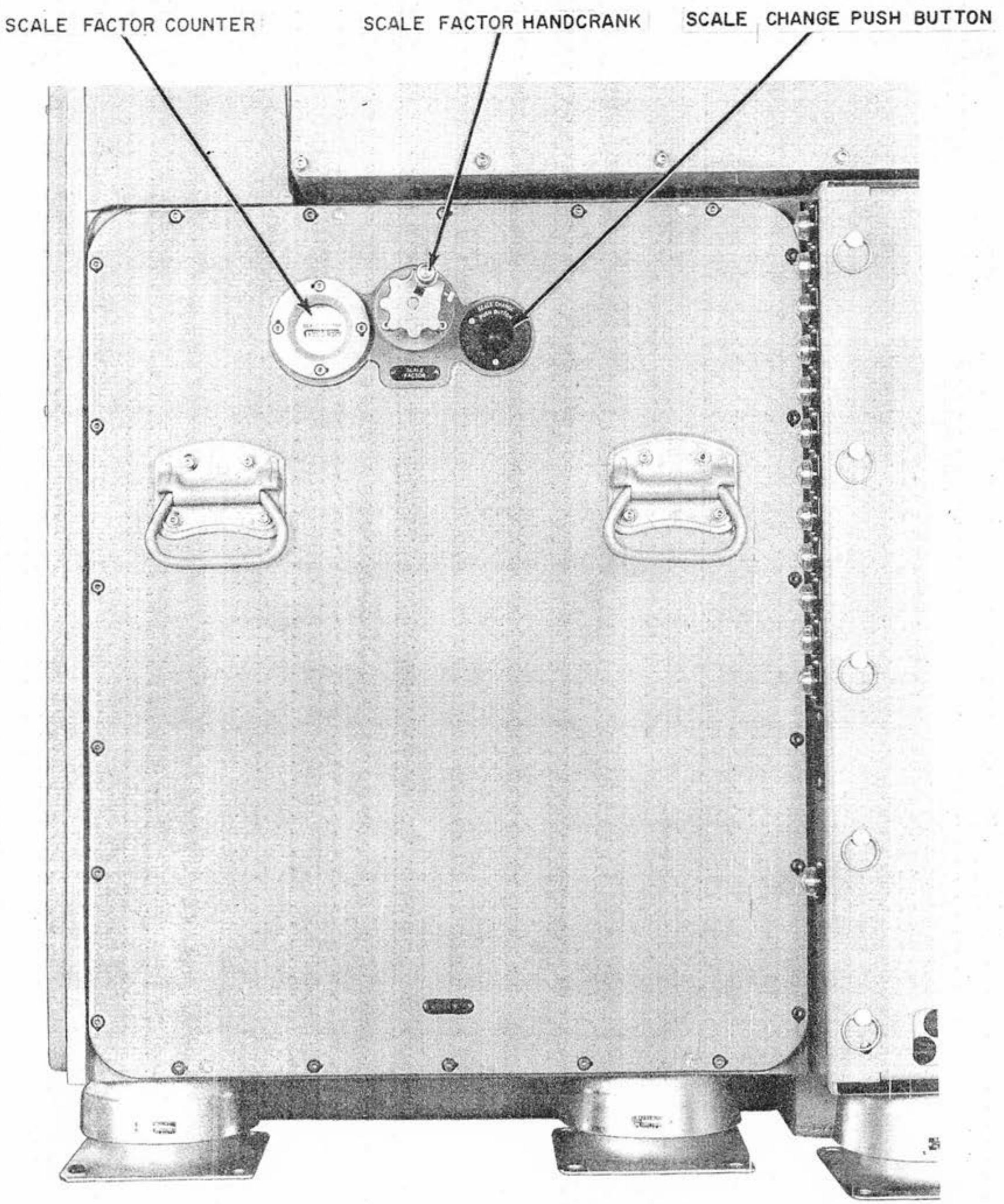

Figure 10. Computer Mk 48 Mod 1, Mechanical Section, Rear View

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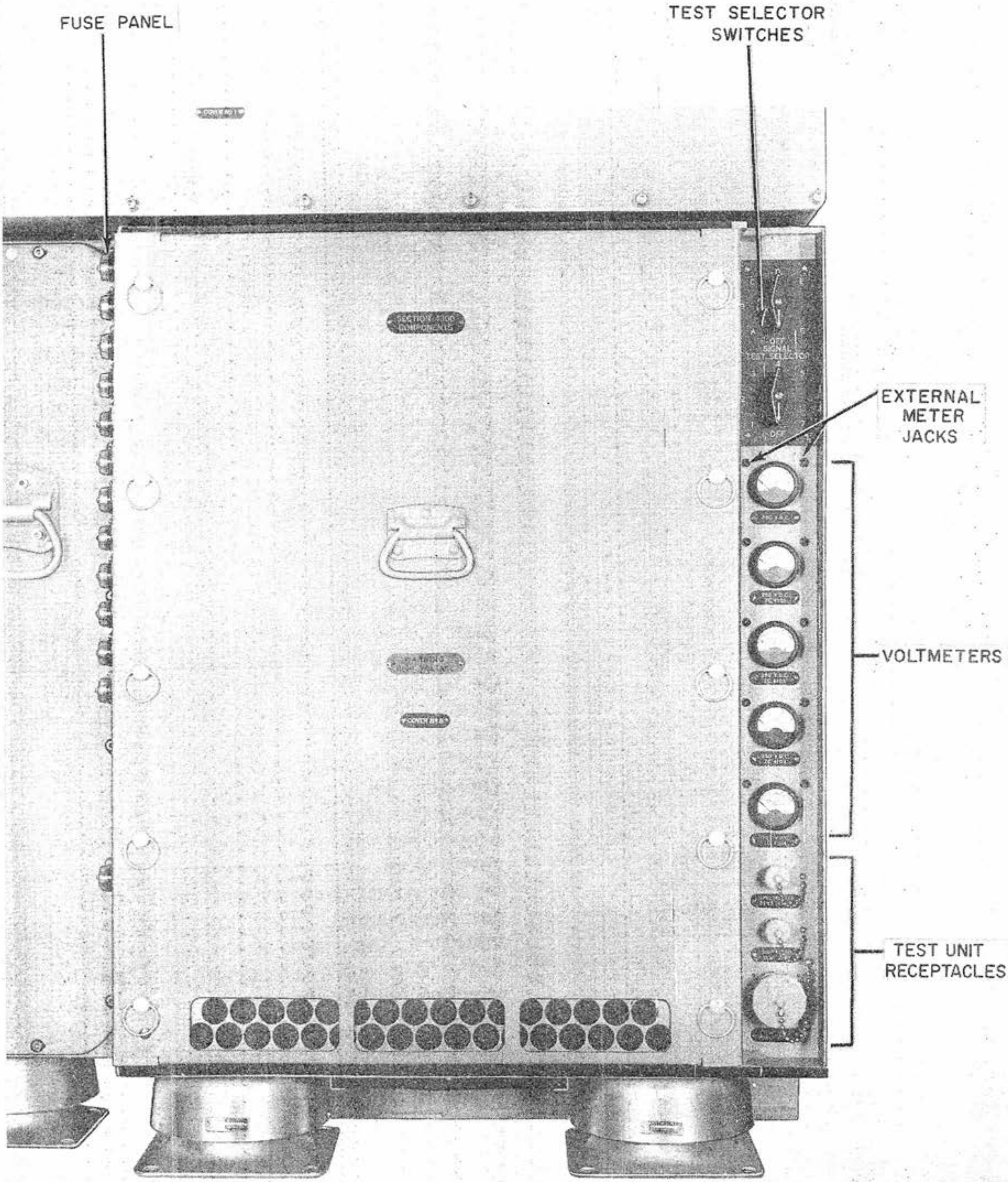

Figure 11. Computer Mk 48 Mod 1, Electronic Section, Rear View

North-south position of target, Yt

East-west spot, Xj

North-south spot, Yj

Radar beacon delay spot, Rj

Scale factor

Automatic Inputs

Ship speed, So

Ship course, Co

Range, R

Director train, B'r' (2-axis) or B'r (3-axis)

Offset level, OL' (2-axis) or OL (3-axis)

Offset cross level, OZh (2-axis) or OZd (3-axis)

Test Inputs (Manual)

Ship speed, So

Ship course, Co

Range, R

Director train, B'r', or (B'r)

Electrical Outputs (by synchro transmission)

Range to target, OR

Target elevation, Et

Increments of generated range, ΔcR

Horizontal Parallax, Ph (3-axis)

Offset relative target bearing (director train to target), OB'r' (2-axis) or OB'r (3-axis)

Train control, Co + jB'r' - jB (2-axis) or Co + jB'r (3-axis)

Level, L' (2-axis) or L (3-axis)

Cross level, Zd (3-axis)

Level and function of cross level, L + Zd/30 (3-axis)

OPERATING LIMITS

The computer mechanisms are protected against damage from overruns by limit stops that engage before the limit of travel of their related mechanisms is reached. The various limit stops, their limits of operation, and the quantities affected are shown in table 1.

TRANSMITTER AND RECEIVER SYNCHROS

The synchro units used in Computer Mk 48 Mod 1 are listed in table 2. Table 2 includes a "speed" column, or synchro shaft value per revolution. Depending on whether the Mk 37 Gun Director drive is of the Arma or Amplidyne type, the quantities level, plus a function of cross level (L + Zd/30), and train control, (Co + jB'r' - jB), are transmitted at either of two speeds. As manufactured, the gearing of Computer Mk 48 Mod 1 is for the Amplidyne director drives (10 degrees per revolution). Change gears are furnished for the Arma director drives (5 degrees per revolution). When the computer is installed, the speed of the (L + Zd/30) and (Co + jB'r' - jB) transmitters should be checked for agreement with the gun director receivers, and the gears in the computer changed if necessary (see chapter 6).

The transmitters for cross level (Zd) and level plus a function of cross level (L + Zd/30) do not enter into MB operation.

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Table 1

LIMIT STOPS

Limit Stop No	Quantity	Limits
L-1	Yp	0-32.8 in
L-2	Xp	0-32.8 in
L-3	Yj	±1000 yds
L-4	Et	2000'-3200' (0 to 20°)
L-5	Hs	0-5000 ft (0-1524 meters)
L-6	Ht	0-5000 ft (0-1524 meters)
L-7	Es	2000'-3800' (0 to 30°)
L-8	OR	500-50,000 yds
L-9	Xj	±1000 yds
L-10	L' (MB) or L (AA)	±25°
L-11	Zd (AA only)	±25°
L-12	OL' (MB) or OL (AA)	±25°
L-13	OZh (MB) or OZd (AA)	±25°
L-14	jOB'r' -jB'r' (MB) or jOB'r -jB'r (AA)	±20°
L-15	jOB'r' (MB) or jOB'r (AA)	±20°
L-16	jB	±15°
L-17	Ph	±12°
L-18	So	0-55 kn
L-19	R	500-50,000 yds
L-20	Scale factor	1:10,000-1:100,000

Table 2

TRANSMITTER AND RECEIVER SYNCHROS

Function	Symbol MB	Symbol AA	Type	Quan	Element	Speed
Ship speed	So	(So)	5B	1	B4070	40/kn/rev
Ship course	Co	(Co)	1HCT	2	B4052, B4053	10°/rev, 360°/rev
Range	R	(R)	1HCT	2	B4050, B4051	2000 yds/rev 72, 000 yds/rev
Director train	B'r'	(B'r)	1HCT	2	B4054, B4055	10°/rev, 360°/rev
Offset level	OL'	(OL)	1HCT	2	B4056, B4057	10°/rev, 180°/rev
Offset cross level	OZh	(OZd)	1HCT	3	B4058, B4059, B4060	5°/rev, 10°/rev, 180°/rev
Range tracking aid	ΔcR	(ΔcR)	5HG	1	B4073	1000 yds/rev
Horizontal parallax		(Ph)	6HG	1	B4074	30°/100 yds
Range to target	OR	(OR)	5HG	2	B4062, B4063	2000 yds/rev, 72, 000 yds/rev
Target elevation	Et	(Et)	5HG	1	B4061	360 mils/rev
Cross level		(Zd)	6HG	2	B4064, B4065	5°/rev, 180°/rev
Level	L'	(L)	6HG, 5HG	2	B4067, B4075	10°/rev, 180°/rev
Level plus function of cross level		(L + Zd/30)	6HGB	1	B4066	10°/rev or 5°/rev (per change-gears)

Table 2 (Cont'd)

TRANSMITTER AND RECEIVER SYNCHROS

Function	Symbol		Type	Quan	Element	Speed
	MB	AA				
Offset relative target bearing	OB'r'	(OB'r)	6HG	2	B4068, B4069	10°/rev, 360°/rev
Train control	Co + jB'r' - jB	(Co + jB'r)	6HG, 5HG	2	B4071, B4072	5°/rev, 10°/rev

MOTOR-GENERATOR SET

This unit supplies +350-volts DC to the 250-volt series voltage regulator, the tuning fork amplifier, and the servo amplifiers in the electronic section of the computer. From this unit, therefore, all the operating DC voltages of the computer are derived. The motor-generator set is equipped with controls for starting, stopping, and functioning under varying conditions. The functions of the motor-generator controls are detailed in table 71. For complete details on the motor-generator set, refer to NAVSHIPS 363-0686.

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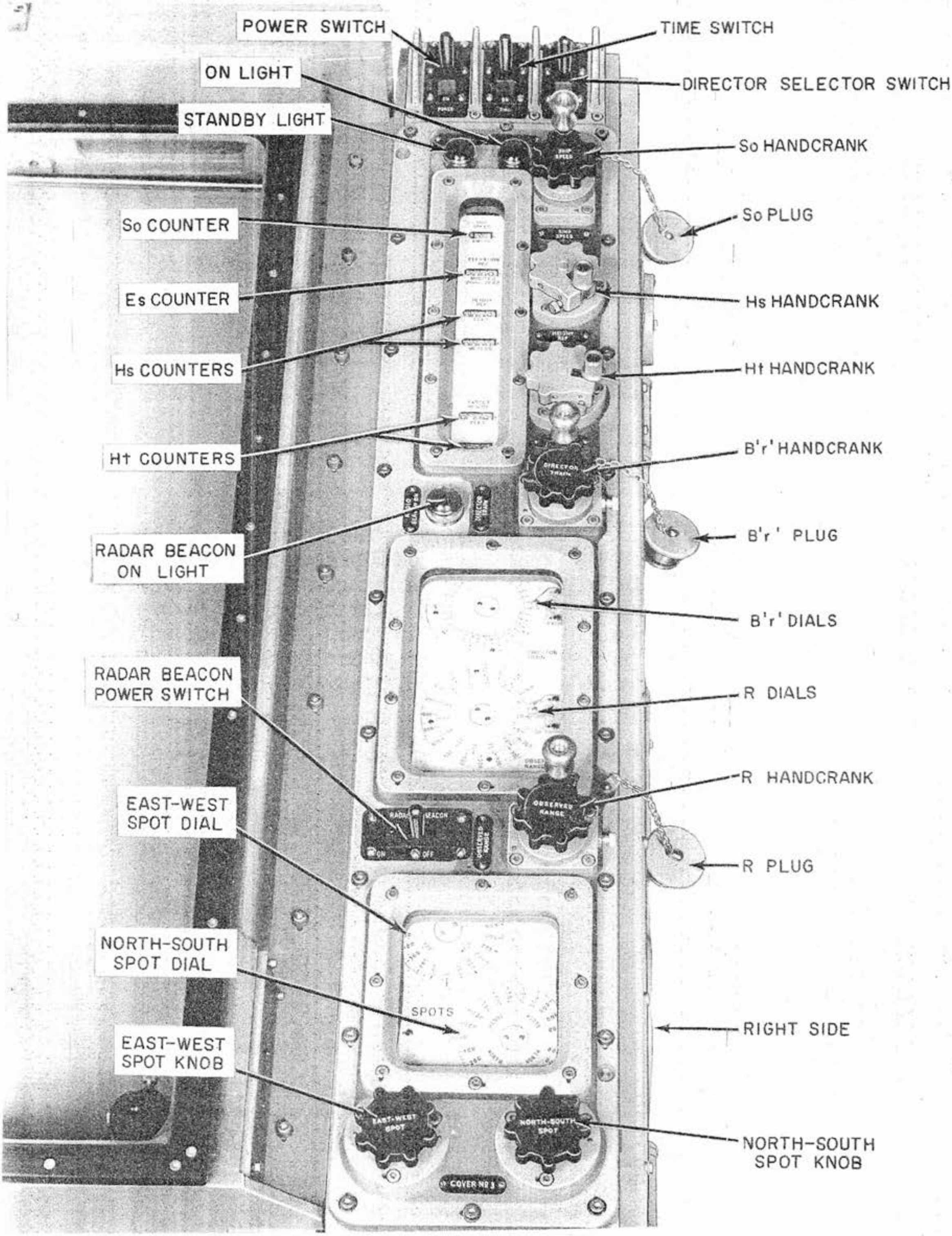

Figure 12. R, B'r', and So Handcranks Installed

Chapter 3

OPERATION

This chapter describes the essential features of the operating controls on Computer Mk 48 Mod 1, tables 3 through 6, and on the motor-generator set, and shows how these controls are used to operate the computer and motor-generator. Operation and use of the test unit is contained in chapter 5.

OPERATING CONTROLS

The operating controls of the computer are handcranks, switches, and indicating devices. These controls are located on the top, front, rear, and right side of the computer. Some of the controls on the front are for monitoring purposes only, and some on the rear are for test purposes.

The storage shelf located near the computer is used to hold the ship speed, ship course, director train, and observed-range handcranks during automatic operation; sealing plugs are provided for plugging the handcrank holes in the covers of the computer, figure 7. When values of these functions are set into the computer for testing purposes, the plugs may be removed and the handcranks installed for manual operation, figure 12. When the handcranks are not in use, the plugs should be kept in place. In circumstances requiring intermittent use of the handcranks, the handcrank assemblies may be partially withdrawn and locked in the unmeshed position by engaging the locking pin in a second hole.

TEST CONTROLS

In addition to the operating controls already listed, five voltmeters, a pair of test-selector switches, three test unit connecting receptacles, and a panel of indicator-type fuses are mounted on the rear of the electronic section of Computer Mk 48 Mod 1, figure 11.

Each voltmeter is calibrated to indicate percentage (from 0 to 120) of the nominal value listed on the legend plate beneath it. These voltmeters are used to give a rough indication of the operation of the motor-generator set and voltage regulators. The terminals of each meter are brought out to the panel jacks so that an external voltmeter can be connected for taking exact readings. From top to bottom, the meters indicate the outputs of the motor-generator set, the three 250-volt voltage regulators, and the -105-volt regulated power supply; the legend plates are marked and the meters indicate as follows:

Legend Plate	Meter Indication (Approximate)
350 V.D.C.	Reading of 100 percent indicates motor-generator set is delivering +350 v DC to computer.
250 V.D.C. ZC4101	Reading of 100 percent indicates voltage regulator ZC4101 is delivering +250 v DC.

Table 3

CONTROLS ON TOP PANEL OF COMPUTER MK 48 MOD 1

(figures 7 and 12)

Device	Function
POWER switch	With 60-cycle power available and the power supply ON as later described, supplies all electrical components except synchros. At STANDBY, the heaters of all tubes are energized, the -105 v supply is available, and the fan operates; no computing or plate voltages are supplied. At ON, all units are energized, provided the switch has been at STANDBY for at least 30 seconds. Otherwise there will be a 30-second time delay before all circuits are operative. If the overvoltage relay in the power supply is actuated, movement of this switch from ON to STANDBY to ON will reset the relay. If it again kicks out, the source of the trouble must be located.
STANDBY (amber) light	Lights whenever POWER switch is at STANDBY or ON and the power-input line to Computer Mk 48 Mod 1 is energized.
ON (red) light	Lights whenever POWER switch is at ON and the power-input line is energized.
TIME switch	Operates when POWER switch is at ON. A two-position switch that turns time motor ON or OFF.
DIRECTOR SELECTOR switch	A two-position switch that sets-up the computer for operation with either the MB or AA director.
SHIP SPEED counter and handcrank	The counter shows the value of ship speed set into the computer. Ship speed can be set in manually by handcrank or received automatically by synchro. Handcrank is disengaged or removed for automatic operation, but So counter must be within 20 knots of true ship speed when receiver is energized or incorrect synchronization will result. Right-hand drum of counter graduated in 2/10 of a knot: one revolution equals 10 knots. Counter limits 0 to 55 knots. One revolution of handcrank equals 1.375 knots.

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Table 3 (Cont'd)

CONTROLS ON TOP PANEL OF COMPUTER MK 48 MOD 1

(figures 7 and 12)

Device	Function
ELEVATION REF counter	Indicates elevation of reference point as computed by the instrument; 2000 minutes equals zero elevation; maximum elevation 3800 minutes. Each graduation of right-hand drum equals 1 minute; one revolution equals 40 minutes. Primarily for test use.
HEIGHT REF counters and handcrank	Handcrank sets in map value of height of reference point in feet or meters. One revolution of handcrank equals 40 feet or approximately 12. 2 meters. Counters indicate height of reference set in by handcrank. Each graduation of FEET counter equals 1 foot, one revolution equals 40 feet. Each graduation of METERS counter equals 0. 2 meters, one revolution equals 10 meters.
TARGET HEIGHT counters and handcrank	Handcrank sets in map value of height of target in feet or meters. One revolution of handcrank equals 40 feet or approximately 12. 2 meters. Counters indicate height of target set in by handcrank. Each graduation of FEET counter equals 1 foot, one revolution equals 40 feet. Each graduation of METERS counter equals 0. 2 meters, one revolution equals 10 meters.
RADAR BEACON ON light	Yellow lamp glows when RADAR BEACON ON-OFF switch is at ON.
DIRECTOR TRAIN dials and handcrank	Dials indicate the value of director train set into the computer. Director train can be received automatically or set in manually by the handcrank, which is disengaged or removed for automatic operation. One revolution of handcrank equals 3 degrees. On ring dial each graduation equals 10 minutes, one revolution equals 10 degrees. On disk dial each graduation equals 10 degrees, one revolution equals 360 degrees.

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Table 3 (Cont'd)

CONTROLS ON TOP PANEL OF COMPUTER MK 48 MOD 1

(figures 7 and 12)

Device	Function
OBSERVED RANGE dials and handcrank	Dials indicate value of observed range set into computer. Observed range can be set in manually by the handcrank or received automatically. Handcrank is disengaged or removed for automatic operation. One revolution of handcrank equals 400 yards. Each graduation of ring dial equals 50 yards, one revolution equals 2000 yards. Each graduation of disk equals 1000 yards, one revolution equals 72,000 yards.
RADAR BEACON ON-OFF switch	A two-position switch. At ON, the radar-beacon delay spot is introduced and the RADAR BEACON ON light glows; at OFF, the spot potentiometer is disconnected and the light is off.
EAST-WEST and NORTH-SOUTH SPOT dials and knobs	The east-west and north-south spot knobs and dials are used to set spots into the computer. One revolution of either knob equals 550 yards. Each graduation on either dial equals 25 yards, one revolution equals 220 yards. Half of the east-west dial indicates for East spots, half for West. Half of the north-south dial indicates for North spots, half for South spots.

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Table 4

CONTROLS ON FRONT PANEL OF COMPUTER MK 48 MOD 1

(figure 8)

Device	Function
OWN SHIP COURSE dials and handcrank	Dials indicate value of own ship course set into computer. Removable handcrank can be used to set in own ship course manually. One revolution of handcrank equals 3 degrees. Each ring dial graduation equals 10 minutes, one revolution equals 10 degrees. Each disk dial graduation equals 10 degrees, one revolution equals 360 degrees.
Mode-and-Plot switch	An 8-position switch, used when setting chart coordinates, for firing without director, or when using computer as navigation aid. Eighth position of switch is OFF. For complete functional description of this switch, see chapter 4.
X or Y TARGET handcrank	These handcranks are used in conjunction with the plotter to crank in the values of the coordinates of target position as obtained from a chart, when mode selector switch is at SHORE BOMB TGT or LOCAL CONTROL TGT. These handcranks position the plotter index light at the map position of the target. Once cranked in, the values continue to be used to compute target for any position of mode selector other than the dead-reckoning positions. One revolution of either handcrank equals 1000 yards.
X or Y REF SHIP handcrank	These handcranks are used to crank into the computer the coordinate values of own ship or reference-point position, as obtained from the map on the plotter. These handcranks position the plotter index light at the map position of the reference point or own ship. The specific quantity cranked in is determined by the mode-and-plot switch position. One revolution of either handcrank equals 1000 yards. For a complete description of the mode-and-plot switch functions, refer to chapter 4.
SC-SA TEST and SC-SA NEON TEST switches (figure 43)	For testing the condition of the servo controls, servo amplifiers, computing amplifiers, and neon lights. Operation of these switches is covered in chapter 5, section 3.

Table 5

CONTROLS ON RIGHT SIDE OF COMPUTER MK 48 MOD 1

(figure 9)

Device	Function
RELATIVE TARGET BEARING dials	Indicate computed value of relative target bearing. One revolution of fine dial equals 10 degrees, each graduation equals 5 minutes. One revolution of course dial equals 360 degrees, each graduation equals 5 degrees.
RANGE TO TARGET dials	Indicate computed target range. One revolution of fine dial equals 2000 yards, each graduation equals 50 yards. One revolution of coarse dial equals 72,000 yards, each graduation equals 1000 yards.
TARGET ELEVATION dial	Indicates computed value of target elevation. One revolution equals 1237.89 minutes, each graduation equals 10 minutes. Zero elevation at 2000 minutes.
RADAR BEACON DELAY YARDS dial and input	Indicates in yards value of range spot introduced to compensate for radar-beacon delay. Spot can vary from 100 to 400 yards; each dial graduation equals 10 yards. Spot is set in with adjustment screw under plug at side of dial.

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Table 6

CONTROLS ON REAR OF COMPUTER MK 48 MOD 1

(figure 10)

Device	Function
SCALE FACTOR counter	Indicates value of map scale in use with plotter, variable from 10,000:1 to 100,000:1. Only three left-hand drums of counter revolve. From left to right, drums indicate tens of thousands, thousands, and hundreds. Upper limit, 100,000:1, reads all ciphers.
SCALE FACTOR handcrank	When SCALE CHANGE PUSH BUTTON is pushed in, handcrank can be used to change scale ratio to agree with scale of chart on plotter. One revolution of handcrank changes scale by 1000:1.
SCALE CHANGE PUSH BUTTON	When button is pushed in, SCALE FACTOR handcrank engages gear line. When button is released, handcrank is disengaged from gear line.

Legend Plate	Meter Indication (Approximate)
250 V.D.C. ZC4102	Reading of 100 percent indicates voltage regulator ZC4102 is delivering +250 v DC.
250 V.D.C. ZC4103	Reading of 100 percent indicates voltage regulator ZC4103 is delivering +250 v DC.
-105 V.D.C. ZC4104	Reading of 100 percent indicates regulator power supply ZC4104 is delivering -105 v DC.

The TEST-SELECTOR switches and the connection facilities near the bottom of the panel are used to connect prescribed test circuit points within the computer to the special test unit. A detailed description of the operation of the switches and the test unit is contained in chapter 5.

The fuse panel is equipped with sockets that have transparent covers for visual detection of blown fuses. A red indicator dot can be seen through these covers when a fuse has burned out. A cover plate at the lower end of the fuse panel provides access to a storage receptable for spare fuses. For detailed information on the fuses, refer to table 24.

PLOTTER AND PROTRACTOR

Plotter

In shore bombardment the plotter is used as an indicator when setting target, reference point, or own ship position into

Computer Mk 48 Mod 1. In conjunction with the protractor, the plotter can be used to lay out target position in terms of range and bearing from own ship or from a spotter's position, or to lay out a new target from the old target position. It also may be used to measure set and drift. Although normally not required for the shore bombardment mode, the protractor may be used to establish safety zones and for similar measurement purposes.

The plotter index light projects the image of a cross mark through a chart mounted on its glass surface. As the TARGET and REF-SHIP handcranks move the projected cross mark to the target position and then to the reference point position (the order is unimportant), the relative positions of the target and the reference point with respect to a N-S E-W rectangular coordinate system are introduced into the computer (see chapter 4).

Protractor

This device consists essentially of a calibrated protractor and linear scale, supported by a parallel motion mechanism over the plotting surface, figure 13. The bracket supporting the mechanism has an adjustable pivot in the form of a knurled screw with a lock nut. This pivot, which permits raising and lowering of the protractor, can be adjusted to eliminate side-play or loosened to remove the mechanism. On each of the pivots of the parallel motion arms, a knob is provided for adjusting the friction of the pivot.

The protractor head is calibrated from 0 to 360 degrees in 1-degree graduations. A quarter turn (counterclockwise) of the PROT LOCK loosens the protractor scale so it can be rotated to align its zero graduation with North on the chart and plotter. With PROT LOCK in a locked position, the protractor scale maintains the alignment regardless of movement over the plotting area.

The witness plate (inner movable ring, figure 13) contains four indexes spaced 90 degrees apart. A quarter turn (counterclockwise) of the scale lock loosens the witness plate so it can be moved to any angular position against the protractor scale by turning the protractor hand knob. When locked in position, the protractor maintains the indexes in a fixed position with respect to the protractor scale.

For fine control of the witness plate, a vernier knob mounted on the hand knob can be engaged by swinging the vernier knob toward the center of the hand knob. The reverse action disengages the vernier for coarse control.

The 24-inch composite scale supplied with the equipment is designed for use with a computer scale factor of 25,000 or 50,000 to 1. It has two sets of range-time-speed calibrations from which the set and drift of own ship can be determined by measuring the directional distance of deviation from course during a fixed-time interval. The scale is illustrated in figure 13. The chuck on the 24-inch composite scale is friction-fitted to the tapered slot of the protractor scale arm. The composite scale moves in correspondence with the witness plate.

SHORE-BOMBARDMENT AUXILIARY SWITCHBOARD

An auxiliary switchboard installed near the computer connects the main switchboard and the computer. This auxiliary switchboard permits connecting the computer to the director, gun order computer, and stable element selected at the main switchboard, or bypassing the computer entirely. The DIRECTOR SELECTOR switch on the computer sets up the computer for operation with either a two-axis (MB) or a three-axis (AA) system. Once the system is selected at the main switchboard, Computer Mk 48

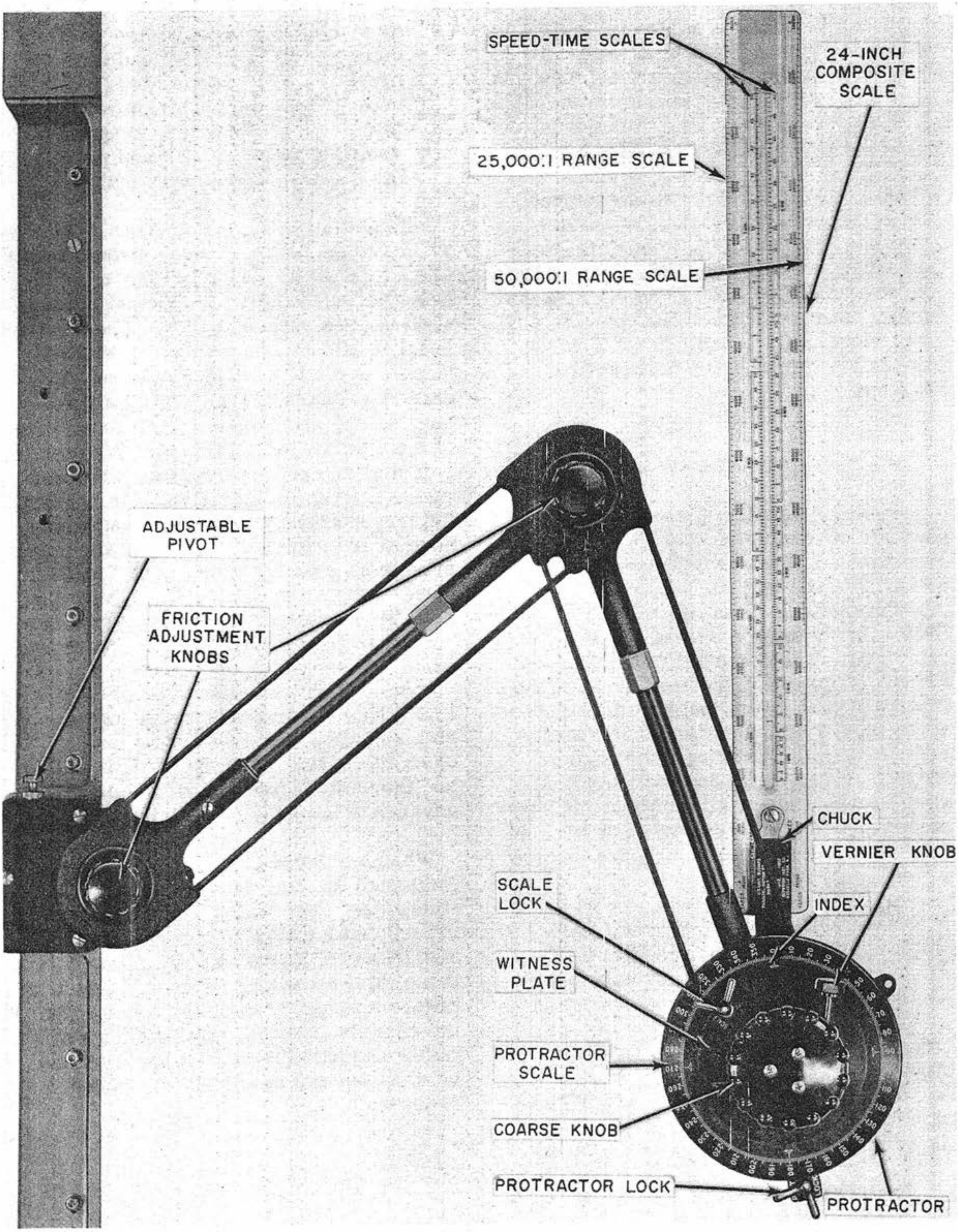

Figure 13. Parallel Motion Protractor

Mod 1 can be connected into the selected system for indirect fire by means of the shore-bombardment auxiliary switchboard.

MOTOR-GENERATOR CONTROLS

The motor-generator set is equipped with controls for operating the motor-generator and for maintaining safe operation under varying loads, for varying the operating method, and for monitoring the output. The functions of the controls are described briefly in table 7. For complete information, refer to NAVSHIPS 363-0686.

OPERATING PROCEDURE

When the computer is secured, all power is off and the synchro signals are disconnected at the switchboard. In STANDBY, the only circuits energized are those of the tube filaments, STANDBY light, -105-v supply, blower, and time-delay unit. The computer can be left in STANDBY condition indefinitely. All the tubes will then be lit, but the plate-supply voltages will not be sufficient to operate the computer. Throwing the computer POWER switch to ON immediately completes application of all power to the computer, provided the computer has been at STANDBY for at least 30 seconds and the motor-generator is ON.

> CAUTION: Do not turn the computer POWER switch to ON unless the motor-generator has been energized.

If the computer POWER switch is thrown from OFF directly to ON, application of plate voltages is delayed for 30 seconds by a time-delay relay, allowing time for the tube filaments to warm up.

> CAUTION: If it becomes necessary to switch the motor-generator from automatic to manual operation, or vice versa, first put the computer at STANDBY and then press the motor-generator OFF button, before switching operation. When restarting, keep the computer at STANDBY and press the motor-generator ON button.

The plotter will accommodate a chart up to 35-inches square. Since standard charts are 35 inches x 45 inches, they must be cropped judiciously. The actual plotting area is 32.8-inches square. The selected chart is attached to the plotter with adhesive tape. For rough alignment, the center meridian of the chart is aligned with the top and bottom center index lines of the plotter, see figure 14. In order to refine alignment, charts should be readjusted so that the meridian in or nearest to the target area is parallel to the North-South axis of the plotter. This alignment may be checked by using the X TARGET handcrank to move the index light to the selected meridian. If the chart is aligned correctly, the Y TARGET handcrank then will move the index light along the meridian. Be sure that the SCALE FACTOR counter reads the same value as the chart scale. For prearranged operations, the chart should be installed and the scale factor adjusted well in advance of the scheduled firing.

When any large errors that cannot be attributed to other sources occur while firing, they may be considered map errors and the EAST-WEST and NORTH-SOUTH SPOT knobs can be used to correct these discrepancies. When shifting to a different target area on the chart, or if the chart is changed, any existing EAST-WEST and NORTH-SOUTH spots should be removed and new ones introduced if necessary.

Table 7

CONTROLS ON MOTOR-GENERATOR SET

Device	Function
ON-EMERGENCY RUN and OFF switches	Two momentary-contact pushbutton switches; the ON-EMERGENCY RUN button, energizes the motor of the motor-generator; the OFF button de-energizes the motor-generator. By pressing and holding in the ON-EMERGENCY RUN button, the motor-generator can be kept operating despite the action of an overload relay, which otherwise would de-energize the motor-generator if the maximum safe load were exceeded.
RESET switch	A pushbutton momentary-contact switch to reset the overload relay if the overload relay has de-energized the motor-generator.
AUTOMATIC-MANUAL switch	Ordinarily, set at AUTOMATIC position. MANUAL position used if voltage regulator in motor-generator set fails to function properly. It then is necessary to regulate the output by adjusting the FIELD RHEOSTAT.
FIELD RHEOSTAT control	May be adjusted (with AUTOMATIC-MANUAL switch in MANUAL position) to obtain 350-v DC output voltage if regulator is faulty.
DC voltmeter	Indicates output voltage of motor-generator.

Initial Operating Setup

The computer and motor-generator are put in operation by following the step-by-step procedure of table 8.

SHORE-BOMBARDMENT Mode

This is the primary mode of operation of Computer Mk 48 Mod 1. After completing the initial operating setup of table 8, proceed as outlined in table 9.

If the inputs from the director to Computer Mk 48 Mod 1 and the outputs from this computer to the gun order computer are steady and smooth, correct target location data is being transmitted to the gun order computer. Relative target bearing, range to target, and target elevation are shown on the dials on the right side of Computer Mk 48 Mod 1. No correction for set and drift need be made at the gun order computer, since the director is continuously establishing true ship position with respect to the reference point. When the gun order computer has a solution for the problem, firing may begin.

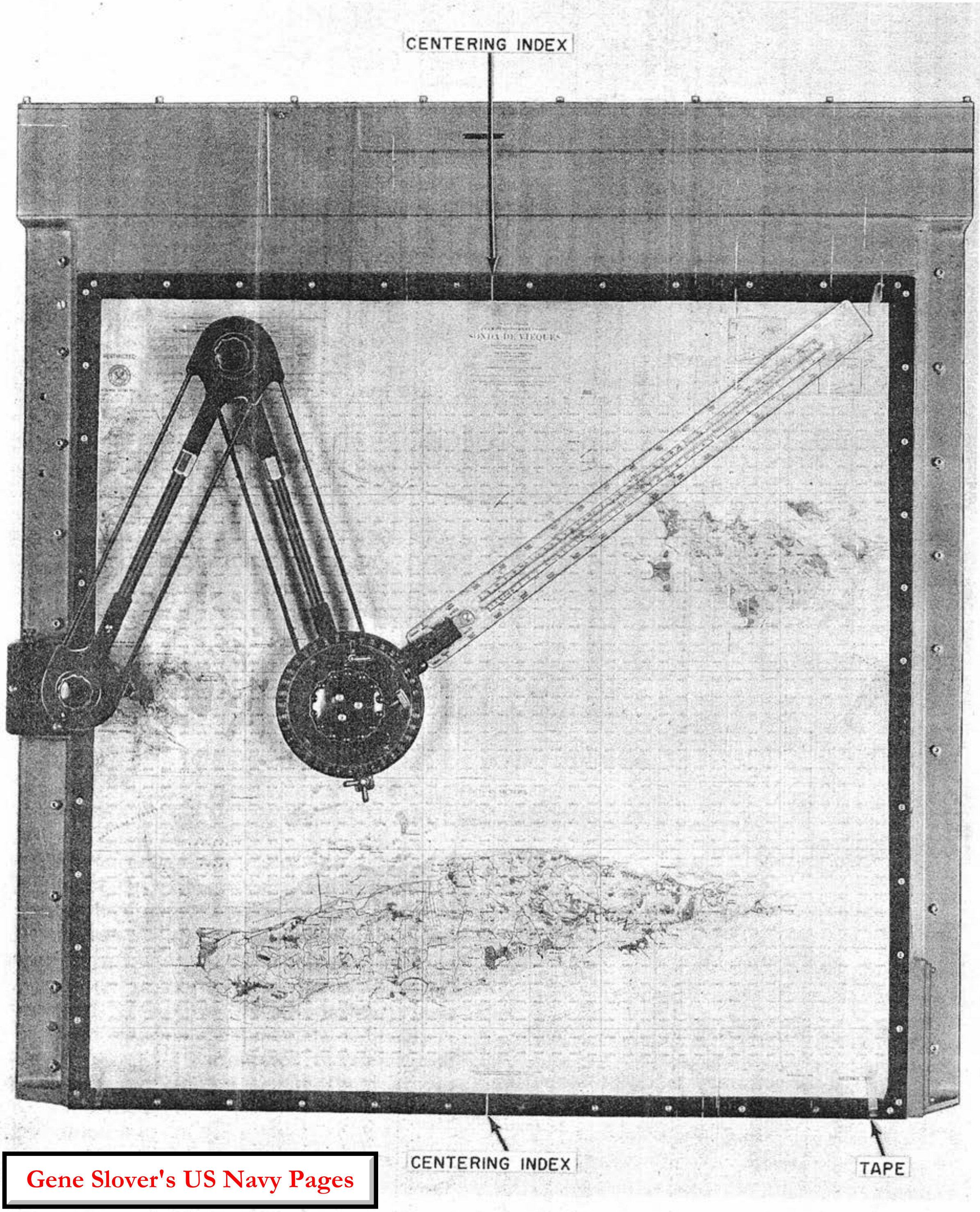

Figure 14. Transverse Mercator Projection Chart Mounted on Plotter

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Table 8

INITIAL OPERATING SETUP

Device	Position or Setting
*AUTOMATIC-MANUAL switch of motor-generator	AUTOMATIC
POWER switch of computer	STANDBY
DIRECTOR SELECTOR switch	MB (Range Keeper Mk 8) or AA (Computer Mk 1A) in accordance with units selected at main switchboard.
Auxiliary switchboard switches	Connect computer synchro inputs and outputs for associated director, gun order computer, and stable element in accordance with units selected at main switchboard.
TIME switch	ON
SCALE FACTOR handcrank	Set counter to show same scale value as chart on plotter.
TEST SELECTOR switches	OFF
SPOT knobs	Rotate until dials are at zero (assuming no known error exists in chart).
Co, B'r', R, So hand-cranks	Removed and stored or disengaged.
*ON-EMERGENCY RUN switch of motor-generator	Press and then release button.
*DC voltmeter of motor-generator	Should indicate 350 volts.
POWER switch of computer	ON
DC voltmeters of computer (5)	Should indicate approximately 100 percent.

Table 8 (Cont'd)

INITIAL OPERATING SETUP

Device	Position or Setting
OWN SHIP COURSE dials	Should show actual value of own ship course.
SHIP SPEED counter	Should show actual ship speed.
DIRECTOR TRAIN dials	Should show actual value of director train.
OBSERVED RANGE dials	Should show actual value of observed range.
S.C.-S.A. switch (figure 43)	SERVO CONTROL TEST.
S.C. NEON-S.A. switch (figure 43)	SERVO CONTROL NEONS. All ZB neons should glow. Replace defective lamps.
S.C.-S.A. switch	AMPLIFIER TEST
S.C. NEON-S.A. switch	AMPLIFIER NEONS. All ZAS and ZAC neons should glow. Replace defective lamps.
S.C.-S.A. switch	S.C. TEST. If any servo-control element is defective, its related neon light in group ZB will glow.
	S.A. TEST. If any servo-amplifier element is defective, its related neon light in group ZAS will glow.
	OPERATE. Observe the neon lights in group ZAC during operation of the computer. If any light glows steadily, the first stage of the corresponding amplifier is defective. Intermittent flashing is due to transient conditions and should be ignored.

* Remotely located equipment. Refer to NAVSHIPS 363-0686.

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After firing begins, spot corrections may be ordered in the E-W N-S plotter coordinates. These should be set in by using the EAST-WEST and NORTH-SOUTH SPOT knobs. These knobs may also be used to correct for any large firing errors due to possible map discrepancies. When the target area is large, the X and Y TARGET handcranks are used to move the plotter index light about (and consequently the point of impact) within the target area.

Since set and drift must be known for operation in local control, these may be ascertained in advance while operating in the shore bombardment mode. To determine set and drift, the following should be done:

1. At intervals shown on the protractor speed-time scale applicable to the chart, set the mode-and-plot switch at SHORE BOMB SHIP. Mark ship's actual position on the chart.

2. For the same time intervals, plot ship's theoretical position as it changes, using ship course, Co, and speed, So. Assume that the ship's position at the beginning of each period is that shown by the plotter light. Use the appropriate protractor speed-time scale to plot this theoretical position on the chart. Note the ship's theoretical position at the end of each period.

3. Use the same time-speed scale to measure the direction and distance from a theoretical position of the ship to its corresponding true position. These measurements give set in degrees and drift in knots.

Changing from SHORE BOMBARDMENT Mode to LOCAL CONTROL Mode

If the reference point is about to become obscured (while in the shore bombardment mode) the following must be done:

1. Set mode-and-plot switch at SHORE BOMB SHIP. The plotter index light now should be over own ship position. Mark this position on the map.

2. In rapid succession, turn the time motor off; turn the mode-and-plot switch to LOCAL CONTROL SHIP; turn the time motor on again; and relocate the plotter index over the previously marked own ship position using the X and Y REF SHIP handcranks. Note movement of the index as it follows own ship movement, and estimate a correction that will compensate own ship plot for motion lost during the operations described in the previous sentence. Introduce this correction through the X and Y REF SHIP handcranks.

LOCAL CONTROL Mode

When an obscured target's range and bearing are known and no reference point is available, the firing problem can be handled by the gun order computer working in regenerative or local control. However, if only the target and ship map locations are known, Computer Mk 48 can be used to compute target range and bearing for the gun order computer. In the LOCAL CONTROL mode, corrections for set and drift must be set into the gun order computer. Computer Mk 48 first must be brought into operating condition as described in table 8, and then the procedure described in table 10 should be followed.

To change targets while in LOCAL CONTROL, put the mode-and-plot switch at LOCAL CONTROL TGT. Use the X and Y TARGET handcranks to position the plotter index light at the new target. Return the mode-and-plot switch to LOCAL CONTROL.

SHIP-TO-SHIP Mode

The purpose of the computer during this type of operation is to supply, as a

Table 9

SHORE BOMBARDMENT MODE OF OPERATION

Device	Position or Setting
HEIGHT REF handcrank	Rotate until HEIGHT-REF counter shows reference height value obtained from chart contour lines.
ELEVATION REF counter	Should show elevation of reference point.
TARGET HEIGHT handcrank	Rotate until TARGET HEIGHT counter shows target height obtained from chart contour lines.
Mode-and-Plot switch	Set switch at following positions in sequence listed; operate handcranks as directed for each switch position: 1. SHORE BOMB REF-PT. Rotate X and Y REF SHIP handcranks to bring plotter index light to reference point on map. 2. SHORE BOMB TGT. Rotate X and Y TARGET handcranks to bring plotter index light to target on chart.

Table 10

LOCAL CONTROL MODE OF OPERATION

Device	Position or Setting
TARGET HEIGHT handcrank	Rotate until TARGET HEIGHT counter shows target height.
Mode-and-Plot switch	Set switch at following positions in sequence listed; operate handcranks as directed for each switch position: 1. LOCAL CONTROL TGT. Rotate X and Y TARGET handcranks to bring plotter index light to target on chart.

Table 10 (Cont'd)

LOCAL CONTROL MODE OF OPERATION

Device	Position or Setting
	2. LOCAL CONTROL SHIP. Rotate X and Y REF SHIP handcranks to bring plotter index light to own ship position.

secondary source of target motion, information to the active gun order computer. Computer Mk 48 Mod 1 receives the usual automatic inputs from the gun director, stable element, gyro compass, and pitometer log. However, in ship-to-ship operation the gun director and stable element are connected directly to the gun order computer, since the mode involves direct fire.

The initial operating setup is outlined in table 8. (If desired, blank paper may be used instead of a chart.) The following additional steps are then performed:

1. Align zero-degree on the protractor scale with the north index of the plotter. Tighten PROT LOCK.

2. Select an area for plotting on the paper that affords the most time before own ship and target would move off the paper.

3. Set the scale-shift counter at 25,000:1, if the range is not expected to exceed 16,000 yards; or at 50,000:1, if the range is to be greater than 16,000 yards.

4. Turn the mode-and-plot selector switch to DEAD REK'NG-TARGET. Travel of the plotter index light represents target.

5. Mark target position and exact time on the paper at regular one-minute intervals.

6. Determine target speed directly in knots by measuring the length of the developed vector with the time-speed section of the composite scale. Use the calibrations that correspond with the elapsed time of the developed vector and the scale factor in use.

7. Align the composite scale with the vector, and read target course on the protractor scale.

8. If desired, the own ship vector can be plotted between target-plot intervals by turning the mode-and-plot switch to DEAD REK'NG-SHIP and marking the ship position on the paper.

DEAD RECKONING Mode

To start a dead-reckoning plot based on the chart location of a known landmark, complete the initial operating setup outlined in table 8. In this case, the "target" is the known landmark. After the director gets on the "target," the following steps are performed:

1. Turn the mode-and-plot selector switch to DEAD REK'NG-TARGET.

2. By means of the REF-SHIP handcranks, position the index light at the landmark location on the chart.

3. Turn the mode-and-plot selector switch to DEAD REK'NG SHIP.

4. The index light now will represent and plot own ship position. The plot can be marked on the chart at regular intervals.

If the plot is to be initiated from a known chart position of own ship instead of a landmark, omit the preceding steps 1 and 2, and proceed with step 3 using the REF-SHIP handcranks to position the index light at present own ship position on the chart.

SPECIAL MODES OF OPERATION

Manual Plotting

The protractor affixed to the plotter can be used for laying out either own ship or target position from information in terms of range and bearing.

When laying out own ship position on a chart with the protractor, target position on the chart, range, and either director train or relative bearing must be known. The procedure for finding own-ship position is as follows:

1. Add ship course to the known value of director train or relative bearing to obtain true bearing; turn the protractor knob so that the protractor reads this value of bearing.

2. Adjust the protractor's position so that the point on the scale edge, that has the same value as the known range, is directly over the target location on the chart. (The composite scale calibrations used must have the same scale factor as the chart in use.)

3. Note the location on the chart over which the zero point on the scale edge falls. This location is own ship position.

When laying out target position on a chart, own ship position, range, and either director train or relative bearing must be known. The procedure for laying out target location is as follows:

1. Add ship course to the known value of director train or relative bearing to obtain true bearing; turn the protractor knob so that the protractor reads this value of bearing.

2. Adjust the position of the protractor so that the zero point on the scale edge is directly over own ship location on the chart. (The composite scale calibrations used must have the same factor as the chart in use.)

3. Note the location on the chart over which the point on the scale edge, having the same value as the range, falls. This location is the target position on the chart.

Area Fire

Using Computer Mk 48, indirect fire on an area of known dimensions and location on the chart can be accomplished with aerial or shore-party spotting. The index light is set near one corner of the target area as marked out on the chart, with the mode-and-plot switch at SHORE BOMB TGT. When the point of impact is spotted to coincide with the index light position on the chart, the X and Y TARGET handcranks can be operated to saturate the area as required for the particular type of target. (Chart errors are corrected by the EAST-WEST and NORTH-SOUTH SPOT knobs. System and ballistic errors may be corrected by introducing range and deflection spots at the gun order computer.) If spotting is unavailable, the bombardment should overlap the area enough to nullify possible chart or system errors.

Firing on Roads and Runways

This type of firing deals with the problem of destroying roads, runways, or truck convoys. Using aerial or shore-party spotting, set the index light at the point on the chart where bombardment is to begin; apply range spots at the gun order computer as necessary to straddle the road with fire. With the X and Y TARGET handcranks, move the index light along the road as represented on the chart, applying any additional range spots required to keep the mean point of impact centered on the road.

PARALLAX CORRECTION

In direct fire, the train output of Gun Director Mk 37 is corrected for horizontal parallax by combining with it an appropriate fraction of the unit parallax correction transmitted by Computer Mk 1A. In indirect fire, however, the Computer Mk 1A unit parallax is based on the target coordinates and can be used only for correcting the gun turrets. The unit parallax receiver in the director must be connected to the transmitter in Computer Mk 48 which transmits a correction based on range and bearing of the reference point.

In the two-axis main battery directors, the parallax correction is computed, or partially computed, by director mechanisms from inputs that normally pertain to the target: director train and range or a function of range. For indirect fire, these inputs must be derived for the reference point as outlined in the following paragraphs.

In direct fire, Gun Director Mk 34 receives the sight angle, Vs, from the range keeper. Vs, shown on a dial in the director, is set manually into the train-parallax computing mechanism. For indirect fire, the sight angle to the reference point must be supplied instead. This may be accomplished by compiling a table listing reference-point range against sight-angle values. From this table the sight angle corresponding to a given range may be ascertained and set into the train parallax computing mechanism. Range to reference point is, of course, available in the director.

Gun Director Mk 38 uses the target-range input to compute the parallax correction for direct fire. In indirect fire, therefore, the range to the reference point is set manually into the parallax mechanism.

In direct fire, Gun Director Mk 54 automatically receives parallax range (the reciprocal of range) and computes the parallax correction. For indirect fire, the reference point range is introduced manually and automatically converted to parallax range by the relation of input dial calibration to receiving mechanism.

A summary of the way in which parallax correction is handled in various directors is given in table 72.

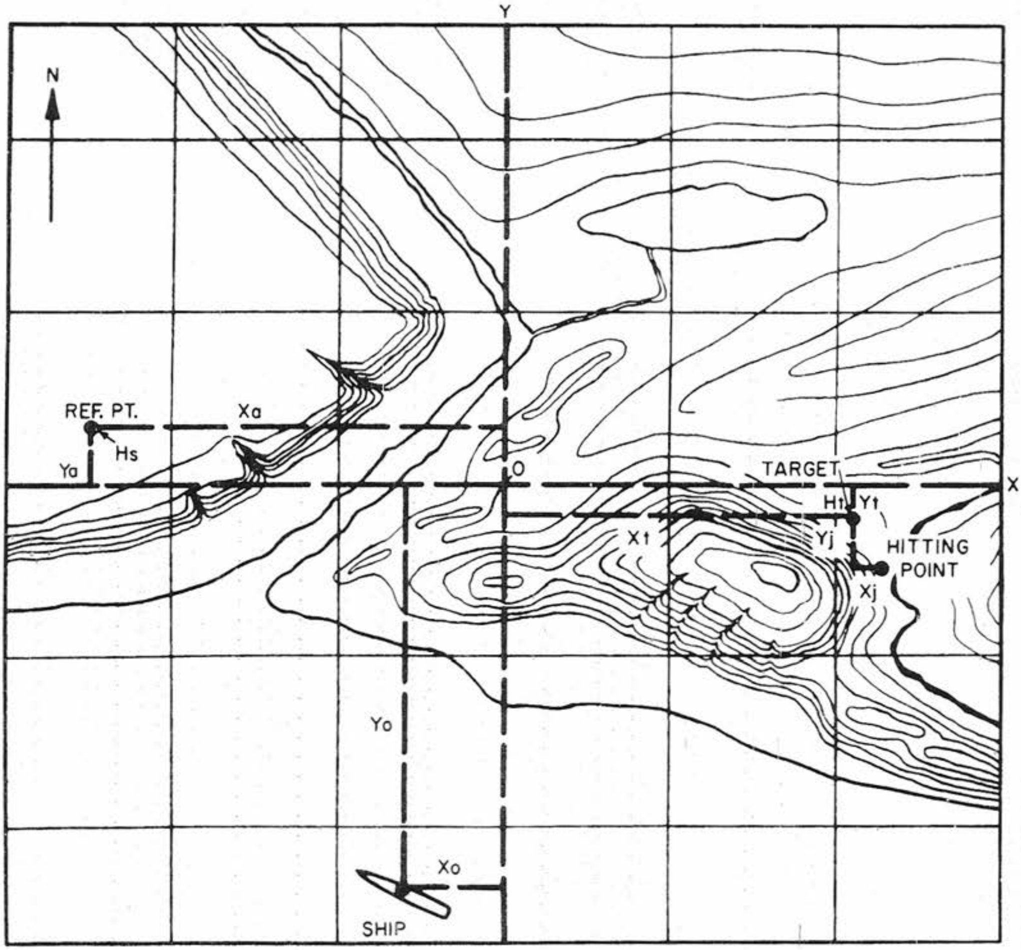


Figure 15. Horizontal Quantities Obtained from Plotter and Map

Chapter 4

THEORY AND FUNCTIONAL DESCRIPTION

Section 4.1—Theory

GEOMETRIC QUANTITIES

The distinction between reference point and target in indirect fire involves new geometric quantities. These do not exist in the direct fire problem, where the point being sighted is the target itself. The new quantities are:

Quantities Obtained from Plotter and Map

Reference point and target locations, (Xa, Ya) and (Xt, Yt), are obtained from a map on which both are shown. The map is laid out on the plotter of Computer Mk 48 Mod 1. An X-Y rectangular coordinate system is used, with the Y axis north-south, figure 15. The origin of the coordinate system is, arbitrarily, the center of the computer plotting table. It is emphasized that the X and Y quantities represent reference point, target, and ship positions, not components of ship or target velocity. Xa and Ya locate the reference point; Xt and Yt locate the target; and Xo and Yo locate the ship. (Xo and Yo are not used in the SHORE BOMBARDMENT mode.) These quantities are introduced into the computer by using handcranks to move an index light under the glass plotting surface. With the proper mode-and-plot switch setting, the light is moved so that it illuminates from below the location on the map that is being introduced into the computer. Since ground distance between the reference point and target, as shown on the map, depends upon the map scale, the map scale is introduced into the computer by a handcrank and counter. Corrections for constant errors in any part of the system may be introduced without disturbing the map target position (Xt, Yt). With Xj and Yj, the east-west and north-south spots, added, the hitting point is changed as shown in figure 15, but the index light still shows Xt Yt as the target position. Reference point and target heights, Hs and Ht, as shown on the map, are introduced manually.

Ship Reference-Point Quantities

These quantities are:

B'r': Reference point bearing measured in the deck plane (from gun director).

Br: Reference point bearing in the horizontal plane (computed).

L' (L): Level for line of sight to reference point (computed).

Zh (Zd): Cross level for line of sight to reference point (computed).

jB: Computed correction to director bearing angle for error due to elevating a line of sight that is not stabilized in cross level (two-axis system).

A complete list of Computer Mk 48 Mod 1 inputs and outputs is given in pages 7 and 14. Figure 16 illustrates most of the angles involved in the Computer Mk 48 Mod 1 functioning.

INSTRUMENT SOLUTION

In computing the location of an obscured target the instrument solution starts with polar coordinates of a reference point obtained from a director that trains in the deck plane, and rectangular map coordinates in a horizontal plane of the reference point and target. From this mixed information the target's location must be calculated in terms of simulated director measurements acceptable to the gun order computer (Range Keeper Mk 8 or Computer Mk 1A). In all, two deck-tilt corrections and two coordinate conversions are required. The director measurement of reference-point position is corrected to the horizontal plane and then converted to N-S E-W map coordinates. These are combined with other map coordinates to locate the target with respect to own ship, after which reconversion to horizontal polar coordinates and correction to the deck plane produce the required gun-order-computer inputs.

The Computer Mk 48 Mod 1, therefore, must combine three sets of input data. These are:

Location of the reference point with respect to the ship. The reference point is located in terms of map height, range, and director train in the deck plane (a form of polar coordinates).

Location of the target with respect to the reference point. The target and reference point are located with respect to a common origin, and therefore to each other, in terms of horizontal rectangular coordinates and heights from the horizontal plane. The origin is the map point that lies at the exact center of the plotting area.

Level and cross level referenced to the target line of sight.

These quantities must be manipulated to produce the outputs:

Offset relative target bearing (director train to target).

Target slant range.

Angle of elevation between line of sight to target and horizontal plane.

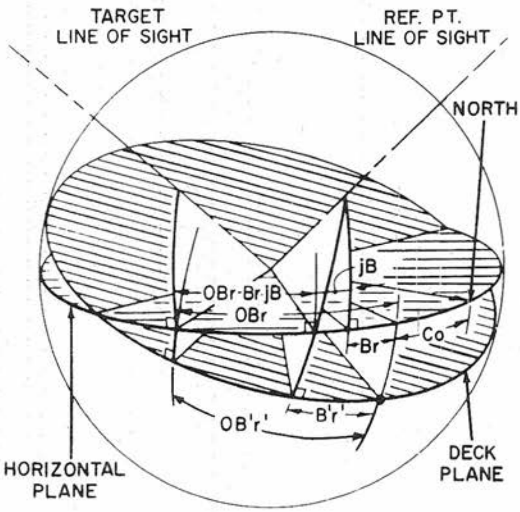
Director train to the reference point, B'r', is corrected for deck tilt by functions of level and cross level. Reference point range, R, is combined with reference point height, Hs, to produce the reference point elevation angle, Es, and horizontal range, Rh. Rh and the reference point horizontal bearing then are solved for Rh sin B and Rh cos B coordinates in the horizontal plane parallel, respectively, to the X and Y map axes.

These then are combined with the horizontal distance from the reference point to target, (Xt - Xa, Yt - Ya), and the spot corrections, (Xj, Yj) to compute ORh sin OB and ORh cos OB, the horizontal rectangular coordinates of the actual hitting point.

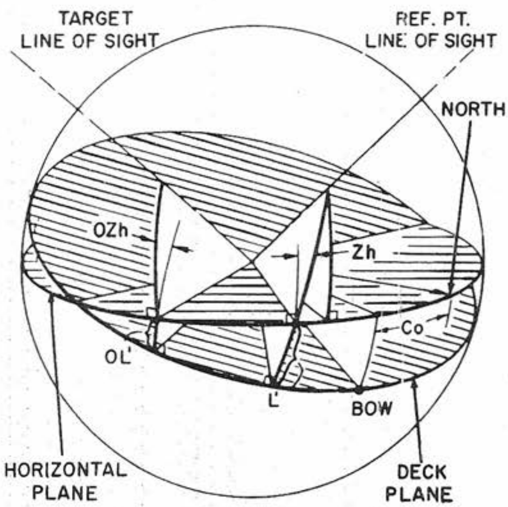
OR sin OB and OR cos OB then are combined to produce ORh, horizontal target range, and OB, horizontal target bearing.

ORh and target map height, Ht, are used to solve for Et, target elevation, and OR, target slant range. OB is modified by deck-tilt corrections to form OB'r', offset relative target bearing in the deck plane.

The quantities, OR, Et, and OB'r' then are transmitted to the gun order computer.



HORIZONTAL PLANE AND DECK PLANE ANGLES



LEVEL AND CROSS-LEVEL ANGLES

Figure 16. Angles Involved in Indirect Fire Control

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In the AA system, Et is used in the computations of ballistic quantities that establish the correct trajectory for a target of given elevation. In the MB system, the trajectory is based on the value of advance range alone, and the value of Et serves merely to elevate a trajectory computed for a horizontal line of sight so that the point of impact coincides with the elevated target. Since the elevation angles involved are small, the inaccuracies introduced by assuming a rigid main battery trajectory are negligible.

Section 4.2—Function

Computer Mk 48 Mod 1 is divided functionally into a horizontal section and a deck-tilt section. The general functioning of these sections is illustrated in flow diagrams, figures 29 and 37.

The horizontal section computes target range, OR, and the target-elevation angle, Et, for transmission to a gun order computer, horizontal parallax, Ph, and a range-tracking aid, Δ cR (both quantities with respect to the reference point) are computed and transmitted to a director. The computation of these quantities is based on inputs of reference range, R, and reference director train, B'r', obtained from a director; ships' course, Co, from the gyro compass; ship's speed, So, from the pitometer log; and on handcrank inputs based on information obtained from a chart mounted on the plotter. These inputs are reference height, Hs, target height, Ht, and the N-S E-W coordinates of reference point and target positions (Xa, Ya, and Xt, Yt). The functioning of the horizontal section also requires inputs of sin Zh, (Br + jB), and (B + jB) from the deck-tilt section of the computer, as shown in figure 29. In addition, the intermediate quantities -jB and OB for use in the deck-tilt section of the computer are computed in the horizontal section.

In the deck-tilt section, figure 29, reference-point level, L', reference-point level plus a function of reference-point cross level, L + Zd/30 (for AA Director Mk 37), and a reference-point bearing-correction train control, Co + jB'r' - jB, are computed and transmitted to a director; target director train, OB'r', is computed and transmitted to a stable vertical (or stable element) and a gun order computer. The computation of these quantities is based on inputs of level and cross level with respect to the target line of sight, OL' and OZh, obtained from a stable vertical, and ship's course, Co, from the gyro compass. The functioning of the deck-tilt section also requires inputs of -jB and OB from the horizontal section of the computer, as shown in figure 37; in turn the deck-tilt section computes the intermediate quantities sin Zh, (Br + jB), and (B + jB) for use in the horizontal section of the computer. Figure 17 shows the symbols used in the schematics of this chapter and chapter 5.

FUNCTIONAL DESCRIPTION OF HORIZONTAL SECTION

Transmitted Inputs

As shown in figure 29, reference range, R, and train, B'r', are received from the director; ship's course, Co, is obtained from the gyro compass; and ship's speed, So, is transmitted from the pitometer log. These quantities are received in the computer by synchro receivers.

The Co, R, and B'r' receivers and their servo loops are similar schematically

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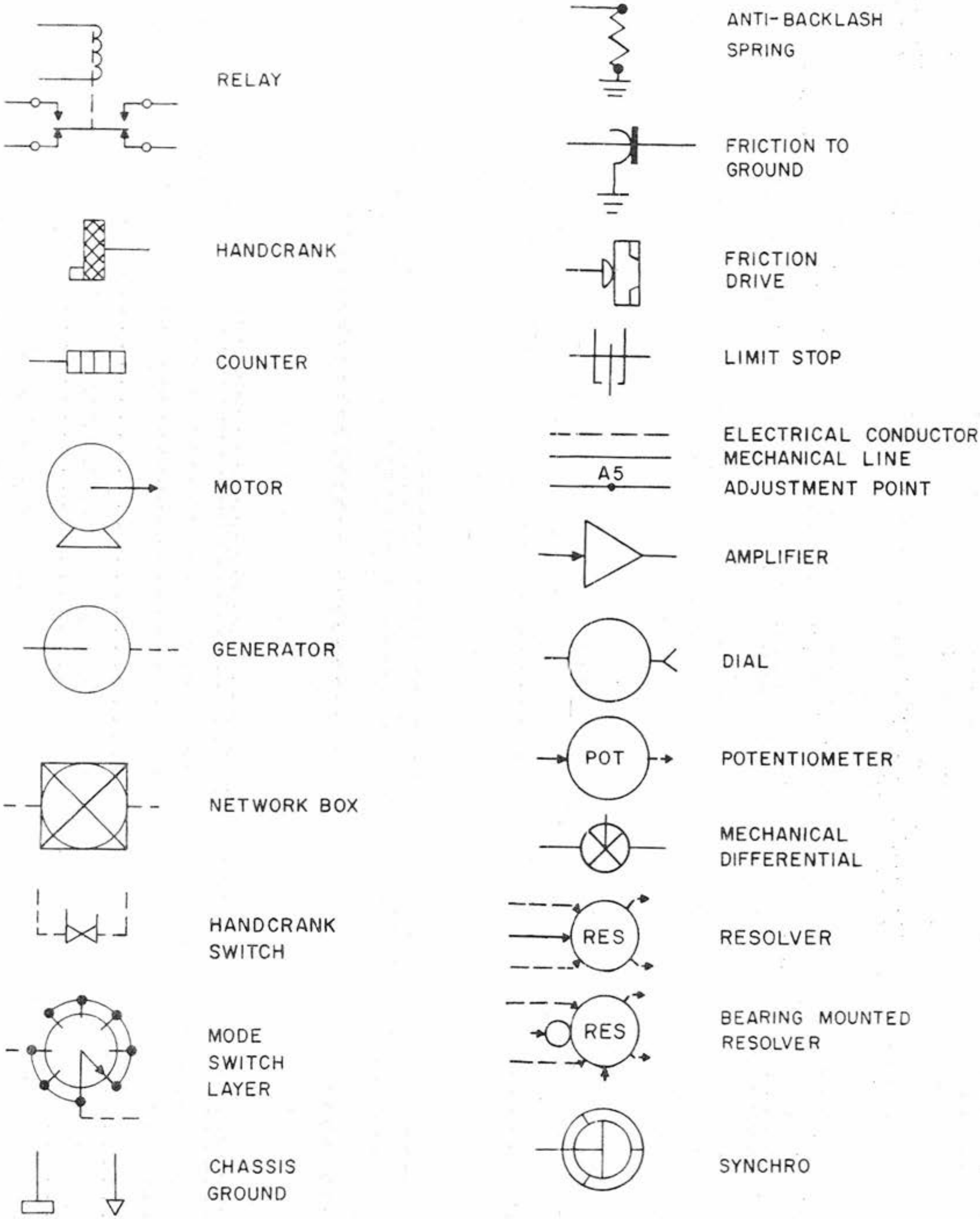

NOTE: NOMENCLATURE SYMBOLS SHOWN ON SCHEMATICS ARE FOR MB OPERATION. FOR AA OPERATION, SUBSTITUTE: Zd FOR Zh, L FOR L', OZd FOR OZh, OL FOR OL' B'r FOR B'r', OB'r FOR OB'r', AND ZERO FOR jB.

Figure 17. Schematic Symbols

and differ only in some of the elements used, figure 18. The value of each quantity is indicated on its respective coarse and fine dials. Handcranks are provided for manually setting in these quantities; when used, the handcranks actuate switches that disconnect the servo mechanisms.

The own ship's speed, So, receiver is a single 5B synchro that controls a 1/50 hp contact-type follow-up control and 1/50 hp servo motor, figure 19. The quantity So also may be cranked into the computer by hand. When the handcrank is used, a switch opens the circuit of the servo motor. The value of So in the computer is indicated on a counter and can vary from 0 to 55 knots. Because the So receiver is of the single-speed type and must cover limits greater than one revolution of the synchro (40 knots), it may have to be synchronized manually before being placed in automatic operation.

Computation of Elevation and Horizontal Range of Reference

The reference point elevation, Es, and the reference-point horizontal range, Rh, computations performed in the horizontal section use the mechanisms shown in figure 20. The geometry involved is illustrated in figure 29, where Rh = R cos Es and Es is the elevation angle formed between R and Rh. Reference slant range, R, is servoed into potentiometer R4002, and applies as a voltage to resolver B4080 through a network box, ZN4334, and an isolating amplifier, ZA4333B. The resolver outputs are R cos Es, which is Rh, and R sin Es, which is Hs. Reference-point elevation, Es, is computed from the relationship Es = arc sin Hs/R or R sin Es = Hs. Reference height, Hs, is cranked into R4005, and a voltage proportional to Hs is compared in summing network ZN4307 with R sin Es, one of the outputs of R4080. The difference, or error, is the signal to the servo motor B4007, which drives the resolver B4080 rotor until the error is nulled. The rotor position is equivalent to Es. The range input to R4014 varies the gain of servo control ZB4107 in inverse proportion to range, keeping the ratio of output error to input error signal approximately constant. Amplifier ZA4333B is one half of a single unit; the other half is used as a resolver amplifier for the resolver B4092 in the deck-tilt section. G4007 is a standard 60-cycle feedback generator. An ON-OFF switch, a transformer, and a potentiometer are provided for adding a range spot to the value of R used in computing R cos Es, when R is being received from a radar beacon.

Approximation of Bearing Correction

The reference-point elevation angle, Es, is used also in the approximation of the bearing correction, jB, for reference point elevation and cross level when operating with an MB system. Referring to the sketch on the flow diagram, figure 29, the computation of jB is based on the solution jB = arc sin [Es sin (Zh)] or sin jB = Es sin (Zh). The true solution for jB would be jB = arc sin [tan Es tan (Zh)]. In the instrument solution, sufficient accuracy is obtained by substituting Es and the available sine function of Zh, since the angles involved are small. As shown in figure 21, sin Zh and Es are multiplied by potentiometer R4018. Resolver B4092 in the deck-tilt section supplies sin Zh, and Es is servoed by B4007, figure 20. The output jB of the servo loop, consisting of summing network ZN4304, servo control ZB4104, amplifier ZA4104, and servo motor B4004, must position the rotor of resolver B4099 at an angle equal to jB, figure 21. This condition is obtained when the output -sin jB of resolver B4099 balances the servo output sin (Es sin Zh) of potentiometer R4018 in network ZN4304. The input to ZN4304 is grounded, causing the loop to zero jB when the DIRECTOR-SELECTOR switch is thrown to AA.

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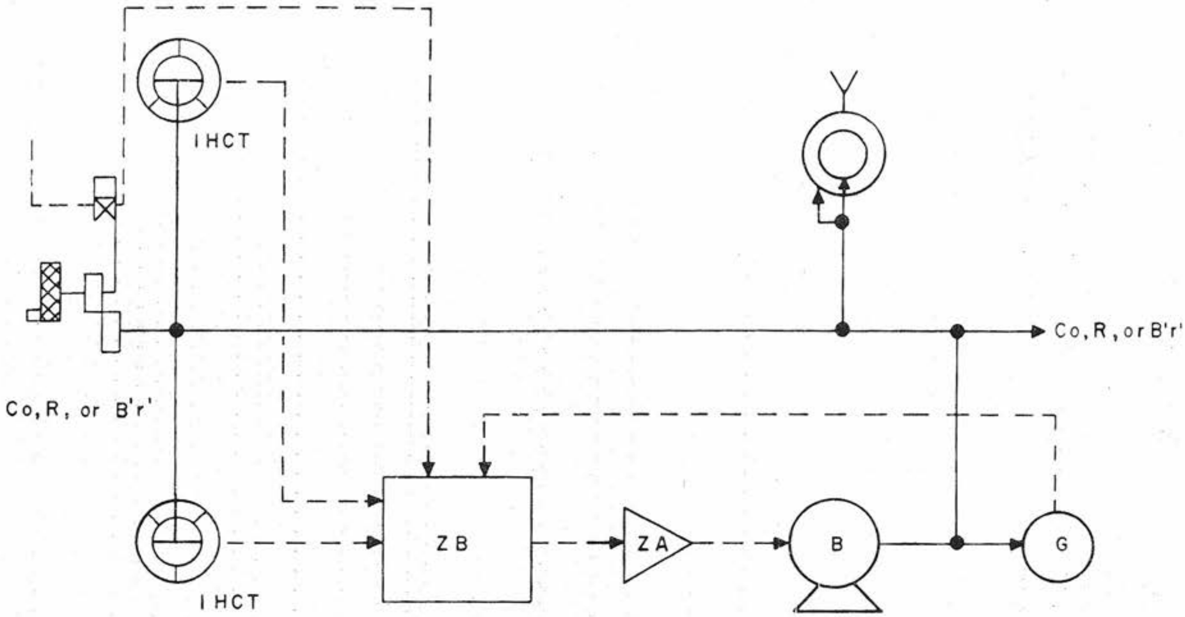

SYNCHROS			SERVO CONTROL	SERVO AMPLIFIER	SERVO MOTOR	GENERATOR	SWITCH
B'r'	B4054 10	B4055 360	ZB4106 (HIGH FIDELITY)	ZA4106	B4006 (10 WATT)	G4006	S4008
Co	B4052 10	B4053 360	ZB4105 (VELOCITY LAG)	ZA4105	B4005 (10 WATT)	G4005	S4011
R	B4050 2000 YDS	B4051 72000 YDS	ZB4102 (VELOCITY LAG)	ZA 4102	B4002 (5 WATT)	G4002	S4009

Figure 18. Co, R, or B'r' Receiver

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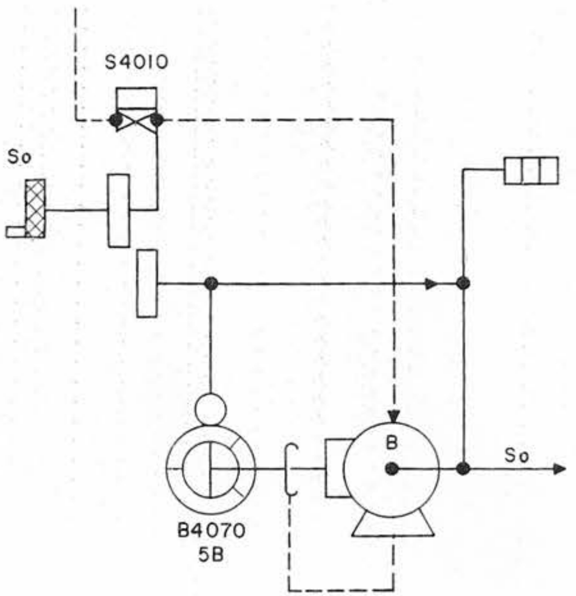

Figure 19. So Receiver and Follow-up

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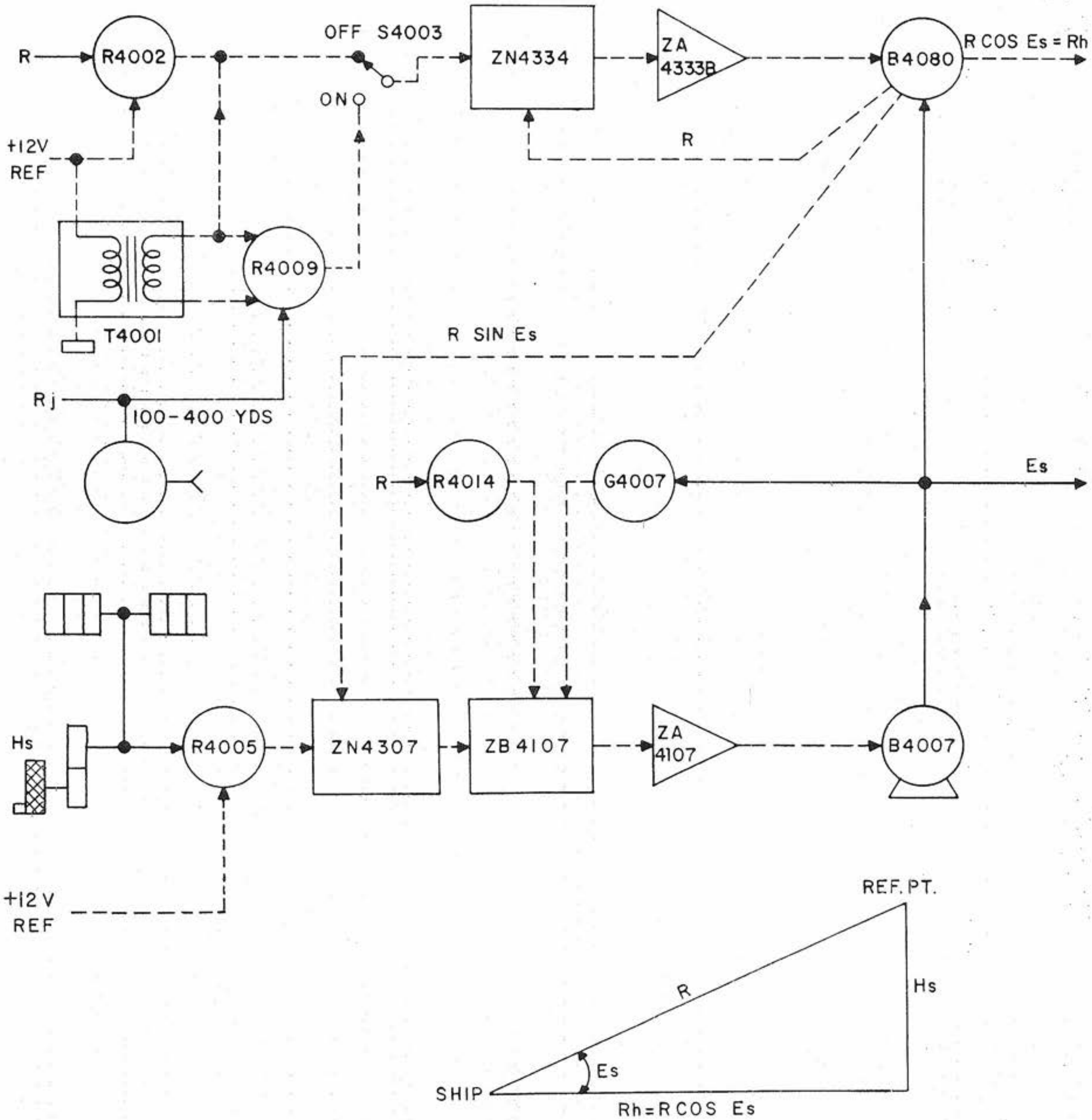

Figure 20. Computation of Es and Rh

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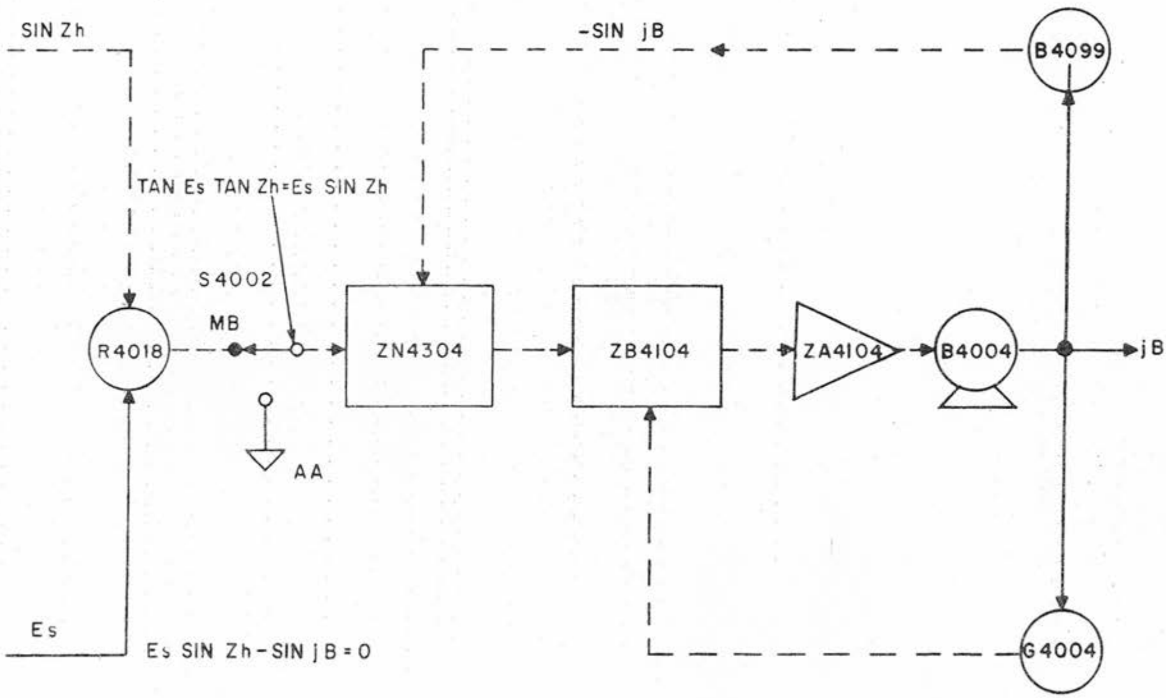

Figure 21. Computation of jB

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Coordinate Conversion

The conversion of the reference-point horizontal coordinates from polar to rectangular, shown on figure 29, is accomplished in the computer by the mechanisms diagrammed in figure 22.

Resolver B4081 computes ±Rh cos B and ±Rh sin B from the inputs Rh, -jB, and (B + jB). The geometry involved is shown on figure 29. Resolver B4081 is bearing mounted, permitting the addition of -jB and (B + jB). Rh is the electrical input obtained from resolver B4080, figure 20, while -jB is servoed from B4004, figure 21, the negative value being obtained by gearing, and (B +jB) is obtained from a differential, H40D1, in the deck-tilt section. Amplifier ZA4339A is one half of a dual-channel unit.

Computation of Target Horizontal Coordinates and Conversion to Polar Coordinates.

The computation of target horizontal coordinates, ORh sin OB and ORh cos OB, and the vector solution of these coordinates to obtain horizontal target range, ORh, and target bearing, OB, is performed in the computer by the mechanisms shown in figure 23. The target horizontal coordinates, ORh sin OB and ORh cos OB, are obtained by adding voltages representing various quantities by means of network boxes. Summing network ZN4337 adds ±Rh sin B, Xa, -Xt, and -Xj and summing network ZN4338 adds the Y-axis components. All of these quantities, except Rh sin B and Rh cos B (see figure 29), are set into the computer by handcranks using the plotter as an indicator and the mode-and-plot switch as means of control. The sine and cosine functions are obtained from resolver B4081, as shown in figure 22.

The conversion to target bearing, OB, and horizontal target range, ORh, from ORh sin OB and ORh cos OB, figure 23, is based on the geometry of the associated flow-diagram sketch from which the equations ORh sin OB cos OB -ORh cos OB sin OB = O and ORh sin OB sin OB + ORh cos OB cos OB = ORh are derived. ORh sin OB and ORh cos OB are applied to the stator windings of resolver B4082 from the two amplifiers ZA4337A and ZA4337B, each of which is half of one unit. The output of one resolver rotor winding, across which the function ORh sin OB cos OB - ORh cos OB sin OB = O appears, is servoed by a loop consisting of servo control ZB4316, servo amplifier ZA4316, servo motor B4016, and generator G4016, causing the resolver rotor to be positioned at angle OB by the servo motor. Generator G4016 provides velocity feedback voltage for servo loop stabilization. Any position of the resolver rotor, at other than the true value of OB, develops an error voltage across the rotor winding that feeds the servo loop. The output of the other rotor winding is ORh sin OB sin OB + ORh cos OB cos OB = ORh. Potentiometer R4022, driven by OR, provides compensation by varying the gain of servo control ZB4316 in accordance with changes in target range. OB is used as an input to differential H40D3 in the deck-tilt section. ORh is used in the computation of target range, OR, and target elevation, Et.

Computation of Target Slant Range and Elevation Angle

The computation of target slant range, OR, and the target elevation angle, Et, is based on geometrical relationships, shown in the appropriate sketch on figure 29, which may be expressed by the equations

$$OR = ORh \cos Et + Ht \sin Et$$

and $$Ht \cos Et - ORh \sin Et = O,$$

where ORh is the range to the target in the horizontal plane, Ht is the target height and Et is the target-elevation angle. These computations are performed by resolver B4095 and the associated networks shown in figure 24. Inputs of Ht, ORh, and Et are

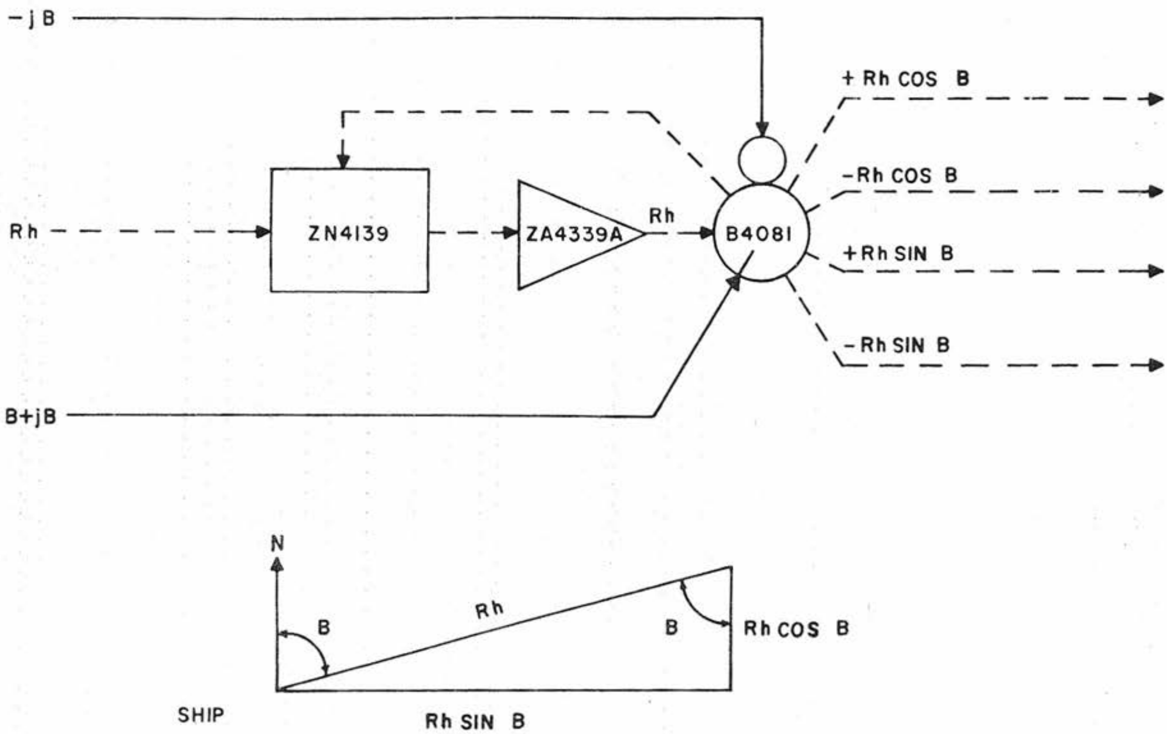
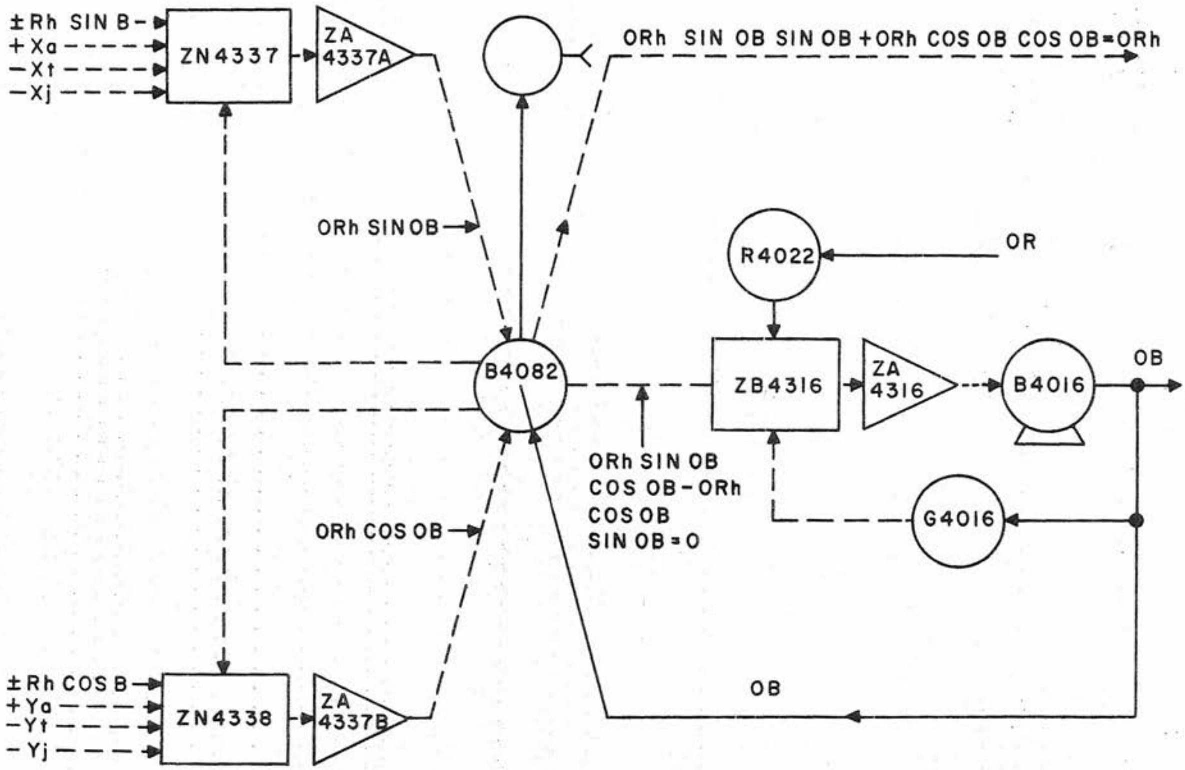


Figure 22. Conversion of Reference Point Horizontal Coordinates



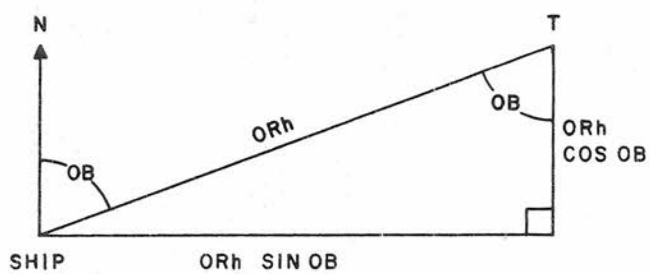


Figure 23. Conversion of Target Coordinates

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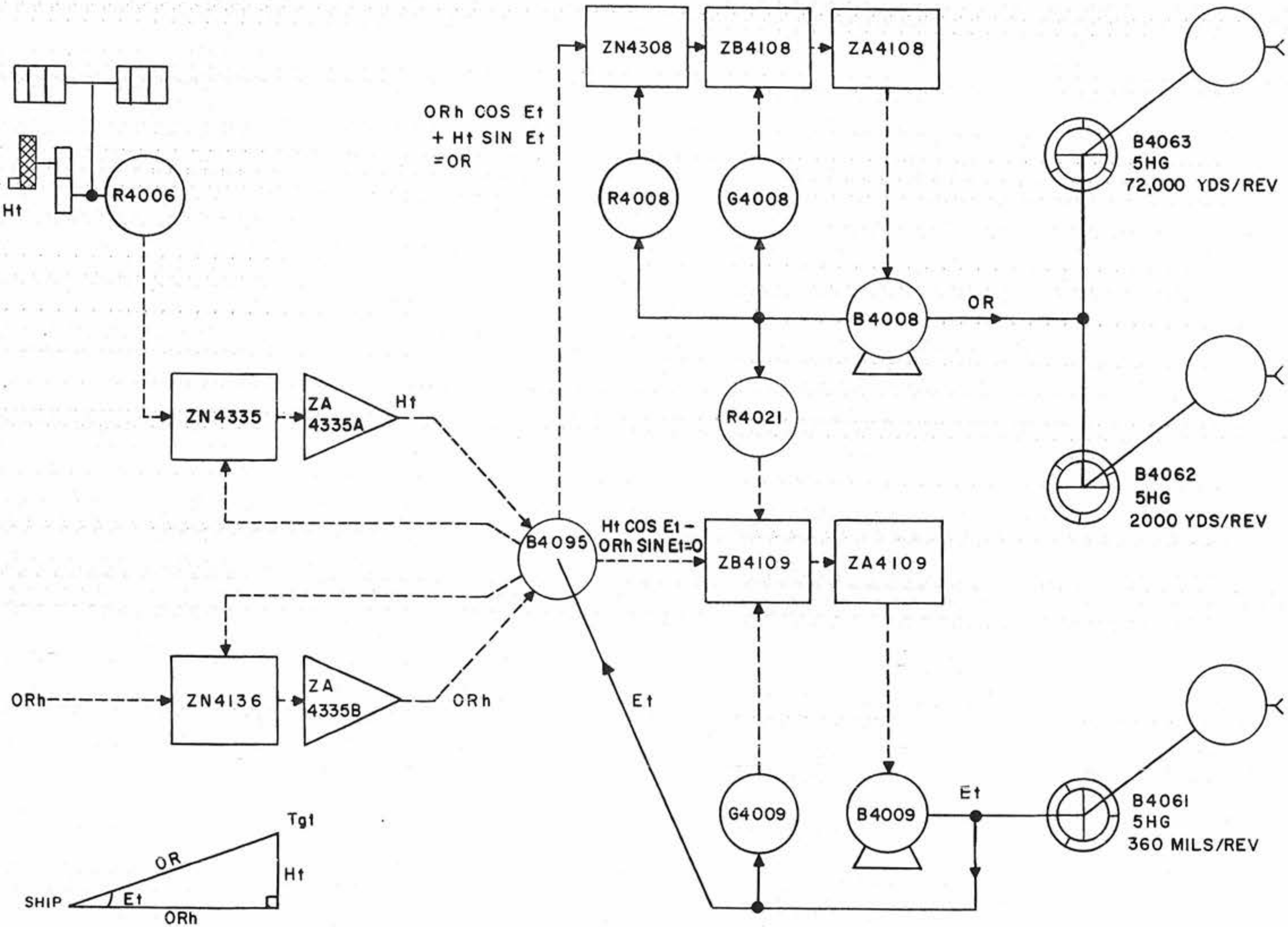

Figure 24. Computation of OR and Et

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applied to resolver B4095. Ht is cranked in manually and sets potentiometer R4006 (the value of Ht cranked in is shown on one counter in feet and on another in meters). The output of the potentiometer is sent through network box ZN4335 and amplifier ZA4335A and appears across one stator winding of the resolver. ORh is applied to the other stator winding from amplifier ZA4335B and network box ZN4136. ZA4335A and ZA4335B are two halves of one dual-channel amplifier. Et sets the angular position of the resolver rotor. With these inputs, resolver B4095 computes an output on rotor winding R1-R3 of ORh cos Et + Ht sin Et, which is equal to OR. (See sketch on figure 29.) The correct value of Et is determined from the equation Ht cos Et - ORh sin Et = 0. This expression is the output of the rotor winding R2-R4 of B4095 and is used to control a servo loop. Any "error" indicates an incorrect value of Et and causes the servo loop to operate until the value of Et is correct, which occurs only when the output of R2-R4 satisfies the expression Ht cos Et - ORh sin Et = O.

The output OR of resolver B4095 is applied to the OR transmitters through a servo loop consisting of summing network ZN4308, servo control ZB4108, servo amplifier ZA4108, servo motor B4008, and velocity feedback generator G4008. Potentiometer R4008 supplies the response feedback to network ZN4308. Two-speed dials are provided to indicate the value of transmitted OR. In main battery operation, OR is transmitted to Range Keeper Mk 8. In secondary battery operation, this quantity is transmitted to Computer Mk 1A. Two 5HG synchros, B4062 and B4063, at 2000 and 72,000 yards per revolution are the Computer Mk 48 Mod 1 transmitters. The transmission limits are from 500 to 50,000 yards.

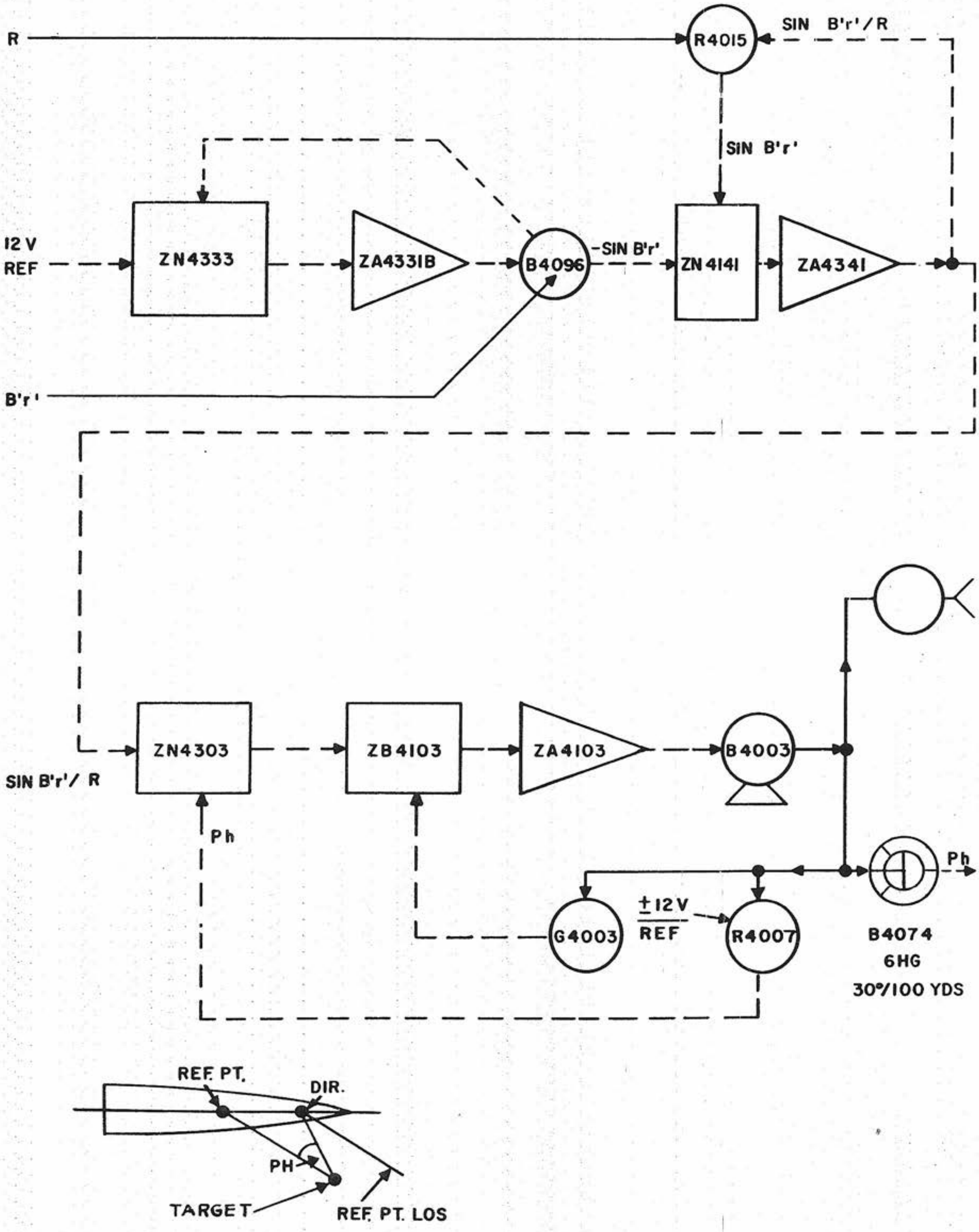
The servo loop output, Et, is transmitted to Computer Mk 1A in secondary battery operation and to Target Elevation Indicator Mk 66 Mod 0, mounted on Range Keeper Mk 8, in main battery operation.

Et is inserted manually into Range Keeper Mk 8 as elevation offset. Et is inserted automatically into Computer Mk 1A. The transmitter, a 5HG synchro (B4061) at 360 mils per revolution, is equipped with a dial to indicate the transmitted value of Et. The transmission limits are 0 to 20 degrees. The Et servo loop consists of servo control ZB4109, servo amplifier ZA4109, servo motor B4009, and velocity feedback generator G4009. Potentiometer R4021, positioned by the OR servo motor, compensates the sensitivity of servo control ZB4109 for variations in range.

Parallax Computation

The flow diagram of the horizontal section, figure 29, shows that horizontal unit parallax, Ph, is computed from inputs of reference range, R, and reference relative bearing, B'r' (director train), which is transmitted to a director. Normally, this function would be provided by Range Keeper Mk 8 or Computer Mk 1A, but when Computer Mk 48 Mod 1 is in the fire control system and the firing is at an offset target, the range and bearing inputs to the range keeper or computer, on which Ph is based, are for the offset target rather than for the reference point being tracked by the director.

Gun Director Mk 37 and Antenna Mount Mk 23 require inputs of horizontal unit parallax, Ph, for correcting train angle to a common parallax reference point on the ship. The corrected train output of each director then is equal to the train value that would be measured at the parallax reference point. Unit parallax correction is computed for a base length of 100 yards; that is, for a 100-yard displacement along the ship's axis from the parallax reference point. Each director or antenna mount determines its individual parallax correction by means of gear ratios which introduce the correction according to the proportion of its individual base length, or displacement from the parallax reference point, to the unit base length of 100 yards.


R
R4015
SIN B'r'/R
SIN B'r'
12 V
REF
ZN4333
ZA4331B
B4096
-SIN B'r'
ZN 4141
ZA4341
B'r'
ZN4303
ZB4103
ZA4103
B4003
SIN B'r'/ R
Ph
Ph
±12 V
REF
G4003
R4007
B4074
6HG
30°/100 YDS
REF. PT.
DIR.
PH
TARGET
REF. PT. LOS

Unit parallax originating in Computer Mk 1A during indirect fire cannot be used to correct director train because it is based on director train and range to the offset target. Instead, a special unit parallax correction is made up in Computer Mk 48 from values of train and range to the reference point tracked by the director.

In Computer Mk 48 Mod 1, the computation of horizontal parallax, Ph, is based on the geometry of figure 29 from which the approximation Ph = 5729.6 sin B'r'/R, for a 100-yard base, is derived. The mechanisms used are shown in figure 25. A resolver B4096 computes -sin B'r' from inputs of B'r' and a reference voltage applied through a network box ZN4333 and an amplifier ZA4331B. Potentiometer R4015 is driven by R.

The quantity -sin B'r' is fed into a summing network. Disregarding network constants, the amplifier voltage output must be such that, when multiplied by R and fed back, it will tend to balance -sin B'r'. The voltage output is, therefore, sin B'r'/R.

Since Ph is approximately equal to sin B'r'/R multiplied by a constant, the conventional servo mechanism, consisting of summing network ZN4303, servo control ZB4103, servo amplifier ZA4103, servo motor B4003, potentiometer R4007, and velocity feedback generator G4003, merely converts the voltage input sin B'r'/R to ZN4303 into a mechanical shaft rotation for driving the Ph transmitter B4074. The constant in the equation is provided by the proper selection of resistances and gearing. An approximation of the true solution for Ph is entirely adequate because of the small angular value of Ph involved. The Ph transmitter transmits at a value of 30 degrees per revolution, and the value of Ph transmitted is indicated on an internal dial.

Generation of Range and Ship's Motion

The range generation performed in the horizontal section provides a reference-range tracking aid, ΔcR (called increments of generated range for Mk 1A and Mk 8), and the generation of changes in own ship position coordinates, ΔXo and ΔYo provides for correcting the computations for the effects of own ship motion. While ΔcR and the coordinate quantities ΔXo and ΔYo are not related functionally, the instrumentation in the computer employs similar units and these quantities are developed in part from the same inputs, as shown in figure 26. Inputs of So, Co, and time, T, are used to compute ΔXo and ΔYo, and the inputs of So, (Br + jB), and T are used to compute ΔcR. ΔcR is transmitted for use in the director and associated radar; ΔXo and ΔYo are used in the plotter and in the computation of target coordinates whenever the reference point is obscured or range and bearing data are not available from the director (local control, dead reckoning, or ship-to-ship operation).

The quantity ΔcR is the integral of So cos (Br + jB) with respect to time. A mechanical resolver and a differential produce So cos (Br + jB) from input of So and Br + jB, figure 26. The disk of the integrator H4004 is driven by time motor B4017 in all modes of operation. The quantity So cos (Br + jB) from the resolver positions the carriage, and the roller output drives the transmitter B4073 at 1000 yards per revolution. The value of ΔcR transmitted is shown on an internal dial. The time line also drives the disks of integrators H4001 and H4002 through clutch H4010, but only when the computer is in one of the dead-reckoning or local-control types of operation. The carriages of these integrators are positioned by dXo and dYo, obtained in the ship's rate computation from a mechanical resolver and differential H40D2 from inputs of So and Co, as shown. The integrator rollers drive ΔXo and ΔYo to differentials H40D8 and H40D7,

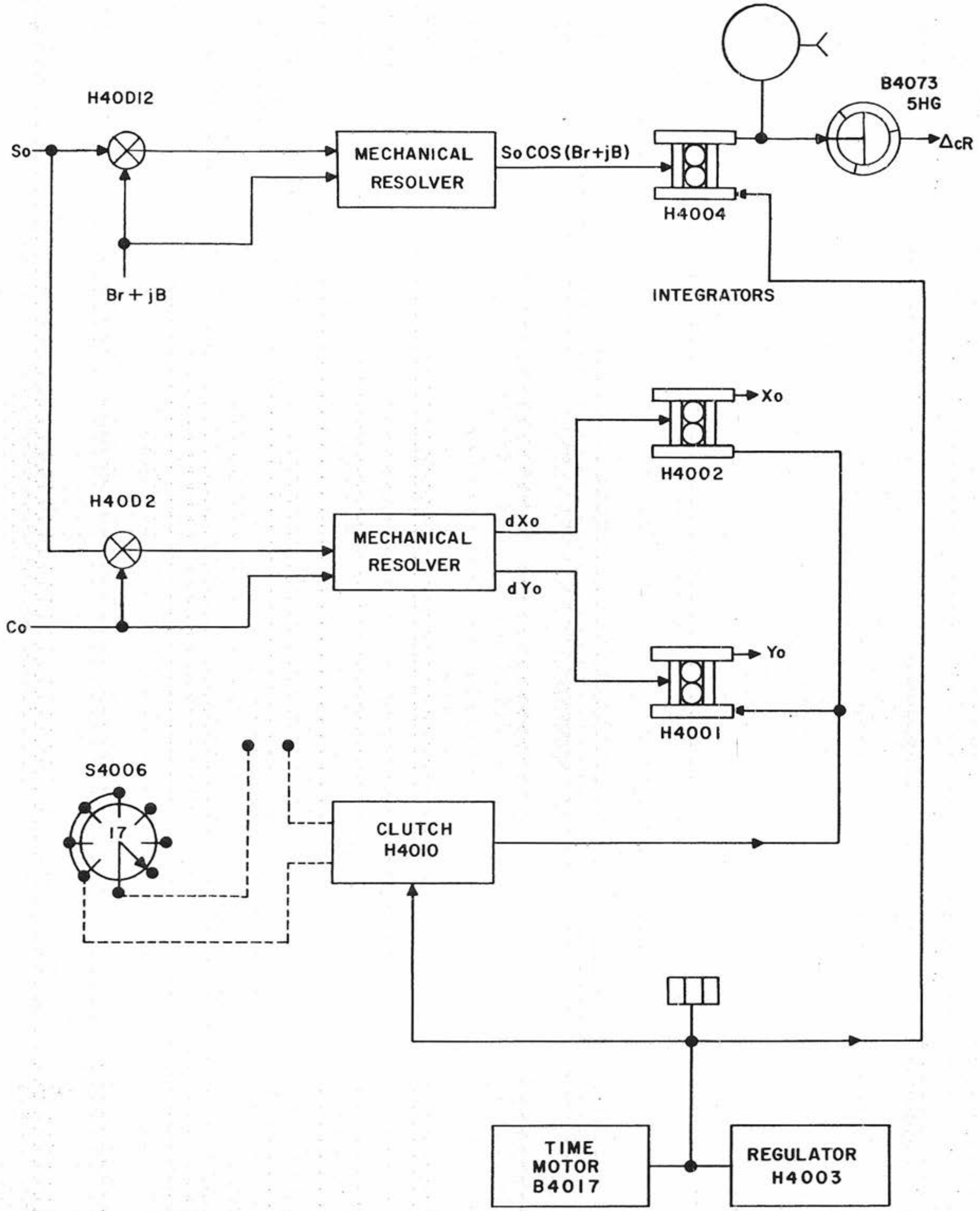


Figure 26. Computation of Δ cR, Δ Xo, and Δ Yo

figure 27; the other side of these differentials is controlled by handcranks that set the initial positions used for the plotter and for the computation of target horizontal coordinates.

Selection of Coordinates and Plot

As figure 29 shows, the functioning of the plotter and the computing of target horizontal coordinates require inputs of X and Y quantities. These quantities, defined in chapter 2, are introduced by handcranks; they are illustrated in figures 15, 27, and 29. The values set in by the handcranks are converted to proportional voltages by means of potentiometers. The two differentials allow the substitution of ΔXo for Xa and ΔYo for Ya as inputs, which is done when the director is not supplying range and bearing information.

The proportional voltages then are applied to the plotter and the target-horizontal coordinate-computing mechanisms through a switch (mode-and-plot switch S4006). This is a seven-position switch that serves to select the various coordinate voltages in accordance with the mode of operation and the position to be plotted. In the dead-reckoning and ship-to-ship modes, the switch reverses the polarity of the reference-point coordinates and the reference voltage going to the OB servo loop to compensate for differences in the geometry of this type of problem. In addition, this switch closes the clutch in the time line for all modes other than shore bombardment, figure 26. The seven positions of the switch are listed in table 11.

The three shore-bombardment positions of the switch, when used in sequence, establish in the plotter and the computer the relative positions of own ship, reference, and target, provided the necessary data are fed in by means of the various handcranks and synchros. For example, in the shore-bombardment mode of operation, which is the main function of the computer, the switch is first set at SHORE BOMB SHIP. In this position the inputs to the plotter are Xa - Rh sin B and Ya - Rh cos B. As can be seen from the sketch on the flow diagram, these are the north-south and east-west distances of own ship from the origin. In terms of X-axis coordinates, the next two positions (SHORE BOMB REF and SHORE BOMB TGT) establish the location of reference point and target with respect to the origin by successively connecting Xa and Xt to the plotter network box ZN4301, figure 28.

The proper values for Xa and Xt are determined by moving the Xa and Xt handcranks to position the plotter index light at the locations of reference point and target on the chart, thus setting up the proper voltage relationships for these quantities in both the plotter-servo mechanisms and the target-horizontal coordinate-computing mechanism.

Since the computer must compute the location of the target continuously, the switch sections controlling the computer are arranged to maintain identical inputs for all the plot positions in a given mode. A summation of the inputs to the plotter and the computer for the various switch positions is shown in table 11. For simplicity, only X-axis coordinates are listed; for Y-axis coordinates, substitute Y for X and cosine for sine. In the secondary modes of operation (local control and dead reckoning) the inputs available, as shown in table 11, are designed for operation without director aids and for navigational purposes.

The mechanisms used in the plotter are diagrammed in figure 28. Because the plotter is designed for use with charts and maps of varying scales, a scale-factor control in the form of a precision potentiometer, R4001, positioned by the scale-factor handcrank and counter, is used to vary the scale of the plotting. The output of this potentiometer, proportional to the scale factor, is supplied through summing network ZN4342 and amplifier ZA4342 to response potentiometers R100 and R101

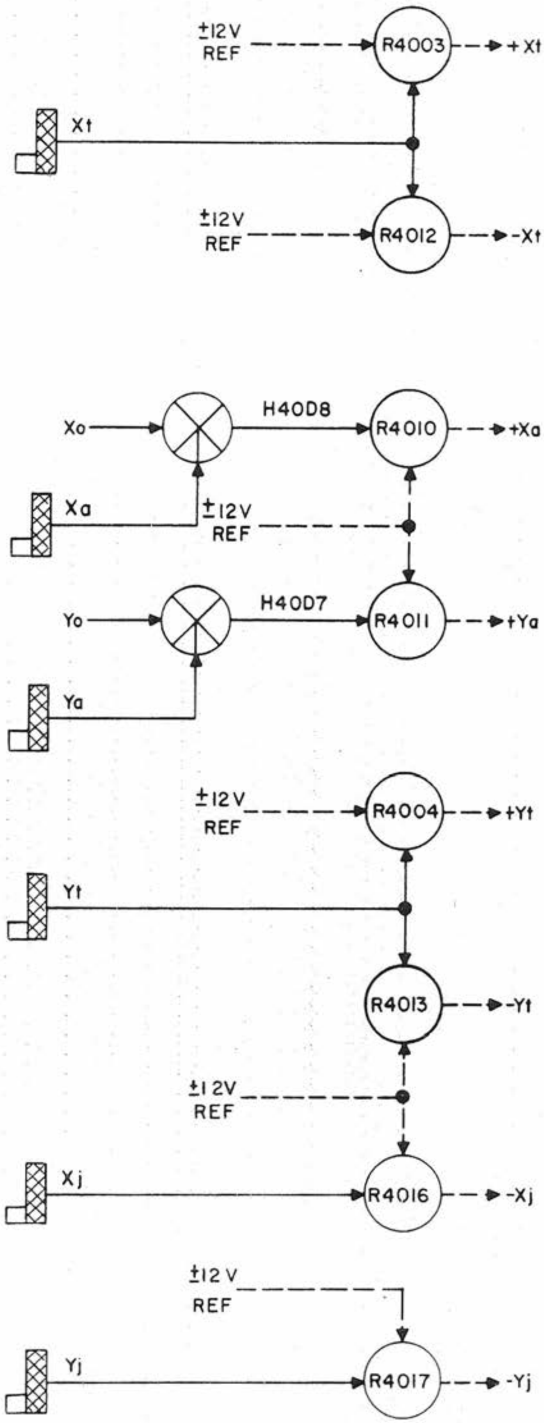


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Figure 27. Target, Reference, and Spot Coordinate Inputs to Computer Mk 48 Mod 1

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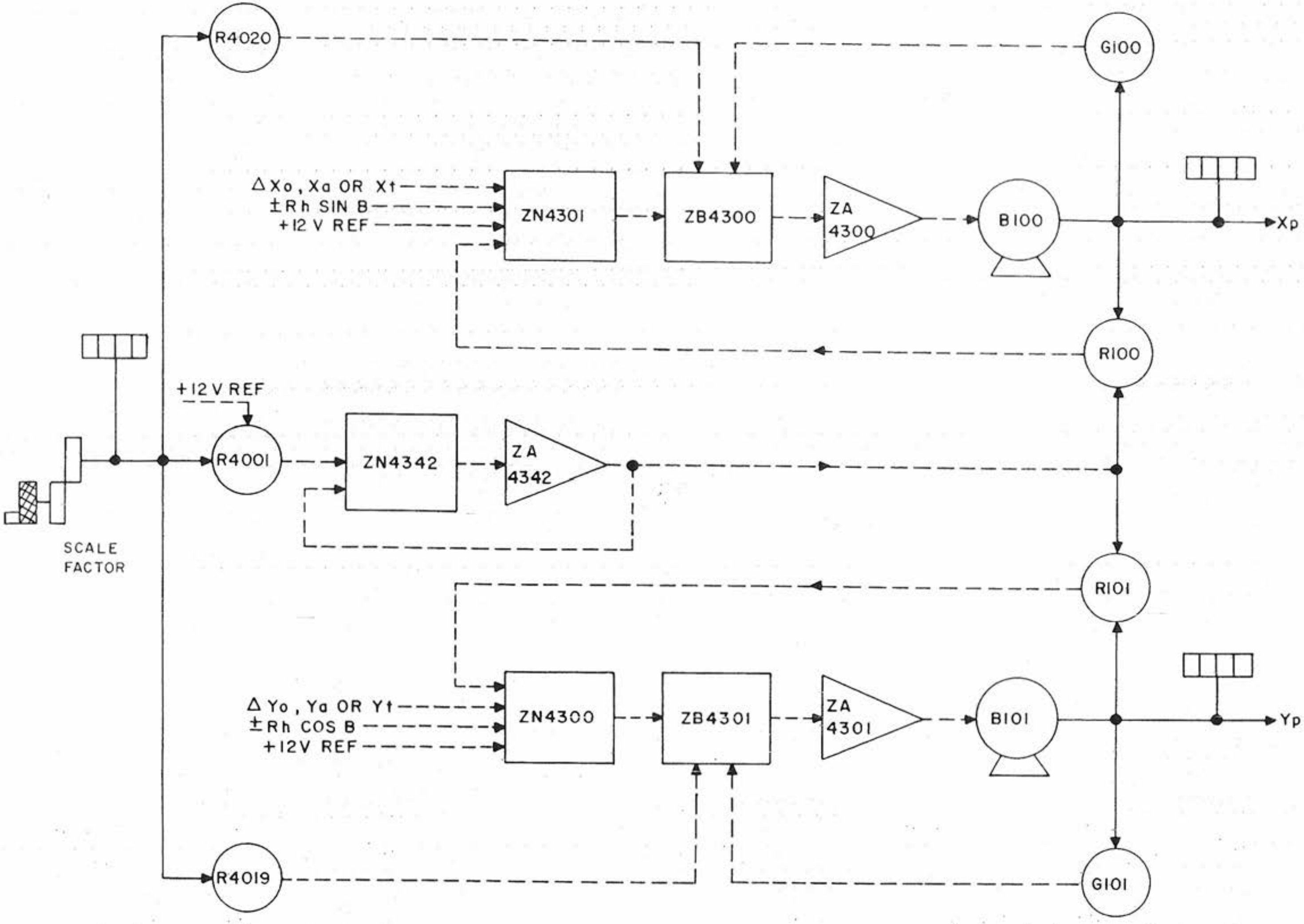

Figure 28. Scale Factor and Coordinate Inputs to Plotter

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Table 11

MODE-AND-PLOT SWITCH FUNCTION

Switch Position	Input to Plotter	Input to Computer
SHORE BOMB SHIP	Xa - Rh sin B	Xa - Rh sin B - Xt
SHORE BOMB REF-PT	Xa	Xa - Rh sin B - Xt
SHORE BOMB TGT	Xt	Xa - Rh sin B - Xt
LOCAL CONTROL SHIP	Xa + ΔXo	Xa + ΔXo - Xt
LOCAL CONTROL TGT	Xt + ΔXo	Xa + ΔXo - Xt
DEAD REK'NG SHIP	Xa + ΔXo	+ Rh sin B
DEAD REK'NG TGT	Xa + ΔXo + Rh sin B	+ Rh sin B

in the Xp and Yp servo loops. The sliding contacts of R100 and R101, positioned by the Xp and Yp servos, therefore deliver to the respective summing networks response voltages which are proportional to the scale factor as well as to Xp and Yp. The result is a variation in mechanical response proportional to scale factor. In order to maintain the servo control sensitivity (stiffness) approximately constant for all scale factors, two additional potentiometers, R4019 and R4020, positioned by the scale-factor handcrank, adjust the gain of the servo controls by varying the feedback voltage in accordance with the scale-factor setting. The output of the Xp and Yp servo loops drive the respective lead screws that position the index light in the plotter. Internal counters that show in inches the value of X and Y servoed into the plotter are provided.

FUNCTIONAL DESCRIPTION OF DECK-TILT SECTION

Inputs

As shown in figure 29, the stable vertical is aligned on the target by a computed value of target bearing derived in Computer Mk 48 Mod 1. The outputs of the stable vertical, which therefore are target level and cross level, OL' and OZh, are transmitted to the OL' receiver synchros B4056 and B4057 and to the OZh receiver synchros B4058 or B4059 and B4060, which are shown in figure 30. The elements used in the standard loops for servoing the received values of OL' and OZh also are shown in figure 30. The other synchro inputs to the deck-tilt section, Co and B'r', are covered in the description of the horizontal section.

The received values of OL' and OZh are introduced mechanically into resolvers B4083, B4084, and B4085 for resolution into various sine and cosine functions as shown on figure 31. The outputs of this group, as shown on figure 37, then are applied in the two principal computations of the deck-tilt section: The computation of deck-tilt corrections for bearing angles used in the computer and the computation of reference line-of-sight deck-tilt angles for use in the director.

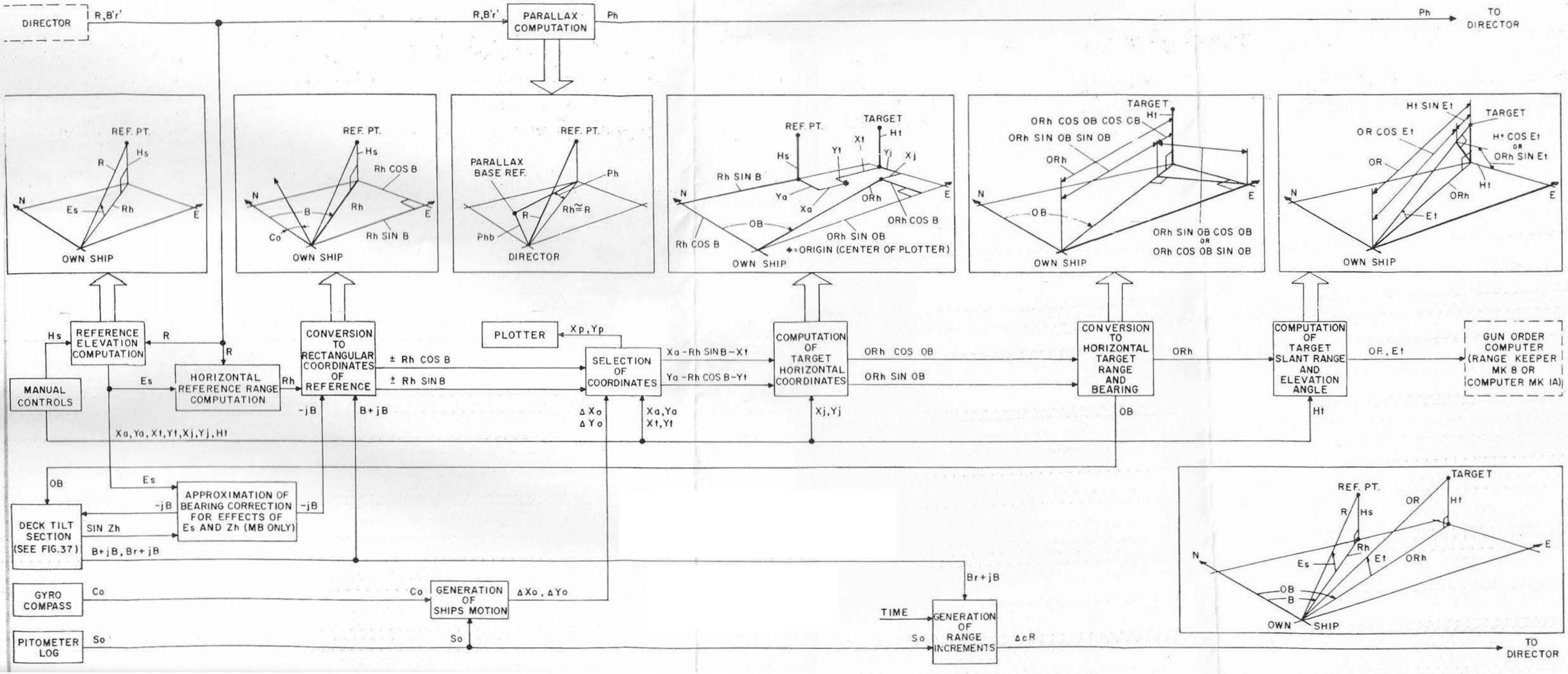
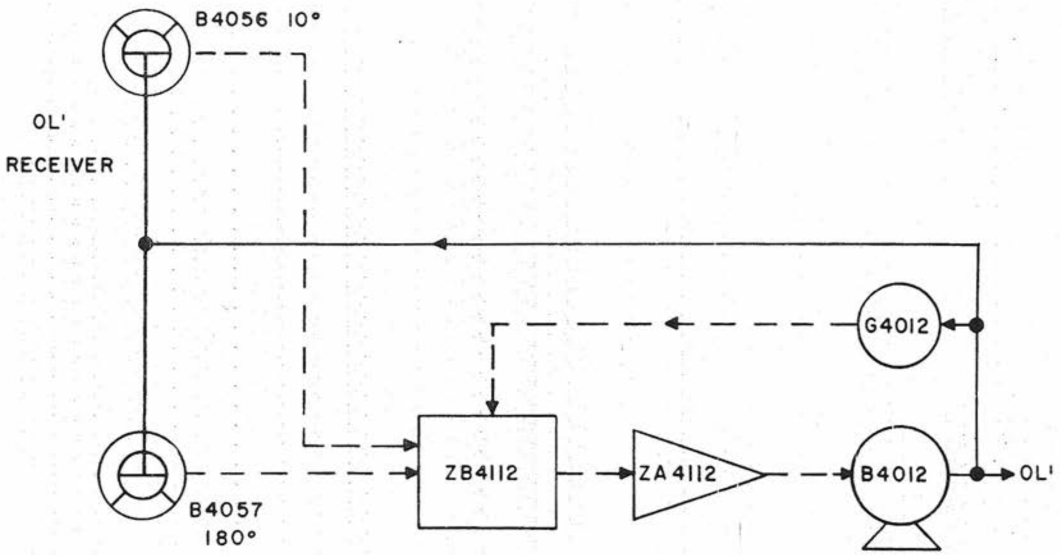


Figure 29. Flow Diagram of Horizontal Section



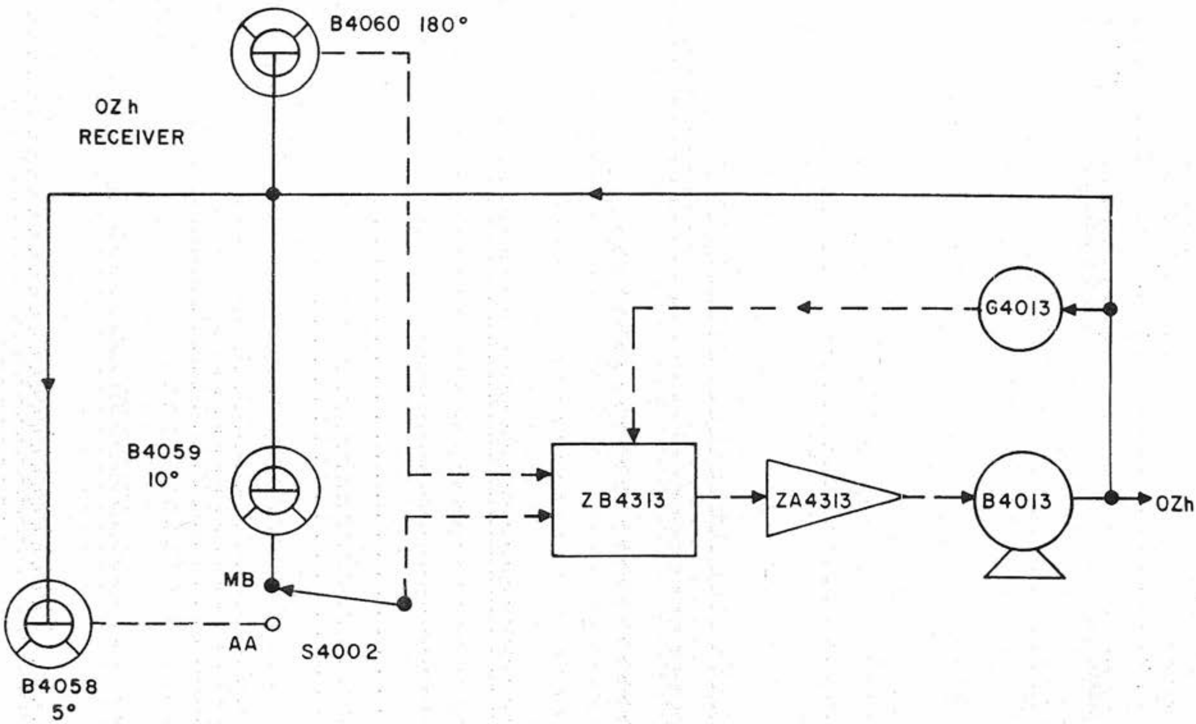


Figure 30. OL' and OZh Receivers

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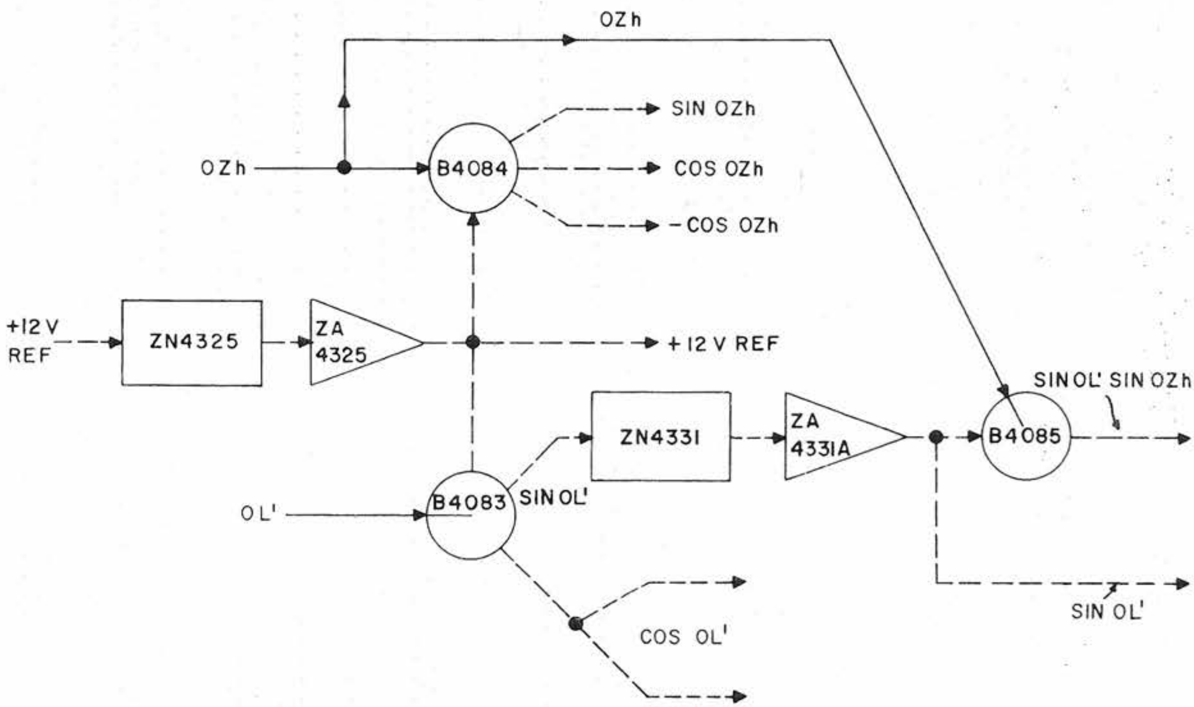

Figure 31. Resolution of Target LOS Deck-Tilt Angles

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Computation of Target-Bearing Deck-Tilt Correction

The sine and cosine functions of OL' and OZh, derived as shown in figure 31, first are applied in the computation of multiple functions required as intermediate quantities for computing the deck-tilt corrections. The components used in combining these functions are shown in figure 32. The resulting multiple functions then are used in the computation of the target-bearing deck-tilt correction jOB'r'

The quantity jOB'r' is defined as equal to OBr - OB'r', target bearing in the horizontal plane minus target bearing in the deck plane, as shown in figure 37. The solution is based on the equation

-sin jOB'r' (cos OL' + cos OZh)

(-)cos jOB'r' (sin OL' sin OZh)

-cos (2 OB'r' + jOB'r') (sin OL' sin OZh)

-sin (2 OB'r' + jOB'r') (cos OL' - cos OZh)

= 0.

The same instrumentation is used to compute the corresponding three-axis correction, jOB'r. As may be seen by comparing the equations for each, only the circled signs differ.

-sin jOB'r (cos OL + cos OZd)

(+)cos jOB'r (sin OL sin OZd)

-cos (2 OB'r + jOB'r) (sin OL sin OZd)

-sin (2 OB'r + jOB'r) (cos OL - cos OZd)

= 0

When Computer Mk 48 is switched from MB to AA operation, the corresponding AA quantities are introduced and the polarity of a unit transmitting -cos jOB'r' (sin OL' sin OZh) (MB) is reversed.

As shown in figure 32, the four terms of this equation are computed in four resolvers, B4086 through 4089, from electrical inputs of multiple-level and cross-level functions and mechanical inputs of jOB'r' and 2 OB'r'. The four resolver outputs are combined in network ZN4315 to set up the equation. Any output value other than zero (null) results in appropriate rotation of the jOB'r' servo, which adjusts the value of jOB'r' and 2 OB'r' until the equation is balanced.

The quantity 2 OB'r' is obtained from differential H40D5, figure 35, through a 2-to-1 gear ratio. This value is introduced mechanically to the stators of bearing-mounted resolvers B4086 and B4087 so that the rotor-stator relationship is 2 OB'r' + jOB'r'.

The sine and cosine quantities are obtained from the resolvers shown in figure 31. Amplifiers ZA4329A and ZA4329B, figure 32, are two halves of a dual-channel unit. The servoed output jOB'r' also is used to drive differentials H40D6, figure 35, and H40D9, figure 34.

Computation of Combined Deck-Tilt Corrections

The computation of the combined bearing-correction angles for deck tilt, jOB'r' - jB'r', also makes use of the multiple sine and cosine functions of OL' and OZh. This computation is based on the relationship jOB'r' - jB'r' = (OBr - Br) - (OB'r' - B'r'), illustrated in figure 16. The equation used in the computer is derived from this diagram, and is:

(+){sin [2(OBr-Br-jB) - (jOB'r'-jB'r')]}

(cos OL'-cos OZh)

(+){cos [2(OBr-Br-jB) - (jOB'r'-jB'r')]}

(sin OL' sin OZh)

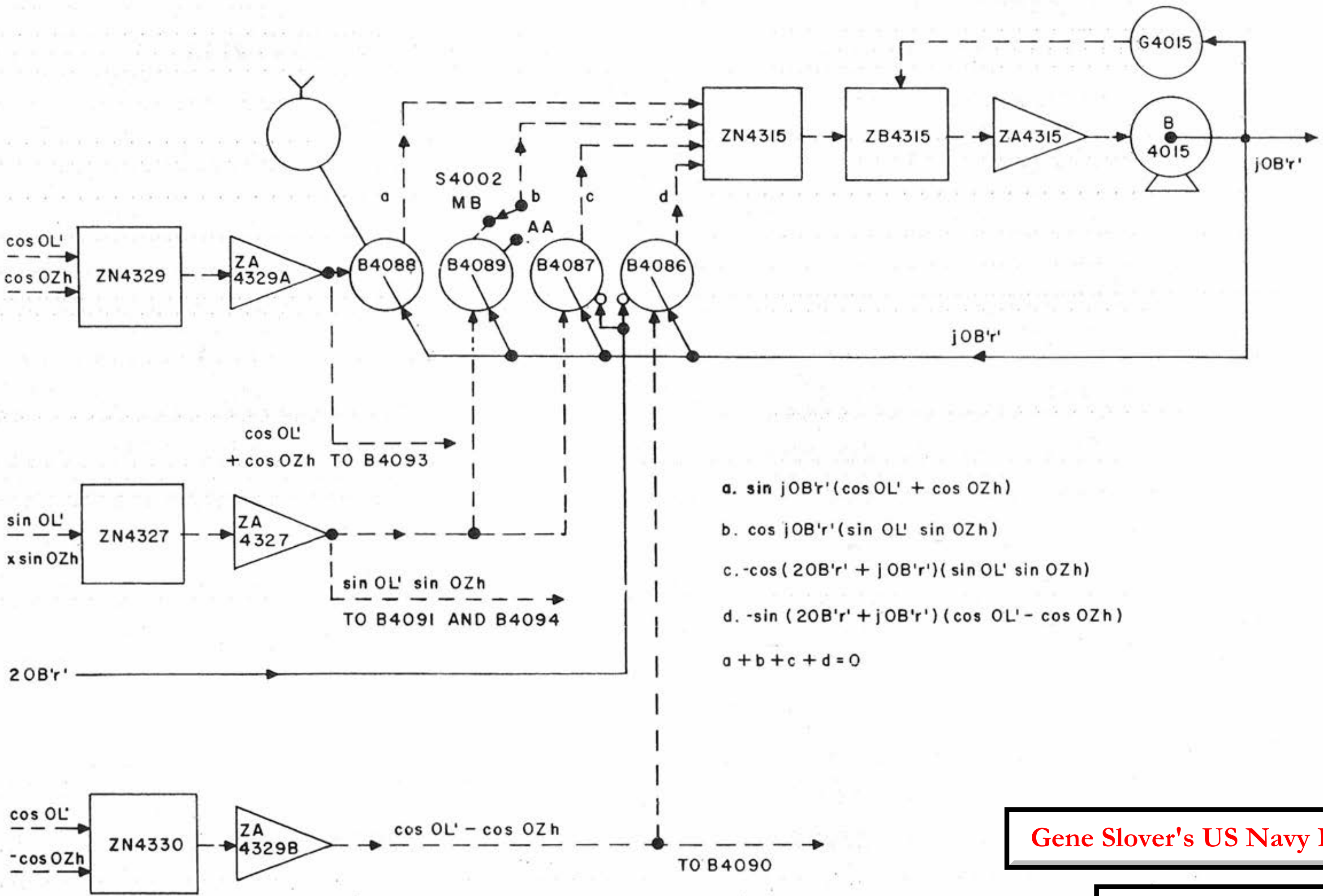

Figure 32. Computation of jOB'r'

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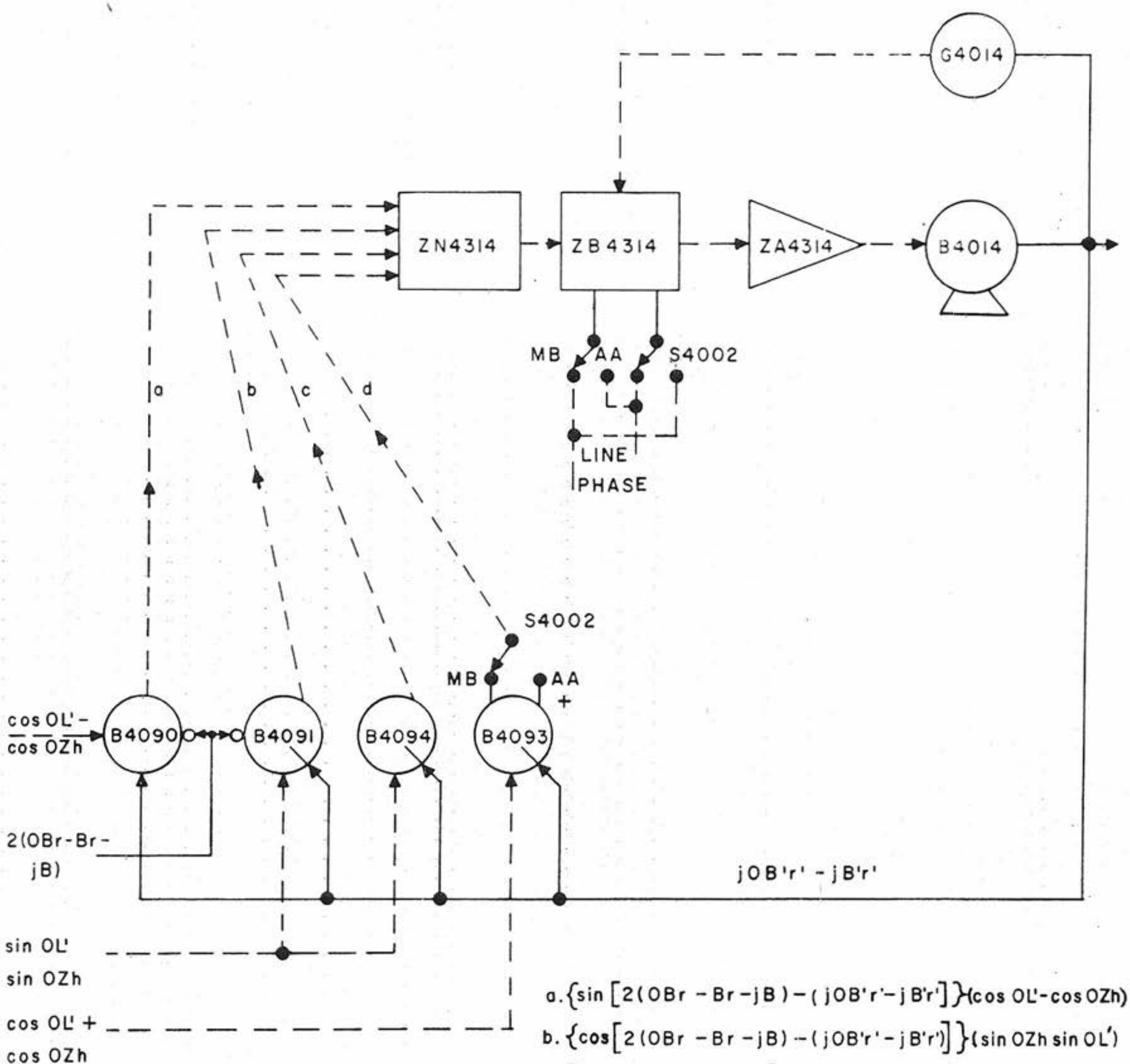

a. {sin [2(OBr − Br − jB) − (jOB'r' − jB'r')]}(cos OL' − cos OZh)

b. {cos [2(OBr − Br − jB) − (jOB'r' − jB'r')]}(sin OZh sin OL')

c. −[cos (jOB'r' − jB'r')] sin OZh sin OL'

d. −[sin (jOB'r' − jB'r')] (cos OZh + cos OL')

a + b + c + d = 0

Figure 33. Computation of jOB'r' - jB'r'

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$$(-)\left[\cos\ (jOB'r' - jB'r')\right]\ (\sin OZh \sin OL')$$

$$-\ \left[\sin\ (jOB'r' - jB'r')\right]\ (\cos OZh + \cos OL')$$

$$= 0.$$

The instrument solution of the equation, shown in figure 33, is similar to that described in the previous paragraph for jOB'r'. Each of the four resolvers, B4090, B4091, B4093, and B4094, produces a term of the equation from electrical inputs of the multiple functions of level and cross level and mechanical inputs of jOB'r' - jB'r' and 2(OBr - Br - jB). Network ZN4314 sums the four resolver outputs, which should total zero. If the mechanical inputs do not correspond with the electrical inputs to the resolvers, the output of the summing network will be other than zero, causing the servo motor to change the mechanical inputs until the equation is balanced.

The same instrumentation is used to compute the corresponding three-axis correction, jOB'r - jB'r.

$$(-)\left\{\sin\ \left[2(OBr-Br) - (jOB'r-B'r)\right]\right\}$$

$$(\cos OL - \cos OZd)$$

$$(-)\left\{\cos\ \left[2(OBr-Br) - (jOB'r-B'r)\right]\right\}$$

$$(\sin OL \sin OZd)$$

$$(+)\left[\cos\ (jOB'r - jB'r)\right]\ (\sin OL \sin OZd)$$

$$-\ \left[\sin\ (jOB'r - jB'r)\right]\ (\cos OL + \cos OZd)$$

$$= 0.$$

The AA equation differs from the MB equation only by omitting -jB and by the circled signs. When Computer Mk 48 Mod 1 is switched from MB to AA operation, -jB is no longer contributed to the solution and the sign changes indicated are accomplished by changing the polarity of the proper components through the contacts of the MB-AA switch, S4002.

Servo motor B4014 also drives one end gear of differentials H40D9 and H40D4, figures 34 and 35, which take part in the summing of mechanical bearing quantities, as described in the following paragraphs. One of these bearing quantities, OBr - Br - jB, obtained from differential H40D3, is doubled in the gearing and positions the stators of bearing-mounted resolvers B4090 and B4091; the rotor-stator relationship is therefore 2(OBr - Br - jB) - (jOB'r' - jB'r'). The sine and cosine functions for the electrical inputs are obtained from the amplifiers shown in figure 32, as previously described.

Summation of Reference-Bearing Corrections

The summation of reference-bearing corrections, shown on figure 37, now can be made from the shaft values of jOB'r', (jOB'r' - jB'r'), Co, and -jB that are added or subtracted in the differential group, shown in figure 34, to produce Co + jB'r' - jB. These servoed quantities were derived as shown in figures 18, 21, 32, and 33. The Co + jB'r' - jB transmitter consists of a 6HG synchro at 5 degrees, B4071, and a 5HG synchro at 10 degrees, B4072. This quantity is transmitted to the directors as a correction to bearing in order to keep the director automatically on the reference point regardless of changes in deck tilt and ship course.

Summation of Target-Relative-Bearing Terms

In the target-relative-bearing computation, OB'r' is derived and transmitted to the stable vertical and a gun order computer. In main-battery operation the stable vertical and gun order computer are Stable Vertical Mk 41 and Range Keeper Mk 8. When the secondary battery is used, OB'r' becomes OB'r and is transmitted to Stable Element Mk 6 and Computer Mk 1A. The

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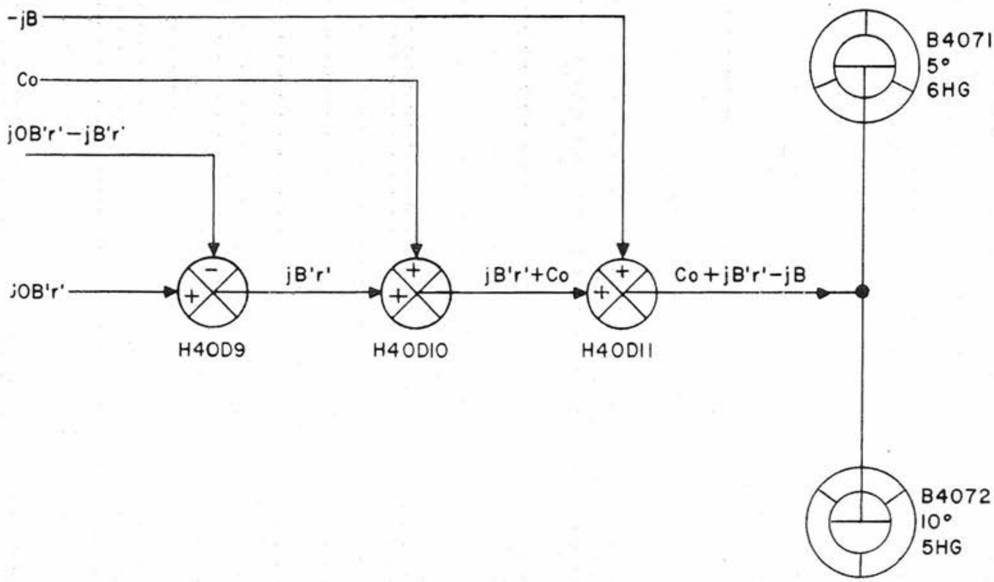

Figure 34. Summation of Reference Bearing Corrections

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transmitter in either case consists of two 6HG synchros (B4068 and B4069) at 10 degrees and 360 degrees per revolution equipped with dials to indicate the computed value of OB'r'.

In terms of main-battery operation, the quantity that drives the relative-target-bearing transmitters is the sum of the two inputs, (OBr - Br - jB) and B'r - (jOB'r' - jB'r'), of differential H40D5. This sum is equal to OB'r', from the sketch on figure 37, where jOB'r' - jB'r' = (OBr - Br - jB) - (OB'r' - B'r'). A group of mechanical differentials, H40D4, H40D6, H40D1, and H40D3, arranged as shown in figure 35, add or subtract various intermediate quantities to provide the inputs to the two end gears of H40D5. The functions performed by the differentials are:

(B'r') - (jOB'r' - jB'r') (H40D4)

B'r' - (jOB'r' - jB'r') + jOB'r' =

B'r' + jB'r' (H40D6)

Since: B'r' = Br + jB - jB'r'

B'r' + jB'r' = (Br + jB)

(Br + jB) + Co = (B + jB) (H40D1)

OB - (B + jB) = (OBr - Br - jB) (H40D3)

Some of these quantities are used for computations elsewhere in the computer. For instance, (OBr - Br - jB) is used in the computation of sin L' and sin Zd, figure 36, and in the computations performed by resolvers B4090 and B4091, figure 33. OB'r' is used also in the computations of resolvers B4086 and B4087, figure 32. Br + jB is used to compute ΔcR, figure 26, and B + jB is used to compute Rh sin B and Rh cos B, figure 22 in the horizontal sections.

DIRECTOR SELECTOR Switch

As mentioned in the beginning of this chapter, provision is made in Computer Mk 48 Mod 1 to compute for both AA and MB fire control systems by means of the DIRECTOR SELECTOR switch, S4002. The functioning of this switch is outlined in the following discussion. As previously described. the train control transmitter, B4071 and B4072, transmits the quantity Co + jB'r' - jB, figure 34. When the computer is operating with an MB fire control system, jB can be any value between plus and minus 15 degrees; when an AA system is in use, jB is always zero. The geometry of these relationships is shown in figure 37. In the computer, the solution for jB, figure 21, is based on the approximation tan Es sin Zh = sin jB. DIRECTOR SELECTOR switch, S4002, functions in the solution as follows: In the MB position, switch S4002 connects a voltage proportional to tan Es sin Zh to the network, follow-up, and resolver used to compute jB. The follow-up positions the resolver rotor so that the sine output of the resolver (-sin jB), when added to tan Es sin Zh, equals zero; this occurs when the resolver rotor is at angle jB; hence the response of the follow-up is a shaft rotation equal to jB. In the AA position, the switch connects the input of the network to ground; the jB servo then nulls the loop by changing jB until the output of the resolver sine winding (response) equals zero or ground potential, at which point jB is equal to zero.

The DIRECTOR SELECTOR switch is used also to switch the fine receivers used with the coarse 180-degree (2-speed) target line-of-sight cross-level receiver B4060, as shown in figure 30. This switching is done to match the receiving synchros with the transmitting synchros in the stable vertical or stable element. Thus, in the MB position the receivers correspond with the 180- and 10-degree (2- and 36-speed) synchros in Stable Vertical Mk 41, which is used in the MB fire control system; in the AA position, the receivers correspond with

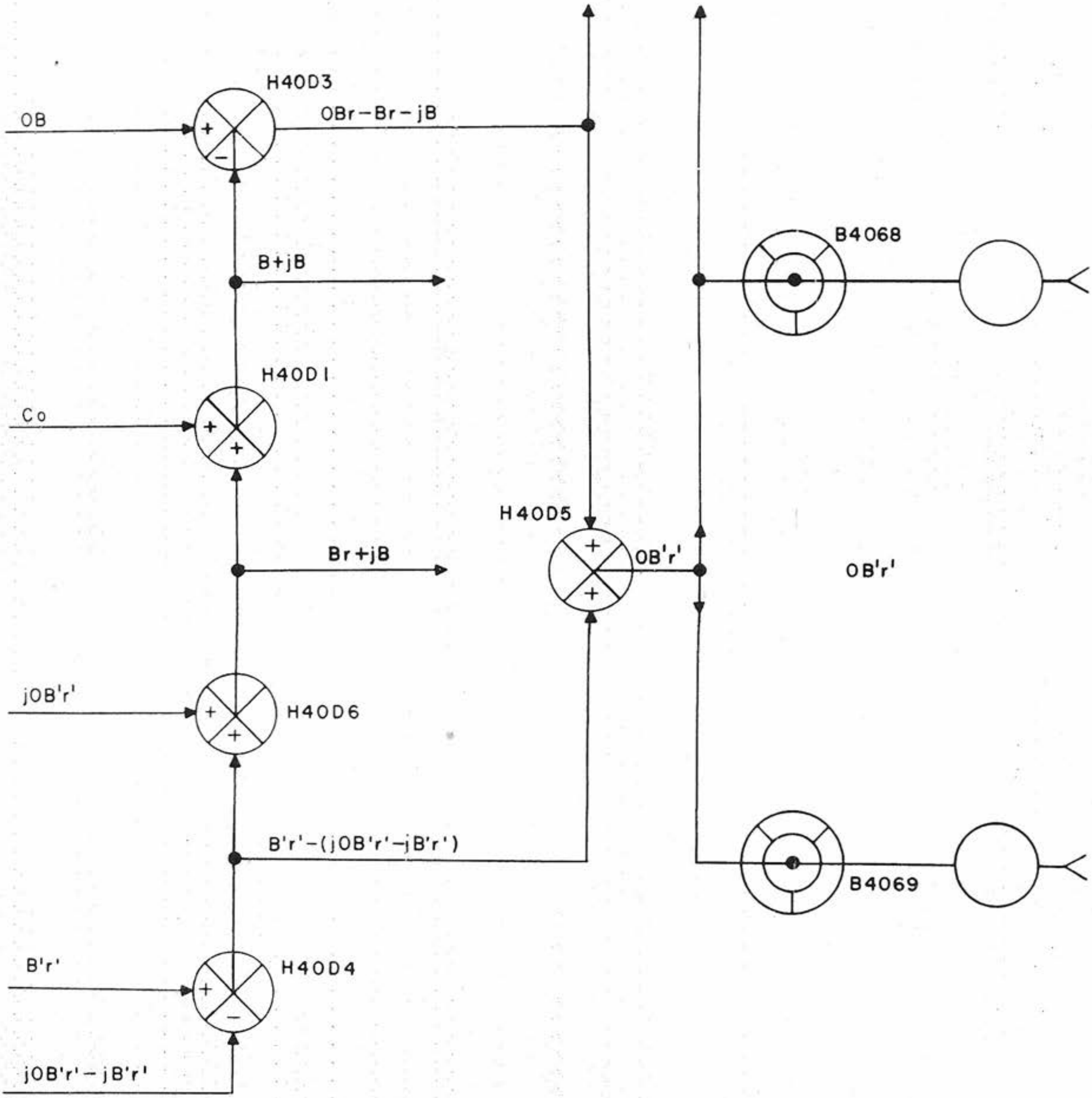
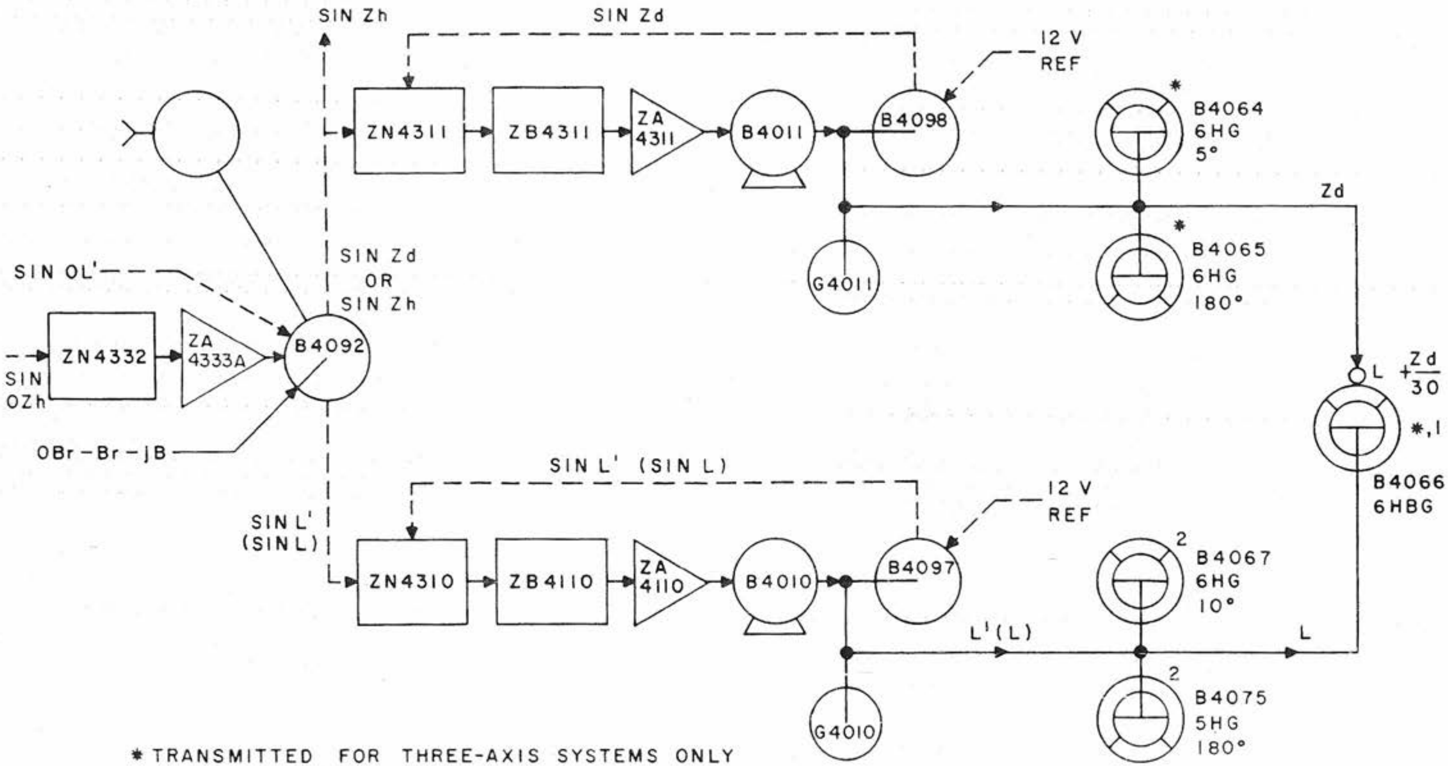


Figure 35. Summation of Target Relative Bearing Terms



* TRANSMITTED FOR THREE-AXIS SYSTEMS ONLY
1. TRANSMISSION SPEEDS:
   72 x - ARMA DRIVES
   36 x - AMPLIDYNE DRIVES
2. FOR ANTENNA MOUNT Mk 23 ONLY

Figure 36. Computation of Reference LOS Deck-Tilt Angles

the 180- and 5-degree (2- and 72-speed) synchros in Stable Element Mk 6 used in the AA fire control system. Switch S4002 is used also to reverse the phase of computing voltages where the mathematics of the problem involved require a reversal of sign. This is the case in the outputs of resolvers B4089 and B4093, figures 32 and 33, where the voltages going to the associated networks represent mathematical quantities. Owing to the difference in the solutions for an AA or an MB system, either a reversal of the signs of the resolver output or a reversal of the signs of all the other quantities, when switching from one system to the other, is required. The same consideration is involved in one additional case, figure 33, where the reference voltage to the servo control is reversed in phase, causing the associated servo motor to run in the opposite direction (adding or subtracting in differential H40D4, figure 34), depending on which system is in use.

Reference-Point Deck-Tilt Computation

Normally, the level and cross-level quantities required for the director originate in the stable vertical (or stable element), but since, in this particular problem, the stable vertical train input, train-to-target, is not the same as director train, the measured values of level and cross level are not directly usable for stabilizing the director. To satisfy the director requirements, values of level and cross level based on the reference line of sight, computed by Computer Mk 48 Mod 1. These quantities are computed for both AA and MB use, but only Gun Director Mk 37 makes use of all three. Due to differences in system design, the computed value of level, L', is employed only during MB operation and the values of cross level, Zd, and level plus a function of cross level, L + Zd/30, are used only by AA Gun Director Mk 37.

The true-solution equations for main-battery quantities from which the mechanized approximations are derived are as follows:

$$\sin L' = \sin OL' \cos(OBr - Br - jB) + \cos OL' \sin(OBr - Br - jB) \sin OZh$$

and

$$\sin Zh = \cos Zh \tan OZh \cos(OBr - Br - jB) \frac{\tan OL'}{\cos OZh} (OBr - Br - jB)$$

The approximations used in Computer Mk 48 Mod 1 are:

$$\sin L' = \sin OL' \cos (OBr - Br - jB) + \sin (OBr - Br - jB) \sin OZh$$

and

$$\sin Zh = \sin OZh \cos(OBr - Br - jB) - \sin OL' \sin (OBr - Br - jB)$$

The corresponding AA equations to compute sin L and sin Zd are:

$$\sin L = \sin OL \cos(OBr - Br) + \sin (OBr - Br) \sin OZd$$

and

$$\sin Zd = \sin OZd \cos(OBr - Br) - \sin OL \sin(OBr - Br)$$

The MB relationships are instrumented to compute L' and Zh as shown in figure 36. With reference to the figure, sin OL' and sin OZh, previously derived, form the electrical inputs to resolver B4092, and the angle OBr - Br - jB, from differential H40D3, mechanically positions the resolver rotor. The terms in the right-hand sides of the simplified equations shown above are established in the resolver from the inputs

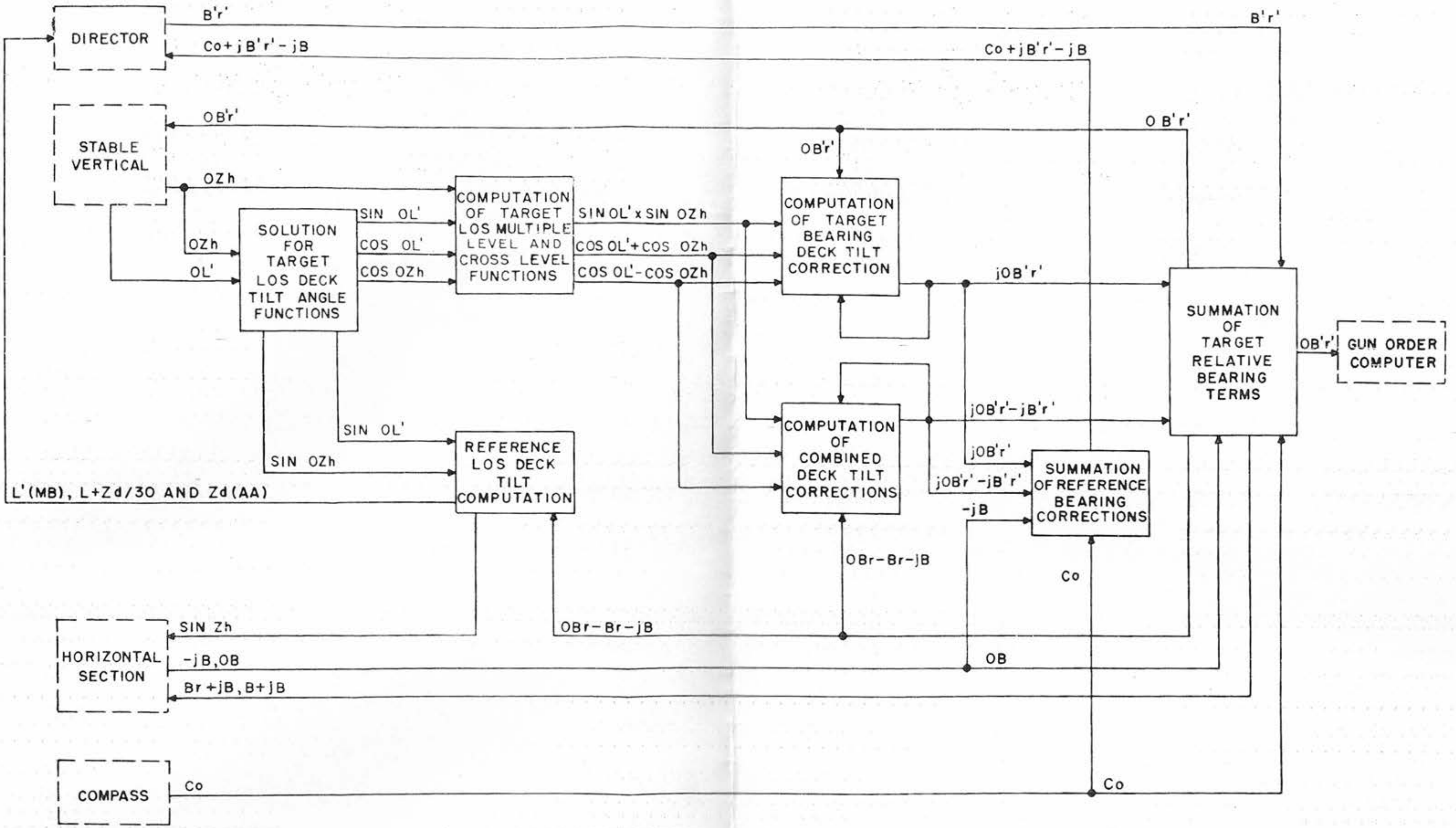


Figure 37. Flow Diagram of Deck-Tilt Section

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by the configuration of the wiring and the phasing, so that the resolver outputs are equivalent to sin L' and sin Zh. These outputs are servoed individually, the loop response being taken from the sine winding of a resolver in each loop. The output of resolver B4097 will null the Zh loop when the servo motor has driven the rotor of B4098 to an angle equivalent to Zh. Synchros for transmitting L' and Zh to a director are connected mechanically to their respective loop servo motors.

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Chapter 5

MAINTENANCE

This chapter contains the tests and maintenance procedures needed to ensure satisfactory operation of Computer Mk 48 Mod 1. It is written primarily for personnel already familiar with fire control and standard electronic test equipment.

The tests and maintenance procedures are divided into five sections:

Section 5.1—Cleaning and Lubrication

Section 5.2—Routine Tests

Section 5.3—Trouble Shooting

Section 5.4—Electronic Unit Trouble Shooting

Section 5.5--Adjustments

All pertinent data considered too lengthy or detailed for inclusion in a section have been assembled in the appendix for easy reference.

Section 5.1—Cleaning, Lubrication, and Inspection

SCHEDULE

The computer should be cleaned, lubricated, and inspected every 1000 hours of operation, as registered by the time meter.

The time meter records the total number of hours the computer has been in ON operation. It is located behind the front panel cover below network box ZN4141, as shown in figure 63. The indicator is useful when planning tests, maintenance, cleaning, lubrication, and inspection schedules. It also provides data for keeping an accurate log of the performance of duties prescribed by ship's doctrine.

CLEANING

Before the instrument is lubricated, it must be cleaned of all metal chips, dirt, dust, and lint. Cleaning should be done with a vacuum cleaner and with a lint-free cloth or brush dipped in white kerosene, MIL-K-3128 (or Deobase, L. Sonneborn and Sons). To avoid the possibility of the cleaning solvent draining onto other units and remaining there, the cleaning process should start at the top of the instrument and progress toward the bottom. The use of compressed air within the instrument is not recommended, because it is liable to blow loose dirt into bearings and onto gears. When cleaning the electronic sections, a long, bristled brush can be used to dislodge accumulated dust into the vacuum cleaner pick-up hose. The solvent, applicators, and other cleaning accessories should be kept clean and free from dirt and chip contamination.

LUBRICATION

After the cleaning operation has been completed and all the solvent has been removed, lubrication should be performed systematically. Fully lubricating one section or area in the instrument before going on to the next helps to avoid missing any of the important points. The lubricating information that follows is presented in the form of detailed instructions for each type of basic mechanism or basic part that requires lubrication. After lubrication, rotate the pertinent shafts and working parts to distribute the lubricant evenly; then wipe away all excess grease and oil with a clean, lint-free cloth.

Lubricants

Grease. Where grease is needed, use Instrument Lubricating Grease, MIL-G-15793.

Oil. Where oil is needed, (except in time-motor regulator) use Instrument Lubricating Oil, MIL-L-6085A.

Chronometer Oil. For time-motor regulator, use Wm. F. Nye chronometer oil, except on ball bearings.

Detailed Lubricating Instructions

Instructions for the routine lubrication of the components are as follows:

Component Solvers. Apply a thin coating of grease to the sliding surfaces, slots, and racks. Apply 3 to 5 drops of oil to each bearing, roller groove, and pivot point.

Integrators. Apply a thin coating of grease to all working parts and surfaces of the integrator. Apply 3 to 5 drops of oil to all bearings, except those that support discs. The discs should be lubricated with grease whenever integrators are disassembled.

Limit Stops. Apply a thin coating of grease to the threads, and run the nut the full length of limit-travel several times to distribute the grease evenly.

Differentials. With differentials that have spider shafts less than 1/4 inch in diameter, lubricate the gears and bearings with oil. With differentials that have larger shaft diameters, apply a thin coating of grease to all gearing. Apply about 3 drops of oil to each bearing to form a protective film.

Gears. Apply a thin coating of grease to all servo motor pinions, and all gears within three meshes of the motor pinions. Grease all gearing driven by the time motor, and all gearing between the Xp and Yp servo motors and the plotter lead screws. On all other gears, apply enough oil to the gear teeth to form a protective film.

Bearings. Apply 3 to 5 drops of oil to all bearings.

Couplings. Apply a thin coating of grease to all pressure contact surfaces.

Worm and Worm Wheels. Apply a thin coating of grease to the gear teeth.

Plotter Lead Screws. Apply a thin coating of grease to the lead screws.

Time-motor Regulator. Apply 3 drops of oil (MIL-L-6085A) to all ball bearings. To each jewel bearing and to the worm-gear mesh, apply Wm. F. Nye chronometer oil, sparingly.

INSPECTION

During the normal course of cleaning and lubricating, all gears and other mechanical parts should be inspected for evidence of damage or abnormal wear due to binding, improper alignment, or presence of foreign material. Similarily, components in the electronic section should be checked for dust accumulation and signs of trouble, such as charring, fraying of insulation, and bleeding of potting compound or capacitor oil. Before repairing or replacing the affected parts, inspection should be extended to determine the cause of the damage so that the possibility of recurrence can be eliminated.

Air filters are installed at the air intakes of the cooling system to prevent the cooling air from carrying dirt into the electronic portion of the instrument. They should be inspected periodically, and cleaned or replaced when necessary.

Section 5.2— Routine Tests

The functional condition of the computer should be known at all times. The routine tests that follow are the only practical means for checking its overall accuracy. If the results obtained during the performance of these indicate a need for computer maintenance, refer to trouble shooting, section 5.3.

Prior to every routine test or firing problem, check the serviceability of the neon indicator lights, and by means of the neon monitoring system and voltmeters, determine if the electronic elements and power supply units are functioning correctly (see section 5.3). Each of the routine tests is designed to check particular sections of the computer. However, the same fundamental method is used for all routine tests. That is, introducing specified inputs, reading resultant outputs, and comparing observed values with calculated values. When all outputs remain within the tolerances, the functional condition of the computer is considered satisfactory.

LIST OF TEST-FORM DRAWING NUMBERS

The routine tests are based on information taken from factory tests. Copies of these tests may be requisitioned from the Naval Gun Factory, Washington 25, D.C. The tests are identified as follows:

A Tests . . . .BuOrd Dwg 456326

All other tests. NAVORD OD 10522 (under preparation)

FREQUENCY OF TESTS

The recommended frequency for performance of routine tests is as follows:

Frequency of Test	Routine Test
Daily (one problem)	A Tests
Weekly	Generation of ΔXo and ΔYo
Weekly	Generation of ΔcR
Weekly	Test of transmission units (except Ph and ΔcR)
Monthly	Test of Ph and ΔcR transmitters
Monthly	Time-motor regulator test
Monthly	Index-light travel test

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TEST INPUT SETTINGS

All output quantities from the computer are direct functions of their respective input quantities. Therefore, no attempt at trouble analysis should be based on test results derived from input settings not made with systematic uniformity and accuracy.

In the absence of specific instructions, an input should be set by turning its input control in the direction that causes its dial to move in an increasing direction, that is, from a lower value to a higher one. If an input is accidentally run beyond the checkpoint, return the dial to the negative side of the value and, turning the dial more slowly than previously, carefully approach the setting again. Exercising such uniformity and exactness with the input setting will result in constant, reliable, and uniform test readings from which instrument performance can be evaluated correctly.

CALCULATION OF ERRORS

To calculate a test error, subtract algebraically the calculated value from its observed value. The following examples may be used as a guide:

Calculated Value	Observed Value	Test Error (in mins)
60° 00'	60° 03'	+3
60° 00'	59° 58'	-2
-60° 00'	-60° 06'	-6
-60° 00'	-59° 59'	+1

Average Error

To calculate the average error, first add the individual errors without regard to signs, then divide the sum by the number of errors recorded. The quotient will be the average error for each quantity. The average of the errors in the preceding tabulation would be 3 minutes.

Maximum Error

To determine the maximum error, select the largest reading of all the readings recorded. The maximum error of the errors in the preceding tabulation would be 6 minutes.

Allowable Limits

To determine whether the errors are permissible, compare the average and maximum errors with the allowable average and maximum values given on the test form for that particular quantity. If the recorded values are within the error range allowed, the test should be considered satisfactory. If the results exceed the range allowed, the test is unsatisfactory and reference should be made to the appropriate test analysis in section 5.3 of this chapter.

Procedure for Excessive Errors

Whenever output errors are excessive, perform an analysis of the errors to determine the exact cause, and immediately take measures to correct it. If the output errors are the direct result of an improper test setup, correct the test setup and repeat the entire test. If the output errors are not caused by an improper test setup, but by the computer itself, refer to the trouble shooting section of this chapter to determine the causes and remedies. After an element has been replaced with a new one, repaired or adjusted, always perform a complete set of tests to be certain the instrument is in satisfactory condition.

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A TESTS

The A tests are static tests and are made to check all computing mechanisms, except those requiring a time input. They test the condition of the interconnection of dials and counters to the input and output shafts, the operation of the various computing elements involved, and the functional accuracy resulting from established adjustments between the various elements.

Tables 12 and 13 give the independent variables, or inputs, and the transmitted quantities, or outputs, respectively, for the sixteen A test problems. The test procedure, basically, involves introducing a prescribed set of input quantities into the computer, reading the resultant outputs, and entering the test results in the appropriate columns on the test form. When discrepancies between observed and calculated values exceed the tolerances, reference should be made to A Test Trouble Analysis in section 5.3.

Since each A test problem is designed to place critical stress on a limited number of the computing elements, no single problem or partial A test proves the functional accuracy of the computer as a whole. The computer is not proven completely until all the A tests have been run and found to be satisfactory.

Problem Setup

Certain quantities listed for the A test problems cannot be read on an external dial or counter on the computer. Therefore, to facilitate running a set of problems without removing the covers, use the test unit and some of the indicating devices in the director and on the stable vertical.

The A test values for Ph and X and Y coordinates were devised to be read as voltages, using the test unit as the measuring device. For these quantities, the SIGNAL TEST SELECTOR switch on the computer is set at the position prescribed on the A test form, and the resultant outputs are read from the dials of the test unit. Refer to Test Unit, page 103 for a complete operational description of this instrument.

Offset level and cross level are the only A test inputs without any hand input facilities on the computer. They must be introduced at the stable vertical and fed into the computer as electrically transmitted inputs. The general procedure for these two quantities is to set up the switchboards for transmitting OL' and OZh to the computer and then to set the stable vertical dials manually at the values specified for the A test problem. Similarly, since there are no indicating facilities on the computer for the transmitted values of L', Zh, and Co + jB'r' - jB, the necessary arrangements must be made for transmitting these quantities to a director and for a director operator to read and report the values received. The complete test procedure may be summarized as follows:

1. Energize the motor-generator set for automatic operation, as explained in chapter 3.

2. Install the removable handcranks.

3. Complete the necessary switchboard connections as previously discussed.

4. Throw the computer POWER switch to ON.

5. Check the voltmeters and neon indicator system for correct operation of the computer.

6. Connect the test unit to the computer.

Table 12

A-TEST INDEPENDENT VARIABLES

Mode	Item	Director Train	Ship Course	Ship Speed	Observed Slant Range	Radar Beacon Delay Spot	Offset Level	Offset Cross Level	Height Point of Aim	Height Target	E-W Spot	N N-S Spot	E-W Offset Target From Reference	N-S Offset Target From Reference	E-W Offset Point of Aim From Reference	N-S Offset Point of Aim From Reference	Scale
	Sym-bol	B'r'	Co	So	R	R	OL'	OZh	Hs	Ht	Xj	Yj	Xt	Yt	Xa	Ya	SF
	Unit	Degrees and Minutes	Degs	Knots	Yards	Yards	Minutes 2000 = Zero	Minutes 2000 = Zero	Feet	Feet	Yards	Yards	3A Read.	3E Read.	2F Read.	3C Read.	
M. B.	1	40°00'	20°	0	5000	0	2300	2300	3000	2500	0	0	-0. 705	-0. 705	-0. 235	+0. 590	1:25000
A. A.	2	40°00'	20°	0	5000	0	2300	2300	3000	2500	0	0	-0. 705	-0. 705	-0. 235	+0. 579	1:25000
M. B.	3	75°00'	110°	0	10, 100	100	1400	2480	4200	1000	0	0	+2. 350	+1. 880	-0. 470	-2. 184	1:10000
A. A.	4	75°00'	110°	0	10, 100	100	1400	2480	4200	1000	0	0	+2. 350	+1. 880	-0. 470	-2. 091	1:10000
M. B.	5	335°00'	230°	0	16, 400	400	1820	1160	1700	1400	E700	N200	-1. 410	0. 000	-1. 880	-0. 625	1:36000
A. A.	6	335°00'	230°	0	16. 400	400	1820	1160	1700	1400	E700	N200	-1. 410	0. 000	-1. 880	-0. 710	1:36000
M. B.	7	210°00'	60°	0	14, 200	200	1640	1880	1000	300	E50	N150	-2. 444	-0. 611	+0. 235	-2. 318	1:36000
A. A.	8	210°00'	60°	0	14, 200	200	1640	1880	1000	300	E50	N150	-2. 444	-0. 611	+0. 235	-2. 277	1:36000
M. B.	9	180°00'	345°	0	20, 000	0	2000	2900	1200	0	W500	N800	0. 000	+0. 705	-0. 151	-2. 387	1:25000
A. A.	10	180°00'	345°	0	20, 000	0	2000	2900	1200	0	W500	N800	0. 000	+0. 705	-0. 151	-2. 398	1:25000
M. B.	11	250°00'	0°	0	25, 000	0	1100	2000	1500	900	E750	S250	-1. 293	+1. 175	+0. 376	-2. 044	1:60000
A. A.	12	250°00'	0°	0	25, 000	0	1100	2000	1500	900	E750	S250	-1. 293	+1. 175	+0. 376	-2. 049	1:60000
M. B.	13	10°00'	270°	0	30, 000	0	2000	2000	5000	4700	W400	S700	+4. 700	+2. 115	-4. 465	-1. 311	1:36000
A. A.	14	10°00'	270°	0	30, 000	0	2000	2000	5000	4700	W400	S700	+4. 700	+2. 115	-4. 465	-1. 311	1:36000
M. B.	15	45°00'	150°	0	-	0	2180	2120	0	300	0	0	+0. 423	+0. 470	-0. 141	+0. 585	1:10000
A. A.	16	45°00'	150°	0	-	0	2180	2120	0	300	0	0	+0. 423	+0. 470	-0. 141	+0. 577	1:10000

Main battery (M. B.) symbols are used throughout. Problems numbered 1 thru 14 are computed with S4006 at SHORE BOMB SHIP position. Problems numbered 15 and 16 are computed with S4006 at LOCAL CONTROL SHIP position. Xt, Yt, Xa, Ya can be read only as voltage outputs of pots R3012, R4013, R4010 and R4011, respectively. Yards = 20, 000 x voltage reading/4. 7 for Xt and Yt; + for Xa and Ya. Ph can be read as voltage output of pot R4007. Degs = 1273 x voltage reading/1248.

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Table 13

A-TEST TRANSMITTED QUANTITIES

OB'r' Rel. Target Bearing			OR Slant Range to Targ.			Et Target Elevation			* Ph Horizontal Parallax			L' Level					Zh Cross Level					Co + jB'r'-jB Brg. Aid to Ref. Tr'k'g.				
Theoretical Solution	Instrument Reading	Error	Theoretical Solution	Instrument Reading	Error	Theoretical Solution	Instrument Reading	Error	Theoretical Solution	Instrument Reading	Error	Theoretical Solution	Class "B" Error	Calculated for Instrument	Instrument Reading	Class "A" Error	Theoretical Solution	Class "B" Error	Calculated for Instrument	Instrument Reading	Class "A" Error	Theoretical Solution	Instrument Reading	Error	Item	Mode
Degrees and Minutes		Min.	Yards	Yards	Yds.	Minutes (2000= Zero)		Min.	Read.	1G Read.	Read.	Minutes (2000= Zero)	Min.	Minutes (2000= Zero)		Min.	Minutes (2000= Zero)	Min	Minutes (2000= Zero)		Min.	Degrees and Minutes		Min.	Units	
50°01'			8775			2327			-0.723			2347	+1	2348			2243	0	2243			9°00'			1	M.B.
49°56'			8810			2326			-0.723			2347	+1	2348			2243	0	2243			0°11'			2	A.A.
114°35'			12097			2095			-0.542			1845	+5	1850			2751	+5	2756			7°56'			3	M.B.
115°26'			12518			2092			-0.542			1851	-1	1850			2752	+4	2756			9°09'			4	A.A.
276°16'			13568			2118			+0.148			2633	+1	2634			1416	+10	1426			1°47'			5	M.B.
273°44'			13895			2116			+0.148			2646	-12	2634			1430	-4	1426			9°35'			6	A.A.
280°17'			13432			2026			+0.201			1765	-1	1764			2298	-1	2297			0°06'			7	M.B.
279°44'			13216			2026			+0.201			1763	+1	1764			2297	0	2297			9°53'			8	A.A.
170°20'			12499			2000			0.000			1845	0	1845			2887	-1	2886			5°22'			9	M.B.
169°39'			12481			2000			0.000			1840	+5	1845			2886	0	2886			5°00'			10	A.A.
255°11'			19542			2053			+0.211			1103	0	1103			2080	-2	2078			0°38'			11	M.B.
254°50'			19526			2053			+0.211			1103	0	1103			2078	0	2078			0°19'			12	A.A.
2°00'			30957			2174			-0.032			2000	0	2000			2000	0	2000			0°00'			13	M.B.
2°00'			30957			2174			-0.032			2000	0	2000			2000	0	2000			0°00'			14	A.A.
45°00'			4547			2074			0.000			2180	0	2180			2120	0	2120			9°58'			15	M.B.
45°00'			4615			2075			0.000			2180	0	2180			2120	0	2120			0°04'			16	A.A.
	Allow.			Allow.			Allow.			Allow.					Allow.					Allow.			Allow.			
Total			Total			Total			Total					Total					Total			Total				
Avg.	15		Avg.	50		Avg.	3		Avg.	.025				Avg.	4				Avg.	3		Avg.	15			
Max.	30		Max.	100		Max.	6		Max.	.050				Max.	8				Max.	6		Max.	30			

* Read Voltage at Voltage Check Point 1G.

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7. Set in OL' and OZh at the stable vertical.

8. Throw the computer DIRECTOR SELECTOR switch to MB or AA, as required for the problem, and set in the remaining independent variables.

9. Read and record the transmitted outputs as follows:

a. Read OB'r', OR, and Et on Computer Mk 48 Mod 1 dials.

b. Read Ph on the test unit dial.

c. Notify the director operator to read and report the received values of L', Zh, and Co + jB'r' - jB.

GENERATION TESTS

The generation tests are performed to check the generating mechanisms of the computer: namely, the ΔXo, ΔYo, and Δ cR integrators, and the rate-computing mechanisms, the Co and Br mechanical resolvers.

Tables 14 and 15 are the test forms to be used in running the 10 generation problems. A problem consists of introducing predetermined input quantities into the rate-computing mechanism under test, running the time input for a specified period, and measuring the accumulated changes in the generated quantity. When the test-result errors exceed the specified tolerances, refer to Generation Test Analysis, pages 142 through 145.

Test for Generation of ΔXo and ΔYo

Problem Setup.

1. Energize the motor-generator set for automatic operation.

2. Install Co and So handcranks.

3. Set the mode-and-plot switch to LOCAL CONTROL SHIP.

4. Throw the POWER switch to STANDBY.

5. Place blank paper on the plotter and tape it securely in place.

6. Throw the TIME switch to ON.

7. Throw the POWER switch to ON.

8. Check the voltmeters and neon system for correct operation of the computer.

9. Check the stop-watch against the ship's chronometer.

Procedure.

1. Crank in the scale factor specified in column 3, table 14.

2. Crank in Co and So as specified in columns 1 and 2.

3. Determine the direction of index-light travel from column 1, and draw a travel-line at the prescribed angle of sufficient length to exceed the five-minute run.

4. Draw a straight line perpendicular to the line-of-travel, near the start end.

5. From the start line, measure off the exact distance the index light should travel in five minutes, as given in columns 4 and 5, and draw a finish line perpendicular to the travel line. For problem two (Co set at 45 degrees), measure off 4.75 inches to the right from the start line (running parallel to the edge of the plotter), and then 4.75 inches straight up to the finish point.

Table 14

TEST FOR GENERATION OF ΔXo AND ΔYo

	Settings		Measurements		Results		
1	2	3	4	5	6	7	8
Co	So Knots (yds/sec)	Scale Factor	Xo inches (yds)	Yo inches (yds)	*Total Time	Error (sec)	Error (yds/sec)
0°	14.8 (8.33)	10,000:1	0.00 (0)	9.00 up (2500)			
45°	27.6 (15.54)	25,000:1	4.75 right (3299)	4.75 up (3299)			
90°	35.5 (19.99)	36,000:1	6.00 right (6000)	0.00 (0)			
180°	45.2 (25.45)	50,000:1	0.00 (0)	5.50 down (7639)			
270°	54.7 (30.80)	70,000:1	4.75 left (9236)	0.00 (0)			
						Allow Error	0.25

*Calculated computer-time is five minutes.

6. With the start and finish lines drawn, bring the index light onto the line of travel, well ahead of the start line.

7. As the index light just crosses the start line, start the stop watch.

8. As the index light (about five minutes later) just crosses the finish line, stop the stop watch and note the exact time taken for the light to travel from the start to the finish line.

9. Enter this total time in column 6, and the error (seconds from five minutes) in column 7.

10. Substitute this last error, and the value of So in yards per second in the following formula:

Error in yards per second =

$$\frac{\text{So (yards per second) x Error (seconds)}}{300}$$

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11. Solve for the error in yards per second, and enter this error in column 8.

Test for Generation of ΔcR

Problem Setup.

1. Energize motor-generator set for automatic operation.

2. Install B'r' and So handcranks.

3. Throw POWER switch to STAND-BY.

4. Set Co, OL', and OZh at zero degree; Hs at zero feet; and Rj at OFF.

5. Set the mode-and-plot switch at SHORE BOMB SHIP.

6. Arrange phone communication with a director for purposes of ΔcR test information.

7. Throw the POWER switch to ON.

8. Check the voltmeters and neon system for correct operation of the computer.

9. Check the stop watch against the ship's chronometer.

Procedure.

1. Throw the TIME switch to ON. Allow the time motor to run for at least a minute before proceeding with test.

2. Set in values for So and B'r', as specified in columns 1 and 2, table 15.

3. Instruct the director operator to select a starting range value that will allow running the problem without reaching a limit.

4. Instruct the director operator to read the fine range dial and to start the stop watch just as the fine range dial passes through its zero mark, and to stop the watch just as the required range change is completed.

NOTE: This test can be conducted without aid from the director if cover No. 5 is removed. With cover No. 5 removed, the ΔcR dial can be read directly.

5. Enter the total time taken to run the particular problem in column 7.

6. Enter the error in seconds in column 8 (observed time minus calculated time in sixth column).

7. Substitute these last two entries, plus the other values that affect the problem, into the following formula:

$$\Delta \text{ cR error (yds/min)} = \frac{\text{So (yds/sec)} \times \cos \text{B'r'} \times \text{error (sec)}}{\text{time} \times 60}$$

8. Solve for the error in yards per minute, and enter this error in column 9.

TRANSMISSION TESTS

These tests, shown in tables 16 to 21, are used to check the accuracy of each receiver and transmitter throughout its range of operation. The basic procedure involves:

1. Setting a synchro transmitter at prescribed angular checkpoints.

2. Reading the received value at the corresponding receiver.

3. Calculating the errors by comparing the received values with the specified transmitted values.

Table 15

TEST FOR GENERATION OF △cR

Setting			Output			Results		
1	2	3	4	5	6	7	8	9
So Knots (Yds/sec)	B'r'	Cos B'r'	△cR Yds	△cR Dial Reading	Time Min Sec	Time Stop-Watch Min Sec	Error Sec	Error Yds/Min
10 (5.63)	30°00'	.8660	-980	20	3:21			
25 (14.075)	135°00'	.7071	+2000	2 Rev and 0	3:21			
35 (19.705)	180°00'	1.0000	+2660	2 Rev and 660	2:15			
45 (25.335)	240°00'	.8660	+2800	2 Rev and 800	3:41			
55 (30.965)	345°00'	.2588	-3290	3 Rev and 710	1:50			
							Allow Error	20

In checking each of the Computer Mk 48 Mod 1 transmission units, it therefore is necessary to perform switching operations at the main and shore bombardment auxiliary switchboards to connect the unit under test with its related unit in another system component. It also is necessary to energize both system components involved in the test. Thus, each test of a Computer Mk 48 Mod 1 transmission unit is actually a test of a complete transmission circuit involving a transmitter, wiring, a switchboard, and a receiver.

When running these tests, approach each checkpoint slowly from both directions, that is, from the lower numbers to the checkpoint, and then from the higher numbers. The spread between the increasing and decreasing readings is an indication of receiver sensitivity as well as the condition of the mechanism of the receiver and the load it drives.

Receiver Accuracy Test

The six receivers in Computer Mk 48 Mod 1 are checked for accuracy by transmitting to them the values listed in table 16. In the case of the level and cross-level receivers, no direct means of indicating received values is provided on the computer. Therefore, in addition to angles to be transmitted from the stable vertical, table 16 lists voltage values representing the outputs of electrical resolvers whose rotors are positioned by the OL' and OZh receivers. Assuming correct resolver functioning, the voltage readings serve as an accurate indication of the received angles. The checkpoint voltages are indicated by means of the test unit with the computer test-point selector switches positioned as indicated in the table.

Receiver Synchronization Test

This portion of the transmission test checks the ability of the six receivers to drive from a position displaced from synchronism to a stable synchronized condition in the specified length of time. Test results are dependent upon the functional condition and adjustment of associated electronic elements as well as the receiver proper and the load it drives.

The following procedure should be used for running the synchronization tests:

1. Throw DIRECTOR SELECTOR switch to MB.

2. Energize the transmission circuit to be tested.

3. Position the transmitter at a value from which the receiver can synchronize through the specified displacement and in the specified direction, as given in table 17. Be sure the receiver synchronizes at this value.

4. De-energize the circuit, and displace the transmitter from synchronism by the amount specified in table 17. Where 180-degree displacements are specified, add or subtract a degree or two as required to assure synchronization in the specified direction (increase or decrease).

5. Again energize the circuit, and simultaneously press the start button of a stop watch.

6. Stop the watch the instant the receiver stops oscillating at the synchronization point.

7. Record the elapsed time on the test form, and compare it with the maximum allowable value.

Accuracy Test of OB'r', OR, Et, and Ph Transmitters

The checkpoint values for this group of transmitters, table 18, can be set up indirectly by handcrank, with the computer energized. Use the B'r' handcrank for OB'r', the R handcrank for OR, the Ht handcrank for Et (R at low value), and the B'r' handcrank for Ph (R at low value). Approach each checkpoint value from both directions. Cover No. 6 must be removed for access to the Ph transmitter dial.

Accuracy Test of Δ cR Transmitter

Performance of this test requires removal of cover No. 5 for access to the Δ cR transmitter dial and operation of the computer time motor. Since the test primarily is concerned with transmitted changes in range rather than static checkpoints, each of the four values given in table 19 represents the difference between

Table 16

RECEIVER ACCURACY TEST

Ship Speed Receiver (So)

Transmitter Knots	Increasing		Decreasing	
	Computer Reading	Error	Computer Reading	Error
5				
10				
15				
20				
25				
30				
40				
55				
	Sub Total		Sub Total	
			Total	
Value 40 Knots			Avg Err 0. 1	
			Max Err 0. 2	

Allow

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Table 16 (Cont'd)

RECEIVER ACCURACY TEST

Ship Course Receiver (Co)

	Increasing		Decreasing	
Transmitter Deg and Min	Computer Reading	Error	Computer Reading	Error
0°00'				
59°00'				
118°00'				
177°00'				
236°00'				
295°00'				
354°00'				
	Sub Total		Sub Total	
			Total	

Values 10° and 360°

Avg Err	3	
Max Err	5	

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Table 16 (Cont'd)

RECEIVER ACCURACY TEST

Director Train Receiver (B'r')

	Increasing		Decreasing	
Transmitter Deg and Min	Computer Reading	Error	Computer Reading	Error
0°00'				
59°00'				
118°00'				
177°00'				
236°00'				
295°00'				
354°00'				
	Sub Total		Sub Total	
			Total	
			Avg Err 2	
			Max Err 4	

Values 10° and 360°

Allow

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Table 16 (Cont'd)

RECEIVER ACCURACY TEST

Range Receiver (R)

	Increasing		Decreasing	
Transmitter Yards	Computer Reading	Error	Computer Reading	Error
600				
3350				
6700				
10, 050				
16, 750				
25, 900				
37, 600				
50, 000				
	Sub Total		Sub Total	
			Total	
			Avg Err 5	
			Max Err 10	
			Allow	

Values 2000 and 720, 000 yds

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Table 16 (Cont'd)

RECEIVER ACCURACY TEST

Offset Level Receiver (OL')

Trans Mins	B4083 5B Read	Increasing		Decreasing	
		Computer Reading	Error	Computer Reading	Error
560	-4.881				
1280	-2.495				
1640	-1.254				
2000	0				
2360	+1.254				
2720	+2.495				
3440	+4.881				
		Sub Total		Sub Total	
				Total	

2000 = 0 min

Values 10° and 180°

	Allow	
Avg Err	0.010	
Max Err	0.020	

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Table 16 (Cont'd)

RECEIVER ACCURACY TEST

Offset Cross-Level Receiver (OZd) AA

Trans Mins	B4084 5E Read	Increasing		Decreasing	
		Computer Reading	Error	Computer Reading	Error
560	-4.881				
1280	-2.495				
1640	-1.254				
2000	0				
2360	+1.254				
2720	+2.495				
3440	+4.881				
		Sub Total		Sub Total	
				Total	

2000 = 0 min

Values 5° and 180° AA

	Allow	
Avg Err	0.010	
Max Err	0.020	

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Table 16 (Cont'd)

RECEIVER ACCURACY TEST

Cross-Level Receiver (OZh) MB

Trans Min	B4084 5E Read	Increasing Computer Reading	Increasing Error	Decreasing Computer Reading	Decreasing Error
560	-4.881				
1280	-2.495				
1640	-1.254				
2000	0				
2360	+1.254				
2720	+2.495				
3440	+4.881				
		Sub Total		Sub Total	
				Total	

	Allow	
Avg Err	0.010	
Max Err	0.020	

2000 = 0 min

Values 10° and 180° MB

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Table 17

RECEIVER SYNCHRONIZATION TEST

Receiver	Displacement	Direction	Time (Sec)	Max Allow
Ship Course (Co) 1x, 36x 1HCT's	180°	Incr Decr		9 sec
Ship Speed (So) 40 knots	20 kn	Incr Decr		5 sec
Director Train (B'r') 1x, 36x 1HCT's	180°	Incr Decr		9 sec
Range (R) 2000 yds, 72, 000 yds 1HCT's	36, 000 yds	Incr Decr		9 sec
Offset Level (OL') 2x, 36x 1HCT's	25°	Incr Decr		4 sec
Offset Cross Level (OZh) 2x, 36x 1HCT's	25°	Incr Decr		4 sec

Table 18

ACCURACY TEST - DIRECT READING TRANSMITTERS

Quantities and Symbols	Values	Check Points				Max Allow
Relative Target Bearing (OB'r')	10° and 360°	59°	118°	236°	354°	2 min
Slant Range to Target (OR)	2000 and 72, 000 yds	1000 yds	10, 400 yds	20, 100 yds	39, 950 yds	7 yds
Target Elevation (Et)	360 mils	60 min	360 min	720 min	1080 min	5 min
Horizontal Parallax (Ph)	30°/100 yds	-10°	-2°	+2°	+10°	6 min

Table 19

ACCURACY TEST - ΔcR TRANSMITTER

Quantity	Values	Check Points				Max Allow
Increments of generated range	1000 yds/ rev	+200 yds	+400 yds	+600 yds	+800 yds	5 yds

a start-reading and a finish-reading. That is, at the start, readings are taken of the transmitter dial and the receiver dial in the director; the time motor is operated until the transmitter has been driven through the required change and stopped; and the receiver dial in the director again is read to obtain the received change. For the two minus runs (decreasing changes), set B'r' at 0 degrees, and for the two plus runs (increasing changes) set B'r' at 180 degrees. The value of ship speed can be varied as a means of control in producing the changes. For example, a high speed can be used for the greater part of the run followed by a low speed as the run nears completion and a zero speed setting to stop the generation as the required change is completed.

Test of L', Zd, and L' + Zd/30 Transmitters

Because these transmitters lack facilities for direct control of the transmitted values, it is necessary to use the OL' and OZh manual controls at the stable vertical for selecting test values, and to use the test unit for indirectly indicating the values selected. The received quantities are checked at a director. Table 20 lists the SIGNAL TEST SELECTOR switch points corresponding to the quantities under test, the voltage values that must be set up to position the transmitters, and the corresponding transmitted angles that the receivers must indicate. After arranging for transmission between the stable vertical and the computer and between the computer and the MB director, the following steps can be performed:

1. With mode-and-plot switch at SHORE BOMB TGT, mark location of plotter index light.

2. Throw mode-and-plot switch to SHORE BOMB REF and, using the REF-SHIP coordinate handcranks, return the index light to the position marked in step 1.

3. Connect the test unit.

4. With the computer SIGNAL TEST SELECTOR switch set at 7D, adjust the manual level input at the stable vertical to obtain the voltage values listed in table 20 on the test-unit dials.

5. For each voltage setting, compare the reading on the MB director level receiver dials with the value given in the table.

6. With the SIGNAL TEST SELECTOR switch at 7C, adjust the manual cross-level input at the stable vertical to obtain the voltage values listed in table 20 on the test-unit dials.

7. For each voltage setting, compare the reading on the MB director cross-level receiver dials with the value given in the table.

Table 20

ACCURACY TEST - DIRECTOR LEVEL AND CROSS LEVEL

Check Points	Value	1	2	3	4	Max Allow
Test Unit Reading		-4.104	-1.046	+1.046	+4.104	
Director Receiver Reading	10° and 180°	-20°	-5°	+5°	+20°	6 min

8. Set and hold cross level at a value that gives a zero voltage indication on test-unit dials.

9. Set SIGNAL TEST SELECTOR switch at 7D, and adjust manual level input at stable vertical to obtain voltage values listed in the table on the test-unit dials.

10. For each voltage value, compare the reading on the director L' + Zd/30 dials with the value given in the table.

Test of Co + jB'r' - jB Transmitter

When testing the bearing-tracking-aid transmitter, two of the quantities, jB'r' and jB, are held at zero, the Co dials are set at the check points, table 21, by means of the Co handcrank, and the values received at the director are compared with those transmitted. To zero jB, throw the computer DIRECTOR SELECTOR switch to AA. To zero jB'r', transmit zero values of level and cross level from the stable vertical to the computer receivers.

TIME MOTOR REGULATOR TEST

Proper operation of the time motor regulator is determined by checking the speed of the time line with a stop watch. Use the test form shown in table 22. The time motor test is summarized as follows:

1. Remove cover No. 5 from the computer to gain access to the time counter.

2. Turn the mode-and-plot switch to LOCAL CONTROL SHIP.

3. Place the Xa and Ya handcranks at normal disengaged position.

4. Set B'r' at zero, Co at 45 degrees, So at 25 knots, OL' at zero, and OZh at zero.

5. Throw the POWER switch to ON.

6. Throw the TIME switch to ON. Allow the time motor to run at least one minute before proceeding with the test.

7. Check that the control power voltage to the regulator is 115 volts.

8. As a starting reference number, select a convenient whole number that will appear shortly on the time counter. As the reference number exactly coincides with the counter-index mark, start a stop watch. When the time counter indicates that exactly 10 minutes have elapsed, stop

Table 21

ACCURACY TEST - TRAIN CONTROL

Transmitter	Values	Check Points				Max Allow
Train Control	5° and 10°	59°	118°	236°	354°	5 min

Table 22

TIME MOTOR REGULATOR TEST

*Time Cal Min Sec	Time Stop-Watch Min Sec	Error		
		Sec	Sec/Min	Allow
10'00.0"				0.05

*Calculated time is for 1000 revolutions of regulator shaft.

the watch, and read the elapsed time in seconds and tenth-seconds. If the watch reads more than 10 minutes, then the time line is slow. If the watch reads less than 10 minutes, the time line is fast.

9. If results indicate that the time-motor regulator needs adjustment, refer to OP 1140A, Basic Fire Control Mechanisms-Maintenance for adjustment procedures.

INDEX-LIGHT TRAVEL TEST

Although the purpose of this test is to determine the accuracy of the plotter gearing, the test results also will reflect upon the operation of those elements shown in figure 51. The quantities Rh sin B, and Rh cos B, however, are grounded out in this test.

To insure that the test results will be accurate, start the test with all lost motion taken up. When moving to the stop line, stop the light exactly on the line. Any movement beyond the stop line will affect the lost motion accumulated and result in an inaccurate test reading. When moving the light back to the start line, stop the light exactly on the line.

Test for Index-Light Travel

Problem Setup.

1. Energize the motor-generator set for automatic operation.

2. Connect the TEST UNIT to computer.

3. Throw the POWER switch to STANDBY.

4. Throw the DIRECTOR SELECTOR switch to MB.

5. Set the SCALE FACTOR at 25, 000:1.

6. Set the mode-and-plot switch at SHORE BOMB REF.

7. Remove cover No. 1 from the plotter.

8. Place a blank paper on the plotter and tape it securely in place.

9. Throw the POWER switch to ON.

10. Check the voltmeters and neon system for correct operation of the computer.

Procedure.

Test for Xp Travel (Run No. 1).

1. Turn TEST SELECTOR switch to 2F.

2. Turn the Xa handcrank to position Xp counter at 20. 00, as shown in column 1, table 23.

3. Turn the Ya handcrank to position Yp counter at 2. 00.

4. Read the TEST UNIT voltage, and enter the value in column 6, top line.

5. Draw a vertical start line (perpendicular to the front of computer) through the index light.

6. Draw a vertical stop line parallel to the start line exactly 12 inches to the right of the start line.

7. Turn the Xa handcrank to position the index light exactly on the stop line.

8. Read the Xp counter and enter the value in column 3, top line.

9. Read the TEST UNIT voltage and enter the value in column 9, top line.

10. Enter the voltage reading of step 9 in column 6, second line.

11. With the Xa handcrank, return the index light to the start line.

12. Read the Xp counter, and enter the value in column 3, second line.

13. Read the TEST UNIT voltage, and enter the reading in column 9, second line.

14. Calculate the error in inches and enter the results in the appropriate error columns.

Test for Yp Travel (Run No. 2).

1. Turn the TEST SELECTOR switch to 3C at the computer.

2. Turn the Ya handcrank to position the Yp counter at 2. 00.

3. Turn the Xa handcrank to position the Xp counter at 16. 4.

4. Read the TEST UNIT voltage, and enter the value in column 6, top line.

5. Draw a horizontal start line (parallel to the front of computer) through the plotter light.

6. Draw a horizontal stop line parallel to the start line exactly 12 inches up from start line.

7. Turn the Ya handcrank to position the index light exactly on the stop line.

8. Read the Yp counter, and enter the value in column 3, top line.

Table 23

TEST FOR INDEX-LIGHT TRAVEL

Column	1	2	3	4	5	6	7	8	9	10
Run	Xp Reading at Start	Xp Reading at Stop Calc	Xp Reading at Stop Inst	Error Inches	2F Start Calc Volts	2F Start Inst Volts	Error Volts	2F Stop Calc Volts	2F Stop Inst Volts	Error Volts
1	20.00	8.00			-0.588			+1.371		
	8.00	20.00			+1.371			-0.588		
		Allow	Error	0.04	Allow	Error	0.012	Allow	Error	0.012

Column	1	2	3	4	5	6	7	8	9	10
Run	Yp Reading at Start	Yp Reading at Stop Calc	Yp Reading at Stop Inst	Error Inches	3C Start Calc Volts	3C Start Inst Volts	Error Volts	3C Stop Calc Volts	3C Stop Inst Volts	Error Volts
2	2.00	14.00			-2.350			-0.392		
	14.00	2.00			-0.392			-2.350		
		Allow	Error	0.04	Allow	Error	0.012	Allow	Error	0.012

9. Read the TEST UNIT voltage, and enter the value in column 9, top line.

10. Enter the voltage reading of step 9 in column 6, bottom line.

11. With the Ya handcrank, return the index light to the start line.

12. Read the Yp counter, and enter the value in column 3, second line.

13. Read the TEST UNIT voltage, and enter the reading in column 9, second line.

14. Calculate the error in inches, and enter the results in the appropriate error columns.

Section 5.3 —Trouble Shooting

Whenever test results exceed allowable limits, or the computer is not functioning properly, immediate steps should be taken to determine the cause. The possibility of human error, such as the incorrect reading of a dial, incorrect input settings, and similar causes, should be considered first. Once this possibility has been eliminated, the trouble-shooting information in this section should be used to find the cause of the malfunction.

After an examination of the test results, the appropriate procedures as outlined in this section may be used as a guide for locating and correcting the trouble. When the fault has been corrected, the basic cause of the error should be determined and eliminated to prevent recurrence of the same condition. Then the test or problem in which the error first was discovered should be run, followed by a complete set of the routine tests to determine if the computer is again in satisfactory condition.

COMMON MECHANICAL AND ELECTRICAL FAULTS

The origin of excessive errors may be mechanical, electrical, or a combination of both.

Possible mechanical faults are:

- Tight gear meshes
- Loose gear meshes
- Sticky shaft lines (caused by foreign particles in gear teeth or bearings)
- Sheared taper pins or slipped clamps
- Damaged gear teeth
- Rusty bearings
- Shaft hangers in misalignment
- Rubbing or similar mechanical interference

Possible electrical faults are:

- Faulty electron tubes
- Excessive electrical pickup possibly due to improper grounding or shielding)
- Short circuits
- Open circuits
- Blown fuses
- Imperfect ground connections
- Defective capacitors (open, grounded, or shorted)
- Deteriorated resistors
- Potentiometers (dirty or pitted contact surfaces)
- Switches (dirty or pitted contact surfaces)
- Relays (poor contact surfaces or faulty solenoids)
- Failure of components within an electronic element

COMPONENT IDENTIFICATION

Element Designation Numbers

The designation system used in this book which identifies all components in Computer Mk 48 Mod 1 except standard hardware such as nuts, bolts, and washers, uses one or two capital letters followed by a four-digit number. Each designation identifies a particular element, such as a resistor, amplifier, or network box, and the designation is not duplicated, even though several identical elements are used in the computer.

The alphabetical symbols have the following meanings:

A - Structural parts, panels, frames, etc

B - All motors, resolvers, and synchro units

C - Capacitors

E - Miscellaneous electrical parts (terminal blocks, etc)

F - Fuses

G - Rate generators

H - Mechanical components (adjustments, differentials, limit stops, integrators, clutches, etc)

I - Indicators (neon lights)

J - Jacks and receptacles

K - Relays

R - Resistors and potentiometers

S - Switches, interlocks, and thermo regulators

T - Transformers and chokes

V - Vacuum and gas-discharge tubes

W - Wires and cables

X - Sockets

CR - Selenium rectifiers

ZA - Amplifiers

ZB - Servo controls

ZC - Power-supply regulators

ZM - Miscellaneous electrical units

ZN - Resistance networks

ZY - Frequency standard for computing voltage

In a four-numbered designation, the first two numbers indicate the element unit number of the drawer assembly or the mechanical section in which the element is located. A legend plate on a panel, for example, may bear the element unit number "4100." Since the first two numbers are four and one, the elements housed in that section are of the 4100 series. The last two numbers of an element designation indicate that an element is one of a series of elements located in that section. Element unit number ZA4107 would indicate that the element is an amplifier located in the 4100 section, and is the seventh element of a series of elements located in that section.

Each element is marked plainly with its designation number. This same designation also is used to identify it on drawings, or whenever it is referred to in tests or adjustment procedures.

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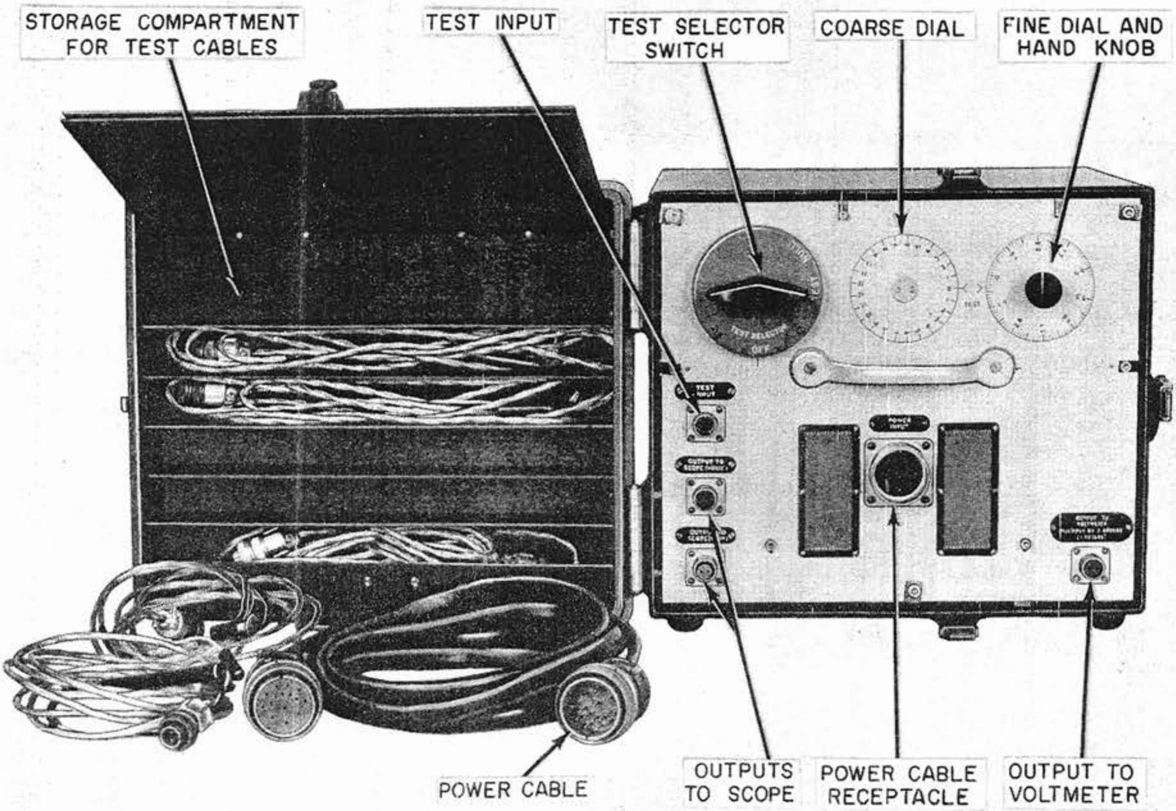

Figure 38. Test-Unit Operating Controls

Manufacturer's Unit Designation Numbers

The manufacturer, in addition to the element unit-number designations, assigns a manufacturer's unit number to each element. The manufacturer's unit number should not be confused with an element's letter-number designation. The manufacturer's unit number will contain four numbers. The first two numbers of the designation identify the principal function of the element. The last two numbers indicate that it is one of a series. The unit number 3200, for example, is assigned to servo amplifiers. The unit number 3204, therefore, indicates that it is a servo amplifier and is the fourth element of a series of servo amplifiers.

The principal unit numbers encountered during normal maintenance of the computer are:

Unit Number	Element
3000	Amplifiers (except servo)
3100	Networks (summing or dividing type)
3200	Servo amplifiers
3300	Servo controls (except contact type)
3400	Frequency standards
3800	Rectifiers and power supplies

Computer elements that possess identical unit numbers may be interchanged readily. Therefore, when a replacement of an element is needed, determine what its unit number is from its schematic or from table 39, and select a new element that has the same unit number.

Drawing Numbers

Another identification system that is used pertains to separate parts, such as shafts, hangers, etc, and to all assemblies and subassemblies (which include the elements referred to previously), and consists merely of either stamping or affixing a drawing number to each part or assembly. These two systems facilitate the procurement of replacement parts as well as simplifying the identification of individual components.

TEST UNIT

The test unit, figure 38, that accompanies the computer is used to perform the trouble-shooting procedures outlined in this section. It functions as a proportional voltmeter, by comparing the voltage under test with the reference voltage from which it was derived. Essentially, the unit is a servo loop with a precision potentiometer in the feedback leg of the loop, figures 39 and 40. The servo action is stopped (nulled) and the test dials mechanically positioned as the output of this potentiometer equals (nulls) the test-input signal. The dials show the fractional part of the computer reference voltage existing at various selected intermediate points in the computing circuits.

In the trouble-shooting tests the specific circuit-point voltages to be measured with this instrument are listed in a column. The circuit point will be a number-letter combination followed by an asterisk, such as 3G*. The same symbol will appear in the schematic adjacent to the point of measurement.

The test circuit points within the computer are connected electrically to the test-unit input cable through the SIGNAL TO TEST UNIT jack and SIGNAL TEST SELECTOR switch on the computer, figure 41. This switch is located in the rear, upper right-hand corner of the computer,

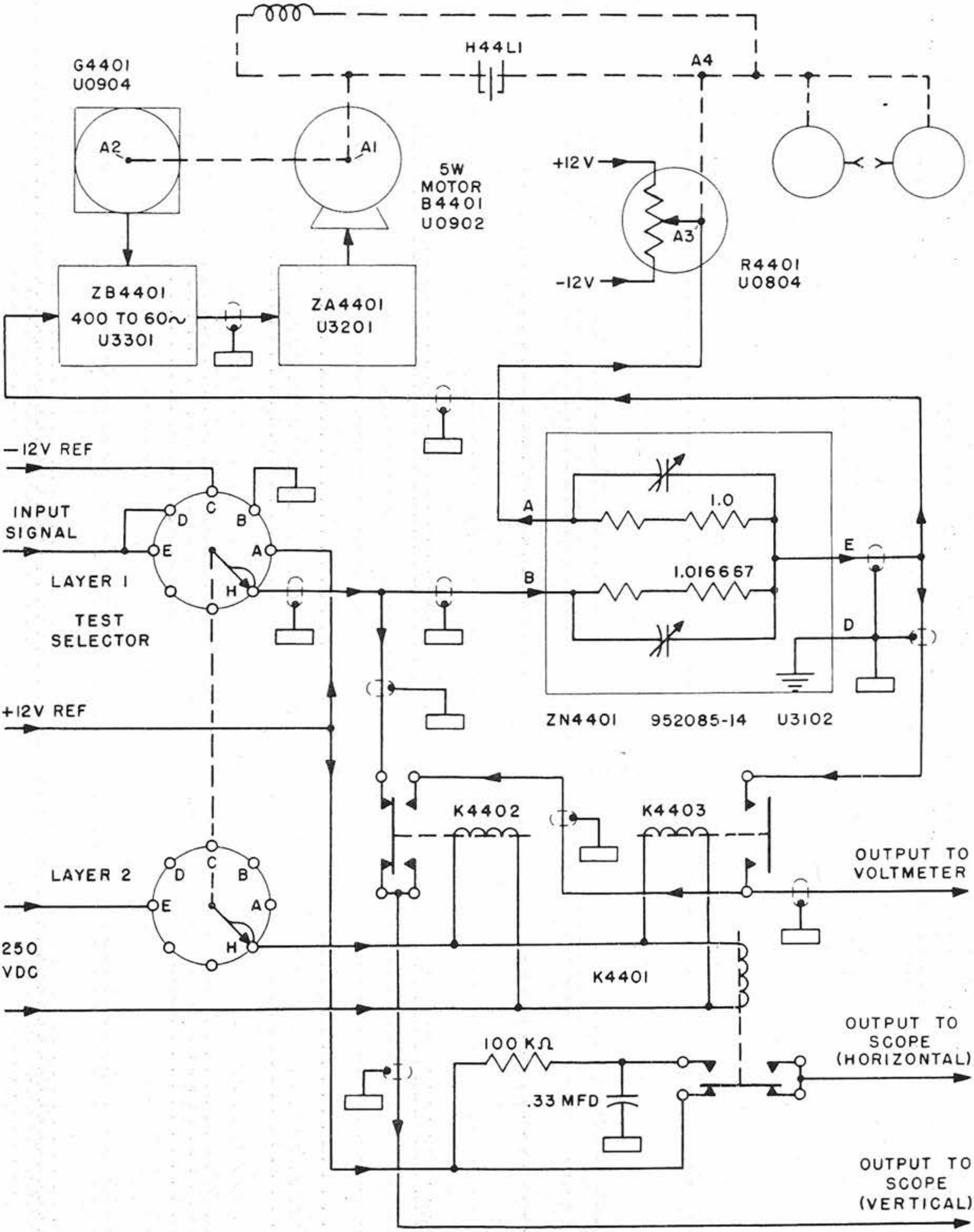

Figure 39. Test Unit, Schematic Diagram

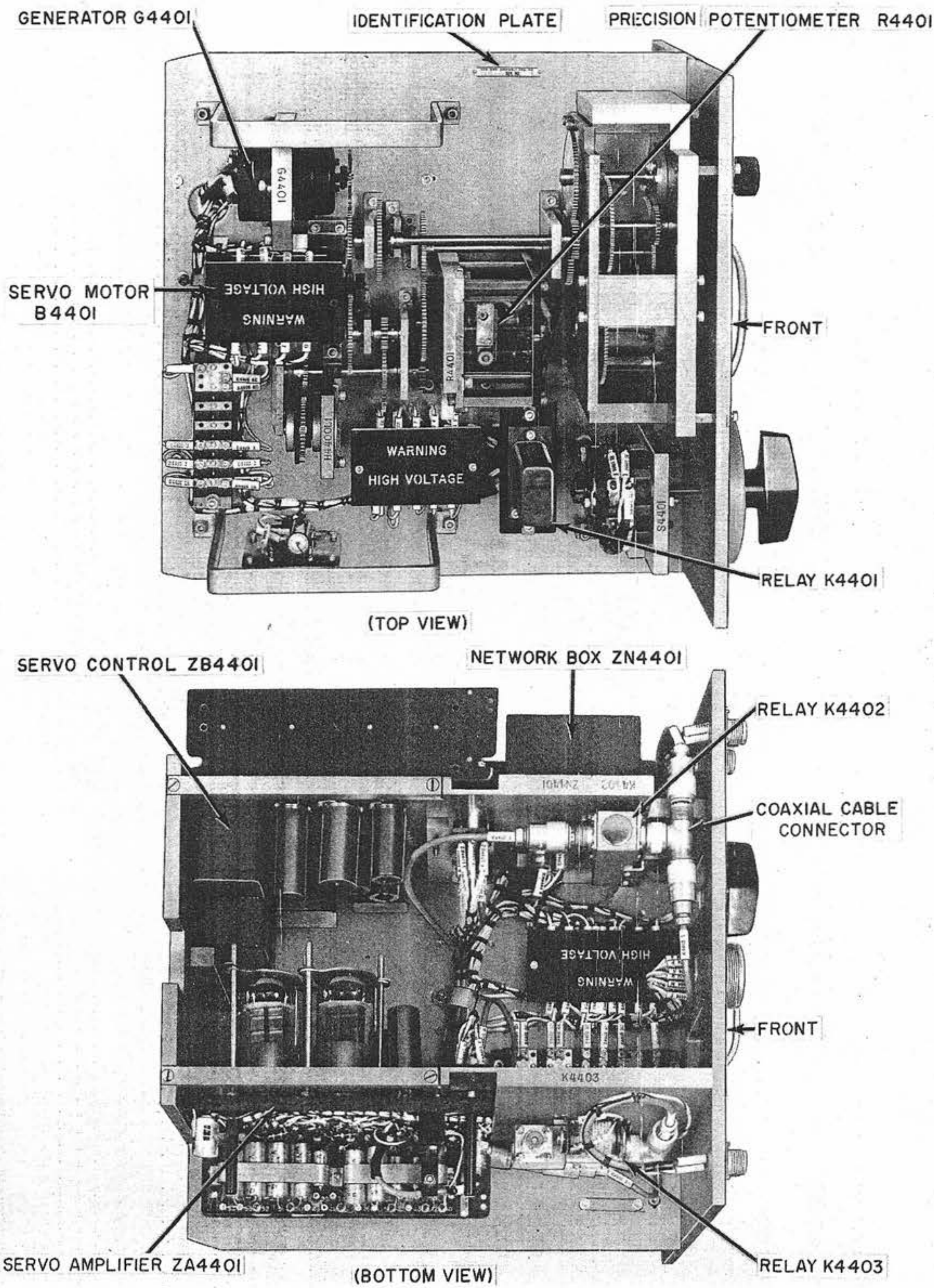

Figure 40. Test Unit Removed from Case

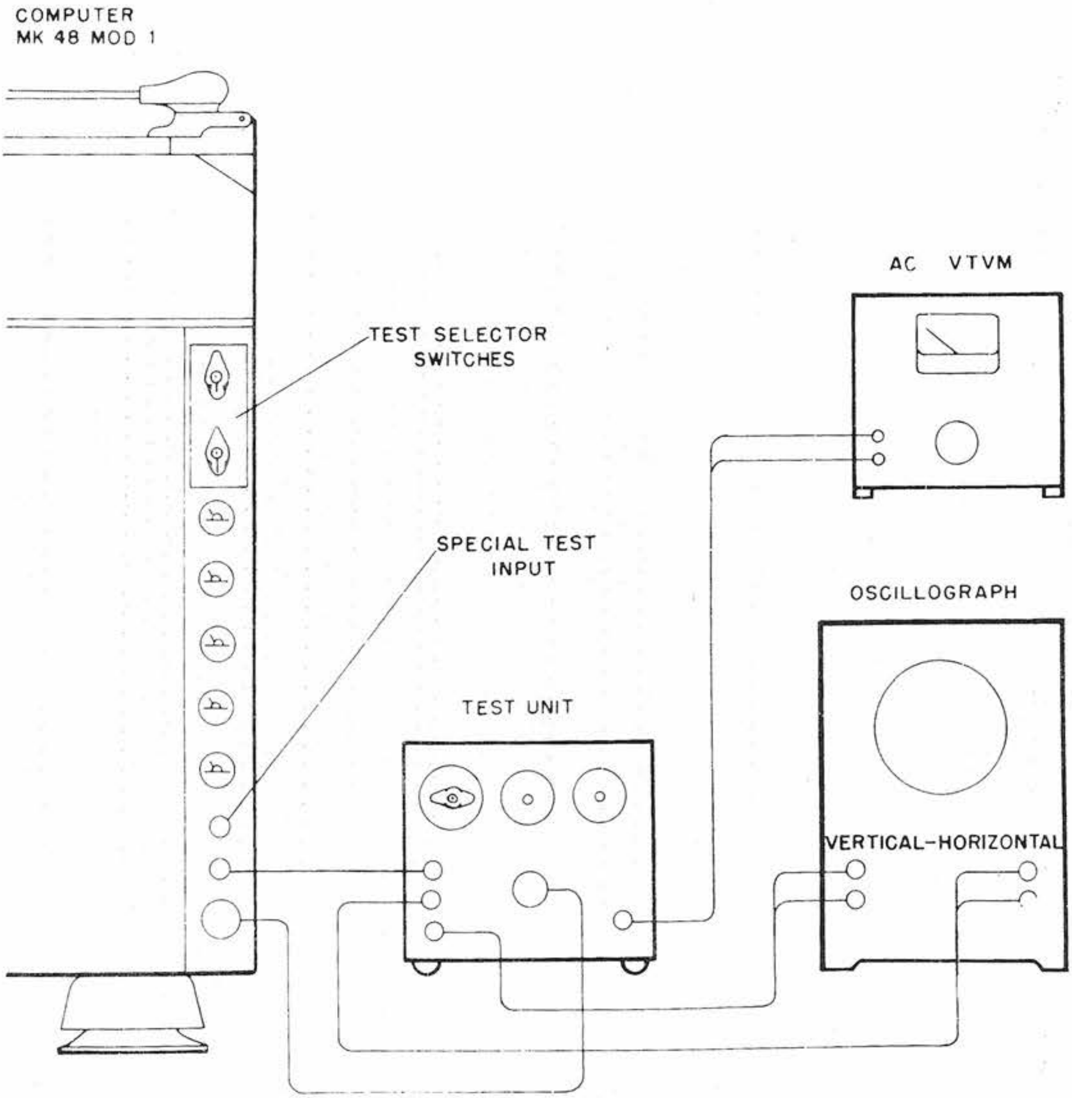

Figure 41. Test-Unit Connections to Computer Mk 48 Mod 1

immediately above the DC voltmeters. If, for example, the prescribed test requires the voltage at circuit point 3G* to be measured, the SIGNAL TEST SELECTOR switch is set to read 3 on the number switch and G on the letter switch.

Reading and Interpretation of Test-Unit Dials

The coarse and fine dials of the test unit cover a range of 25 units - from -12.50 to +12.50. Red numerals are used for the negative values and black for the positive values. The fine dial has 100 graduations representing ten millivolts each. A reading, however, can be readily extended to three decimal places by estimating the fractional part between the significant graduation and the dial index mark.

The polarity or sign of the test voltage, as established by the position of the coarse dial, determines which numerals on the fine dial should be read. If, for example, a red number is observed on the coarse dial, the red numbers on the fine dial should be noted.

All values specified by the tests are expressed in terms of twelfths of the reference voltage. That is, with a nominal reference voltage of 12 volts, a reading of 12 would be 12 volts, and a reading of 8 would be 8 volts. However, if the reference voltage was only 9, a reading of 12 would be 9 volts (12/12 of 9 volts). Similarly, a reading of 8 would be 6 volts (8/12 of 9 volts). Although the intermediate test values sometimes are referred to as voltages, the test-unit dials do not necessarily indicate true voltage values but rather the computed proportion of the reference voltage that is independent of the actual reference voltage value. Any discrepancy in the reference voltage value would have to be determined by means of an independent AC meter.

Test-Unit Operating Procedure

The following procedure shall be used when measuring intermediate computed voltages with the test unit.

1. Open the compartment in the test-unit cover, and remove the large cable and one small cable (connectors at both ends).

2. Turn the TEST SELECTOR switch on the test unit to OFF.

3. Turn the SIGNAL TEST SELECTOR switch on the computer to OFF.

4. Connect the large cable from the POWER INPUT on the test unit to the computer receptacle designated TEST UNIT POWER SUPPLY.

5. Connect the small cable from the TEST INPUT on the test unit to the computer receptacle designated SIGNAL TO TEST UNIT.

6. Energize the computer.

7. Check the test unit for proper operation as follows:

   a. Turn the TEST SELECTOR switch on the test unit to +12. The coarse dial should read +12 and the fine dial zero.

   b. Turn the TEST SELECTOR switch on the test unit to OFF. Both dials should read zero.

   c. Turn the TEST SELECTOR switch on the test unit to -12. The coarse dial should read -12 and the fine dial zero.

8. Turn the SIGNAL TEST SELECTOR switches on the computer to the combination prescribed for the particular test.

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9. Turn the TEST SELECTOR switch on the test unit to TEST.

10. Read the measurements on the test-unit dials.

Special Applications

When difficulty is experienced in determining the exact cause of faulty operation, it may be helpful to analyze the pertinent computing voltages through the use of special provisions on the test unit. These include connecting and switching facilities for an oscilloscope, an AC vacuum tube voltmeter, and a special test probe. When the test equipment is set up as shown in figure 41 additional information can be gained regarding the test-point voltage that is fed into the test unit via the computer test selector switches or through the special probe.

Waveform Checks. Electrical quantities to be viewed on the oscilloscope should be checked as follows: First, the waveform is displayed using the internal linear sweep of the scope. To accomplish this, turn the TEST SELECTOR switch of the test unit to TEST, and check the signal for excessive noise and distortion. Next, switch the scope horizontal input to EXTERNAL to connect in the +12 volt, 400-cycle reference from the test unit. Examine the pattern to determine the extent of phase shift.

This procedure may indicate the presence of excessive quadrature voltage; that is, the 90-degree component of an input signal that is out-of-phase with the reference source because of a circuit fault. For example, a voltage vector with a 20-degree phase shaft would be represented as vector B shown in figure 42. The in-phase component of this vector, which is usable servo control voltage, is represented by vector C in the diagram. The quadrature component, vector A, has no controlling effect on the servo, but along with the in-phase component, contributes toward saturation of the servo amplifier. The total amplifier output therefore contains a percentage of quadrature voltage to which the servo cannot respond. Since the full amplifier output is not usable control voltage, the servo takes on a loose response characteristic.

If the scope pattern and the action of the test-unit servo indicate the presence of quadrature voltage, the magnitude of this voltage may be determined as follows: The TEST SELECTOR switch is turned to NULL, transferring the oscillograph vertical input to the null of the test-unit servo loop, connecting the VTVM to the same point, and switching the horizontal input of the oscillograph through a 90-degree phase shift network. The knob on the test-unit fine dial then is used to manipulate the servo within the dead space to the extent necessary to shape the oscillograph pattern into a straight line. This will occur when the in-phase component of the signal voltage has been perfectly nulled, leaving only the 90-degree component present in the null. The null quadrature voltage then can be read on the AC VTVM.

Test Probe for Random Measurements. To extend the usefulness of the test unit a special probe is provided to measure signal voltages at points not covered by the SIGNAL TEST SELECTOR switch. For instance, after localizing trouble to a small group of elements through performance of the trouble-shooting tests, the signal then can be traced component-by-component or stage-by-stage between the regular test points until the trouble is pinpointed. Using a setup similar to that shown in figure 41, plug the special test probe into the SPECIAL (7E) TEST INPUT jack on the computer and connect it to the test unit by setting the SIGNAL TEST SELECTOR switch at 7-E. The probe then is ready for use following the general procedure previously described. Thus, the signal voltage at any point can be

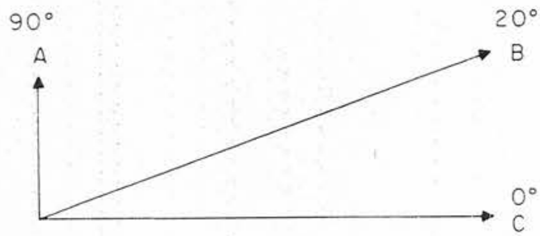

Figure 42. In-Phase and Quadrature Components of 20-Degree Voltage Vector

measured and examined for wave form, noise, and quadrature voltage.

NEON MONITORING SYSTEM

The neon lights, figure 43, indicate the functional condition of the computing amplifiers, servo controls, and servo amplifiers. The computer also contains a provision for testing the individual neon lights. Each light is identified with the particular element or elements it monitors by element designation symbols above the light.

The first stage of each dual-channel amplifier is monitored continuously for proper minimum plate current. To check the computing amplifiers, observe the neon lights in group ZAC during operation of the computer. If a light glows steadily during operation, it indicates that the first stage of the corresponding amplifier is defective. Intermittent flashing of the computing amplifier neons usually is caused by transient conditions in computer operation and should be disregarded.

To check the second and third (output) stages of all dual-channel computing amplifiers (except ZA4329B and ZA4335A), set up the computer as follows:

B'r' at 45°	Yj at 0 yards
Co at 0°	DIRECTOR SELECTOR switch at MB
So at 0 knots	
	RADAR BEACON DELAY spot switch at OFF
R at 20,000 yards	
OL' at 25°	Connect test unit to computer for the following settings:
OZh at 25°	
Hs at 1000 feet	Xt at 20,000 yards = -4.700 volts at 3A
Ht at 5000 feet	Yt at 22,454 yards = -5.277 volts at 3E
SF at 50,000:1	Xa at 10,000 yards = +2.350 volts at 2G
Xj at 0 yards	Ya at 10,000 yards = +2.350 volts at 3D

With both test switches at the OPERATE position, all computing amplifier neon lights (group ZAC) should remain off.

To check all servo-control elements and the first stages of the four single-channel computing amplifiers (ZA4325, ZA4327, ZA4341, and ZA4342), hold the S.C.-S.A. switch in its up position, designated SERVO CONTROL TEST. If one of these elements is defective, its related neon light in group ZB or ZAC will glow.

To check all servo-amplifier elements and the second and third stages of the four single-channel computing amplifiers, hold the S.C.-S.A. switch in its down position, designated AMPLIFIER TEST. If any element is defective, its related neon light in group ZAS or ZAC will glow.

To check the neon lights of group ZB, hold both S.C.-S.A. and S.C. NEON-S.A. NEON switches in the up position, designated SERVO CONTROL TEST and SERVO CONTROL NEONS, respectively. All the ZB neon lights should glow.

To check all amplifier neon lights in group ZAS and ZAC, hold both S.C.-S.A. and S.C. NEON-S.A. NEON switches in the down position, designated AMPLIFIER TEST and AMPLIFIER NEONS, respectively. All ZAS and ZAC neon lights should glow.

In addition to the neon lights on the indicating panel, each element monitored is equipped with a similar neon bulb connected in series with the panel bulb. The bulb on the element chassis glows whenever the panel light glows, making it possible to visually locate a faulty element in either of the drawer baskets.

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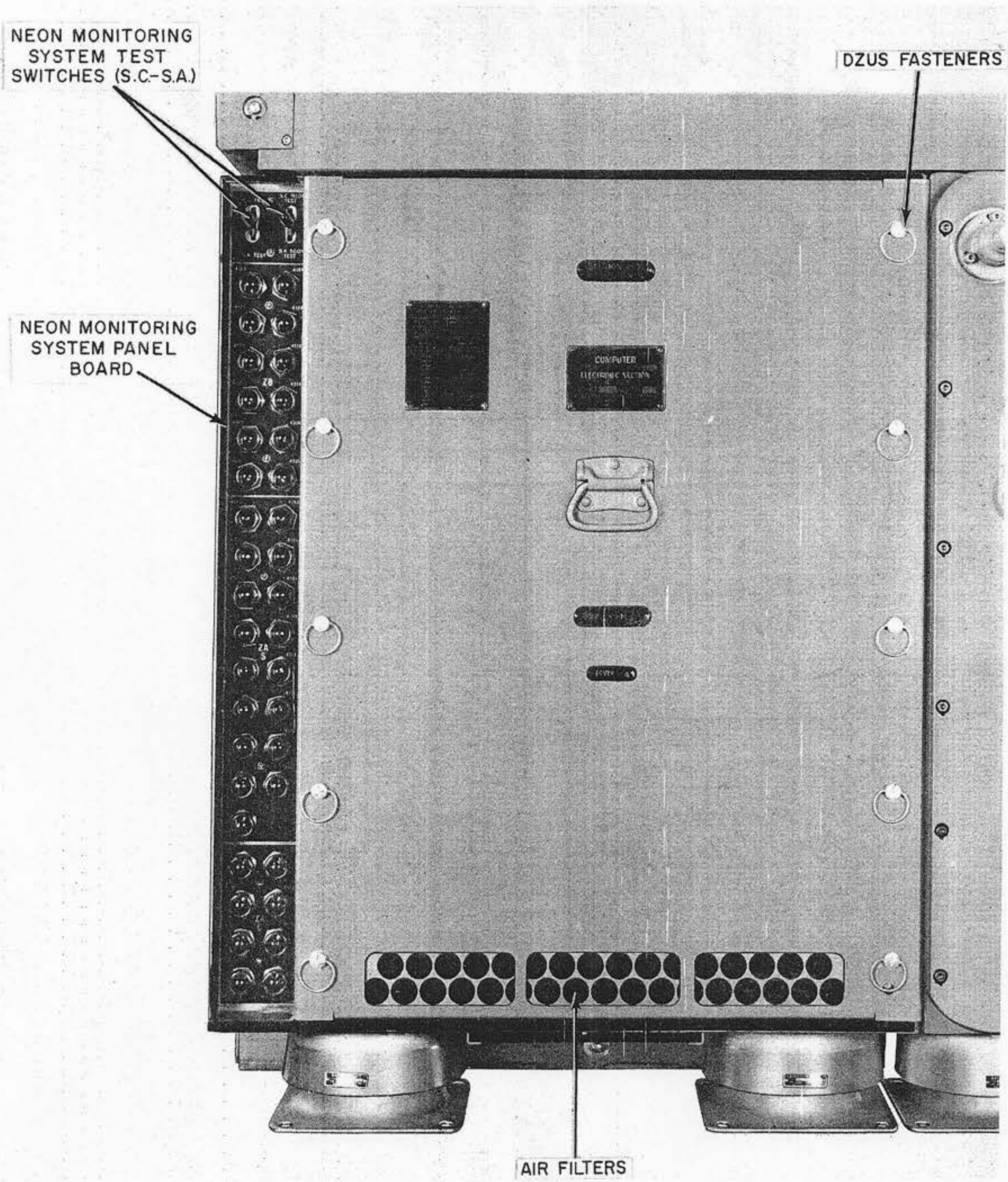

Figure 43. Computer Mk 48 Mod 1, Front Electronic Section

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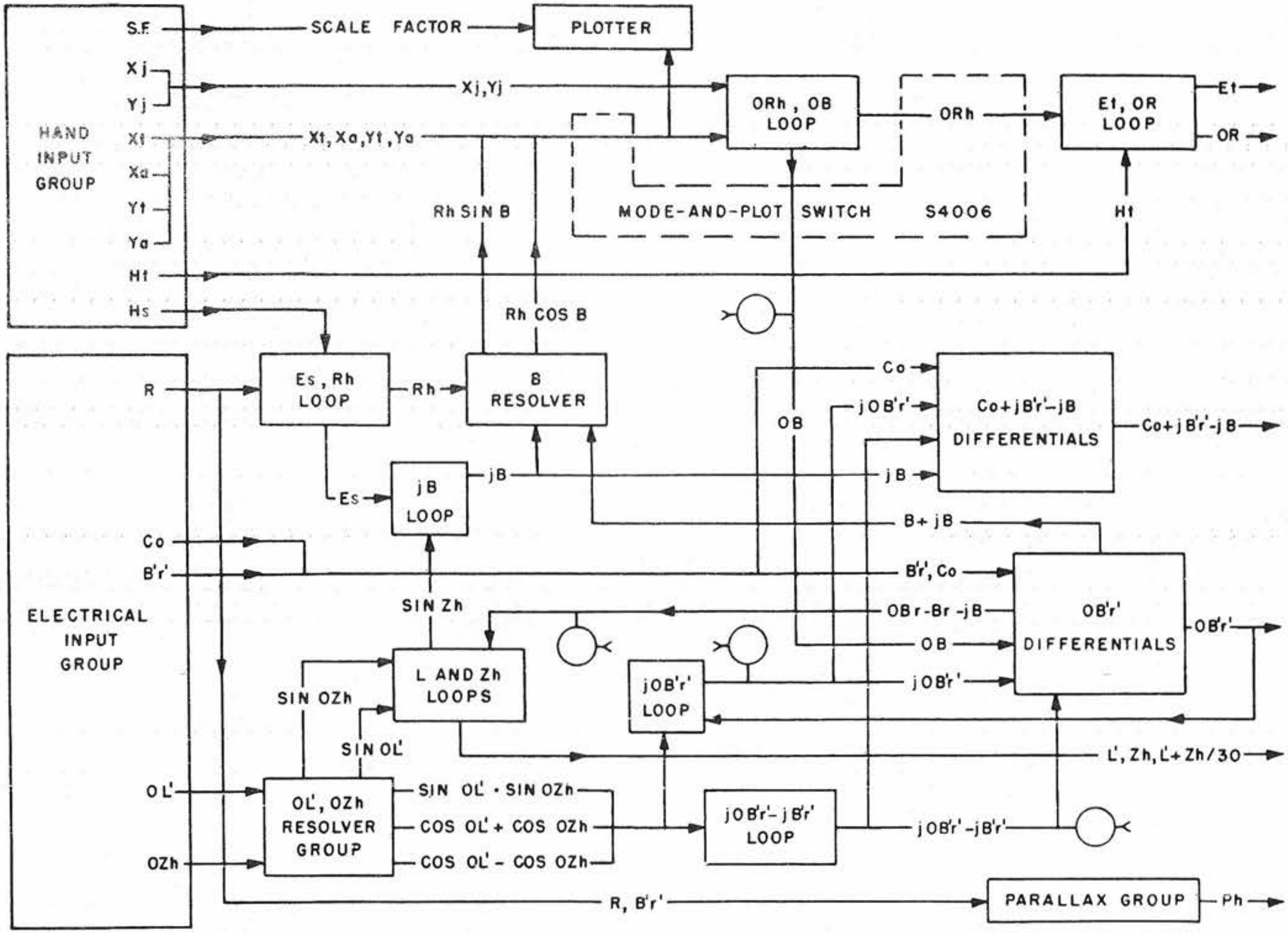

Figure 44. A-Test Trouble Shooting, Overall Block Schematic

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FUSES

The computer is protected from overloads by 13 fast-acting thermal-cutout cartridge fuses. All fuses are plainly visible, and are arranged on a panel at the rear of the computer. Each fuse is held in place and protected by a removable clear plastic cover. A blown fuse is indicated by the appearance of a red dot in the center of its plastic cover.

The fuse number designation next to each fuse identifies that particular fuse in accordance with the power-supply diagram, BuOrd Dwg 1371754. When replacing a fuse, check the rating stamped on the fuse cap against the rating specified in the power-supply diagram.

A compartment for six spare fuses is located in the fuse panel. To gain access to the spares unscrew the two cover screws one-half turn and remove the cover.

Table 24 is a general reference table for the fuses used in this computer.

A-TEST ANALYSIS

Before performing any procedure for isolating the cause of an A-test error, the possibility of a faulty problem setup, a power-supply failure, a transmission failure, or a computing element casualty of the type traceable through the neon-indicator system first must be eliminated. The complete routine for preparing the computer for A tests should be rechecked as well as the entire set of independent variables for the test problem or problems in question. All power-supply meters should be checked for indication of correct voltage. Check switch positions and fuses on Computer Mk 48 Mod 1, the motor-generator set, the main switchboard, shore-bombardment auxiliary switchboard, gyro-compass, pitometer log, and all other associated equipment used in the test problem. Check all transmission circuits directly involved in the A test by comparing the received values with the transmitted values. Finally, the routine neon-indicator test of electronic elements, as described under the previous heading, should be rerun for indication of newly developed casualties. Once the need for further trouble shooting has been ascertained, the steps suggested in the following procedure may be carried out.

1. Examine the A-test results, and list all outputs that have excessive errors.

2. Refer to figure 44 and table 25 to determine the blocks, or sections, of the computer that contribute to the computation of the quantity or quantities in error. Table 25 shows which groups of elements are common to various combinations of output quantities.

3. Refer to the detail functional schematics of the suspected groups (figures 47 through 59, and list the pertinent test points (intermediate voltages) and mechanical intermediate quantities.

4. Connect the test unit, and rerun the critical problems, that is, the problems that have the largest errors. Read and record all mechanical and electrical intermediate quantities selected in step 3.

5. Compare the intermediate quantity readings with those given in tables 26 and 27, and compute the errors.

6. From a study of the intermediate quantity errors and the pertinent detail schematics, determine in which element or group of elements the trouble originates.

7. Check each electronic element in the suspected group by substitution of spare units.

8. If the trouble persists, inspect the mechanical components of the affected group for the common faults listed at the beginning of this section.

Table 24

FUSES

Fuse Designation	Current Rating (Amperes)	Protects
F4301	1	+250 v supply
F4302	1	+250 v supply
F4303	1	+250 v supply
F4304	1/10	-105 v supply
F4305	3	Line 1
F4306	5	Line 3
F4307	1	B'r' transmitter
F4308	1	OZh transmitter
F4309	1	OL' transmitter
F4310	1	R transmitter
F4311	1	Co transmitter
F4312	10	Line 2
F4313	15	+350 v supply (MG set)

SPARES

Quantity	Current Rating (Amperes)
2	1
1	1/10
1	3
1	5
1	10

Table 25

A-TEST TROUBLESHOOTING

	Output in Error					
	OB'r'	Et or OR	Et, OR, OB'r'; and L', Zh, and L +Zh/30	Et, OR, OB'r'; Ph	L', Zh and L + Zh/30	Ph
Possible Source of Error	OB'r' differentials jOB'r' loop jOB'r' -jB'r' loop OL' and OZh resolver group Electrical inputs	Et and OR loop ORh or Ht input	ORh and OB loop Hand input group and mode switch Plotter jB loop and B resolver Es and Rh loop L' and Zh loops OL' and OZh resolver group OB'r' differentials	R input	L' and Zh loop	Parallax group

9. Check the mechanical limit stops in the affected group (see table 28). These checks cover the possibility of slippage in certain mechanical adjustments, as can be determined from the detail schematic. Also, run the pertinent trouble shooting test, tables 28 through 33, to obtain additional information for localizing the trouble.

10. Check each adjustment in the group, excluding limit stops checked in step 9, for conformance with the conditions specified in the adjustment procedure, section 5.5. The order given in the adjustment procedure should be followed and any adjustment not satisfying the requirements should be readjusted.

Special Trouble-Shooting Tests

If difficulty is experienced in localizing the trouble to a specific point, additional information can be obtained by running a special trouble-shooting test on the group of elements to which the trouble has been traced. The first of these is the test of operating limits, table 28. All limit stops in the group of elements selected for detailed analysis should be checked according to the data given in the table. In general practice, all limits should be checked after any repair or readjustment procedure. The rest of the special tests are performed in a manner similar to A tests, but are designed for greater convenience in trouble shooting by limiting their scope to smaller groups of computing

Table 26

MECHANICAL INTERMEDIATE QUANTITIES FOR A TESTS

PROB	OB DEG MIN	OBR-BR-JB * DEG MIN	JOB'R' DEG MIN	JOB'R'-JB'R' DEG MIN	Es (2000=0) MINUTES	Xp (16.4=0) INCHES	Yp (16.4=0) INCHES	Ph** DEG MIN
1	69°50'	10°00'	359°49'	359°59'	2692	23.89	16.20	0°44'
2	70°11'	10°00'	0°15'	0°04'	2692	23.96	16.44	0°44'
3	224°42'	40°00'	0°07'	0°25'	2483	21.77	18.54	0°33'
4	224°09'	40°00'	358°43'	359°34'	2483	21.02	19.92	0°33'
5	146°26'	300°00'	0°10'	358°44'	2122	17.20	27.90	359°51'
6	144°35'	300°00'	0°51'	1°16'	2122	17.75	27.92	359°51'
7	340°13'	70°00'	359°57'	359°43'	2082	1.40	6.51	359°48'
8	339°53'	70°00'	0°09'	0°16'	2082	1.40	6.74	359°48'
9	155°39'	350°00'	0°19'	359°40'	2069	24.54	29.63	0°00'
10	155°00'	350°00'	0°21'	0°21'	2069	24.72	29.52	0°00'
11	255°40'	5°00'	0°29'	359°49'	2069	1.29	16.15	359°47'
12	255°19'	5°00'	0°30'	0°10'	2069	1.32	16.22	359°47'
13	272°00'	352°00'	0°00'	0°00'	2191	5.90	5.62	0°02'
14	272°00'	352°00'	0°00'	0°00'	2191	5.90	5.62	0°02'
15	194°58'	0°00'	359°58'	0°00'	2000	18.56	25.36	0°00'
16	195°04'	0°00'	0°04'	0°00'	2000	18.56	25.24	0°00'

Symbols are given for Main Battery operation.

* This quantity becomes (OBr - Br) for antiaircraft operation.

** This quantity, which is a transmitted quantity, is included because its dial cannot be read with covers on.

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Table 27

A-TEST ELECTRICAL INTERMEDIATE QUANTITIES

PROB NO	1A R4002 R	1B B4080-R4 E_s	1C B4080-R2 E_s	1D R4005 H_s	1E B4096-R4 B'R'	1F R4015 R	1G R4007 P_H	2A B4099-R4 JB
1	+1.175	-0.235	+1.151	+ 7.074	- 7.713	+0.067	-0.723	-0.173
2	+1.175	-0.235	+1.151	+ 7.074	- 7.713	+0.067	-0.723	0.000
3	+2.374	-0.329	+2.327	+ 9.903	-11.591	+0.101	-0.542	-0.370
4	+2.374	-0.329	+2.327	+ 9.903	-11.591	+0.101	-0.542	0.000
5	+3.854	-0.133	+3.758	+ 4.008	+ 5.071	-0.044	+0.148	+0.071
6	+3.854	-0.133	+3.758	+ 4.008	+ 5.071	-0.044	+0.148	0.000
7	+3.337	-0.078	+3.289	+ 2.358	+ 6.000	-0.052	+0.201	-0.025
8	+3.337	-0.078	+3.289	+ 2.358	+ 6.000	-0.052	+0.201	0.000
9	+4.700	-0.094	+4.699	+ 2.829	0.000	0.000	0.000	-0.061
10	+4.700	-0.094	+4.699	+ 2.829	0.000	0.000	0.000	0.000
11	+5.875	-0.118	+5.874	+ 3.537	+11.276	-0.098	+0.211	-0.005
12	+5.875	-0.118	+5.874	+ 3.537	+11.276	-0.098	+0.211	0.000
13	+7.050	-0.392	+7.039	+11.789	- 2.084	+0.018	-0.032	0.000
14	+7.050	-0.392	+7.039	+11.789	- 2.084	+0.018	-0.032	0.000
15	———	———	———	———	- 8.485	+0.074	0.000	0.000
16	———	———	———	———	- 8.485	+0.074	0.000	0.000

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Table 27 (Cont'd)
A-TEST ELECTRICAL INTERMEDIATE QUANTITIES

PROB NO	2B R4018 Es	2C B4081-R2 B	2D B4081-R3 B	2E R4016 XJ	2G R4010 XA	3B R4017 YJ	3D R4011 YA	3F B4082-R3 OB
1	+0.258	-0.987	-0.593	0.000	-0.235	0.000	+0.590	+2.053
2	0.000	-0.999	-0.572	0.000	-0.235	0.000	+0.579	+2.061
3	+0.578	+0.119	+2.324	0.000	-0.470	0.000	-2.184	+2.842
4	0.000	+0.168	+2.321	0.000	-0.470	0.000	-2.091	+2.941
5	-0.110	+1.693	+3.355	-7.679	-1.880	-2.194	-0.652	+3.187
6	0.000	+1.563	+3.417	-7.679	-1.880	-2.194	-0.710	+3.263
7	+0.039	+3.289	-0.006	-0.549	+0.235	-1.646	-2.318	+3.157
8	0.000	+3.289	+0.007	-0.549	+0.235	-1.646	-2.277	+3.106
9	+0.096	-1.187	+4.547	+5.485	-0.151	-8.776	-2.387	+2.937
10	0.000	-1.216	+4.539	+5.485	-0.151	-8.776	-2.398	+2.933
11	+0.008	+5.542	+1.948	-8.228	+0.376	+2.743	-2.044	+4.592
12	0.000	+5.531	+1.978	-8.228	+0.376	+2.743	-2.049	+4.588
13	0.000	+6.932	-1.222	+4.388	-4.465	+7.679	-1.311	+7.266
14	0.000	+6.932	-1.222	+4.388	-4.465	+7.679	-1.311	+7.266
15	0.000	——	——	0.000	-0.141	0.000	+0.585	+1.092
16	0.000	——	——	0.000	-0.141	0.000	+0.577	+1.084

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Table 27 (Cont'd)

A-TEST ELECTRICAL INTERMEDIATE QUANTITIES

PROB NO	3G B4082-R2 OB	4A R4006 HT	4B B4095-R2 ET	4C B4095-R3 ET	4D R4008 OR	4F R101 YP	4E R100 XP	4G R4001 SF
1	0.000	+ 5.895	0.000	-2.062	+2.061	+0.002	+0.650	+3.000
2	0.000	+ 5.895	0.000	-2.070	+2.069	-0.003	+0.656	+3.000
3	0.000	+ 2.358	0.000	-2.843	+2.841	-0.074	+0.186	+1.200
4	0.000	+ 2.358	0.000	-2.942	+2.940	-0.122	+0.160	+1.200
5	0.000	+ 3.301	0.000	-3.188	+3.187	-1.438	+0.100	+4.320
6	0.000	+ 3.301	0.000	-3.265	+3.264	-1.440	+0.169	+4.320
7	0.000	+ 0.707	0.000	-3.157	+3.155	+1.236	-1.875	+4.320
8	0.000	+ 0.707	0.000	-3.106	+3.104	+1.208	-1.875	+4.320
9	0.000	0.000	0.000	-2.937	+2.936	-1.148	+0.707	+3.000
10	0.000	0.000	0.000	-2.933	+2.932	-1.139	+0.722	+3.000
11	0.000	+ 2.122	0.000	-4.592	+4.590	+0.051	-3.148	+7.200
12	0.000	+ 2.122	0.000	-4.589	+4.586	+0.038	-3.142	+7.200
13	0.000	+11.082	0.000	-7.275	+7.271	+1.347	-1.312	+4.320
14	0.000	+11.082	0.000	-7.275	+7.271	+1.347	-1.312	+4.320
15	0.000	+ 0.707	0.000	-1.092	+1.092	-0.311	+0.075	+1.200
16	0.000	+ 0.707	0.000	-1.085	+1.084	-0.307	+0.075	+1.200

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Table 27 (Cont'd)

A-TEST ELECTRICAL INTERMEDIATE QUANTITIES

PROB NO	5A B4083-R1 OL'	5B B4083-R2 OL'	5C B4084-R1 OZ_H	5D B4084-R3 OZ_H	5E B4084-R2 OZ_H	5F B4086-R2 $(2OB'_R' + JOB'_R')$	5G B4093-R2 $(JOB'_R' - JB'_R')$	6A B4088-R2 JOB'_R'
1	+11.954	+1.046	+5.977	-5.977	+1.046	0.000	+0.003	+0.038
2	+11.954	+1.046	+5.977	-5.977	+1.046	0.000	+0.014	-0.054
3	+11.818	-2.084	+5.942	-5.942	+1.670	-0.199	-0.087	-0.026
4	+11.818	-2.084	+5.942	-5.942	+1.670	-0.200	-0.089	+0.264
5	+11.984	-0.628	+5.822	-5.822	-2.903	+0.299	+0.262	-0.035
6	+11.984	-0.628	+5.822	-5.822	-2.903	+0.197	+0.261	-0.176
7	+11.934	-1.254	+5.996	-5.996	-0.419	-0.082	+0.057	+0.012
8	+11.934	-1.254	+5.996	-5.996	-0.419	-0.078	+0.057	-0.033
9	+12.000	0.000	+5.796	-5.796	+3.106	+0,533	+0.069	-0.066
10	+12.000	0.000	+5.796	-5.796	+3.106	+0.569	+0.071	-0.071
11	+11.591	-3.106	+6.000	-6.000	0.000	+0.797	+0.036	-0.100
12	+11.591	-3.106	+6.000	-6.000	0.000	+0.814	+0.035	-0.102
13	+12.000	-0.000	+6.000	-6.000	0.000	0.000	0.000	0.000
14	+12.000	0.000	+6.000	-6.000	0.000	0.000	0.000	0.000
15	+11.984	+0.628	+5.996	-5.996	+0.419	+0.037	0.000	+0.006
16	+11.984	+0.628	+5.996	-5.996	+0.419	+0.037	0.000	-0.015

Table 27 (Cont'd)

A-TEST ELECTRICAL INTERMEDIATE QUANTITIES

PROB NO	6B B4090-R4 (20BR-BR-JB)	6C B4085-R2 0ZH	6D B4091-R1 (20BR-BR-JB)	6E B4094-R3 (JOB'R-JB'R)	6F B4087-R3 (20B'R'+JOB'R')	6G B4089-R3 JOB'R'	7A B4092-R3 (OBR-BR-JB)	7B B4092-R4 (OBR-BR-JB)
1	0.000	+0.182	+0.343	-0.365	+0.062	-0.365	-2.423	-1.697
2	0.000	+0.182	+0.343	-0.365	+0.064	+0.365	-2.423	-1.697
3	-0.257	-0.580	-0.210	+1.160	-0.757	+1.160	+1.046	-5.237
4	-0.258	-0.580	-0.193	+1.160	-0.752	-1.160	+1.046	-5.237
5	-1.193	+0.304	-0.292	-0.608	+0.593	-0.608	-4.400	+3.991
6	-1.163	+0.304	-0.315	-0.608	+0.601	+0.608	-4.400	+3.991
7	-0.149	+0.088	-0.135	-0.175	+0.164	-0.175	+1.645	-2.071
8	-0.151	+0.088	-0.134	-0.175	+0.165	+0.175	+1.645	-2.071
9	-0.550	0.000	0.000	0.000	0.000	0.000	+1.079	-6.117
10	-0.569	0.000	0.000	0.000	0.000	0.000	+1.079	-6.117
11	-0.289	0.000	0.000	0.000	0.000	0.000	+6.188	-0.542
12	-0.279	0.000	0.000	0.000	0.000	0.000	+6.188	-0.542
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	+0.044	+0.088	+0.088	0.000	-0.088	-1.256	-0.838
16	0.000	+0.044	+0.088	+0.088	0.000	+0.088	-1.256	-0.838

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Table 27 (Cont'd)

A-TEST ELECTRICAL INTERMEDIATE QUANTITIES

PROB NO	7C B4098-R4 Zm	7D B4097-R4 L'	7F B4081-R2 B	7G B4081-R3 B
1	+0.848	+1.211	-0.987	-0.593
2	+0.848	+1.211	-0.999	-0.572
3	+2.619	-0.523	+0.119	+2.324
4	+2.619	-0.523	+0.168	+2.321
5	-1.995	+2.200	+1.693	+3.355
6	-1.995	+2.200	+1.563	+3.417
7	+1.035	-0.823	+3.289	-0.006
8	+1.035	-0.823	+3.289	+0.007
9	+3.059	-0.539	-1.187	+4.547
10	+3.059	-0.539	-1.216	+4.539
11	+0.271	-3.094	+5.542	+1.948
12	+0.271	-3.094	+5.531	+1.978
13	0.000	0.000	+6.932	-1.222
14	0.000	0.000	+6.932	-1.222
15	+0.419	+0.628	—	—
16	+0.419	+0.628	—	—

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Table 28

TEST OF OPERATING LIMITS

Limit Stop	Function	Location	Range	Reading on Dial or Counter Lower Limit	Upper Limit
H40L1	Yp	U1204	±16.4 in	0	32.8
H40L2	Xp	U1204	±16.4 in	32.8	0
H40L3	Xj	U4004	±1000 yds	-1000	+1000
H40L4	Et	U1403	0 to 20°	2000	3200
H40L5	Hs	U4004	0 to 5000 ft	0	5000
H40L6	Ht	U4004	0 to 5000 ft	0	5000
H40L7	Es	U1202	0 to 30°	2000	3800
H40L8	OR	U1402	500 to 50,000 yds	500	50,000
H40L9	Yj	U4004	±1000 yds	-1000	+1000
H40L10	L' or L	U1404	±25°	* -5.071	+5.071 at 7D
H40L11	Zh or Zd**	U1404	±25°	* -5.071	+5.071 at 7C
H40L12	OL' or OL	U1301	±25°	* -5.071	+5.071 at 5B
H40L13	OZh or OZd	U1304	±25°	* -5.071	+5.071 at 5E
H40L14	jOB'r' -jB'r'	U4005	±20°	-20	+20
H40L15	jOB'r'	U4005	±20°	-20	+20
H40L16	jB***	U1201	±15°	*+3.106	-3.106 at 2A
H40L17	Ph	U1405	±12°	-12	+12
H40L18	So	U4004	0 to 55 knots	0	55

*Voltages to be read at indicated voltage check points.
**Remove potentiometer R4018 when checking limit stop.
***Remove ZN4304 when checking limit stop.

Table 28 (Cont'd)

TEST OF OPERATING LIMITS

Limit Stop	Function	Location	Range	Reading on Dial or Counter	
				Lower Limit	Upper Limit
H40L19	R	U4004	500 to 50,000 yds	500	50,000
H40L20	S.F.	U4009	10,000 to 100,000:1	10,000	100,000

elements. Thus, a suspected group of elements may be examined by using simplified problem setups.

The special trouble-shooting tests are presented in tabular form, with columns of figures for the input settings, intermediate quantities, and final problem results. Wherever an input "setting" column heading includes the word "volts," the values given must be indicated by means of the test unit. This is done by setting the SIGNAL TEST SELECTOR switch at the test-point symbol given in the column heading below the input function symbol. Column headings for the intermediate check voltages, which must also be indicated on the test-unit dials, contain the test-point symbol, the element identification number with the terminal number being tested, and the symbol of the principal quantity involved in the computation at that point. Reference to the appropriate schematic, figures 47 through 59, will show the complete designation of the function at each test point.

The special tests are:

Deck-tilt test

Deck-tilt resolver check

Es computation test

Et or OR computation test

Xp or Yp computation test

Ph computation test

Deck-Tilt-Correction Test. This test statically checks the computing accuracy of the elements in the OB computing loop, figure 52, the OL' and OZh resolver group, figure 54, the jOB'r - jB'r' loop, figure 56, the jOB'r' loop, figure 57, and in the L' and Zh loops, figure 55. Only seven inputs must be varied, four of which are the reference and target coordinates needed to provide the required OB input for the deck-tilt-corrector elements. The deck-tilt test is given in two tables: table 29 for the main-battery computation; and table 30 for the antiaircraft battery computation.

The mechanical outputs to be read and recorded are the transmitted quantity OB'r' and the loop outputs jOB'r' and jOB'r' - jB'r'. Through the use of the

Table 29

TEST FOR DECK TILT CORRECTION COMPUTATION (MB)

Settings

OL' Min 2000 = 0	OZh Min 2000 0	B'r' Deg Min	Xa* 2F Read	Ya* 3C Read	Xt* 3A Read	Yt* 3E Read
2000	3200	0°00'	+1.175	+1.175	-2.350	-1.250
3200	2000	0°00'	+1.175	+1.175	-2.350	-1.104
3200	3200	0°00'	+1.175	+1.175	-2.350	-1.165
1400	1400	15°00'	+1.175	+1.175	-2.350	-0.415
800	800	15°00'	+1.175	+1.175	-2.350	-0.341
2000	800	45°00'	+1.175	+1.175	+0.000	-1.763

*Rotate Xa, Ya, Xt, Yt handcranks to give desired readings at respective voltage checkpoints. Refine with handcranks so that (OBr - Br - jB) dial reads 45 degrees for problems 1, 2 and 3; 60 degrees for problems 4 and 5; and 300 degrees for for problem 6.

Settings

5A B4083-R1 OL'	5B B4083-R2 OL'	5C B4084-R1 OZh	5D B4084-R3 OZh	5E R4084-R2 OZh
+12.000	0.000	+5.638	-5.638	+4.104
+11.276	+4.104	+6.000	-6.000	0.000
+11.276	+4.104	+5.638	-5.638	+4.104
+11.818	-2.084	+5.909	-5.909	-2.084
+11.276	+4.104	+5.638	-5.638	-4.104
+12.000	0.000	+5.638	-5.638	-4.104

Table 29 (Cont'd)

TEST FOR DECK-TILT-CORRECTION COMPUTATION (MB)

Check Voltages

6C B4085-R2 OZh	6F B4087-R3 (2 OB'r' + jOB'r')	5F B4086-R2 (2 OB'r' + jOB'r')	6G B4089-R3 jOB'r'
0.000	0.000	-2.882	0.000
0.000	0.000	+2.882	0.000
+2.807	+0.428	0.000	-5.606
+0.724	+1.285	0.000	-1.447
+2.807	+4.832	0.000	-5.615
0.000	0.000	-2.890	0.000

Check Voltages

6A B4088-R2 jOB'r'	6B B4090-R4 2(OBr - Br - jB) -(jOB'r' -jB'r')	6D B4091-R1 2(OBr - Br - jB -(jOB'r' -jB'r')	6E B4094-R3 (jOB'r' - jB'r')
+0.360	+2.893	0.000	0.000
-0.360	-2.893	0.000	0.000
+0.642	0.000	-0.372	-5.603
+0.020	0.000	-0.753	-1.447
+0.038	0.000	-3.271	-5.588
-0.159	-2.546	0.000	0.000

Table 29 (Cont'd)

TEST FOR DECK-TILT-CORRECTION COMPUTATION (MB)

Check Voltages

5G B4093-R2 (jOB'r' -jB'r')	2A B4099-R4 jB	7A B4092-R3 (OBr - Br - jB)	7B B4092-R4 (OBr - Br - jB)
-0.362	0.000	-5.804	-5.804
+0.362	0.000	-5.804	+5.804
+0.747	0.000	-11.609	0.000
+0.275	0.000	+5.693	-1.525
+1.107	0.000	+11.213	-3.005
+0.318	0.000	-7.109	+4.104

Check Voltages

7C B4098-R4 Zh	7D B4097-R4 L'
+2.902	+2.902
-2.902	+2.902
0.000	+5.804
+0.763	-2.846
+1.502	-5.606
-2.052	+3.554

Table 29 (Cont'd)

TEST FOR DECK-TILT-CORRECTION COMPUTATION (MB)

Results

Calc Deg Min	OB'r' Reading Deg Min	Error Min	Calc Deg Min	jOB'r' Reading Deg Min	Error Min
43°13'			358°14'		
46°47'			1°46'		
48°48'			356°42'		
76°20'			359°54'		
80°38'			359°49'		
346°34'			0°47'		
Total	Allow		Total	Allow	
Average			Average		
Maximum			Maximum		

Results

Calc Deg Min	(jOB'r' - jB'r') Reading Deg Min	Error
1°47'		
358°13'		
356°12'		
358°40'		
354°22'		
358°26'		
Total	Allow	
Average		
Maximum		

Table 30

TEST FOR DECK-TILT-CORRECTION COMPUTATION (AA)

Settings

OL Min 2000 = 0	OZd Min 2000 = 0	B'r Deg Min	Xa* 2F Read	Ya* 3C Read	Xt* 3A Read	Yt* 3E Read
2000	3200	0° 00'	+1.175	+1.175	-2.350	-1.175
3200	2000	0° 00'	+1.175	+1.175	-2.350	-1.175
3200	3200	0° 00'	+1.175	+1.175	-2.350	-1.175
1400	1400	15° 00'	+1.175	+1.175	-2.350	-0.431
800	800	15° 00'	+1.175	+1.175	-2.350	-0.411
2000	800	45° 00'	+1.175	+1.175	0.000	-1.601

*Rotate Xa, Ya, Xt, Yt handcranks to give desired readings at respective voltage checkpoints. Refine with handcranks so that (OBr - Br - jB) dial reads 45 degrees for problems 1, 2 and 3; 60 degrees for problems 4 and 5; and 300 degrees for problem 6.

Check Voltages

5A B4083-R1 OL	5B B4083-R2 OL	5C B4084-R1 OZd	5D B4084-R3 OZd	5E B4084-R2 OZd
+12.000	0.000	+5.638	-5.638	+4.104
+11.276	+4.104	+6.000	-6.000	0.000
+11.276	+4.104	+5.638	-5.638	+4.104
+11.818	-2.084	+5.909	-5.909	-2.084
+11.276	-4.104	+5.638	-5.638	-4.104
+12.000	0.000	+5.638	-5.638	-4.104

Table 30 (Cont'd)

TEST FOR DECK-TILT-CORRECTION COMPUTATION (AA)

Check Voltages

6C B4085-R2 OZd	6F B4087-R3 (2 OB'r +jOB'r)	5F B4086-R2 (2 OB'r +jOB'r)	6G B4089-R1 jOB'r
0.000	0.000	-2.893	0.000
0.000	0.000	+2.893	0.000
+2.807	-0.328	0.000	+5.605
+0.724	+1.241	0.000	+1.447
+2.807	+4.677	0.000	+5.579
0.000	0.000	+1.538	0.000

Check Voltages

6A B4088-R2 jOB'r	6B B4090-R4 2(OBr - Br) -(jOB'r -jB'r)	6D B4091-R1 2(OBr - Br) -(jOB'r -jB'r)	6E B4094-R3 (jOB'r -jB'r)
+0.362	+2.893	0.000	0.000
-0.362	-2.893	0.000	0.000
-0.660	0.000	+0.328	-5.605
-0.336	0.000	-0.695	-1.447
-1.282	0.000	-2.637	-5.593
-0.192	-2.467	0.000	0.000

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Table 30 (Cont'd)

TEST FOR DECK-TILT-CORRECTION COMPUTATION (AA)

Check Voltages

5G B4093-R4 (jOB'r -jB'r)	2A B4099-R4 jB	7A B4092-R3 (OBr - Br)	7B B4092-R4 (OBr - Br)
-0. 362	0. 000	-5. 804	-5. 804
+0. 362	0. 000	-5. 804	+5. 804
+0. 660	0. 000	-11. 608	0. 000
+0. 267	0. 000	+5. 693	-1. 525
+0. 995	0. 000	+11. 213	-3. 005
+0. 309	0. 000	-7. 109	+4. 104

Check Voltages

7C B4098-R4 Zd	7D B4097-R4 L
+2. 902	+2. 902
-2. 902	+2. 902
0. 000	+5. 804
+0. 763	-2. 846
+1. 502	-5. 606
-2. 052	+3. 554

Table 30 (Cont'd)

TEST FOR DECK-TILT-CORRECTION COMPUTATION (AA)

Results

Calc Deg Min	OB'r Reading Deg Min	Error Min	Calc Deg Min	jOB'r Reading Deg Min	Error Min
46°47'			358°13'		
43°08'			1°47'		
41°39'			3°21'		
73°42'			1°38'		
69°56'			6°32'		
343°29'			0°57'		
Total	Allow		Total	Allow	
Average			Average		
Maximum			Maximum		

Results

Calc Deg Min	(jOB'r - jB'r) Reading Deg Min	Error Min
358°13'		
1°47'		
3°21'		
1°18'		
5°04'		
1°31		
Total	Allow	
Average		
Maximum		

test unit and the computer SIGNAL TEST SELECTOR switch, 19 intermediate check voltages are made available for localizing the source of trouble.

The following list gives the steps necessary for performing the deck-tilt test either for MB or AA computation. In addition to the steps listed, the computer DIRECTOR SELECTOR switch must be positioned appropriately as shown in the table titles. The procedure is:

1. Connect the test unit to the computer.

2. Remove cover No. 6 for visual access to the jOB'r' and jOB'r' - jB'r' dials.

3. Energize the computer as for operation but leave time motor turned off.

4. Set and hold Co, Hs, Xj, Yj, So, and Hs at zero.

5. Set R at 5000 yards.

6. Set mode-and-plot switch at SHORE BOMB SHIP.

7. Transmit values of OL' and OZh given in the first two columns of table 29 from the stable vertical.

8. Manually set in values of B'r' given in third column.

9. Using the REF SHIP and TARGET coordinate handcranks, the voltage values shown for Xa, Ya, Xt, and Yt are set up on the test-unit dials with the SIGNAL TEST SELECTOR switch at the positions designated in the respective column headings.

10. Read and record the check voltages and the mechanically indicated problem results.

Deck-Tilt Resolver Check. In this procedure, each resolver in the jOB'r' and jOB'r' - jB'r' loops is checked separately for function, polarity, and adjustment. Where trouble-shooting procedure has indicated a faulty resolver in one of the two loops, perform the appropriate portion of the deck-tilt resolver check to verify the diagnosis. Part 1 checks the resolvers that compute the terms of the equation used in solving for jOB'r' - jB'r', as shown in figure 56. Similarly, Part 2 covers the jOB'r' loop shown in figure 57. The loop equation is included with each part of the test to identify the terms with the resolvers computing them.

NOTE: In the deck-tilt resolver check, the word "increase" or "increasing" means a change in the positive direction, that is, positive values become larger or negative values become smaller. Likewise, "decrease" or "decreasing" means a change in the negative direction; positive values become smaller or negative values become larger.

The procedure is:

1. Remove cover No. 6, and disconnect the line phase of the (jOB'r' - jB'r') and jOB'r' motors.

2. Connect the test unit to Computer Mk 48 Mod 1.

3. Energize the computer as for operation but leave the time motor turned off.

4. Control OL' and OZh from the stable vertical.

5. Control OB - B through the Co handcrank.

6. Control OB'r' through the B'r' handcrank.

7. Control (jOB'r' - jB'r') and jOB'r' at the respective servo motors.

8. Set the DIRECTOR SELECTOR switch at MB, except as indicated.

9. Set the SIGNAL TEST SELECTOR switches at the combination indicated for each check.

10. Observe output indications on test-unit dials.

PART 1

jOB'r' - jB'r' Loop

Term	Resolver	Test Point
$-\left[\sin(jOB'r' - jB'r')\right](\cos OZh + \cos OL')$	B4093	*5G
$+\left\{\sin\left[2(OBr - Br) - (jOB'r' - jB'r')\right]\right\}(\cos OL' - \cos OZh)$	B4090	*6B
$+\left\{\cos\left[2(OBr - Br) - (jOB'r' - jB'r')\right]\right\}\sin OZh \sin OL'$	B4091	*6D
$-\left[\cos(jOB'r' - jB'r')\right]\sin OZh \sin OL' = 0$	B4094	*6E

Resolver B4093 *5G

a. Increasing (jOB'r' - jB'r') makes the output decrease.

b. Set (jOB'r' - jB'r' = 345 degrees. The output should be positive for any combination of OZh and OL' and maximum (+3.491 volts) when OZh and OL' = 0.

c. The sign of output should reverse when DIRECTOR SELECTOR switch is thrown to AA.

Resolver B4090 *6B

a. When OL' = ± OZh, output = 0

b. Set OZh = 0, OL' = -20 degrees (800 min), (OB - B) = 0, (jOB'r' - jB'r') = 0. The output should be 0. The output should decrease as (OB - B) is increased, and increase as (OB - B) is decreased. Output should increase as (jOB'r' - jB'r') is increased, and decrease as (jOB' - jB'r') is decreased.

* SIGNAL TEST SELECTOR switch position.

PART 1 (Cont'd)

jOB'r' - jB'r' Loop

Resolver B4091 *6D

a. When OL' or OZh = 0, the output = 0

b. Set OZh = 3200 min, OL' = 800 min, (jOB'r' - jB'r') = 0
With (OB - B) = 0 degrees, the output = maximum negative value (-2.729 volts).
With (OB - B) = 45 degrees, the output = 0
With (OB - B) = 90 degrees, the output should be at maximum positive value (+2.729 volts)
With (OB - B) = 45 degrees, the output decreases as (jOB'r' - jB'r') is increased, and increases as (jOB'r' - jB'r') is decreased.

Resolver B4094 *6E

a. When OL' or OZh = 0, the output = 0.

b. Set OZh = 3200 min, OL' = 800 min, (jOB'r' - jB'r') = 0.
The output should be at maximum value (+2.729 volts).
The output to decrease when (jOB'r' - jB'r') is moved either way from zero.

PART 2

jOB'r' Loop

Term	Resolver	Test Point
- sin jOB'r' (cos OZh + cos OL')	B4088	*6A
- sin(2 OB'r' +jOB'r') (cos OL' - cos OZh)	B4086	*5F
- cos(2 OB'r' + jOB'r') sin OZh sin OL'	B4087	*6F
- cos jOB'r' sin OL' sin OZh = 0	B4089	*6G

Resolver B4088 *6A

a. Increasing jOB'r' makes the output decrease.

b. Set jOB'r' = -15 degrees (1100 min). The output should be positive for any combination of OZh and OL', and should be at maximum value (+3.419 volts) when OZh and OL' = 0.

---

* SIGNAL TEST SELECTOR switch position.

PART 2 (Cont'd)

jOB'r' Loop

Resolver B4086 *5F

a. When OL' = ± OZh, the output = 0

b. Set OZh = 0 (2000 min), OL' = -20 degrees (800 min), OB'r' = 0, jOB'r' = 0: the output should be 0. The output should increase as OB'r' or jOB'r' is increased and decrease as OB'r' or jOB'r' is decreased.

Resolver B4087 *6F

a. When OL' and OZh = 0, the output = 0

b. Set OZh = 3200 min, OL' = 800 min, jOB'r' = 0.
With OB'r' = 0 degrees, the output should be at maximum positive value (+2.729 volts)
With OB'r' = 45 degrees, the output = 0
With OB'r' = 90 degrees, the output = maximum negative value (-2.729 volts).

c. With OB'r' = 45 degrees, the output should decrease as jOB'r' is increased, and should increase as jOB'r' is decreased.

Resolver B4089 *6G

a. When OL' or OZh = 0, the output = 0

b. Set OZh = 3200 min, OL' = 800 min, jOB'r' = 0, the output should be at maximum positive value (+2.729 volts). The output to decrease when jOB'r' is moved either way from zero.

c. The sign of the output should reverse when the DIRECTOR SELECTOR switch is thrown to AA.

---

* SIGNAL TEST SELECTOR switch position.

Es Computation Test. The elements shown in figure 48 are checked separately in this test. Reference height, Hs, and range, R, are the only inputs involved. Connect the test unit, and energize the computer as for operation, but leave the time motor turned off. Run the test according to table 31, reading and recording the check voltages as well as the values for Es.

Et and OR Computation Test. This test checks the elements shown on figures 48, 50, 52, and 53. All inputs (table 32) are controlled manually. To bypass the plotter and limit the scope of this test, reference and target-coordinate input settings are made in conjunction with the test unit. The deck-tilt corrector elements are eliminated, for further simplification, by locking the two output servo loops on zero.

The problem results shown in table 32 fall into three categories: ten check voltages representing electrical intermediate quantities; one mechanical

Table 31

TEST FOR ELEVATION POINT OF AIM, Es, COMPUTATION

Settings		Check Voltages			Results		
					Es		
Hs Ft	R Yds	1A R4002 R	1B B4080-R2 Es	1D R4005 Hs	Calc 2000 = 0 Min	Read 2000 = 0 Min	Error Min
100	5000	+ 1.175	-0.008	+ 0.236	2023		
1000	6000	+ 1.410	-0.078	+ 2.358	2191		
2500	20,000	+ 4.700	-0.196	+ 5.895	2143		
4000	35,000	+ 8.225	-0.313	+ 9.432	2131		
5000	50,000	+11.750	-0.392	+11.789	2115		
300	40,000	+ 9.400	-0.024	+ 0.707	2009		
1200	30,000	+ 7.050	-0.094	+ 2.829	2046		
3000	15,000	+ 3.525	-0.235	+ 7.074	2229		
5000	5000	+ 1.175	-0.392	+11.789	3168		
					Total	Allow	
					Average		
					Maximum		

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Table 32

TEST FOR TARGET ELEVATION, Et, AND TARGET RANGE, OR

Settings

R Yds	B'r' Deg Min	Hs Ft	Ht Ft	Xj Yds
1500	30°00'	0	0	0
5000	75°00'	100	300	East 100
6000	135°00'	1000	1200	East 300
20, 000	240°00'	2500	3000	West 600
35, 000	300°00'	4000	3900	West 750
50, 000	0°00'	5000	5000	East 1000

Settings

Yj Yds	Xa 2F Read	Ya 3C Read
0	0	0
North 100	+0.235	+0.235
South 500	+1.175	+2.350
North 400	-3.525	-1.175
South 750	-7.050	+4.700
North 1000	+10.575	+10.575

Table 32 (Cont'd)

TEST FOR TARGET ELEVATION, Et, AND TARGET RANGE, OR

Settings

	Xt 3A Read	Yt 3E Read
	0	0
	-1.175	-1.175
	-1.763	-2.350
	+2.820	+1.410
	+5.875	-5.875
	-9.400	-9.400

Check Voltages

2C B4081-R2 B	2D B4081-R3 B	2E R4016 Xj	3B R4017 Xy	4A R4006 Ht	3G B4082-R4 OB
-0.176	- 0.305	0.000	0.000	0.000	0.000
-1.135	- 0.304	- 1.097	- 1.097	+ 0.707	0.000
-0.995	+ 0.995	- 3.291	+ 5.485	+ 2.829	0.000
+4.067	+ 2.348	+ 6.582	- 4.388	+ 7.074	0.000
+7.118	- 4.109	+ 8.227	+ 8.227	+ 9.196	0.000
0.000	-11.743	-10.970	-10.970	+11.863	0.000

Table 32 (Cont'd)

TEST FOR TARGET ELEVATION, Et, AND TARGET RANGE, OR

Check Voltages

3F B4082-R3 OB	4B B4095-R2 Et	4C B4095-R3 Et	4D R4008 OR
+ 0.353	0.000	- 0.353	+ 0.352
+ 2.452	0.000	- 2.452	+ 2.451
+ 1.993	0.000	- 1.995	+ 1.994
+ 4.298	0.000	- 4.304	+ 4.302
+ 7.971	0.000	- 7.977	+ 7.973
+10.846	0.000	-10.853	+10.847

Intermediate Quantity

OB			
Calc Deg Min	Read Deg Min	Error Min	
30°00'			
58°52'			
123°57'			
234°36'			
309°51'			
355°02'			
	Total		Allow
	Average		
	Maximum		

Table 32 (Cont'd)

TEST FOR TARGET ELEVATION, Et, AND TARGET RANGE, OR

Final Results

Et			OR		
Calc 2000 = 0 Min	Read 2000 = 0 Min	Error Min	Calc Yards	Read Yards	Error Yards
2000			1500		
2033			10433		
2162			8491		
2188			18315		
2132			33944		
2124			46182		
Total	Allow		Total	Allow	
Average			Average		
Maximum			Maximum		

intermediate quantity dial reading; and dial readings of the two transmitted outputs, Et and OR. The Et and OR computation test is performed as follows:

1. Connect the test unit to the computer.

2. Remove cover No. 6, and disconnect the line phase from the jOB'r' and jOB'r' - jB'r' servo motors. Set and lock the jOB'r' and jOB'r' - jB'r' dials at zero.

3. Set and hold Co at zero.

4. Set the So counter on zero.

5. Energize the computer as for operation, but leave the time motor turned off.

6. Apply the inputs listed under settings in table 32. Using the REF SHIP and TARGET coordinate handcranks, the input values shown for Xa, Ya, Xt, and Yt are set up on the test-unit dials with the TEST SELECTOR switch at the positions designated.

7. Read and record all electrical and mechanical values covered in the columns of table 32 under the headings CHECK VOLTAGES, INTERMEDIATE QUANTITY, and FINAL RESULTS. Compare each reading with the specified value and note the error.

Xp and Yp Computation Test. Although primarily a test for the plotting elements shown on figure 51, this test also involves most of the computing and switching elements shown on figures 48, 49, and 50. Each of the problems, table 33, consists of first manually setting the Xp and Yp counters and the R, Hs, and B'r' indicators at specified values that represent the position of a reference point on which the director is trained. Ship-course and deck-tilt correction are fixed at zero. The plot then is shifted to own ship, where the values of Rh sin B and - Rh cos B, derived from range, bearing, and reference height, enter into the computation of Xp and Yp, the counters for which assume new positions. These represent the final problem results given under Results, table 33. In addition, seven check voltages to be measured with the test unit are tabulated for checking intermediate points. The procedure is:

1. Connect the test unit to the computer.

2. Remove cover No. 6, and disconnect the line phase from the jOB'r' and jOB'r' - jB'r' servo motors. Set and lock the jOB'r' and jOB'r' - jB'r' dials at zero.

3. Remove cover No. 1 for access to the Xp and Yp counters.

4. Set and hold Co at zero.

5. Energize the computer as for operation, but leave the time motor turned off.

6. Set the mode-and-plot switch at SHORE BOMB REF, and apply the inputs in the order listed in the first six columns of table 33. The values for Xa and Ya are set up on the Xp and Yp counters, respectively, by turning the REF SHIP hand inputs.

7. Turn the mode-and-plot switch to SHORE BOMB SHIP.

8. Read on the test-unit dials all check voltages for which calculated values are given. Compute the errors.

9. Read and record the problem results on the Xp and Yp counters. Record the errors.

Ph Computation Test. Trouble in the parallax group of elements shown in figure 59 can be analyzed by means of this test. Inputs of range and director train are set in manually as specified in table 34. The test unit is used for indicating the intermediate electrical quantities (check voltages), and the output, Ph, is read directly on the transmitted dial. The computer must be energized for operation (time motor turned off), and cover No. 6 removed to gain visual access to the Ph dial.

GENERATION TEST ANALYSIS

The sections of the computer that contribute to the results of the generation tests are block-diagrammed in figure 45. Detailed functional schematics for the various sections are given in figures 47, 50, and 51.

After taking the necessary steps to verify the problem results, make an analysis of the rate errors based on tables 35 and 36. Examine the errors of all problems to establish a pattern of symptoms along the same lines as those covered in the tables. If the symptoms are similar to those symptoms shown in the appropriate table, then the possible source indicated should be investigated. Refer to section 5.5 of this chapter for the procedure given under the adjustment number listed in the table, and perform the steps of the procedure. Refine the adjustment as necessary, taking into consideration the test results as well as the indications observed in performing the adjustment procedure. If an adjustment cannot be corrected to give the specified performance, look for mechanical trouble in the associated gearing and mechanism.

As shown on figure 45 the two generating mechanism groups have a common time source. Furthermore, the time input for

Table 33

TEST FOR Xp AND Yp COMPUTATION

Settings*

R Yds	Hs Ft	B'r' Deg Min	Xa** 16.4 = 0 In	Ya** 16.4 = 0 In	Scale
500	0	30°00'	16.40	16.40	10,000:1
5000	100	75°00'	14.96	17.84	25,000:1
6000	1000	135°00'	11.40	26.40	36,000:1
20,000	2500	240°00'	27.20	12.80	50,000:1
35,000	4000	300°00'	31.83	26.69	70,000:1
50,000	5000	0°00'	0.20	32.60	100,000:1

Check Voltages***

4G R4001 SF	2G R4010 Xa	7F B4081-R2 B	4E R100 Xp	3D R4011 Ya	7G B4081-R3 B	4F R101 Yp
1.20	0.000	-0.059	0.538	0.000	- 0.102	0.519
3.00	0.235	-1.135	0.945	0.235	- 0.304	1.387
4.32	1.175	-0.995	2.146	2.350	+ 0.995	3.830
6.00	-3.525	+4.067	3.135	-1.175	+ 2.348	3.471
8.40	-7.050	+4.109	2.422	4.700	- 7.118	2.700
12.00	10.575	0.000	11.319	10.575	-11.743	5.073

*Set jOB'r' and (jOB'r' - jB'r') dials on zero. Set Co receiver at electrical zero and So counter on zero.

**Set switch S4006 on SHORE BOMB REF and read Xa and Ya inputs on Xp and Yp counters, then set switch S4006 to SHORE BOMB SHIP.

***Check voltages to be used only when final results are not within allowable limits.

Table 33 (Cont'd)

TEST FOR Xp AND Yp COMPUTATION

Results

Xp		
Calc In.	Read In.	Error In.
17.300		
21.915		
15.636		
14.740		
16.250		
0.200		
Total	Allow	
Average		
Maximum		

Results

Yp		
Calc In.	Read In.	Error In.
14.959		
15.977		
30.636		
19.994		
17.690		
14.610		
Total	Allow	
Average		
Maximum		

Table 34

TEST FOR HORIZONTAL PARALLAX, Ph, COMPUTATION

Settings		Check Voltages			Results		
					Ph		
R Yards	B'r' Deg	1E B4096-R4 B'r'	1F R4015 R	1G R4007 Ph	Calc Deg Min	Read Deg Min	Error Min
1000	30°00'	- 6.000	+0.052	-2.809	2°52'		
5000	75°00'	-11.591	+0.101	-1.085	1°06'		
6000	135°00'	- 8.485	+0.074	-0.662	0°41'		
20,000	240°00'	+10.392	-0.091	+0.243	-0°15'		
35,000	330°00'	+ 6.000	-0.052	+0.080	-0°05'		
50,000	0°00'	0.000	0.000	0.000	0°00'		
					Total	Allow	
					Average		
					Maximum		

the test runs is controlled by a stop watch rather than with a computer time dial, making it possible for a malfunctioning time-motor regulator to introduce errors in all three generated quantities. If the time-motor regulator is not functioning properly, then all problems of both tests will be fast or all will be slow as indicated in tables 35 and 36. If this is the case, run the complete test of the time-motor regulator, table 22 and replace or adjust the unit as required. For information on servicing the time-motor regulator, refer to OP 1140A.

If the error pattern fails to fall into one of the tabulated categories, more than one source of error is possible or the coordinates' inputs group or plotter group may be at fault. Whichever of these two possibilities seems more likely should be eliminated first. The possibility of more than one source of error or more than one incorrect adjustment can be eliminated by performing the procedures for all the adjustments listed in table 35, in the order presented in section 5.5. To check the performance of the coordinates' input group and the plotter group, run the test for Xp and Yp computation, table 33. This test covers the computer elements from the coordinate inputs through the mode-and-plot switch to the plotter group, and contains intermediate check voltages for locating trouble in those groups.

TRANSMISSION TEST ANALYSIS

The first thing to determine, when transmission errors are encountered, is whether the trouble originates within the computer

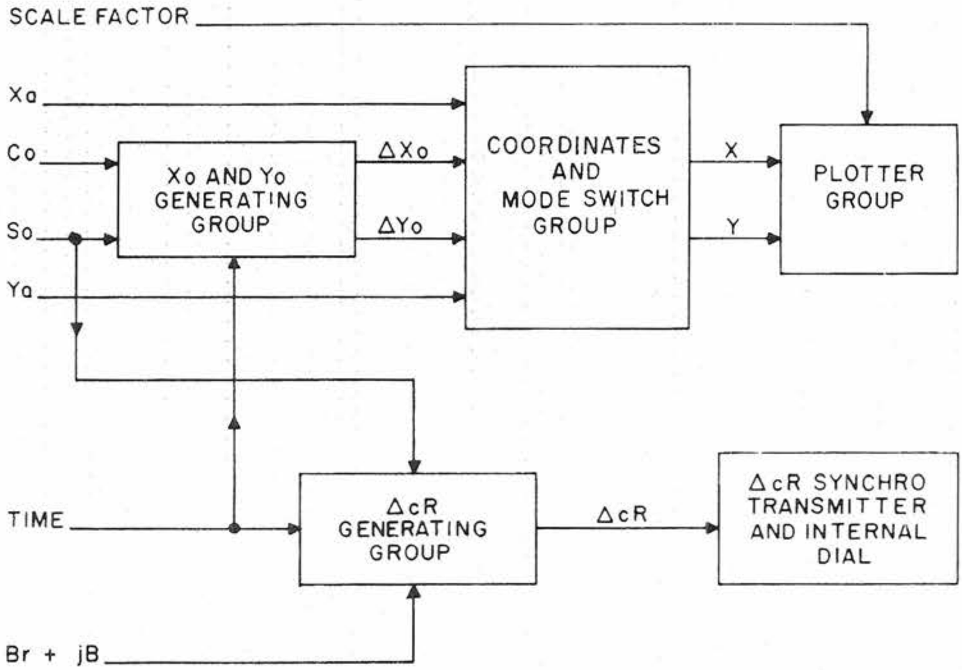

Figure 45. Generation Test Analysis, Block Schematic

Table 35

ΔXo AND ΔYo ERROR ANALYSIS

Symptoms	Possible Source
All problems fast or all problems slow with errors proportional to So.	Time-motor regulator
All problems fast or all problems slow with approximately equal rate errors.	So to mechanical resolver — A58
All problems exhibit a course deviation in the same direction.	Co to mechanical resolver — A65
1st problem fast and 4th slow or 1st problem slow and 4th fast.	dYo to integrator carriage — A70 or A114
3rd problem fast and 5th slow or 3rd problem slow and 5th fast.	dXo to integrator carriage — A69 or A115

Table 36

ΔcR ERROR ANALYSIS

Symptoms	Possible Source
All problems fast or all problems slow with errors proportional to So.	Time-motor regulator
All problems fast or all problems slow with approximately equal errors.	So to mechanical resolver — A66
1st and 4th problems slow and 2nd problem fast or 1st and 4th problems fast and 2nd problem slow.	Br to mechanical resolver — A67
1st and 5th problems slow and 2nd, 3rd, and 4th problems fast or 1st and 5th problems fast and 2nd, 3rd, and 4th problems slow.	dR to integrator carriage — A68 or A116

or from the external transmission system. Most cases of receiver instability or complete failure to respond can be assumed to be the fault of a receiver element. However, in cases where a receiver responds but fails to synchronize at the correct value, or where the computer transmitter unit fails the transmission test, the trouble can originate at either end of the transmission circuit or in the wiring between.

After checking out any electronic elements involved to the extent made possible by use of the neon indicating system, the trouble can be localized roughly by the substitution method. Disconnect the external circuit from the computer terminal block, and connect in its place the cable of an appropriate synchro test set—a test transmitter or test receiver. Rerun the transmission test with the test set. Compare the results obtained with the test set with those obtained under normal conditions. The result will establish whether the trouble is within the computer or external.

If the trouble is external, the receiving or transmitting unit at the other end of the circuit should be checked and, if necessary, followed by a check of the interconnecting wiring. Refer to BuOrd dwg 1371758 for external cable connections.

When transmission errors are localized to the computer, the following procedure is recommended:

Receivers (Double Speed)

1. Remove the servo control, and substitute a good spare. Rerun the test.

2. Remove the servo amplifier, and substitute a good spare. Rerun the test.

3. Refer to pertinent schematic, figures 47 through 59, and list the numbers of all adjustments of the receiver in question. Then refer to section 5.5 for the procedures given under the numbers listed. Perform each of the procedures in the order given, and readjust as necessary.

4. If the preceding steps have not eliminated the trouble, use an analyzer to check the windings of the synchros and servos for shorts or opens. Replace any defective units and readjust as necessary.

Ship's Speed Receiver

Maintenance for this receiver is covered in OP 1140A.

Transmitters

1. Refer to the pertinent schematic, figures 47 through 59, for the numbers of the adjustments that affect the accuracy of the transmitter. Perform the procedures for these adjustments, as given in section 5.5.

2. If the preceding procedures fail to eliminate the trouble, use an analyzer to check the windings of the transmitter synchros. Replace defective units and readjust.

INDEX-LIGHT TRAVEL TEST ANALYSIS

The electronic and mechanical units of the plotter and scale factor groups are shown in figure 51. Whether the errors are due to mechanical or electrical difficulties can be determined as follows:

Mechanical

With the computer de-energized, slowly run the index-light manually from one end of the plotter to the other, and back again. Check that there is no stiffness, tight spots, or any other mechanical irregularities. The motion should be smooth and continuous. Also, check each gear mesh for excessive lost motion. If mechanical trouble is found, refer to OP 1140A for gearing maintenance. In the absence of any mechanical irregularities, the source of trouble should be assumed to be electrical.

Electrical

Using the neon system, check the servo controls and servo amplifiers for correct operation. Check the servo action of the Xp and Yp loops as follows:

Manually displace the output gearing of the Xp and Yp servos from synchronization and release it. Check that the gearing returns to the synchronous position with positive action. If the servo tends to drive sluggishly or to oscillate, substitute a new servo control or new servo amplifier, and check the servo action again. It also may be possible to improve the servo action by readjusting the servo control potentiometers. Information for this procedure is given in section 5.4.

SCHEMATICS OF COMPUTING MECHANISMS

The following schematics of the computing mechanisms are presented for easy reference according to the principal functions with which a group of mechanisms is associated. All irrelevant matter has been omitted to facilitate study of a particular group of mechanisms. To be certain that the symbols used in the schematics are being interpreted correctly, refer to figure 17.

The individual schematics are drawn with their input sections toward the left-hand side of the page, with their respective computing mechanisms and outputs progressing toward the right-hand side.

The arrowheads on a schematic indicate quantity-travel, that is, the direction a quantity would be traveling under normal conditions, from its input to output or to the place where the quantity is used. In most cases, beginning with the output of a quantity, and tracing it step-by-step to its input source, will prove the most effective method of detecting a faulty mechanism.

Servo Loops

The typical electronic servo loop is illustrated in figure 46, which shows the basic components represented by a single block on the functional schematics that follow. It consists of a servo control, servo amplifier, a rate generator, and a servo motor. There are 17 such servo loops used in this computer.

Each servo loop has a particular type of servo control, amplifier, motor, and rate generator associated with it. Components of one loop, therefore, cannot be interchanged indiscriminately with those of another. Table 37 identifies every component associated with each servo loop. The numerical designation of each loop is given on the schematics. It is only necessary to locate this same number in the extreme left-hand column of the table, and to trace horizontally across the columns for the desired information.

The complete set of schematics given on the following pages are listed for easy reference in table 38.

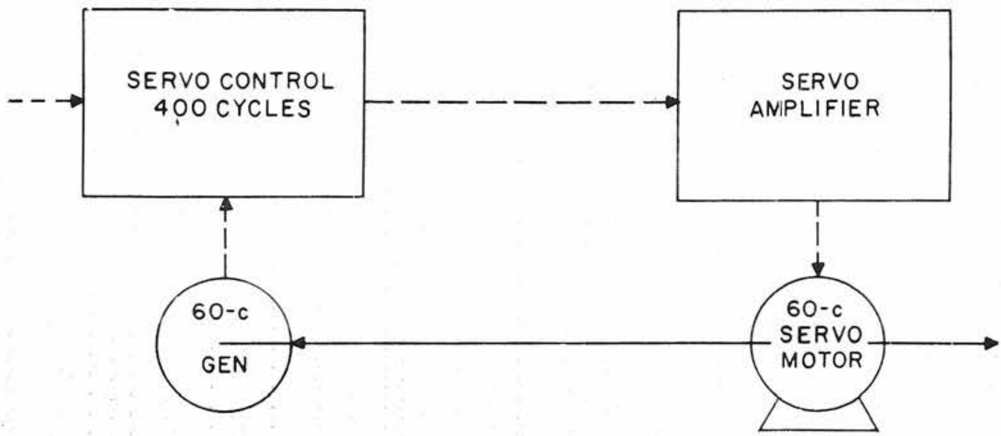

Figure 46. Typical Servo Loop

Table 37

SERVO LOOP ELEMENTS

Servo Loop		Servo Controls			Servo Amplifier		Servo Motor		Generator
No	Function	Symbol	Type	Neon	Symbol	Neon	Symbol	Type	Symbol
2	R	ZB4102	2SVL	None	ZA4102	4113	B4002	5w	G4002
3	Ph	ZB4103	VL	4101	ZA4103	4114	B4003	5w	G4003
4	jB	ZB4104	HF	4102	ZA4104	4115	B4004	5w	G4004
5	Co	ZB4105	2SVL	None	ZA4105	4116	B4005	10w	G4005
6	B'r'	ZB4106	2SHF	None	ZA4106	4117	B4006	10w	G4006
7	Es	ZB4107	VL	4103	ZA4107	4118	B4007	5w	G4007
8	OR	ZB4108	VL	4104	ZA4108	4119	B4008	5w	G4008
9	Et	ZB4109	VL	4105	ZA4109	4120	B4009	5w	G4009
10	L'	ZB4010	HF	4106	ZA4110	4121	B4010	10w	G4010
11	Zh	ZB4311	HF	4107	ZA4311	4122	B4011	10w	G4011
12	OL'	ZB4112	2SHF	None	ZA4112	4123	B4012	10w	G4012
13	OZh	ZB4313	2SHF	None	ZA4313	4124	B4013	10w	G4013
14	jOB'r' -jB'r'	ZB4314	HF	4108	ZA4314	4125	B4014	10w	G4014
15	jOB'r'	ZB4315	HF	4109	ZA4315	4126	B4015	10w	G4015
16	OB	ZB4316	VL	4110	ZA4316	4127	B4016	10w	G4016
100	Xp	ZB4300	VL	4111	ZA4300	4128	B100	10w	G100
101	Yp	ZB4301	VL	4112	ZA4301	4129	B101	10w	G101