RESTRICTED

ORDNANCE PAMPHLET NO. 755
1ST. REV.

Pocket 27

ASSEMBLIES

3148

16-INCH TRIPLE GUN TURRETS

(45 CAL.)

U.S.S.	NORTH CAROLINA	(BB55)
U.S.S.	WASHINGTON	(BB56)
U.S.S.	SOUTH DAKOTA	(BB57)
U.S.S.	INDIANA	(BB58)
U.S.S.	MASSACHUSETTS	(BB59)
U.S.S.	ALABAMA	(BB60)

DESCRIPTION AND INSTRUCTIONS

DECEMBER 1941

7A64-13 Nov.

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NAVY DEPARTMENT, BUREAU OF ORDNANCE, WASHINGTON, D.C.

To all holders of Ordnance Pamphlet 755 (1st. Rev.)
Insert change; write on cover "Change 1 entered"
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W. H. Purnell
Acting Chief of Bureau

OP 755 (1st. Rev.) CHANGE 1

30 October 1944

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ORDNANCE PAMPHLET 755 (1st. Rev.) 16" TRIPLE GUN TURRET (45 CAL.)
is changed as follows:

Insert the following on Page 39, Paragraph 38; Page 41, Paragraph 39:

CAUTION: Do not elevate gun after air has been bled from the counterrecoil system with gun at or near the horizontal.

1. During an overhaul of some 16" Slides Mark 5 it was found that the locking pins 202214-2 (general arrangement drawing 215645, 16" Slide Mark 4, drawing 231089, 16" Slide Mark 5, and drawing 232188, 16" Slide Mark 6, Locking Piece 232376-2) had been damaged and in one slide the pin was sheared. It is believed that damage to the pins was caused by the guns sliding out of battery after air had been bled from the counterrecoil system.

2. Should the air be released from the counterrecoil system while the gun is at or near the horizontal and then elevated, the gun will move toward the recoil position and the plunger yoke shoe will strike the studs in the face of the counterrecoil cylinder, stopping the gun but the inertia of the counterrecoil plunger may be sufficient to shear or damage the locking pin.

3. Ship's forces are cautioned not to elevate any gun after the air has been bled from the counterrecoil system with the gun at or near the horizontal. It is believed that with proper instruction to the ship's forces further damage to the locking pins will be prevented.

D I S T R I B U T I O N

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Ordnance Pamphlet No. 755
1st. Rev.

ASSEMBLIES

16-INCH TRIPLE GUN TURRETS
(45 CAL.)

FOR BATTLESHIPS 55 TO 60 INCL.
(U.S.S. NORTH CAROLINA AND CLASS)

DESCRIPTION AND INSTRUCTIONS

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

December 1941

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PREFACE

This edition of Ordnance Pamphlet No. 755 includes descriptions and instructions for all ordnance assemblies installed in the main batteries of the six ships of the U.S.S. NORTH CAROLINA class. It is a revised text with addition of the chapters omitted in the issue dated February, 1941 but like that edition contains no illustrations other than diagrams and adjustment figures. The descriptions give reference to the general arrangement drawings; - those required for study of the text are listed in Appendix IV.

The ordnance units of each turret have 16-inch turret assembly designation and ship installation as tabulated below.

Assembly Number	BB No.	Turret No.	Assembly Number	BB No.	Turret No.	Assembly Number	BB No.	Turret No.
66	55	1	72	57	1	78	59	1
67	55	2	73	57	2	79	59	2
68	55	3	74	57	3	80	59	3
69	56	1	75	58	1	81	60	1
70	56	2	76	58	2	82	60	2
71	56	3	77	58	3	83	60	3

The text includes reference to the following publications:

O.P. 239 - Firing Lock, Mark 14 and Mods.
O.P. 483 - Bore Sight Telescopes
O.P. 757 - 16-inch Range Table (2300 f.s.)
O.P. 758 - 16-inch Range Table (1800 f.s.)
O.P. 762 - Alignment of Ordnance Installations
O.P. 810 - Gun Director, Mark 38
O.D. 1914 - Recoil Cylinder Liquid
O.D. 3447 - Standard Fire Control Symbols
O.D. 3455 - 16-inch Range Table (1725 f.s.)
O.D. 3456 - 16-inch Range Table (2225 f.s.)
O.D. 3508 - Gun Elevation Receiver Regulator, Mark 10
O.D. 3860 - Turret Train Receiver Regulator, Mark 8
O.S. 687 - Hydraulic Flax Graphite Coated Coil Packing
O.S. 749 - Hydraulic Packings for Hydropneumatic Systems
O.S. 1113 - Hydraulic Oil
O.S. 1162 - Plastic Metallic Packing
O.S. 1165 - Breechblock Lubricant

The text includes descriptions, diagrams and instructions from contractors' Ordnance Data 3358, 3476, 3550, 3634 and 4047.

Chapter X

16-INCH PROJECTILE RING, MARK 1

General Description

1. Turret projectile stowage in each turret is arranged in two annular-shaped compartments designated the upper and lower projectile flats. These levels are located twenty-five feet one inch and thirty-two feet ten inches, respectively, below the shelf plate. (Turret 2 has additional stowage as indicated in par. 2.) The spaces are enclosed between the cylindrical lower roller path foundation (35.25 ft. inside dia.) and a concentric circular bulkhead (17 ft. dia.). The latter separates machinery compartments at the center of each flat from the annular-shaped stowage and handling compartment. In each stowage compartment the floor is subdivided into three concentric ring-shaped platforms. The outer ring is a non-rotating shelf attached to the cylindrical turret foundation and providing projectile stowage designated as "fixed". The center ring is part of the rotating structure and is the shell handling platform. In its rear segment are located the loading apertures of the three projectile hoists. The inner ring is a roller mounted platform supported by the turret rotating structure and arranged to be power driven, clockwise or counterclockwise, with respect to the center ring. It provides projectile stowage designated as "rotating". The control and drive mechanisms which independently serve these two projectile rings comprise the ordnance assembly designated as 16-inch Projectile Ring, Mark 1. The assembly does not include the rotating platforms or their worm drive mechanisms. These are of other cognizance.

2. All projectiles ("fixed" and "rotating") are stowed erect (on base) and each is separately lashed to adjacent rotating or fixed bulkheads. Each projectile ring provides stowage for 72 projectiles arranged in two concentric rows (360 degrees). Each shelf for fixed stowage provides space for 130 projectiles. In turret 2 a third level of fixed stowage, located immediately below the lower projectile flat, fixed stowage, provides additional stowage for 121 projectiles. Thus the total stowage per turret, exclusive of hoist capacity, is 404 projectiles turrets 1 and 3, and 525 projectiles turret 2 (16-in. Type "A" or "C"). All projectiles are brought into the respective turrets for stowage through normally closed watertight doors located in the circular foundation bulkhead at the 2nd flat. An overhead track extends into the powder handling room for transporting each projectile (horizontal), with chain hoist and Mark 3 projectile carrier (dr. no. 233420),

to point below a 24 inch diameter hatch in the projectile stowage level above. The projectile is raised in vertical position to the stowage platform by means of a drum type electric hoist (cognizance Bu. Ships).

3. In this arrangement of upper and lower shell flat stowage, the projectile rings function to move projectiles to positions near to and convenient for loading the hoists. All three hoists can be simultaneously served quickly from one ring, the loading being performed by parbuckling. The projectile rings and the parbuckling gear also provide for delivery of projectiles from "fixed" stowage to the ring and thence to the hoists. Semiautomatic control arrangements which operate the ring through arcs of thirty degrees (and stop until again manually started) facilitate continuous delivery to the hoists. A rate of delivery of three shells per minute per hoist is provided by the above described arrangements.

Projectile Ring Control

4. The electric hydraulic drive assembly for each rotating ring is located in the forward segment of the respective machinery compartment. (The center portions of those compartments are principally occupied by the three powder hoist trunks.) The control station is in the projectile handling space adjacent to the center hoist. Direction and speed of ring rotation is controlled by tilting the yoke of the A-end pump. This is initiated by means of a control gear (separate for each ring) which extends from the control station through the circular bulkhead to the power unit.

5. The control gear comprises a bracket mounted control handle and a bevel gear and shaft installation coupled to the A-end speed control. From the control handle bracket this assembly includes three coupled-in-line shafts horizontally positioned at the ceiling of the projectile flat. A bevel gear bracket unit located above the A-end and a vertical shaft extending downward to coupling with the speed gear control complete the control subassembly. This manual control mechanism provides output shaft rotation equal to the arcs of movement of the control handle. The latter is arranged for 150 degrees movement each side of neutral. The assembled control arrangements as described above are shown on drawing 232355, for the upper projectile flat, and drawing 232356, for the lower projectile flat.

ELECTRIC HYDRAULIC EQUIPMENT

6. The projectile ring power drive units are electric hydraulic assemblies, of commercial design and manufacture (Vickers, Inc.). Each comprises the following listed subassemblies which are arranged as shown on drawing 271675.

(a) Power plant and control devices.

(1) Electric motor and controller.

(2) A-end.

(3) Auxiliary pump.

(b) Hydraulic motor drive unit (B-end).

(c) Couplings for connecting units.

Power Plant and Control Devices

7. *Electric motor.* - The electric motor is a power unit of commercial design and manufacture (Louis Allis Co.). Details of the design and general arrangement of the assembly, with rotor shaft drive coupling provisions for the A-end and the auxiliary pump, are shown on drawing 231543. Type and performance data are as follows:

Type: -	Squirrel cage induction; 440 volts; 60 cycle; 3 phase; horizontal mounting; fan-cooled; waterproof enclosure.
H.P. - - - - - - - - - - -	40 (overload rating, 72)
Speed -	Constant
R.P.M., full load - - - - - - - - - - - - - - -	1160
Amperes, full load - - - - - - - - - - - - - - -	48
Weight, pounds - - - - - - - - - - - - - - - -	1200
Manufacturers type designation - -	RX-frame 445-S

8. *Controller.* - The controller is an across-the-line, magnetic motor starter, of shockproof design, semiautomatic operation, waterproof enclosure, arranged with an externally operated door interlock disconnect switch. It is an assembly of commercially manufactured parts (Ward Leonard Electric Co.) providing control and protection for the above described motor. With a master switch push-button station it is mounted on the circular bulkhead, in the machinery space, immediately forward of the power drive unit. The installation has arrangement of the starting circuit, power circuit and protective devices as shown on the wiring diagram of drawing 231545. The protective features there indicated comprise undervoltage, short circuit and overload protection of the following types.

(a) *Short circuit protection.* - Two main line fuses, 400 amperes, 250 volts, each, bridge two phases of the power circuit to provide motor short circuit protection.

(b) *Undervoltage protection.*- A contactor drop-out arrangement, which functions at potentials of 110 volts or less, provides the undervoltage protection.

(c) Overload protection is of the inverse time limit thermal type with magnetic reset mechanism. Two of these devices are connected in separate phases of the motor circuit. At occurrence of overload of sufficient duration the head from each unit is transmitted to a fusible alloy tripping device which causes the main line contactor to open. Thereafter depressing the "Start" button of the push-button station causes the resetting mechanism to reposition the overload contacts. When the contacts have reset, the main line contactor closes and in closing de-energizes the coil of the resetting mechanism. With normal setting of 60 amperes and with load at 72 H.P., 100 amperes, the device will trip in less than one minute. The adjustment range is 59.1 to 71 amperes.

9. *A-end.* - The A-end consists of the main operating pump, safety relief valves, case with oil reservoir, control valve block, timing and control mechanisms and a motor starting interlock switch and cam. This subassembly is shown on drawing 271679. The electric motor shaft end (opposite the auxiliary pump end) is direct coupled to the operating pump drive shaft. The coupling is described in paragraph 11. All other elements of the A-end are of the type, arrangement and functional purpose indicated in the subparagraphs below. (Nomenclature underlined.)

(a) The operating pump is a multiple piston variable stroke type. It rotates at motor speed but delivers pressure fluid to the B-end, through connecting leads, according to the direction and degree of tilt or offset. Such offset is imparted from the hand control lever through the control linkage and the pump yoke.

(b) The pump yoke is the mechanical element through which pump reciprocation is varied from "on center" (neutral) to full stroke. When the yoke is on center the pump is idling and is not displacing fluid. (At neutral the pump delivery is also by-passed by the valve arrangements.) Shifting the yoke off center gives pump displacement through the closed system to the B-end. Shifting in the opposite

direction from center reverses the direction of flow and the direction of B-end rotation.

(c) Safety relief valves are high pressure relief valves functioning to relieve the closed system in the event of excessive torque or too rapid shifting from neutral toward maximum stroke. The valves by-pass from the high to the low (return) pressure lead.

(d) The valve block (dr. 271698) is a housing for the control circuit valves and fluid passages. It is supplied by fluid displaced by the auxiliary pump. The following valves are located in the block.

Starting valve

Control valve

Interlock valve

Hydraulic motor by-pass

Auxiliary pump relief valve

Main circuit replenishing checks

(e) The starting cam contour controls the displacement movement of the spring loaded starting valve. The valve is shifted to operating position when the control lever is shifted from neutral and with the valve thus set the valve vents are closed, the interlock valve is vented to the tank and is shifted to starting position. When the cam moves the starting valve to "stop" position, the brake cylinder, the control valve piston, and the by-pass valve operating line, are vented to the tank. Simultaneously the interlock valve is reset and held in starting position by pressure.

(f) The control valve cam guides the latch of the control valve. The latter is spring loaded to require the latch to follow the cam contour (except as cited below). The control valve is a three piece unit comprising a piston, plunger and valve. It has three-position movement: To start, run and stop. In the starting position the spring is relieved and the piston is held by pressure only. B-end

response through gearing rotates the cam one revolution per thirty degrees of projectile ring rotation. At the end of this cycle the latch moves into the cam notch and the valve shifts from its run position to stop position. When the valve moves to stop position the by-pass valve operating line and the interlock valve venting line are opened to the tank. Shifting of the control valve to starting is accomplished when the starting valve is depressed and pressure is ported from the interlock valve to the control valve piston. With the control valve in starting position the by-pass vent is closed and the by-pass valve shifts to operating position. As the drive and ring movements start to rotate the cam turns and smoothly forces the latch from the recess. This moves the control valve plunger and shifts the control valve to running position. It is held there until the ring approaches the next station. While the valve is in the "run" position the pressure line ported through it continues to hold the by-pass valve in the operating position. At the same time pressure is also ported to shift the interlock valve to its opposite side where it vents the control valve piston pressure area to the tank. This enables the spring to move the control valve to its stop position and to register the latch in the cam recess when the end of the cycle is reached.

(g) The interlock valve has the functional purpose of opening and closing fluid passages to permit shifting of the control valve piston (as explained above, subpar. f.). The valve is held by a detent when shifted to either of its operating positions.

(h) The by-pass valve is a dual purpose valve. In its vented position it by-passes the operating lines and vents the brake cylinder to the tank; in its operating position the by-pass lines are closed and the brake is held at released position by pressure. The valve is held at its venting position by spring and when shifted to its operating position it is held down, against the compressed spring, by auxiliary pump pressure.

(i) The auxiliary pump relief valve acts to dump to the tank all fluid displaced by the pump that

exceeds the requirements of control circuit operation and main system replenishment.

(j) The replenishing check valves function to supply fluid to the suction side of the main system to compensate for internal leakage.

(k) The timing and control mechanisms are semi-automatic cycle control devices which operate by response drive from the B-end when the control action is manually initiated. The mechanisms include timing and control cams, (dr. 271712) keyed to a cam shaft and directly coupled to the B-end worm wheel. These cams make one revolution for every thirty degrees of projectile ring movement. Separate timing cams control each direction of offset of the A-end pump. When the pump is centered (neutral) clearance exists between the timing cams and cam link rollers. This clearance limits the pump offset at the beginning of a cycle and is sufficient to allow the pump to overcome normal internal leakage and to start projectile ring rotation when the manual lever is moved from neutral. That lever movement (150° for each direction) controls the starting cam and control link gearing movement. In conjunction with the timing cams the manual control also controls the movements of the control link, yoke and cam links, and the interlock switch cam. All of these elements follow the manual control, when starting, until all clearance is taken up between a cam roller and its respective timing cam. Thereafter the starting cam, control link gearing and the centering spring follow the manual control lever until it has moved through its full arc of 150 degrees. The arrangement operates at starting to give gradual acceleration up to full speed of the drive output. At the start of a cycle the cam roller, held against the timing cam by the offset centering spring, is in contact with the highest point of the cam. It follows the cam contour (as the cam rotates) and permits the centering spring to expand and to gradually increase pump offset (and drive speed) until maximum velocity is attained. Deceleration at the end of the cycle is similar and is similarly controlled when the cam roller approaches the high point. Then the centering spring offset again gradually increases until the pump yoke returns to neutral.

The control link centering spring is arranged to control the pump offset for both directions of projectile ring rotation.

(*l*) The interlock switch is an electric motor starting circuit switch arranged in the A-end to open the circuit whenever the pump yoke is offset from neutral. It prevents starting the motor at any mid-cycle position until the pump has been restored to neutral by means of the hand control. Opening of the circuit occurs through movement of the cam roller from the cam recess.

(*m*) The auxiliary pump is a balanced vane type of constant displacement. It is continuously driven when the motor is running, by drive from the rotor shaft (end opposite the A-end coupling). It delivers control circuit fluid at constant pressure, determined by the auxiliary relief valve setting.

Hydraulic Motor Drive Unit

10. The B-end assembly consists of the hydraulic motor, mechanical brake with hydraulic cylinder, a brake release lever and the timing worm and worm wheel. These elements, shown on drawing 271678, are of the types, arrangements and functional purposes indicated in the subparagraphs below. (Nomenclature underlined.)

(*a*) The hydraulic motor is a multiple piston fixed stroke type. It is direct coupled through its output shaft to the projectile ring drive worm. The direction and speed of shaft rotation is determined by the direction and degree of offset of the operating pump.

(*b*) The brake is a spring engaged, power released, friction disk type. It is equipped with a hydraulic cylinder which functions under auxiliary pump pressure to release the brake and the load during operating cycles.

(*c*) The brake release lever is a manual brake release arrangement provided to enable brake release whenever it is desired to manually rotate the projection ring.

(*d*) The worm and worm wheel unit is the B-end response drive to the A-end timing and control

cams. The worm rotates with the output shaft and has fixed value of 60 revolutions per 30 degrees of projectile ring movement. The worm wheel makes one revolution per cycle of ring rotation.

Couplings

11. Five flexible couplings are used to interconnect the units of the drive and to couple the drive assembly to the driven projectile ring worm gear. These are of commercial design and manufacture, of three different types, with installed arrangements as shown on drawing 271675.

(a) *Auxiliary pump coupling.* - A Falk Steelflex coupling provides direct drive coupling from the electric motor rotor shaft to the auxiliary pump rotor shaft. The unit is enclosed within the electric motor end housing. It is an assembly of two identical steel hubs, a specially heat treated and tempered alloy steel grid spring, and two duplicate steel shells which form the cover. The design gives drive connection through the grid spring which is nested in grooves that are accurately milled in the outer flange of each hub. The hubs and grid spaces are packed with lubricant confined within the steel shells. The unit is designated by the manufacturer as: - Falk size 3 FAS.

(b) *A-end coupling.* - A Falk Steelflex coupling of the same design as the above provides direct coupling from the electric motor rotor shaft to the A-end shaft. This unit is designated by the manufacturer as: - Falk size 9 FAS.

(c) *B-end response coupling.* - A special coupling of Oldham type provides the response drive connection to the control cam shaft. This design incorporates a floating center member, constrained to slide across the face of one coupling flange on a line passing through the center. At the same time this center member is free to slide across the face of the second flange in a direction at right angles to the first. The block-shaped center piece is equipped with special removable graphite-impregnated bearing strips which, together with grease reservoir (in the block), provides primary and secondary lubrication. The coupling is an American Flexible Coupling Co., size 8-1/2, unit.

(d) *B-end drive couplings.* - Two internal gear, lubricant retaining "Fast" type couplings provide the drive coupling from the B-shaft, through a short connecting shaft, to the worm shaft of the projectile ring drive.

Hydraulic Power and Control Circuits

12. The mechanical arrangements of the drive and control mechanisms as described above, have complementary hydraulic arrangements interconnected and functioning as indicated by the schematic diagrams of figures 32 to 36. These show sequential phases of the circuit during a full cycle of operation with flow conditions and resultant movements as explained in the paragraphs which follow.

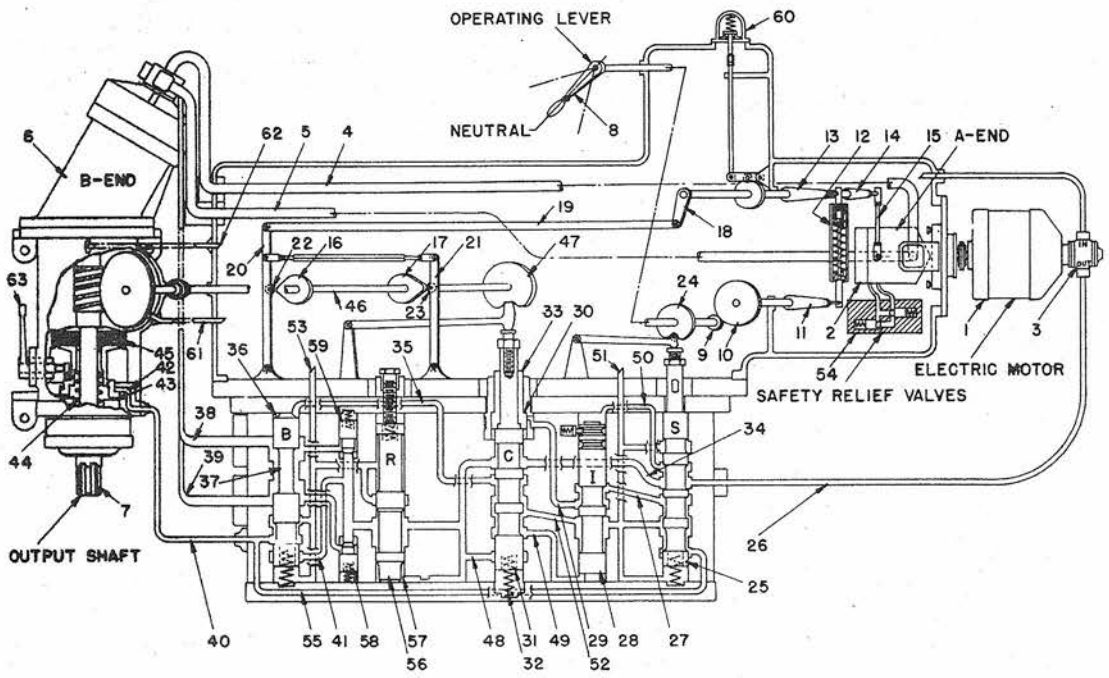

Fig. 32 - Projectile Ring Circuit Diagram
Neutral Position

13. *Stop position,* figure 32. - To start, the operating lever (8) is moved in the direction to give the ring rotation desired. Motion is carried through gears (9) and (10), lever (11), control link (12), lever (13), lever (14), link (15) and hence to move pump yoke away from its neutral (center) position. Lever (18) is connected by link (19) to links (20) and (21). Link roller (22) or (23) contacts its respective timing cam; depending on direction of pump offset.

Although at the start the operating lever (8) is moved the full distance the yoke can only be offset a slight amount, limited by cams (16) or (17). The full movement of the operating lever is made possible by offsetting and compressing the centering spring within the control link (12). This spring under compression exerts a force causing the link roller to follow the contour of its timing cam throughout the cycle, thus governing the pump offset. In the position as shown on the schematic diagram of figure 32, the cams permit only a slight offset of the pump yoke, just sufficient to overcome the normal internal leakage and to start the hydraulic motor (6) rotating.

14. *Start position,* figure 33. - The movement of the operating lever rotates the cam (24), forcing the roller to move out of notch and depress the starting valve (25). When the starting valve is depressed the auxiliary pump pressure is ported from line (26) into line (27), around spool of interlock valve (28) to line (29) and into chamber (30). Pressure now acts on the differential area of piston (33) and moves it to the positive stop on valve block. The movement of this piston shifts the control valve (31) to its mid-position, where it is held by spring (32). Valve (31) now ports pressure from

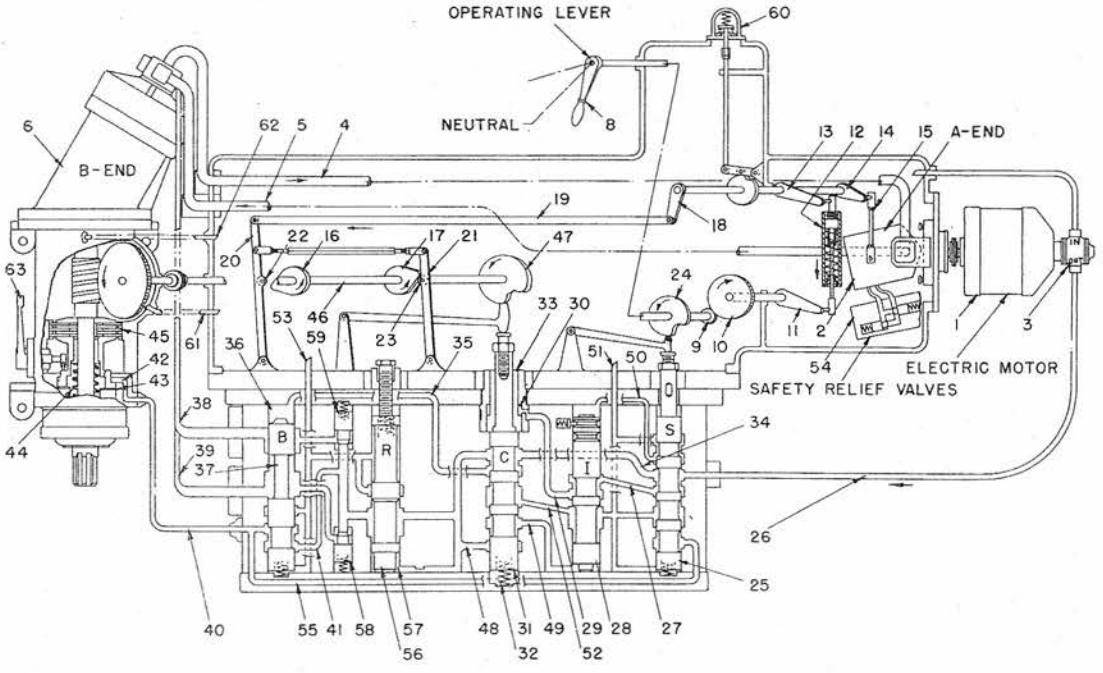

Fig. 33 - Projectile Ring Circuit Diagram
Starting Position

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line (34) to line (35) then into chamber (36). The pressure applied in this chamber overcomes spring and shifts the by-pass valve (37). Lines (38) and (39) from the operating circuit are no longer by-passed through the valve spool, thus allowing the system to build up pressure. Auxiliary pump pressure is ported from line (41) around the by-pass valve spool to line (40) and into chamber (42), moving the piston (43) to compress spring (44) and release brake (45). Thereafter the equipment is free to operate at a speed controlled by the pump offset. Cam shaft (46) is worm driven to make one complete revolution for each 30 degrees of projectile ring rotation.

15. *Running position,* figure 34. - Valve (31) is depressed the remainder of its stroke by the latch being forced out of the notch by the rotation of cam (47). Pressure is then ported from line (48) to line (49) and into the lower end of the interlock valve chamber. The opposite end of this valve

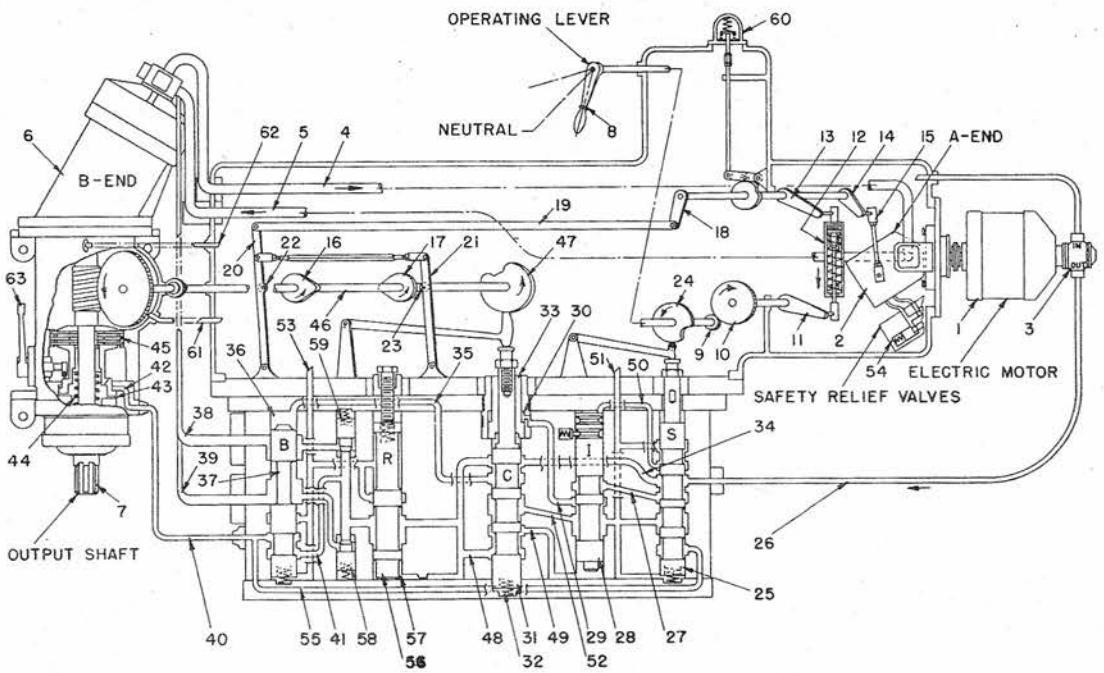

Fig. 34 - Projectile Ring Circuit Diagram
Running Position

is ported to tank through line (50), around the spool of valve (25) and line (51). Valve (28) is therefore free to shift. Chamber (30) is then vented to tank via line (29), around valve spool and line (51). Valve (31) then becomes free to move the latch into the notch of cam (47) when the ring station is reached. Ring deceleration is accomplished by cam action on the pump yoke, while positioning of the ring at the station is affected by the control latch shifting into the notch of cam

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(47). Chamber (36) then becomes vented to tank by lines (35), (52) and (51). Lines (38) and (39) by-pass, relieving pressure on operating pump (2). Brake line (40) vents to tank through line (53) and the spring engages the brake.

In order to re-start, it is first necessary to bring the operating lever (8) to the neutral position to allow the starting valve (25) to return by spring force. Pressure from line (26) is then ported to line (50) and with line (49) vented to tank via (52) and (51) the interlock valve resets, permitting the cycle to be repeated.

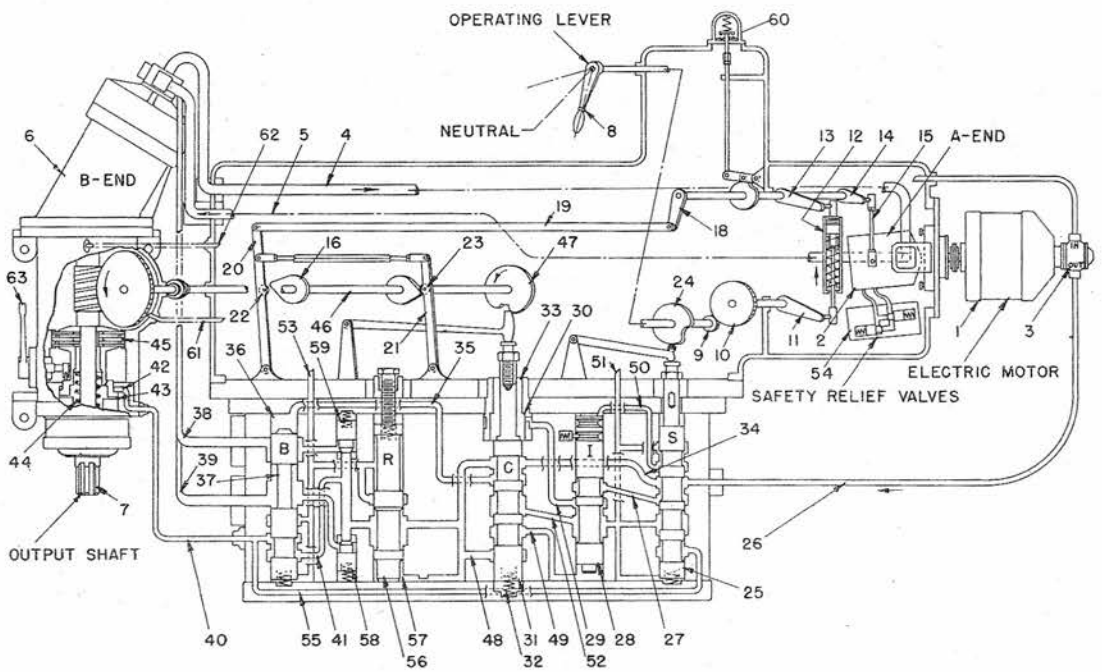

Fig. 35 - Projectile Ring Circuit Diagram
Approaching Automatic Stop

16. *Approaching automatic stop position,* figure 35. - The diagram shows conditions as the equipment approaches the end of a cycle of movement. At this time all valves are in the same position as at start of cycle except valve (28) which is in the interlock position. The interlock valve had been shifted to this position to prevent starting the equipment before operating lever has been returned to neutral position.

It is possible for the operator by manipulation of the control lever (8) to stop, re-start or reverse the direction of ring rotation at any other time.

While doing so, acceleration and deceleration are controlled by the operator, limited by the setting of the safety relief valves (54).

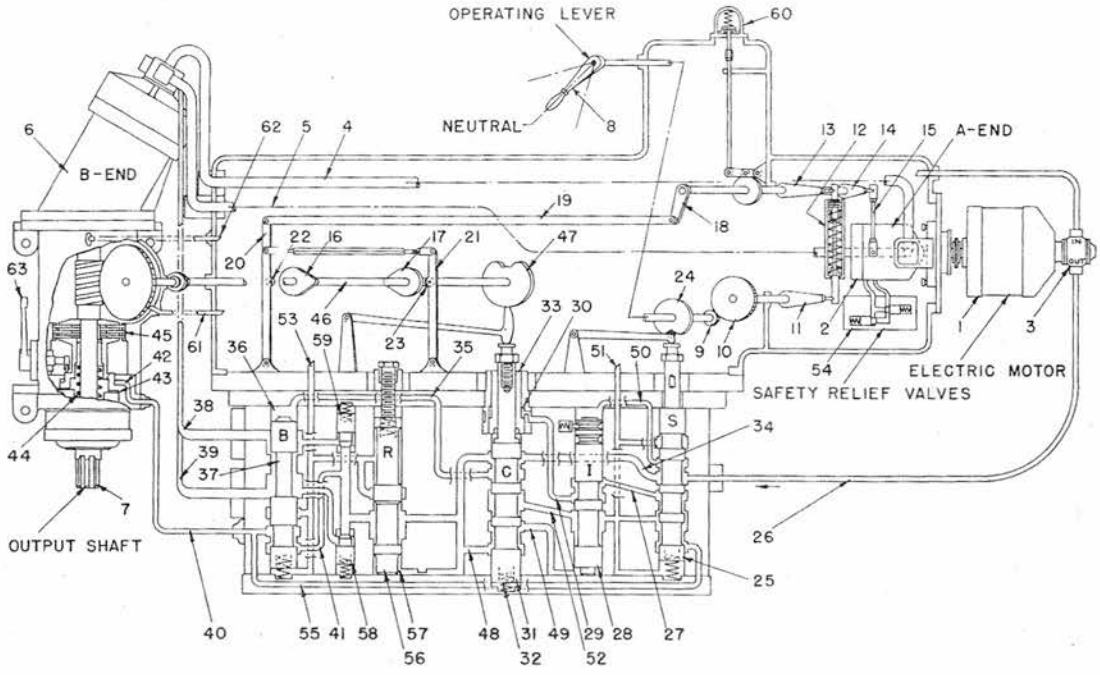

Fig. 36 - Projectile Ring Circuit Diagram
Stopped Between Stations by Operator

17. *Between stations, stop position,* figure 36. - In instances of manual control action to stop the drive, the equipment assumes positions and pressure fluid is ported as indicated by the diagram. Auxiliary pump displacement is vented to tank. Valve (31) is depressed and pressure line (41) is ported to line (55), around valve spool (25) and line (51) to tank.

18. Other special hydraulic and mechanical, arrangements shown by the diagrams, have performance characteristics or functional purposes as follows:

(*a*) Valve (56) is the auxiliary pump relief valve. Chamber (57) is directly connected to the auxiliary pump pressure line. The pressure within this chamber acts to overcome the spring setting of the valve and port the auxiliary pump displacement to tank through line (53).

(*b*) A restriction has been placed in the relief valve operating line to prevent pressure surges which may cause the relief valve to flutter.

(*c*) The purpose of the replenishing check valves (58) and (59) is to admit fluid supplied by the auxiliary pump into the operating circuit to compensate for the normal internal leakage.

(*d*) The starting interlock switch (60) prevents starting the electric motor unless the pump yoke is in neutral.

(*e*) Line (61) is the drain for internal leakage within the B-end case and is connected to the A-end case.

(*f*) Line (62) carries to tank the air displaced by internal leakage within the B-end case.

(*g*) Lever (63) provides for manual release of the brake should it be desired to manually drive the projectile ring at another source.

MAINTENANCE AND OPERATING INSTRUCTIONS

19. The projectile ring assemblies are to be operated and maintained, including periodic exercise, adjustment and lubrication, in accord with the regulations of the Ordnance Manual and the specific directions below and in the chapter entitled "Hydraulic Equipment".

20. *Hydraulic oil.* - The fluid required for correct performance of the hydraulic system is a special oil with properties as designated in Ordnance Specification No. 1113. When initially filling a system and when replenishing, the oil is to be poured through a fine mesh wire strainer of at least 120 wires to the inch. Do not use cloth. New assemblies should be drained after fifteen hours operation, and should then be thoroughly flushed clean and refilled with fresh oil or carefully salvaged oil. Perform test inspection and analysis of oil sample from each system monthly. If there is evidence of sludge, water or acidity, drain, flush and refill with fresh oil. The amount of oil required to fill the system of one projectile ring drive unit is approximately 25 gallons. The procedure for filling that quantity into an empty system is as follows:

(*a*) Remove the filler cap from the A-end and fill case to the upper level petcock. This requires 22 gallons.

(*b*) Remove inspection cover from the B-end and fill case with one gallon of oil.

(c) Start the electric motor. Run for twenty minutes. Manipulate controls to fill voids of the control and operating circuits. The unit is self venting.

(d) Add two gallons at the A-end.

21. *Electric motor, direction rotation.* - If the assembly is new, or has been disassembled, or if the power leads to the motor or any leads of the controller have been disconnected and subsequently reconnected, it is imperative to verify the motor direction of rotation before operating. Only run the motor long enough to determine the direction of rotation. Running in the wrong direction will damage the auxiliary pump.

22. *Lubrication.* - Internal elements of the A-end, B-end units are lubricated by circulation of the hydraulic oil. All other parts of the assembly shall be lubricated with the materials and according to the frequencies specified by instruction plates and the lubrication charts.

23. *Brake lever position.* - The B-end manual brake lever must be in its "Power-on" position at all times during power operation.

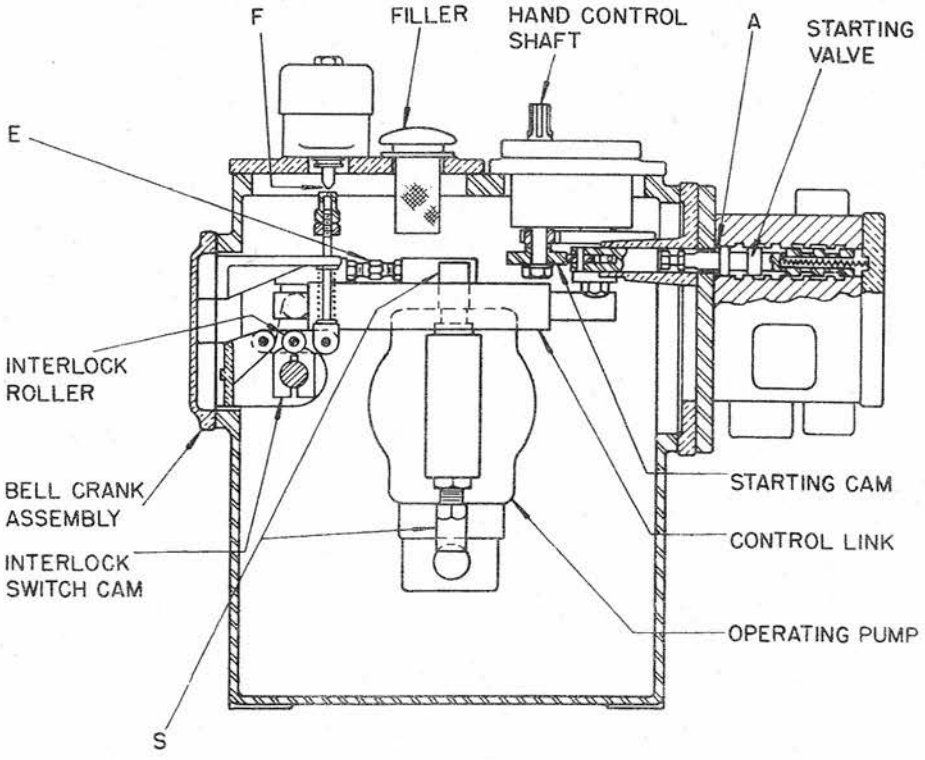

Fig. 37 - Projectile Ring Adjustments

Adjustments

24. The hydraulic mechanisms have been factory adjusted to satisfactorily meet all operating conditions. If it is necessary to dismantle the equipment, adjustment must be made at reassembly as the work progresses. When disassembling, it is desirable to mark all mating parts such as cams, gears, linkages and adjustable pieces. The adjustments prescribed in the following paragraphs are given in the order of reassembly.

25. *Starting valve adjustment.* - The starting valve must be adjusted before the valve block is mounted on the A-end case. The adjustment is located at point "A" as indicated on figure 37. The clearance required is .005 inch between the shoulder of the top land of the valve and the valve block mounting plate as shown on figure 38.

With the valve held against shoulder by spring 271702-11 and with the clevis roller held in the notch of the starting cam, measure the distance from the bottom of the clevis to the valve block mounting face. Adjust the valve to suit. For accuracy a depth gauge should be used in making the setting.

Best performance of the assembly will be assured if this setting is maintained.

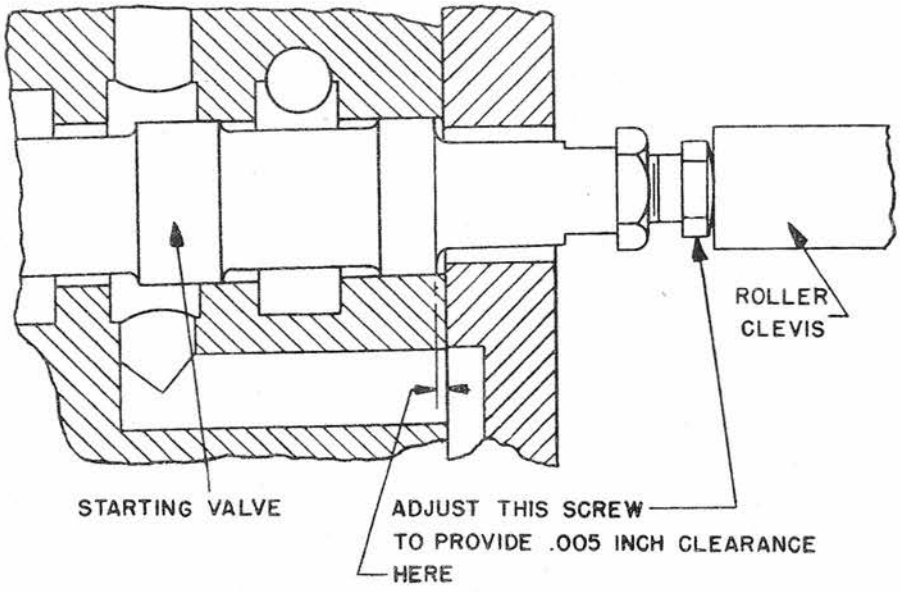

Fig. 38 - Starting Valve Adjustment

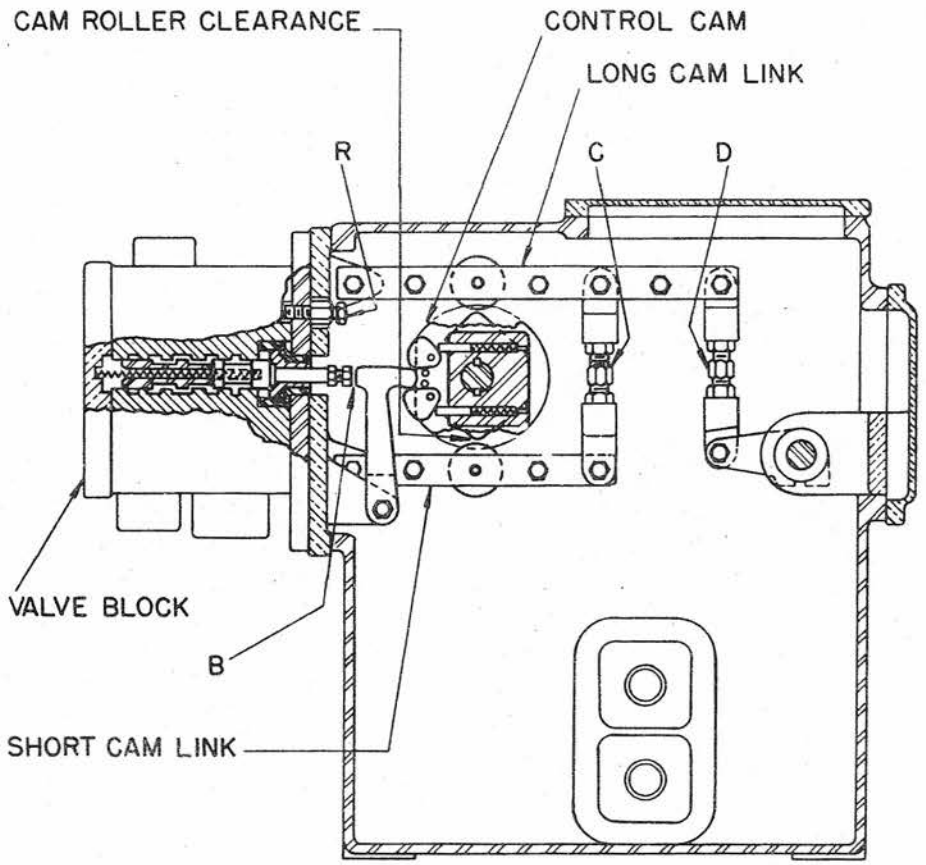

Fig. 39 - Projectile Ring Adjustments

26. *Control valve adjustment.* - The control adjustment prescribed below, although not critical, should be maintained in order to obtain best results. The adjustment is located at point "B" as indicated on figure 39. The desired clearance is .005 inch between the adjusting screw of the valve plunger and the latch as shown on figure 40.

Loosen nut 200022-11 with the latch held in the bottom of notch on the control valve cam and with plunger 271700-2 held in its up position by valve 271700-6 and spring 271700-4, rotate adjusting screw 271702-3 until the desired setting is obtained.

27. *Cam roller link adjustment.* - The cam roller link adjustment is located at point "C" as indicated on figure 39. The details of this linkage are shown in figure 41. The clearances shown on the latter figure provide for normal pump offset to start the ring rotating.

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Loosen right hand thread nut 220718-7 and left hand thread nut 271727-9, then rotate clevis screw 271727-8 to the desired position shown on figure 39. The adjustment is made when the unit is in the latched position.

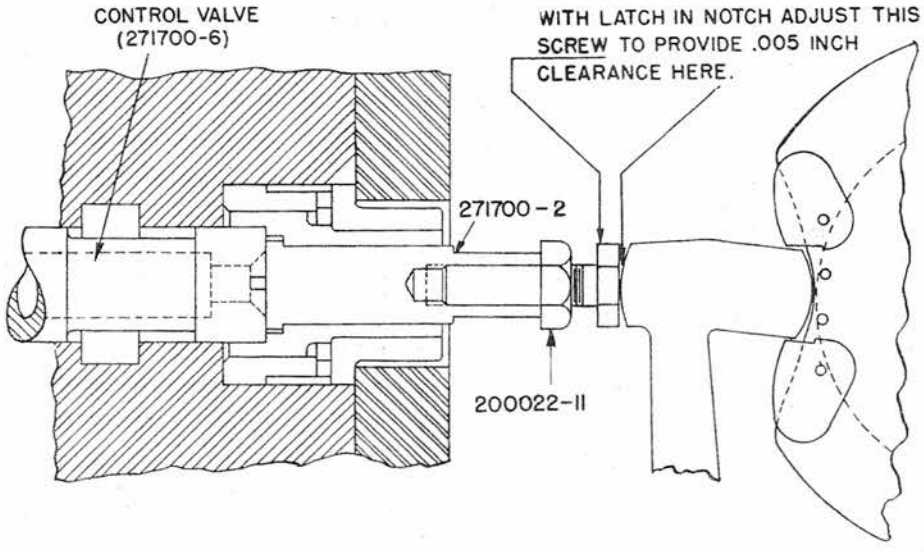

Fig. 40 - Control Valve Adjustment

28. *Cam timing link adjustment.* - The cam timing link adjustment is located at point "D" as shown on figure 39. The adjustment is made when the bell crank assembly is in place and the interlock roller is in the notch of the interlock switch cam.

Loosen right hand thread nut 220718-7 and left hand thread nut 271727-9, then rotate clevis screw 271727-8 until the proper clearance, as shown on figure 41 is obtained between the upper and lower rollers and the timing cams.

29. *Control link adjustment.* - This subassembly (dr. no. 271717) is completely adjusted before it is installed in the A-end.

Assemble in place the control rod 271717-6, retainers 271718-7 and 271718-9, with spring 271718-10, washer 271717-5, nut 271730-6 and cotter pin 196749-8. Then insert in tube 271718-1 and screw the retainer nut 271718-4 in place. Gradually screw rod retainer 271717-7 until all lost motion between it and retainer 271718-9 is taken up. When completely assembled install in the A-end.

When this unit is properly assembled and the hand control shaft is in neutral, the starting valve and interlock switch rollers will fit into the notches of their respective cams.

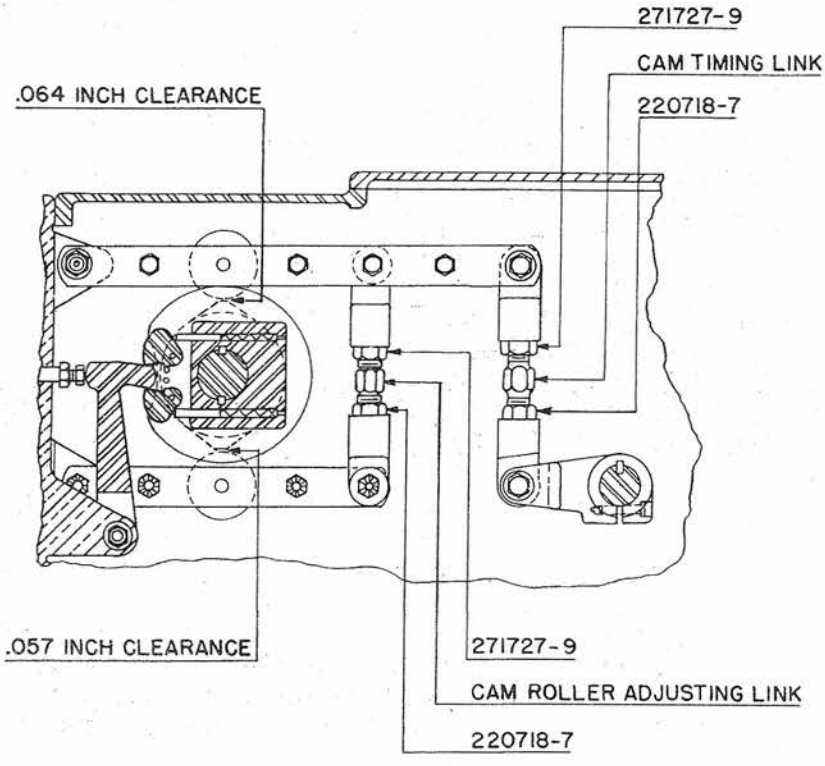

Fig. 41 - Cam Roller Link Adjustment

30. *Yoke link adjustment.* - The yoke link adjustment is located at point "E" as indicated on figure 37.

With the cam links and control link fully adjusted, set hand control shaft in neutral, then loosen nuts 220718-7 and 271727-9 and rotate screw 271727-8 until pump yoke is in the central position. It may be necessary to readjust this link for the neutral position of pump after power is turned on.

31. *Interlock switch mechanism adjustment.* - The starting interlock switch must be provided with a clearance of one-sixty fourth inch at the plunger position indicated by "F" on figure 37. The adjustment must be made with the interlock roller in the recess of the cam.

32. *Auxiliary relief valve adjustment.* - The auxiliary relief valve is adjusted at point "R", indicated on figure 39.

Normal setting is 100 P.S.I. Before this adjustment can be made a pressure gauge must be placed in line #5 at valve block flange. With system filled with oil, start the electric motor, then loosen nut 271702-2 and rotate adjusting screw to the desired setting. Securely tighten nut 271702-2 after the adjustment is obtained.

33. *Safety relief valve adjustment.* - There are two of the relief valves, one for each direction of ring rotation. These relief valves are located at points designated "S" on figure 37. Their details are as shown on figure 42. Both valves have been set at the factory to give a maximum reading of 2200 pounds square inch. This is the desired setting. It is therefore only necessary to turn the adjusting screw 271711-4 until it bottoms, then tighten jam nut 271730-7. If it is desired to check the setting of these valves it is necessary to block the B-end output shaft to prevent it from rotating, install pressure gauges in lines #3 and #4 at the valve block, then move the operating lever each side of neutral. Clockwise rotation of the operating lever gives counterclockwise rotation of the output shaft when viewed from shaft ends. This puts the upper safety relief valve under pressure. Conversely the opposite direction of rotation puts the lower relief valve under pressure.

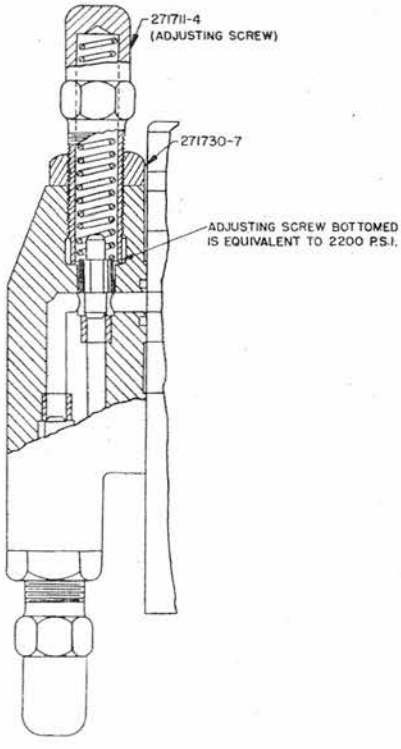

Fig. 42 - Safety Relief Valve Adjustment

34. *Adjustment for projectile ring stopping out of phase.* - If the ring operates and stops at intervals of thirty degree movements but does not stop at ring stations, the equipment has been connected out of phase. To correct this condition verify that the control valve is in its latched position, then disconnect the B-end output shaft coupling from the driven worm and manually rotate the ring to the proper stopping position. Reconnect the coupling.

Operating Trouble Diagnosis

35. The causes of various possible operating troubles which may occur in the electric hydraulic system are outlined in the paragraphs that follow. In each instance the correction necessary to eliminate the identified trouble (or its audible or visual indication) follows in a separately indented subparagraph. An understanding of these causes and effects will facilitate adjusting the mechanisms as prescribed in paragraphs 25 to 34, inclusive. The "trouble-shooting" items are arranged in a continuity which avoids extensive disassembly until the more simple causes have been eliminated as the source of the trouble.

In case of operating difficulties immediately after installation or after the equipment has been worked on, the trouble may be due to obstructions such as rags or plugs in the circuit, and it is advisable to make sure all lines are clear before looking for functional disorders. If rags are left in the tank they will be drawn into suction lines and prevent circulation of the oil.

It is poor policy to use rags or waste to *plug* disconnected pipe openings during overhaul or dismantling. Such plugs may get pushed in out of sight or only partly removed at assembly. Then when pressure is first built up in the system this material is forced into some obscure position causing malfunctioning or failure to obtain any operation.

Before working on equipment assure that electrical circuit is off at the controller panel.

36. *No electric power.* - If the electric motor fails to run current is probably unavailable. This may be due to one of the following.

(*a*) Circuit breaker cutout.

(*b*) Main line fuses blown.

(*c*) Interlock switch stuck open or incorrectly adjusted.

37. *Circuit breaker cuts out when starting.* - If the electric motor starts but the circuit breaker cuts out, the trouble will be due to one of the following causes.

(*a*) Overload relay dashpots in controller box set too low.

Check with instruction sheet located on inside of controller cover.

(*b*) Insufficient or improper oil in dashpots.

The oil in the dashpots should be checked about once a month, as it may become depleted due to leakage or to evaporation in heating. See drawing 231545 for complete instructions.

(c) Obstruction in line between main pump and hydraulic motor or between auxiliary pump and valve block.

Check lines for obstructions.

(d) Damaged pump.

Check pumps for damage. If auxiliary pump is damaged it was possibly caused by running electric motor in the wrong direction for an extended period. (Especially in new installations.)

(e) Excessive friction or locked rotor in auxiliary pump.

The auxiliary pump rotor may be locked as a result of flange screws in rear head being too tight. This head part 220648-8, shown on subassembly 271680 is pressure sealed by corprene ring 164481-5 and the screws must be loose enough to permit free movement of the rotor.

IMPORTANT: -

If a binding condition is found to exist in the auxiliary pump, the loosening of the screws must not be considered a sufficient correction. The head must be removed and an inspection made to see whether the pump has been damaged by the starting action. The rotor should be removed and an inspection made to determine if the faces of the bronze bushings in pump body and head have been scored. An examination should be made of the rotor vanes to see that sheared particles of brass have not become lodged beneath them. When head is replaced, the flange screws should be tightened while the pump is running, if possible.

38. *Projectile ring inoperative due to pressure failure.* - Although the main pump supplies the pressure for rotating the projectile ring, the auxiliary pump must be in operating condition at all times to shift the valves to proper position to make rotation possible. To determine what part of the system is responsible for malfunctioning, pressure gauges should be placed in both the operating and control lines. Probable causes are as follows:

(*a*) Electric motor running in the wrong direction.

Check rotation with direction arrow on A-end.

(*b*) Insufficient oil supply in system.

Check oil level in supply tank.

(*c*) Obstruction in auxiliary pump intake line.

Inspect for foreign matter such as rags, etc.

(*d*) Linkage in A-end improperly adjusted.

Place operating lever in neutral and check linkage for tightness and proper adjustment.

(*e*) Relief valves improperly adjusted.

Determine by pressure gauge which lines are responsible, then adjust to proper setting.

(*f*) Relief valve, by-pass valve or check valve stuck open.

Inspect and clean.

(*g*) Starting and control valves improperly adjusted.

Although this is improbable, due to liberal openings, check to determine if settings agree with those prescribed in paragraphs 25 and 26.

(*h*) Interlock valve failing to shift.

Check for binding condition and clean.

(*i*) Loose or broken operating line.

Leaks in pressure lines are not likely to occur except in piping and may therefore be easily located by inspection of external lines and those inside of A-end tank.

(*j*) Scored valve plate in main pump or hydraulic motor.

Inspect and check for foreign matter in system.

(*k*) Broken or distorted auxiliary pump shaft.

Inspect auxiliary pump.

(*l*) Excessive internal leakage in auxiliary pump.

Pump head too loose. Screws should be tightened. Precautions should be taken not to clamp head too tightly as rotor must rotate freely when moved by hand. Check internal parts for scoring by foreign matter.

39. *Failure to rotate.* - If pressure is available in the system and the projectile ring will not operate it will probably be due to one of the following causes.

(*a*) Insufficient pressure in operating lines.

Lock output shaft and check setting of main pump relief valves for 2200 lbs. per sq. in. pressure.

(*b*) Insufficient clearance between deceleration cams and link rollers.

There must be approximately 3/64" clearance between rollers and cams when unit is in latched position. This is to permit sufficient offset of pump yoke to overcome internal leakage and to start rotation.

(*c*) Excessive internal leakage in main pump or hydraulic motor.

Manually drive projectile ring to mid-position. Then turn power on and shift

yoke completely over. If operation is possible remove main pump and hydraulic motor and check for scoring by foreign matter.

Mechanical bind.

Check drive worm for excessive torque by manual operation, then disconnect coupling and rotate drive shaft. If in unit check worm gearing for foreign matter and the mechanical brake for binding condition.

40. *Improper acceleration or deceleration.* - Faulty starting and stopping action may be caused to a limited degree for the same reasons as are cited in paragraph 39. Such improper action may also be due to one of the replenishing check valves being stuck in a partly open position.

41. *Rotation cycle imcomplete.* - An incompleted cycle can be caused by the same conditions cited in paragraph 40 or by incorrect adjustment of the control valve. Check the latter against the prescribed adjustment of paragraph 26.

42. *Failure to stop at station.* - If the linkage is properly adjusted the projectile ring will stop whenever operation lever is moved to neutral regardless of the position of valves. However if operation lever is held in position for rotation the ring will not stop automatically, as intended, when the ring station is reached because of any or all of the following conditions:

(*a*) Control valve stuck in depressed position.

Inspect and clean.

(*b*) By-pass valve stuck in depressed position.

Inspect and clean.

(*c*) Interlock valve stuck in starting position.

Inspect and clean.

43. *Stopping out of phase.* - If the projectile ring operates through 30 degree arcs of movement and stops but does not stop at ring stations, the equipment has been coupled out of phase. To correct this condition refer to the instructions of paragraph 34.

44. *Excessive oil temperature.* - Maximum permissible oil temperature rise for the hydraulic unit is 70° F. above ambient temperature. The assembly will perform at temperatures up to 180° F. but a rapid rise toward these limiting values indicates one of the following conditions:

(*a*) Insufficient oil in the system.

Check oil level in the supply tank.

(*b*) Mechanical bind in projectile ring.

Check pressure with gauge in the operating lines.

(*c*) Sticking auxiliary relief valve.

Check pressure in auxiliary line with gauge.

(*d*) Excessive friction in auxiliary pump.

Remove auxiliary pump and check to determine if rotor can be turned freely.

45. *Oil pressure in the B-end case.* - External leakage and possibly structural damage may result from high oil pressure in the B-end case. Abnormal case pressure results from the following causes:

(*a*) Drain line too small.

(*b*) Obstruction in drain line.

(*c*) Excessive internal leakage.

46. *Unusual noises and their cause.*

(*a*) Popping and sputtering are caused by air entering the pump through the intake line. This may result from a tco small intake pipe, lifting head being too great, air leak in suction line or low oil level in supply tank; may also be caused by cold or heavy oil. (Perhaps wrong oil is used.)

(*b*) Grinding noise is caused by dry bearings, gears, foreign matter in the oil, or the worm adjustment on projectile ring being too tight.

(*c*) Hydraulic chatter or hammer is caused by vibration of a spring actuated valve, long pipes not being secured by clamps, air in the system, or excessive resiliency or binding in the driven equipment.

(*d*) Squeals or hydraulic hum are caused either by the head on auxiliary pump being clamped too tight against the rotor, or by high frequency vibration in the auxiliary or main pump relief valves. Relief valve noises of this nature, however, do not indicate mechanical or other defects and for all practical purposes may be disregarded.

47. *Leakage* either inside or outside of the system may be the result of any of the following causes:

(*a*) Improperly fitted or torn gaskets.

(*b*) Distorted or scored sealing rings or oil seals. A single cut or scratch on the working surface of these parts may cause a steady slow leak.

(*c*) Worn or scored valves.

(*d*) Worn or scored pistons in main pump or hydraulic motor.

(*e*) Scored valve plates in main pump or hydraulic motor.

(*f*) Scored bushings in auxiliary pump.

Disassembly and Assembly

48. The remaining paragraphs of this chapter give instructions as to disassembly of the elements of the hydraulic equipment. In general, the equipment may be reassembled by simply reversing the dismantling procedure. To aid in the reassembly of the unit, it is desirable to mark all mating parts such as cams, gears, linkages and adjustable pieces, so that they may be replaced in the same relative position to each other. This procedure will eliminate much unnecessary labor in fitting the parts, and also in final adjustment of the equipment.

49. *Disassembly of the A-end.* - The components of the A-end unit and their reference drawings are:-

A-end	271679
Valve block	271698
Variable delivery pump	271704
Cam unit	271712
Control link	271717
Hand control	271715
Bell crank control	271719

To completely dismantle the A-end unit, first remove the drain plug 271730-15 from the bottom of case 271723-1 to drain all the oil. Then remove all the external piping connected to the entire hydraulic equipment and move the electric motor clear of the A-end.

Remove screws 206446-3 and lock washers 196733-1 to free the top cover 271724-3. The filler assembly and the starting interlock switch will remain intact.

Inspection cover 271724-1 is freed by the removal of screws 206446-3 and lock washers 196733-1. Disconnect adjustable link at clevis 271726-4 by removing cotter pin 196749-8, nut 271730-9, washer 271727-10 and screw 271727-6.

Removal of the component subassemblies and dismantling is separately described in paragraphs 50 to 55. However before the cam unit and bell crank control subassemblies can be removed the A-end case mounting bolts must be disassembled and the case must be shifted to allow sufficient space for their removal. After removal of the subassemblies the only parts remaining in the tank are the valve block spacer 271729-1 with its attached linkage and the flange mounting plate 271726-1. The valve block spacer with linkage attached can be removed as an assembly by removing screws 206446-3, and lock washers 196733-1, and then sliding it free of dowels 271729-2.

Remove the auxiliary pump suction line. This pipe was freed when the flange screws for the external piping were removed.

The operating lines 271728-3 and 271728-1 are disconnected at the time pump is being removed.

Further disassembly of the A-end is apparent from the drawings.

50. *Dismantling the valve block,* (dr. 271698). - The valve block can be removed as an assembly by removing screws

180226-7 and lock washers 196733-1 in mounting plate 271700-1. If it is desired to remove only the valve block assembly, the complete dismantling of the A-end is unnecessary. It would then be necessary to only partly drain case and to remove only the piping connected to the valve block before proceeding with its removal.

Remove screws 200075-6, lock washers 196787-6 and cover 271701-1. Valves 271701-4, 271700-5, 271700-6, 271702-5 and 271702-6 with springs 221504-2, 271700-4, 271702-10 and 271702-11 are then free to be removed.

Remove screws 206590-7, lock washers 196787-6 and plate 271700-1. Plunger 271700-2, piston 271700-3, and bushing 271701-5 can then be removed by gently tapping on the bottom of the plunger.

The replenishing check valves 196788-10 and springs 271702-1 become free when plugs 196826-10 are removed.

Detent 271702-4 and spring 271702-9 are freed by the removal of plug 271702-7.

51. *Dismantling the variable delivery pump* (dr. 271704).- The variable delivery pump can be removed as an assembly from the A-end by the following procedure. Remove cotter pin, 229122-3 and nut 206529-9 to free the yoke control linkage from the bell crank. Then remove the four screws 206701-7 from the top yoke flange 271711-2 and the four screws 206446-3 from the flange mounting plate 271726-1 located on the front of case. Tube 271728-1 is now free. The pump, including the lower tube 271728-3 can now be removed from case by removing nuts 180226-10 and lock washers 191344-3.

If it is desired to remove only the pump complete dismantling of the A-end is unnecessary and in such instance proceed as follows before attempting removal as outlined above. Drain all the oil. Remove the two operating lines connected to plate 271726-1 and the two lines connected to the auxiliary pump. Then remove top cover 271724-3 and move the electric motor clear of the A-end.

To completely dismantle the pump the relief valve assembly should be removed first. This is done by removal of screws 271710-2 and lock washers 196733-1.

Remove screws 196825-11, lock washers 196787-6 and cover 271707-2 with oil seal 271730-1. Then remove lock nut 271731-3 and lock washer 271731-4. The upper end of drive shaft 271706-1 is now free.

Remove screws 206702-4 and lock washers 206449-7 and tap upper and lower support plates 271707-1 free of dowels 271705-3. Yoke 271709-1, pump head 271710-1, valve plate 271708-4 and bearing pin 271711-6 are now free. The cylinder block 271708-1 may now be slipped off the pistons.

The drive shaft can be removed by tapping on its splined end.

Further dismantling is apparent by reference to the drawings.

52. *Dismantling the cam unit,* (dr. 271712). - To remove the cam unit from the A-end it is only necessary to remove screws 206446-3 and lock washers 196733-1 in housing 271713-1 and then tap it free.

However if it is desired to remove the cam unit without completely disassembling the A-end the procedure is as follows: Drain all the oil, remove external piping, shift the case free of B-end, remove top cover 271724-3 and disconnect adjustable link at clevis 271726-4. Then proceed as above.

To dismantle the complete cam unit remove screws 206446-3, lock washers 196733-1 and cover 271712-2 with oil seal 271730-2. Remove lock nut 229152-2 and lock washer 220719-1. The cam shaft 271712-3 and the remaining parts can be tapped free.

53. *Dismantling the control link,* (dr. 271717). - The top cover 271724-3 and inspection cover 271724-1 must be removed to gain access to the control link.

To free the control link assembly from the A-end, remove cotter pins 229122-3 and nuts 206529-9 at both the bell crank and hand control ends.

To effect complete dismantling of this unit, first remove the cotter pins 271730-14, plugs 271718-6, bearings 271718-3 and the socket joint balls 271718-8. Then remove lock nut 271718-5, socket joint retainer 271717-7, retainer nut 271718-4 and lock washers 271718-2. This leaves the retained centering spring 271718-10. To dismantle this portion of assembly securely clamp the control rod 271717-6, and compress spring at retainer 271718-9, and then remove cotter pins 196749-8, nut 271730-6 and washer 271717-5. Gradually release the spring force on retainer 271718-9 and all parts become free.

Inasmuch as spring 271718-10 is under compression when assembled precautionary measures should be taken to assure that it is completely restrained before removing nut 271730-6, otherwise parts may snap free and become damaged.

54. *Dismantling the hand control,* (dr. 271715). - Before proceeding with the removal of the hand control assembly be sure that control link assembly is free at arm 271716-3.

To remove the hand control assembly from the A-end, remove screws 206446-3 and lock washers 196733-1. Then slide unit off dowels 196700-8.

To effect complete dismantling of the hand control unit proceed according to the following instructions:

Remove screws 180226-6, lock washers 196733-1 and the cover 271715-3 with oil seal 271730-2 and washer 271715-5. Then remove lock nut 229152-2 and lock washer 220719-1. The remaining parts can then be tapped free.

Whenever the hand control unit is reassembled on the A-end while the valve block is in place it is necessary to hold the starting valve clevis assembly 271714 depressed. This permits the proper assembly of clevis against the starting valve cam 271717-4. Necessary access to the clevis can be obtained thru the inspection cover 271724-1.

55. *Dismantling the bell crank control* (dr. 271719). - To remove the bell crank control assembly from the A-end remove screws 206446-3 and lock washers 196733-1, then slide unit off dowels 196700-8.

Before proceeding with the removal of this unit be sure arms 271721-6, 271721-3 and 271721-4 have been disconnected from the linkages.

To completely dismantle the bell crank control assembly proceed as follows:

Loosen lock nut 196804-4, then remove it with the link nut 271722-3. Remove screws 220718-1 with lock washers 196733-1. Guide bracket 271721-2 then becomes free.

Remove screws 180226-7 and lock washers 196733-1 from the four levers. Then slide cam 271721-5 on shaft against arm 271721-6. Remove arms 271721-3 and

271721-4 and the loose keys 206693-5. Restrain lever 271721-6 and cam 271721-5; then tap the end of operating shaft 271721-1 until arm and cam become free.

Remove screws 196825-6 and lock washers 196733-1. Shaft bracket 271722-1 can then be slipped off dowels 196700-8.

Further dismantling of this unit is evident from the drawings.

56. *Disassembly of the B-end,* (dr. 271678). - Due to the limited space it is necessary to move the entire unit to a portion of the projectile flat with available working space. In preparation for moving proceed as follows:-

Drain the entire system by removing the drain plugs in the A and B-ends. Remove the external piping. Disconnect the couplings on the output and the worm wheel shafts, and remove the mounting bolts.

57. *Dismantling the B-end.* - When completely dismantling the B-end a minimum of time will be required and trouble will be eliminated if the unit is dismantled according to the following instructions:

Remove screws 206446-3 and cover 271697-3. Remove bearing housing 271696-1 and worm wheel 271697-1 as an assembly.

Remove screws 206446-3 in control shaft bearing 271697-8. Then remove bearing complete with shaft 271694-2, oil seal 271730-4, spacer 271693-3, and lever 271692-7.

Remove pilot bearing 271692-8. Shaft 271695-4 may be left assembled in place until yoke 271694-4 is removed from housing.

Remove screws 180226-6 and retainer 271691-2 with oil seal 271730-3. Remove bearing lock nut 271731-10 and lock washer 271731-11.

Remove screws 220678-3 in cylinder 271693-1. This cylinder with retainer 271691-1, screws 200075-6, bearing 271731-6, spacer 271688-4, piston 271694-1, spring 271694-3, bushing 271692-6 and end plate 271695-7 with screws can be removed from the housing as an assembly. When these parts are removed the yoke 271694-4 and retainer spacer 271693-6 become free.

Disc plates 271695-5 and 271693-5 and thrust plate 271696-2 can now be removed from shaft 271690-1. This leaves the output end of the shaft free.

Remove screws 271730-12 and the manifold head 271687-1. Bearing pin 271688-2 and valve plate 271689-1 will become free with the manifold head.

Remove nuts 180226-10 and lock washers 191344-3. Remove the hydraulic motor housing 271688-1. Slip cylinder block 271689-4 off of the pistons. The output shaft with attached parts can now be tapped free.

To dismantle the cylinder 271693-1, and the parts that were removed from the B-end as an assembly, it is first necessary to obtain, from the tools provided with the spare parts, four each of the special assembly screws 271732-3, nuts 271732-2, and washers 271733-1. Then remove four alternate screws 200075-6 from retainer 271691-1, and assemble in their place these special parts, with the washers held against the retainer by the nuts. Remove the remaining four screws 200075-6. The retainer is now held in place by the special assembly screws.

Gradually unscrew the assembly nuts 271732-2 until the spring is no longer under compression. Then remove assembly screws and the retainer with bearing 271731-6 and spacer 271688-4.

It is highly important that the cylinder is dismantled according to instructions. The purpose of the special screws is to restrain the compressed spring 271694-3 to prevent possible damage by the retainer springing free when the screws 200075-6 are removed.

Further dismantling of the B-end is apparent from the drawings.

58. *Disassembly of the auxiliary pump,* (dr. 271680). - To remove the auxiliary pump from the end of the electric motor disconnect the two pipe lines and remove the pump mounting screws 196825-11. Then slide the pump shaft out of the flexible coupling.

59. *Dismantling the auxiliary pump.* - To dismantle the pump first remove screws 180226-6, then the pump head 220648-8, head end bushing 164481-2, rotor 221544-8 with vanes 221543-2, pump ring 196741-1 with pin 164481-4 and the bushing 164481-1. Remove mounting flange 271680-3 with oil seal 271730-5, then the pump shaft 271681-3.

It is possible to assemble this pump for opposite hand rotation, and care should be taken upon reassembly, to check the rotation. In this particular installation, the rotation is as indicated by the arrow on the A-end. It should be noted that there are arrows on both bushings and the rotor, and when properly assembled, all three of these arrows will point in the direction of the desired rotation. The vanes are assembled with the chamfer on the trailing edge.

When replacing pump head 220648-8, care should be taken to tighten screws that are diametrically opposite. It is good practice to turn the shaft while these screws are being tightened to insure that the rotor is not binding.

60. *Reassembly.* - It is essential before reassembly that all parts are carefully washed in a non-acid cleaning fluid to insure absolute cleanliness.

Care should also be exercised upon reassembly not to injure oil seals.

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Chapter XI

16-INCH PROJECTILE HOIST, MARK 7 AND MARK 7, MODS. 1 AND 2

General Description

1. The projectile hoist equipment installed in each turret comprise the three hoist assemblies designated in the title. These are identically arranged in all turrets:- The right gun being served by the Mark 7 design, while the center and left guns are served by Mark 7, Mods. 1 and 2, respectively.

2. These designs are hydraulic ram type tubular lifts of rack and pawl arrangement. They are independently driven and controlled and are similar in all essential features. They resemble the main battery projectile hoists of recent heavy cruisers, cf., U.S.S. New Orleans, etc., with principal differences from that type in that they are reversible and are equipped with power mechanisms for operation of the cradle. Each such hoist is an assembly of hoist tube and platform structure together with power units, a cradle and control devices. These subassemblies are designated and are separately described as follows:-

Hoist tube and platforms
Hoist cylinder and rack assembly
Power drive assembly
Cradle assembly
Cradle operating power unit
Tube pawl and tripping cam operating mechanisms
Hoist control, interlock and indicator arrangements.

3. The outboard hoists are alike but to opposite hand. Their courses are vertical from the lower end to the pan floor and slope thence rearward 16°-40' to the cradle. The center hoist differs from the outboard machines in that the course is straight all the way, nearly vertical, and the rack casing, doors and other elements have different position or arrangement. All cradles are aligned between their respective rammers and guns, and when open extend the rammer track, at gun loading angle, from the rammer to the gun breech.

4. Functionally all hoists are alike. Each operates to raise or to lower projectiles by equal stages. A stage of movement is equal to full stroke (97.5 inches) of the power

cylinder piston and attached rack. And at the upper end such stroke is equivalent to delivery of a projectile above the cradle projectile latch. Total lift to that position is four stages from the lower handling platform, three from the upper handling platform.

Hoist Tube and Platforms

5. Structurally the tube and rack casing sections are a bolted assembly supported from the lower and upper platforms and braced by flange attachment at the shelf plate, pan floor and electric deck. The cradle unit is aligned with the tube but is mounted on and secured to the shelf plate. The arrangement is as shown on drawing number 215941 for the outboard hoists, and drawing number 215946 for the center hoist.

6. In each such assembly the two platforms are the foundation elements for the hoist tube, the door assemblies and the power cylinder-rack casing group. These platforms are similar large steel castings arranged with top surfaces flush with the stowage levels and the rotating rings. The platforms are accurately machined and keyed to locate and secure door and shutter brackets, rack casing sections and the cylinder. The latter is vertically mounted between the platforms and extends through both with the upper cylinder head and piston rod crosshead coupling located immediately above the upper platform level.

7. Door and shutter brackets are substantial cast steel columns which structurally support the hoist and hoist load above. They are arranged with virtually full opening of the hoist-way vertically in each stowage compartment and with the several openings fitted with hinged doors and shutters.

8. The moving rack is an assembly of connecting bars, links and pawl carriers arranged with crosshead as shown by figure 43. The units are the same in right and left hoists. Center hoists with straight casing track for the entire course of rack movement are similar assemblies of fewer parts.

Hoist Cylinder

9. The hoist cylinder, located as described in paragraph 6, is an assembled arrangement of steel tube cylinder, cast bronze cylinder heads and piston-piston rod as shown by the sectional view of drawing 216379. This is a hydraulic ram of 5.875 inches bore and 97.5 inches stroke. It operates at maximum pressure of 700 pounds* per square inch when lifting full load of four projectiles. The arrangement of cylinder

* Normal working pressure hoisting full load; relief valves are set for 800 P.S.I.

head ports and the design of the piston assembly operate to provide dashpot buffing at both extremes of piston stroke. The upper head buffing space is equipped with needle type vent valve.

10. The piston and rod assembly is a single cupped-leather type which operates to seal by pressure distension. It consists of a steel rod (2.5 in. dia.) and a bronze piston, with the leather secured by bolted attachment thru a piston follower. This follower is shaped to prevent collapse of the leather and to function as the down stroke buffer plunger.

The upper end of the rod is secured to the crosshead with a steel pin (1.5 in. dia.) locked in place with 1/2 inch set screw.

11. The cylinder head pressure ports are flange coupled to special steel leads (2.375 ins. dia.) which extend upward with "easy" bends to attachment with the A-end valve plate on the electric deck.

Power Drive Assembly

12. The power drives for all hoists are located on the electric deck with arrangement as shown on drawing number 215940. Each power plant consists of an electric motor with controller panel and remote push-button station, a reduction gear, a variable displacement pump and a solenoid brake.

13. *Electric motor.* - The electric motor is an induction type of commercial manufacture (Reliance Elec. & Eng. Co.) mounted with rotor axis horizontal and having the following specification data.

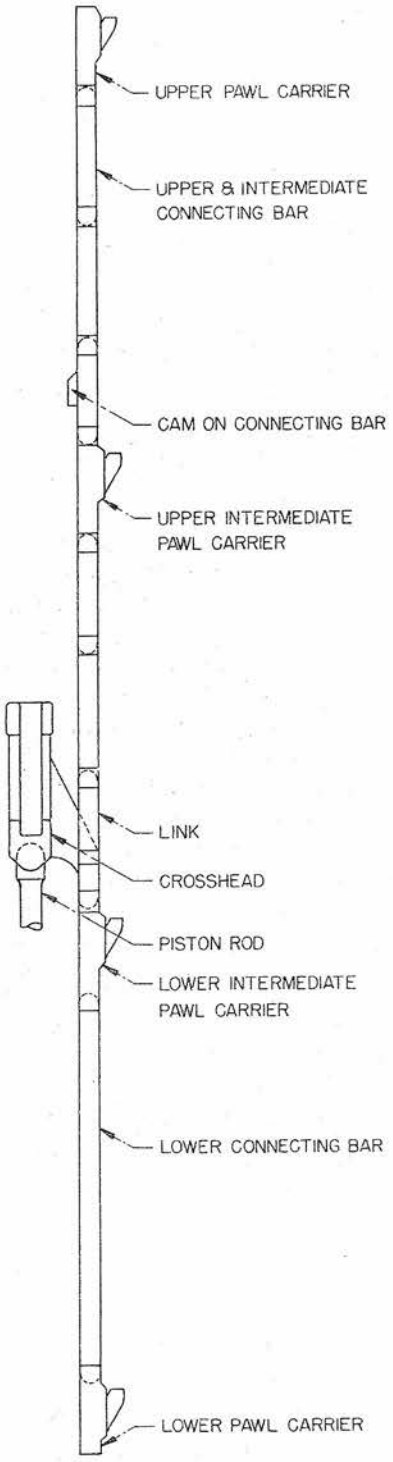

Fig. 43 - Rack Arrangement

Motor Data

Type	60 cycle, 440 volt, 3 phase, squirrel cage induction.
Horsepower	60
Speed	Constant
R.P.M. (full load)	1750
Amperes, full load	81
Rotation, center & left motors, fan end	clockwise
Rotation, right motor, fan end	counterclockwise
Lubrication	grease cups
Manufacturer's type designation	AA-B-504-Y
General arrangement drawing	231723

14. *Electric controller.* - Each of the above described motors is provided with starting circuit push-button control mounted in the gun compartment (cradle operator's station) and connected to a controller circuit. This circuit includes "Stop" push-buttons at the two hoist control stations (par. 34). The controller is located on the circular bulkhead within the machinery space of the lower projectile flat. It is a cabinet enclosed unit of commercial manufacture (Ward Leonard Co.) equipped with door interlocked safety switch. The design is an across-the-line magnetic starter arranged with overload, undervoltage and short circuit protection for the motor as shown on drawing number 231722.

15. *Solenoid brake.* - The motor output is coupled to the reduction gear unit (par. 16) through the drum shaft of a solenoid brake. This is a power-failure brake which operates mechanically to set and thus prevent overhaul in instances of mid-stroke power-failure. It is actuated to release the brake through solenoid plunger stroke and brake band linkage when the motor supply circuit is closed; the solenoid is a 440 volt, 60 cycle, single phase, continuous duty type, 125 foot pound torque, eight inch brake wheel. The assembled unit (dr. no. 231727) with separate mounting base is of commercial design and manufacture (Clark Controller Co.) and is similar to standard commercial elevator brakes. Shaft coupling between motor and brake shaft (reduction gear input) is through a gear type flexible coupling (#2 Waldron, dr. no. 231758).

16. *Reduction gear.* - The reduction gear is a separately mounted, case enclosed unit of commercial design and manufacture (Michigan Tool Co.). See drawing number 275600. It is a worm and worm-wheel drive, oil bath lubricated, providing 400 r.p.m. output speed (at normal motor speed). The output is coupled to the A-end shaft through a gear type flexible coupling (#2-1/2 Waldron, dr. no. 231762).

17. *Hydraulic pump.* - The A-end is a standard commercial speed gear, type K, size 35 (Waterbury Tool Co.) modified

as to adaptation of the control. See drawings number 52187 and 234230. This unit is an assemblage in a case of a multi-cylinder reciprocating pump, a main shaft, a tilting box-socket ring assembly, with case mounted tilting box control mechanism. The rotating assembly comprises a cylinder barrel (having nine parallel axially disposed cylinders, pistons and connecting rods), a socket ring and the main shaft. The latter has roller bearing mounting in the case and the valve plate, respectively; on it the cylinder barrel and socket ring are so mounted as to rotate with the shaft. The barrel is spring compressed against the valve plate face and semiannular ports which align radially with cylinder ports in the barrel; the socket ring is trunnion pivoted in the shaft and has radial-thrust bearing support in the tilting box, which is trunnion mounted within the case. Thus, as the tilting box-socket ring assembly has selective angular movement (by control mechanism) with relation to the shaft axis, reciprocation of the pistons and consequent pumping action through the valve plate ports occurs according to the degree of inclination of the tilting box. Zero reciprocation (neutral) is the condition when the socket ring is perpendicular with respect to the shaft axis. Full stroke occurs with socket ring twenty degrees inclined from vertical. Direction of flow of high pressure oil is dependent upon direction of tilt from neutral. Tilting movement of the tilting box and socket ring is the function of the control described in paragraphs 34 to 36, inclusive.

The operating oil pressure from this pump which functions to lift or to lower a full projectile load is controlled by the adjusted spring loads of the relief valve assembly.* Minimum required system pressure for a normal operating hoist is 700 pounds per square inch hoisting. Back pressure when lowering full load of four projectiles is 500 pounds per square inch.

Cradle

18. The cradle assembly mounted on the shelf plate above the hoist tube is a conventional cradle fulcrum, cradle and spanning tray unit. It is equipped with a hydraulic power cylinder (see par. 21 and 26) for opening the cradle to gun loading position and for returning it to hoist position. The arrangement is as shown on drawings number 215943, 215944 (right), 215948, 215949 (center), and 215962, 215963 (left).

19. The cradle is a cast bronze trough with integral trunnions, a hinged spanning tray of cast aluminum and a cast bronze projectile latch. The latter is pivoted and spring loaded at the bottom or rear of the bronze trough. This group is trunnion pivoted (horizontally) in the fulcrum bearings, its tray is connected to the fulcrum by a hinge and control link, and it is provided with pin bearing for attachment of the operating cylinder piston.

* See figures 49 and 50. Refer paragraph 51.

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20. The fulcrum and cradle assembly is equipped with indicator, interlock and buffer devices which have arrangement and purpose as indicated below.

(a) *Cradle buffer.* - A buffer of hydraulic, variable flow type is mounted on the fulcrum, offset at the front, with plunger positioned in the way of a phenol-fabric pad on bottom of the cradle. The unit operates to buff cradle opening.

(b) *Spanning tray buffer.* - A rubber pad cemented in a recess in the bottom of the cradle provides for contact buffing between the tray and cradle when the unit is closed.

(c) *Cradle latch.* - A latch is located on the inside of the fulcrum in the way of a cam lug on the cradle. It is moved by spring to latch the cradle in hoist or folded position. It is actuated to release the cradle by a foot pedal and connecting lever and shaft linkage. It is interlocked by a trigger and bumper unit in such manner that the latch cannot be released until the bumper, which is on the loader's platform, contacts the trigger. The bumper and trigger function only when the gun is at loading position. The arrangement is shown on the reference drawings of paragraph 18.

(d) *Projectile indicator lever and indicator retainer.* - A bracket secured to the shelf plate provides a hinge pivot for a lever which is positioned in front of the folded cradle. The hook-shaped toe of this lever projects through a cored hole in the cradle. It is displaced when a projectile rises into the cradle and thus actuates two interconnected elements of an indicator system. These are: a projectile hoist indicator located at each hoist control station, and a projectile indicator retainer. The latter is attached in a guide on the fulcrum in the way of a latch lug and arc-shaped cam on the cradle. Its movement unlatches the cradle, and thereafter, during cradle opening and until the cradle is again folded, the arc cam holds the retainer unlatched. This action holds the indicator at the control stations at "Danger". (See also Control Handle Interlock, pars. 37, 38 and 39.)

Cradle Operating Mechanism

21. The cradle operating power plants are located beneath the shelf plate to the rear of the gun pockets. The hydraulic power derived from these units is used to operate the cradle and also to actuate hydraulic devices which make the hoist reversible. The cradle operating unit (par. 24) is located in the gun compartment to the rear of the cradle with mounting bracket secured to the shelf plate. The other devices (pawl operating cylinders) are mounted on the hoist tube in the electric deck space. Each cradle operating assembly comprises an electric motor, a pump, a cradle operating cylinder, a control valve and a pipe system with expansion and supply tanks. The arrangement is shown on drawing number 236513 for a right assembly, left and center are similar.

22. *Electric motor. (Cradle operating system.)*- The electric motor is a ten horsepower unit of commercial manufacture (Louis-Allis Co.). It is mounted with rotor shaft vertical and with direct drive coupling to pumps at each end. The upper pump is the operating unit for the cradle mechanism; the lower pump is arranged in a system which operates the upper door of the powder hoist (see ch. XII). The motor controller, an across-the-line magnetic starter with conventional protection, is arranged with starting circuit push-button station located at the cradle operator's station.

Motor Data

Type- - - - -	60 cycle, 440 volt, 3 phase, squirrel cage induction, vertical.
Horsepower- - - - - - - - - - - - - - - - - - - -	10
Speed -	-Constant
R.P.M., full load - - - - - - - - - - - - - - - -	1160
Amperes, full load- - - - - - - - - - - - - - - -	26.5
Rotation, from above- - - - - - - - - - - -	Clockwise
Lubrication - - - - - - - - - - - - - - - - -	grease cups
Manufacturer's type designation - - - - - -	RX-326-W
General arrangement drawing - - - - - - - - -	231764

23. *Pump.* - The pump is a rotary multiple vane type (Vicker's) of 30 gallon per minute capacity. It is driven at motor shaft speed and supplies oil at intermittent, varying pressures according to the relief valve and circuit arrangements described in paragraph 26. This pump functions not only to operate the cradle through the cylinder described in the following paragraph but also supplies pressure for operating the pawl control mechanisms described in paragraphs 27 to 33.

24. *Cradle operating cylinder.* - The cradle operating cylinder is a hydraulic ram subassembly. The design arrange-

ments of piston and cylinder heads are shown in the sectional view of figure 44 and general arrangement drawing number 232476. The unit has maximum stroke of 13.785 inches and through its valve port restrictions and piston details operates to buff both cradle opening and cradle folding. The circuit operation is described in paragraph 26.

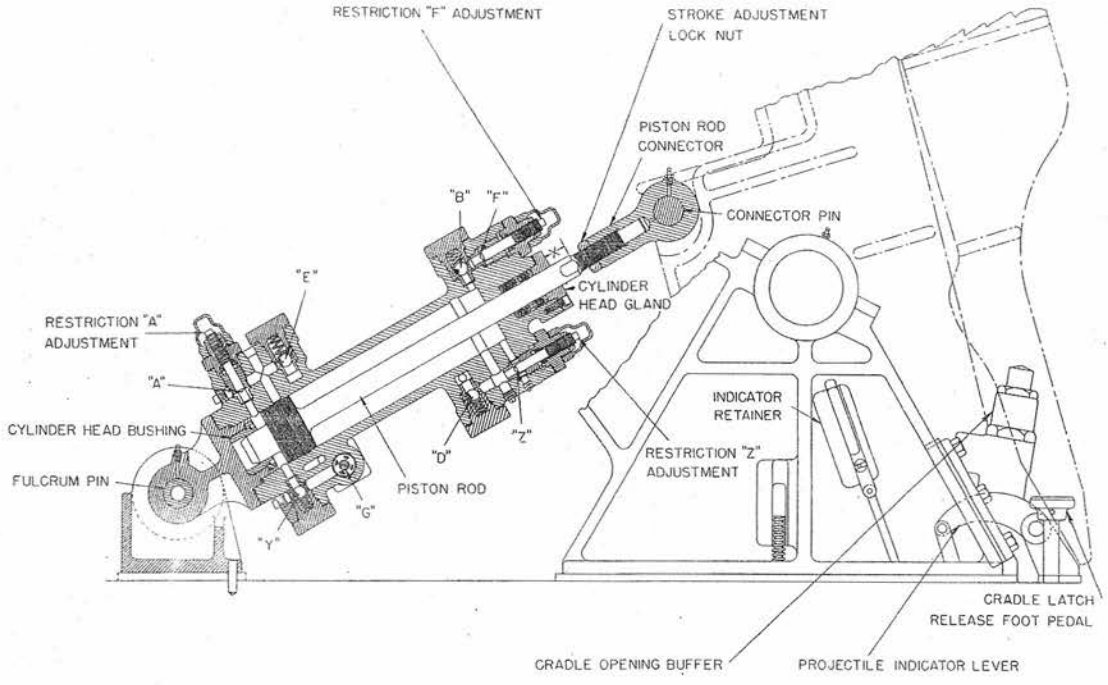

Fig. 44 - Cradle Operating Cylinder

25. Cradle movement to open and to fold is manually controlled by means of a hydraulic valve hand lever. This is located at a station immediately forward of the turret officer's compartment bulkhead and on one side of the rammer and cradle. The valve is arranged in a hydraulic circuit as shown on the diagrams of figures 45 to 48, inclusive.

26. The hydraulic arrangement of the cradle operating cylinder is shown on drawings number 235389 to 235392, inclusive, and the diagrams of the figures. The design provides adjustable restrictions to control piston starting and buffing movements in both directions. These restrictions are paired with check valves in such manner that a complete cycle to "Lower" and "Raise" the cradle functions as follows:

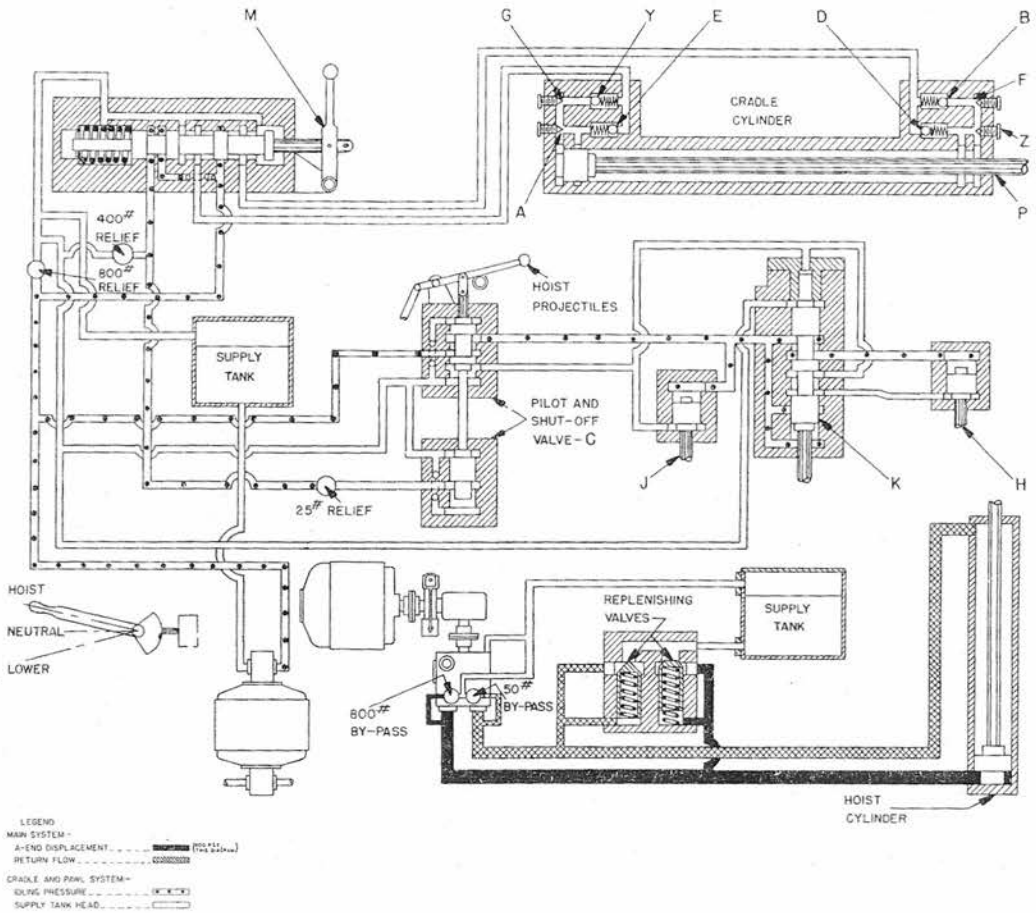

Fig. 45 - Hoisting Projectiles.
Beginning to hoist. Cradle Circuit Idling.

When the control handle is positioned to "Lower" the cradle, high pressure is ported through check "E" and restriction "A". The latter limits oil flow and piston starting movement until the piston uncovers the main port. In this movement the other side of the piston is open to the tank through check "B" and restriction "F". The end of the stroke (cradle open) being buffed by that restriction.

When the control is positioned to "Raise" the cradle, check "D" and restriction "Z" function similarly to start the return stroke, and check "Y", restriction "G", to buff cradle folding.

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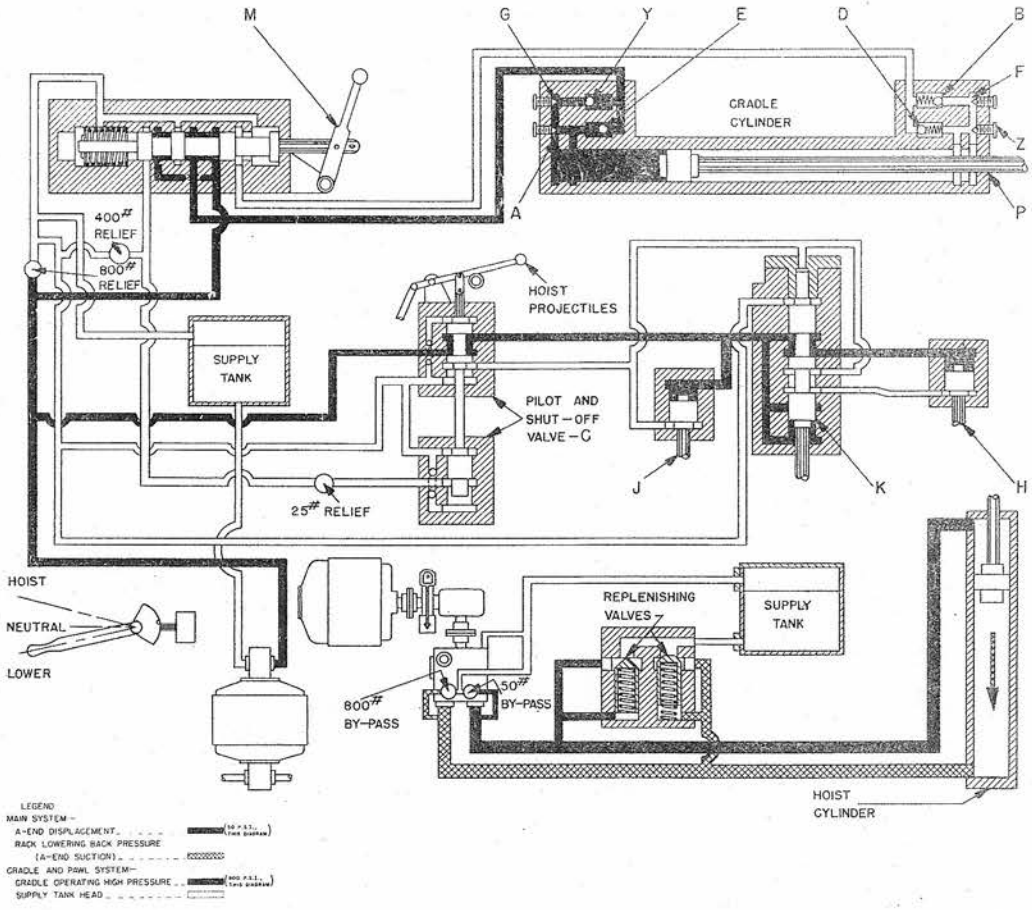

Fig. 46 - Hoisting Projectiles.
Lowering Empty Rack. Opening Cradle.

In order to obtain this operating cycle with its high pressures and at other periods permit the motor and system to "idle", but at the same time provide for the pawl operating circuit, the three relief valves have functional arrangement as follows:

(a) With the pilot and shut-off valve at "Hoist" and the cradle control valve neutral, the pump and circuit are *"idling"*. (See fig. 45.) Pressure flows straight through the 800 and 400 pound relief valves and lifts the 25 pound relief. The latter valve functions in this arrangement for purpose of maintaining slight pressure above the pawl control operating piston "J" and the tripping cam operating piston "H" to block any possibility of pawl lowering action. This pressure also operates to hold

operating valve "K" in up position, thus preventing the cam lever from moving into the path of the rack cam.

(b) With the pilot and shut-off valve "C" at "Hoist" and the cradle control valve moved to "Raise Cradle" or to "Lower Cradle", (fig. 46) the 25 pound and 400 pound relief valves are blocked out of the circuit (by cradle control valve "M") and pressure will build up to 800 pounds (depending on cradle load). This pressure extends throughout the pressure leads, including the tops of the two pawl operating cylinders, "J" and "H".

(c) With the pilot and shut-off valve at "Lower Projectiles" and the cradle control valve at neutral, (fig. 47) the 400 pound relief maintains pressure throughout the pressure leads (including the cradle control valve). This minimum pressure required to operate the pawl and tripping mechanisms increases to a maximum of 800 pounds when the cradle control valve is moved from neutral, blocking off the 400 pound relief. The cradle latch foot pedal must always be operated to release the latch prior to such cradle control valve movement.

Rack and Tube Pawl Assemblies

27. Projectiles when lifted in the hoist are supported at the end of each of the first three lifting strokes by tube pawls which are spring actuated to move beneath the base of the projectile as the projectile is lifted on the rack pawls. At the end of the fourth stroke the cradle projectile latch supports the projectile that has risen into the cradle.

28. Rack pawls are similarly arranged with springs to move each pawl into the hoistway. When the rack descends, after a lifting stroke, the pawls are depressed by any projectiles in the stages below. Thus rack pawls and tube pawls have conventional free bearing for "hoisting" but are arranged with operating mechanisms which retract the pawls in reverse cycle for "lowering". Rack pawls are seated with pin pivot and spring plunger in four elements of the rack assembly. These are designated: Upper pawl carrier, upper intermediate pawl carrier, lower intermediate pawl carrier and lower pawl carrier. Tube pawls are housed, the lower pawl being mounted within the upper projectile handling platform, the intermediate in a housing integral with a cast tube section and the upper one in an attached housing.

29. *Tube pawl control mechanism.* - Tube pawls have splined mounting on horizontal shafts which have bearings in the respective housings. Each pawl shaft is fitted with a crank which is connected to a system of control rods. The latter extends to the piston of a tube pawl operating cylinder "J" (see par. 31). This cylinder is located on the tube immediately adjacent to the upper pawl.

30. *Rack pawl tripping cam mechanism.* - When the rack is at the bottom of its stroke the three upper rack pawls are aligned with tripping cams (attached to the rack casing). These are arranged to be simultaneously actuated by a system of rods that extends to the piston of a rack pawl operating cylinder "H" (see par. 31). This cylinder is located adjacent to the tube pawl operating cylinder. The tripping cam action is such that it will retain the pawls in retracted position until each pawl on the upward moving rack is past the base of a projectile on the stage above. (See fig. 47.)

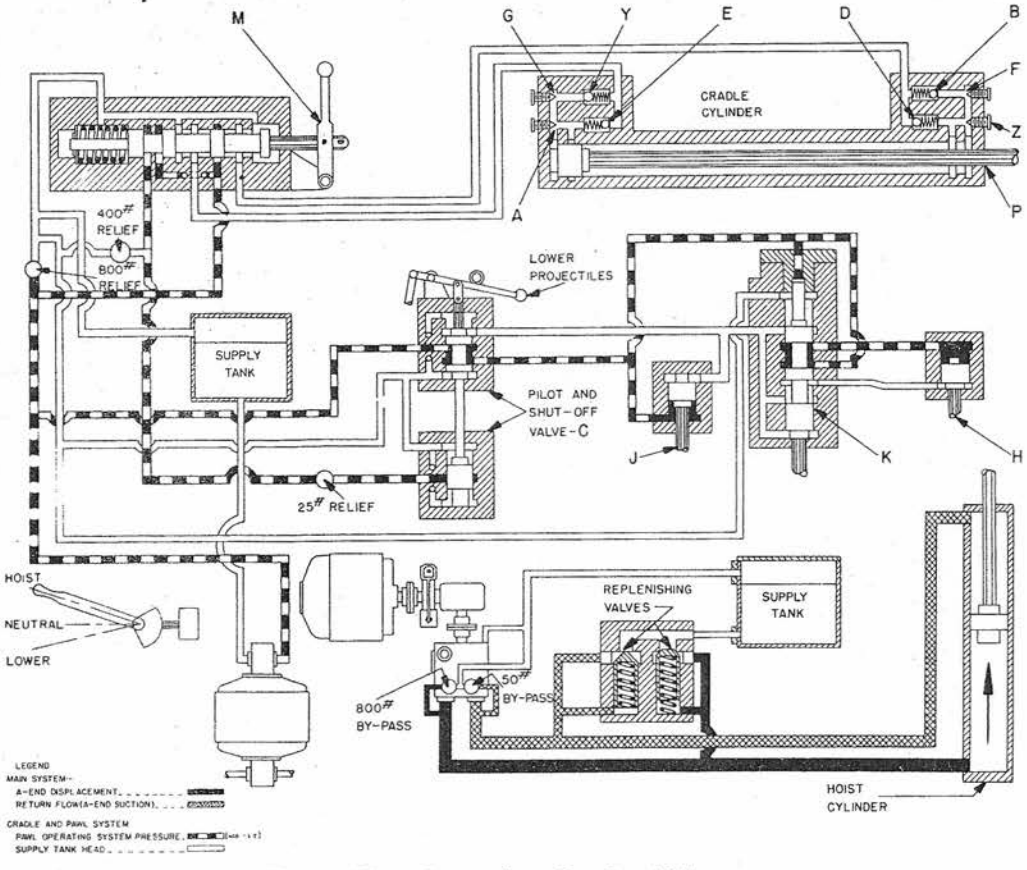

Fig. 47 - Lowering Projectiles.
Raising Empty Rack. Cradle Closed.
Rack pawl control set to trip.

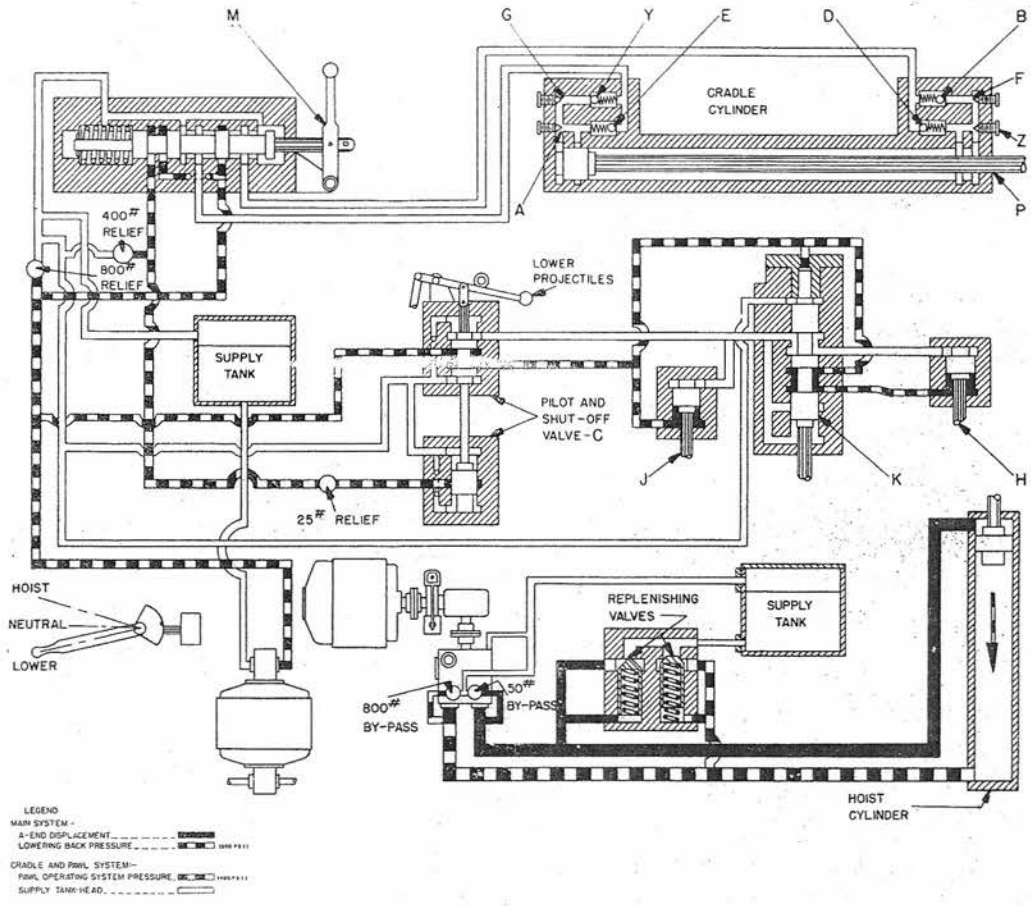

Fig. 48 - Lowering Projectiles
Rack about to descend. Tube Pawls Retracted.

Tube Pawl and Tripping Cam Hydraulic Operating Mechanism

31. The hydraulic circuit referred to in paragraph 26 also includes the tube pawl operating cylinder and the tripping cam operating cylinder (rack pawl mechanism). This portion of the circuit is arranged with semiautomatic control separate from the cradle operating valve. It includes, in addition to the two operating cylinders, a pilot valve "C" located at the upper end adjacent to the cradle control valve, and an operating valve "K" located on the tube above the tripping cam operating cylinder.

32. The hydraulic arrangement of these elements is shown on the diagrams of figures 45 to 48, inclusive. Valve "C" is the direction control valve. It is manually positioned from "Hoist" to "Lower" in order to set the pawl mechanisms to operate for the reverse cycle. When in either position it is locked by a solenoid plunger which is energized by either of two switches. These are located at the two hoist controls and function to interlock lever "C" whenever the control is moved from neutral. (See drs. no. 234274 and 234275 and par. 38.)

33. Operating valve "K" is arranged to be actuated by movement of the rack (when lever "C" is in lowering position only). (See fig. 48.) This is accomplished by a cam surface (fig. 43) on a rack connecting bar (located immediately above the upper intermediate rack pawl). This cam surface contacts and lifts a roller and cam lever in the final four inches of upward rack movement. At that position the rack pawls are projecting to lift projectiles supported on the tube pawls and as the load is relieved from the latter, valve "K" is moved (by the cam lever), pressure is ported to the tube pawl operating cylinder, and those pawls are retracted to permit the descending projectiles to pass. Each tube pawl moves back into the hoistway as the passing projectile is lowered and thus is positioned (by spring) to receive the projectile from the stage above. At the bottom of the stroke the tripping cams retract the rack pawls as the load is again taken by the tube pawls.

Hoist Controls, Interlocks and Indicators

34. The hoist controls, interlocks and indicator devices include the arrangements described in the cradle assembly text, paragraphs 20-c, 20-d, the cradle operating control, paragraphs 25, 26, the pawl control devices, paragraphs 27-31, and the main circuit hoist controls and signal devices described below.

35. The main hoist control comprises duplicate installations of control handles with their respective mechanical interlock, electrical interlock and audible and visual signals. The control stations are adjacent to the hoist loading apertures on the upper and lower projectile handling flats. Typical arrangements are as shown on drawings number 234278 and 234279.

36. *Control handle station.* - The control handles are mounted on shaft brackets which also function as mountings for the interlock and indicator devices and for the vertical control shaft that extends upward to the A-end. Tilting box angle-of-tilt adjustments are obtained through bevel gear and spur gear train (dr. no. 234276) from the control shaft with shaft rotation and equivalent tilt as indicated in the following description of control handle limits of movement.

The arrangement of each control handle is such that the total arc of movement (161 degrees) is unequally divided from neutral to "Hoist" and from neutral to "Lower". Full lever movement to "Lower" is 116 degrees and is equivalent to 20 degree inclination of the tilting box. The control handle however cannot be manipulated to give high speed lowering with load by reason of handle limit stop which limits handle movement to seven degrees. This device, actuated by lever "C", is shown on drawing 236523. Full lever movement to "Hoist" is 45 degrees and is equivalent to 7.5 degree inclination of the tilting box. These factors limit the acceleration and speed of rack upward movement and permit full speed retraction of the unloaded rack. Conversely, when projectiles are being lowered, the arrangement prevents movement of the handle toward high speed lowering. This device permits manipulation to throttle the pump delivery and thus to check descent of the load.

The bracket arrangements which provide these limiting movements of the control handle are the safety stop and mechanical interlock devices described in the next paragraph.

37. *Control handle limit stops.* - Both control handles are mounted with free bearing on a coupled vertical control shaft with a positive clutch element arranged with each to provide engagement of the handle with the shaft. Each clutch is manually operated and is provided with a locking pin for securing in both open and closed positions. In addition to this facility for engaging or disengaging the handle from the control the bracket contains the following elements of the indicator mechanism which operate to restrain control handle movement or to free the handle from mechanical interlock.

(a) *Safety stop.* - The "Lower" indicator rod is arranged with a safety stop lever, bracket and tongue as shown on drawing 234280 so that when the direction control (lever "C") is positioned to "Lower", the tongue lifts to limit control handle movement to seven degrees. This is equivalent to very slow hoist lowering action.

(b) *Hoist latch stop.* - The "Hoist" indicator rod is arranged with a latch (pc. 215994-1 or 2) and a plunger so that when the indicator moves from "Hoist" to "Danger" (see par. 39) the plunger lifts to prevent moving the control to "Hoist". (The control can be moved however to retract the empty rack, i.e. lower in readiness for another hoist stroke.)

(c) *Latch release.* - The latch plunger is spring mounted in the latch and the plunger is arranged with a pin (pc. 216371-5) positioned under a lever (pc. 216371-3) which is mounted on the "Lower" indicator rod. These parts function to nullify the latch when the direction control is moved to "Lower".

38. *Hoist control interlocks.* - In each control bracket are a solenoid switch and a plunger type solenoid. These are arranged, together with interlock switches on the four shutters of each loading flat and together with a solenoid at the direction control lever (lever "C"), so that the hoist controls and the direction control are interlocked as indicated in the following.

(a) The interlock switch at each handle is a neutral interlock, normally open but closed when the hoist control handle is in neutral. This position releases the solenoid plunger at lever "C" and permits the direction control to be shifted.

(b) The shutter switches are interlock switches for the control handle solenoid plungers. They are normally open. When a shutter is moved, as in parbuckling a projectile into the hoist, the switch is closed and the control is locked at neutral.

This system of interlocks is operated through a circuit designated "QE", shown by diagram on sketch 97317. That circuit includes modification of the controller which has provided two starting circuit solenoid interlocks located in the controller cabinet. These open the circuit at occurence of power failure and block starting the motor until the tilting box and the control handles have been restored to neutral.

39. *Indicator mechanisms.* - The control station indicators are three signal devices: (1) a red signal light, (2) a "ready-to-hoist" gong and (3) a moving three-position sign. The first is a flashing signal operated by a switch at the top of the crosshead casing. It is actuated by the crosshead at the top of an upward moving cylinder piston stroke. The purpose of the signal is to advise the hoistman that projectiles on the rack pawls have moved above the tube pawls and that the top projectile is above the cradle projectile latch.

The gong signal is actuated by the "Hoist" indicator rod of the visual signs, as explained below.

The moving signs are two:- One carries legends "HOIST" and "DANGER", the other, "LOWER". Both signs are mounted in the same bracket, but are separately actuated. "LOWER" is attached to the direction control indicator (lever "C"); "HOIST" - "DANGER" is attached to the indicator retainer, paragraph 20-d, and is positioned by the cradle - when the cradle is open "DANGER" is displayed and when the cradle is closed "HOIST" appears and the gong is tripped. The "hoist-danger" sign has the same cycle of movement when the direction control is set to lower projectiles, but the "LOWER" sign covers "HOIST-DANGER".

MAINTENANCE AND OPERATING INSTRUCTIONS

40. The hoist machines are to be operated and maintained, including periodic exercise, adjustment and lubrication, in accord with the regulations of the Ordnance Manual, the specific instructions below, and instructions as to care of hydraulic mechanisms contained in chapter XV, "Hydraulic Mechanisms, Installation and Maintenance".

41. *Operating precautions.* - Personnel should observe the following instructions when operating the projectile hoists and when preparing for operation.

(*a*) In operating the hoist it is important that the hoistman holds the control handle in "Hoist" position until the full lifting stroke is completed.

(*b*) Before starting the electric motor for the hoist power unit or for the cradle operating system verify that the oil level in the expansion tank of the respective circuit is normal. Replenish with the oil specified in paragraph 42.

(*c*) Before operating the hoist power unit or the cradle operating system under projectile loads run the respective electric motor for approximately ten minutes. The minimum oil temperature for correct performance of either system is 90 degrees F.

(*d*) Before operating the hoist to raise projectiles inspect and check the brake action. Verify the solenoid brake release movement and that the drum is oil-free.

(*e*) Before operating the hoist to raise or lower projectiles check all indicator mechanism and control interlock actions to assure positive signal and lock movements.

(*f*) Before operating the hoist under projectile loads verify adequacy of rack pawl and tube pawl lubrication.

(*g*) *Electric motor direction rotation.* - If either power unit is new, or has been disassembled, or if any lead to either motor or controller has been disconnected, it is imperative to verify the motor direction of rotation before operating. This is particularly important with respect to the cradle operating motor as the two vane type pumps driven by that unit will be damaged if reversed.

(*h*) *Pressure tests.* - Gauge checks should be performed quarterly to verify correct pressures in the pawl operating circuits.

42. *Hydraulic oil.* - The hydraulic oil to be used in both the main system and the cradle operating system is that specified in O.S. 1113. When replacing or when replenishing oil pour through a fine mesh wire strainer of at least 120 wires to the inch. New assemblies should be drained after fifteen hours operation and should then be thoroughly flushed clean and refilled with fresh oil or carefully salvaged oil. Perform test inspection and analysis of oil sample from each system monthly. If there is evidence of sludge, water or acidity, drain, flush and refill with fresh oil. The amount of oil required to fill each cradle operating system (including the powder hoist upper door circuit) is 35 gallons. The system is self venting. The amount of oil required to fill the main hoist system is 25 gallons. This circuit requires venting at the needle valve in the upper cylinder head.

43. *Buffer fluid.* - The liquid to be used in the cradle buffer is recoil cylinder liquid as specified in the latest revision of O.D. 1914.

44. *Lubrication.* - All projectile hoist assemblies must be lubricated with the lubricants and according to the frequencies specified on the lubrication chart.

45. *Exercise checks.* - Exercise each cradle operating assembly including the pawl control mechanisms at least once weekly. The operation must include check of response action to verify normal functioning of all control, indicator and pawl operating devices.

46. *Installation and maintenance.* - When installing, overhauling or servicing the hydraulic units comply with the instructions of chapter XV.

ADJUSTMENTS

47. The hoist assemblies have provision for adjusting the controls, indicators, brake and operating pressures as described in the following paragraphs and references.

48. *Indicator mechanism and upper end control adjustment.* The adjustment of the indicator rope and rods to eliminate slack in the indicator mechanism is vital inasmuch as slack in the assemblage will not give positive control gear interlock. The correct action of both the "HOIST" indicator and the "LOWER" indicator is obtained if the respective ropes are adjusted so that the signs at the control stations move to signal as described in paragraph 39. The hoist latch, the latch release and the safety stop will then have intended actions. These ropes can be adjusted to remove slack at cable adjustments that are located on the hoist and are accessible in the pan floor level (see sk. no. 88878). The positions of the indicators at the lower station are fixed with respect to the upper station and are not adjustable.

When making adjustment of the "HOIST" indicator rope the parts should be adjusted with a projectile in the cradle (cradle folded). This will displace the projectile indicator lever to the position that should synchronize with "DANGER" at the control stations. Adjust the indicator rope to center "DANGER" in the windows. Adjust the indicator retainer, 216369-3, so that it is in position to ride the cam arc on the cradle. This adjustment can be made by repositioning the connecting rod that is between the retainer and the rope yoke or by re-setting adjusting rod 216368-5.

When making adjustment of the direction control indicator, place the direction control at "LOWER PROJECTILES" and position the sign "LOWER" in the windows. Adjust the cable clamp to remove slack.

49. *Cradle operating cylinder piston adjustment.* - Refer figure 44. The cradle operating piston must be coupled to the cradle so that the piston will not "bottom" or cover the starting port. The piston is in correct position when dimension "X", figure 44, equals the following (approx.):-

Outboard hoist, "X" = 1.5 ins.

Center hoist, "X" = 2.135 ins.

50. *Brake adjustment.* - Refer drawing number 231727. The solenoid brake is adjustable as to (1) braking action, (2) brake release action and (3) brake band position.

(a) *Brake action.* - Brake torque value is adjusted by means of spring pressure adjusting screw #55. Turning the spring cage *in* increases the brake holding action. Turning the cage *out* decreases brake action. After adjustment set lock nut #54 tight against yoke #53.

Note: This brake is only intended to hold the A-end and reduction gear worm against overhaul at occurence of power-failure with full hoist load. It is not a motor brake.*

(b) *Brake release.* - The brake release is adjusted by altering the position of eyebolt #34 in yoke #36. The release should permit the band to ride clear of the drum when the band is centered thru adjustment (c). The release movement must permit the solenoid plunger to "bottom"; a "suspended" plunger will cause the solenoid coil to burn out.

(c) *Bcnd position.* - With the brake "off" the band is adjusted to ride clear of the drum by adjusting cap screw #48 to position the band support yoke, piece #27.

51. *Adjustment of main system pressure.* - Main system high pressure is controlled by the adjusted spring loads of the relief valve, figure 49 and the high pressure by-pass valve, figure 50. These valves are adjusted to lift at pressure of 800 pounds per square inch, pressure being checked by test gauge installed at valve plate plugged port "T". Relief valve spring load may be increased by increasing the thickness of washer. By-pass valve spring load is increased by adjusting the set screw inward. If a by-pass valve has been disassembled care must be observed to seat the spring cap bearing as shown when reassembling and adjusting. An incorrectly seated pivot may result in malfunction, damage and high pressure relief at substantially lower pressure than the required pressure. The low pressure by-pass is similarly adjusted to relieve at 50 pounds per square inch.

* The control circuit is arranged so that the hoist can be operated even though a brake solenoid fuse is blown. Under such circumstances the brake will not release, it will not hold the motor nor blow main fuses and burned bands and fire may result.

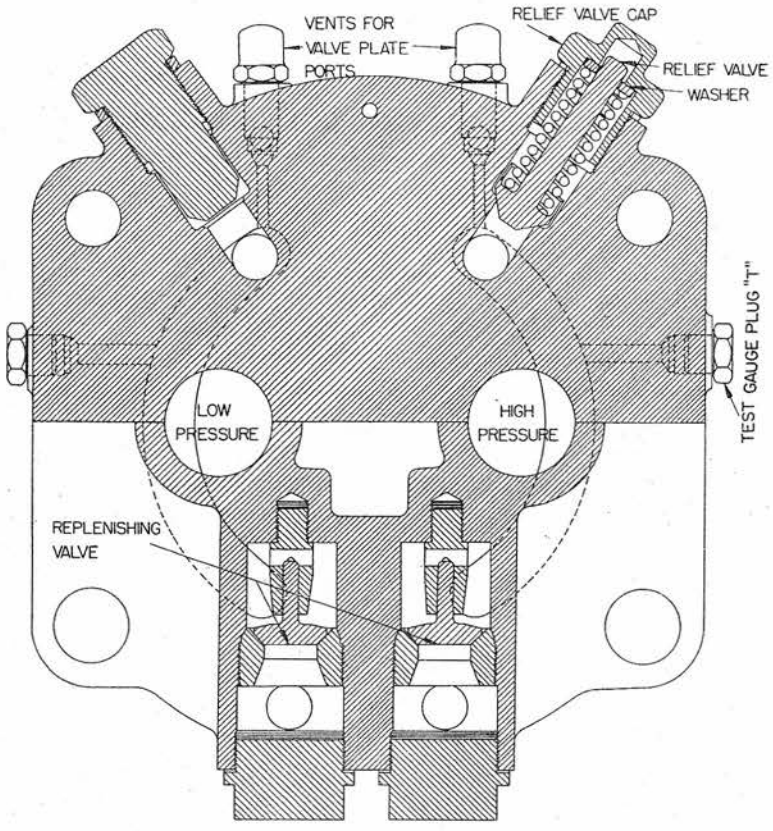

Fig. 49 - Relief and Replenishing Valves

52. *Relief valves, pawl control system, adjustment.* - Two of the three pressure controlling relief valves which are arranged in the control system circuit as described in paragraph 26 must be tested periodically and maintained at the required pressures. These are the 400 pound and 800 pound pressure reliefs. Refer to drawing number 293674.

The design is a differential type in which relief piston action is controlled by adjusting the balancing pressure of a relief valve adjusting screw located under an adjusting screw cap. Attach a test gauge in the plugged hole of the relief valve body.

The 25 pound relief is not adjusted to restrict pressure. Back pressure in the pipe system provides the desired minimum pressure for the system. This back pressure is actually higher than 25 pounds per square inch.

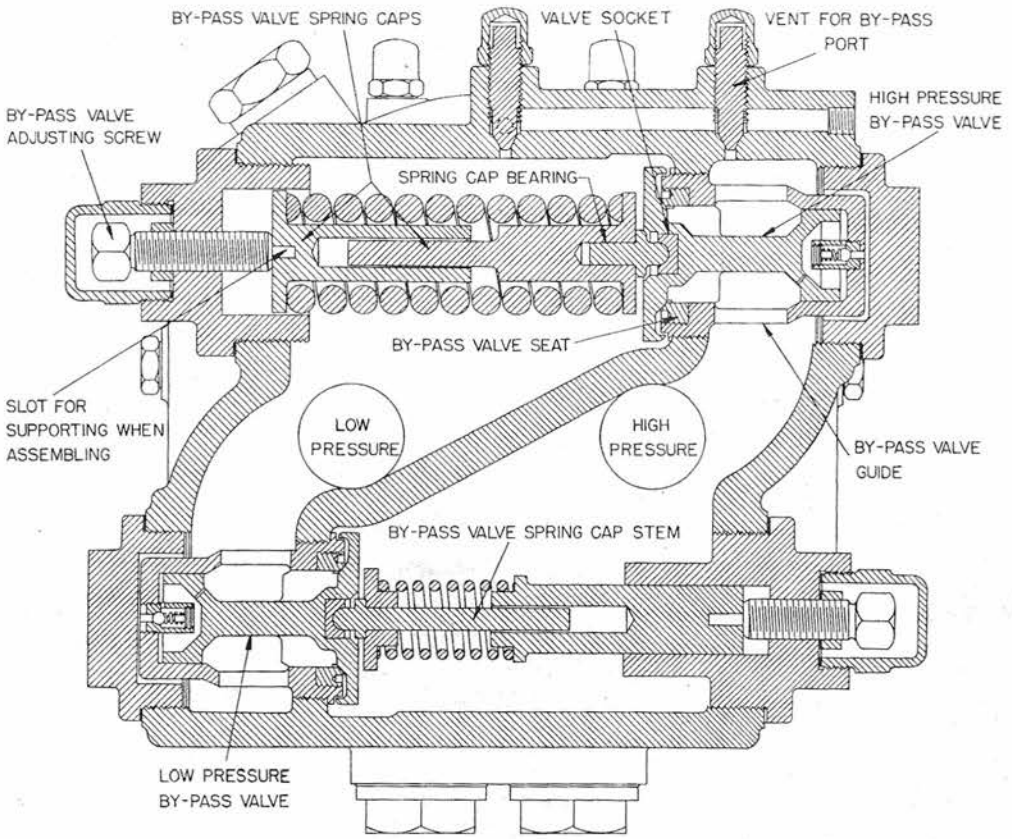

Fig. 50 - By-Pass Valve Adjustment

53. *Tube pawl operating mechanism adjustment.* - Refer to figure 51.

The adjustment shown on figure 51 is located at the upper tube pawl operating lever sliding collar. It is an adjustment that has been found to be extremely important in order to prevent the pawls from "sticking" in retracted position when the hoist is operating to "LOWER PROJECTILES". The adjustment has the effect of slightly reducing the 1.375 inch stroke movement transmitted by the operating piston to the assembled operating rods.

Preliminary to making the adjustment verify the lengths of all operating rods from clevis pin to clevis pin as shown on the details; verify the operating piston stroke. Thereafter the adjustment is made with the pawl unclutched (fully extended into the hoistway), with the piston "bottomed", with pressure in the pawl operating system and with lever "C" (pilot and shut-off valve) set to "HOIST PROJECTILES". Under these conditions there is slight pressure on top of the piston (holding it at "bottom").

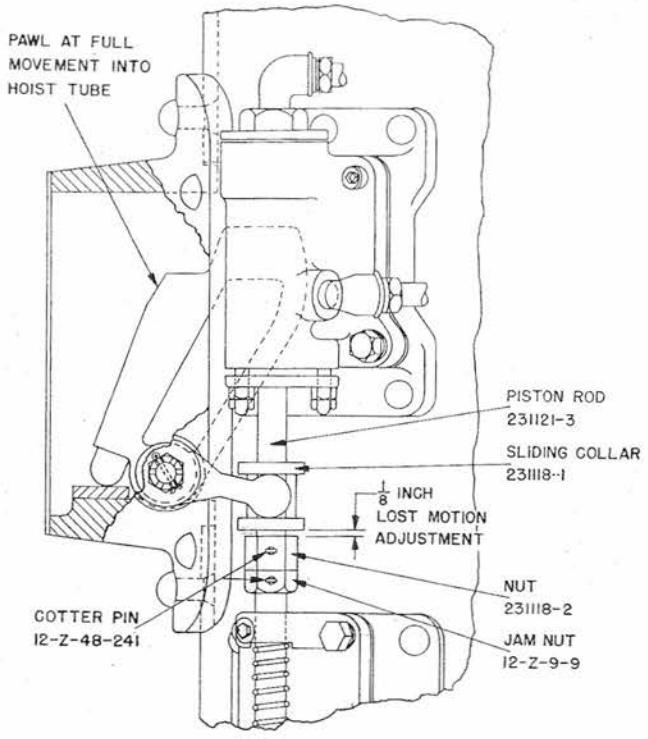

Fig. 51 - Tube Pawl Adjustment

Adjust the jam nut 12-Z-9-9 and nut 231118-2 on rod 231121-3, until there is a gap of 0.125 inch between the sliding collar 231118-1 and the nut; tighten the locking nut, drill both nuts for cotter pin 12-Z-48-241 and set pins.

ASSEMBLY AND DISASSEMBLY

54. Disassembly and reassembly of most elements of the projectile hoists are readily apparent from the general arrangement drawings. The speed gear and the hoist hydraulic cylinder are exceptions, the former is disassembled according to the instructions for the A-end unit as described in chapter VIII. Instructions as to removal of the hydraulic cylinder are given in paragraph 55.

55. *Hydraulic cylinder removal.* - Because of the size, position and arrangement of the hydraulic cylinder, removal is difficult. The following outlined routine will enable removal

without disturbing any of the hoist castings. This operation is prescribed for disassembly of the piston group. The reassembled cylinder can be installed in the reverse procedure.

(a) Disconnect the pipe flange (216383-2) from the upper cylinder head (216381-1, center and left hoists; 216381-2, right hoist) and lower cylinder head (216382-1).

(b) Remove set screw (12-Z-4-112) from piston rod (216380-2) and drive piston pin (216384-2) from crosshead (230700-1, center hoist; 230701-1, right hand or left hand hoists).

(c) Disassemble the four bolts that secure upper cylinder head (216381-1, center and left hoists; 216381-2, right hoist) to the intermediate rack casings (230711-1 and 230719-1, center hoist; 217294-1 or 2 and 217295-1 or 2, right hand and left hand hoists) and remove the two keys (216384-4) from same.

(d) Lower the hydraulic cylinder approximately 30.0 inches so that the upper cylinder head will clear the upper projectile handling platform (230702-1, center hoist; 230723-1 or 2, right hand or left hand hoist).

(e) Tilt the hydraulic cylinder to the side (for center hoist) and to the rear (for right hand and left hand hoists) and remove.

Chapter XII

16-INCH POWDER HOIST, MARK 8 AND MARK 8, MODS. 1-17, INCLUSIVE

General Description

1. The powder hoist assemblies of the title are car type vertical lifts, electro-hydraulically driven, arranged for selective servo or manual control. All are of the same general design, have identical drives and functionally have identical installation of hoistway, car, doors, interlock and control devices. They differ only as to height of lift and as to right, left and center positions of various elements of the respective assemblies.

2. The installations according to ship, mount and position in each are as tabulated below.

Powder Hoist		Emplacement			Vertical Lift*
Mark	Mod.	Ship	Mount	Gun	
8	-	USS NORTH CAROLINA USS WASHINGTON	1	Right	45 ft. 6.75 in.
8	1		1	Center	"
8	2		1	Left	"
8	3		2	Right	53 ft. 6.75 in.
8	4		2	Center	"
8	5		2	Left	"
8	6		3	Right	42 ft. 6.75 in.
8	7		3	Center	"
8	8		3	Left	"
8	9	USS SOUTH DAKOTA USS INDIANA USS MASSACHUSETTS USS ALABAMA	1	Right	46 ft. 2.75 in.
8	10		1	Center	"
8	11		1	Left	"
8	12		2	Right	54 ft. 3.75 in.
8	13		2	Center	"
8	14		2	Left	"
8	15		3	Right	42 ft.11.75 in.
8	16		3	Center	"
8	17		3	Left	"

* From powder handling room floor to horizontal plane of axis of trunnions.

3. The components of each of the above assemblies are: The hoistway trunk, upper and lower doors, upper door operating assembly, the car, car buffers, upper and lower, the electric hydraulic hoisting machine and a system of hoist controls and interlocking devices. Each such assembly is installed within flameproof enclosures, is arranged to serve a single gun and is operated and controlled independent of other hoists. (The hoist delivers powder bags to the open projectile hoist cradle, but it is not interlocked with that unit. The door can be lowered and raised without regard to cradle position.)

4. The descriptions that follow are typical of right, center and left hoists except as noted.

Powder Hoist Trunk

5. The three powder hoist trunks of each turret are enclosed vertical hoistways of rectangular section in plan which curve upward and rearward from the powder handling room to the turret roof. Left and center trunks rise within the left center gun girder box. The right trunk is similarly located within the right center gun girder box. The curving car guides or rails are thus in vertical planes parallel to each other and to vertical planes of their respective gun axes. The arrangements locate the upper end delivery doors to the rear of the respective gun's breech with each adjacent to a projectile hoist cradle. Each door when open provides a shelf across which powder bags roll from the car into the open cradle and tray. The lower end of the trunk at the car loading aperture is provided with two loading trays. These are fixed trough-like trays horizontally placed and spaced 22.5 inches. They are located to align with the car loading trays when the car is in the loading position. The arrangement is shown on drawing number 216495.

6. In addition to the car guide rails the hoist trunk interior assembly includes upper and lower buffers, a hoisting sheave at the top, limit switches in the path of the car at lower and upper car limits of movement, a lower door latch, elements of upper door and lower door interlocking devices, and a car safety latch located at the upper end stations. All of these arrangements provide for car movement control or for securing and releasing the doors or car with respect to car position. Many have mechanical or electrical connection with each other or with devices outside of the trunk. Details of their assembly and function are described in the text below in connection with the units with which they operate.

The Trunk Lower Door

7. The powder handling room car loading aperture in the trunk is fitted with a vertically sliding, manually operated, balanced door. The assembly is shown on general arrangement drawing number 216493. The principal components are the door, the door operating gear, the door latch assembly and the door stops.

8. The door is a flat plate aluminum casting, rectangular in shape and weighing approximately 111 pounds. It is arranged to slide in vertical ways located at each side of the trunk opening. It is operated by a system of lifting and downhaul wire ropes and sheaves which are connected to a housed, cylindrical counterweight. The counterweight is provided with an operating handle. Door opening movement is limited by two stops located on the inner trunk face above the doorway.

9. The door latch assembly is a mechanical latch located at the inside of the door sill and spring actuated to latch when the door is closed. It is arranged with a car actuated unlatching lever located inside of the hoist trunk. This lever projects into the path of a cam bracket on the forward side of the powder car. Cam and lever function to unlatch the door when the car descends. The unlatching movement occurs during the final 2.75 inches of car descent. See drawing number 216493.

10. In addition to the preceding details of the lower door assembly elements of three interlocking devices are located adjacent to the door. These function to block hoist operation when the door is open. One is an electric switch, designated No. 4 on the diagrams of plates 7 to 14. It operates in servo-electrical control only (see pars.37-55) to open the hoist control circuit and de-energize an operating valve solenoid in the A-end assembly whenever the door is open.

Another of the devices is also an electric switch, designated "A" on figure 53 and functioning in all methods of hoist control as a door interlock. See description of starting lever interlock, paragraph 32.

The third interlock device* is a bell-crank above the door. This, through an attached rope, rod and lever mechanism, which extends to the upper end, operates to lock the hoist control lever at neutral (see "Control Lever Interlock," par. 30). Neither of these interlocks affects lower door opening or closing, the door being latched and unlatched only as indicated in paragraph 9.

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* Not installed initially.

The Trunk Upper Door

11. The trunk unloading aperture in the gun compartment is fitted with a door hinged at the doorway sill. It opens outward and down to form a transfer tray between the car and the open projectile hoist cradle. The assembly as shown on general arrangement drawings number 216459 and 216458 includes the door, the door locking dogs, the door operating mechanisms, and two selective mechanisms for operating the door locking dogs.

12. The door is a rectangular panel of cast aluminum. It has integral hinge lugs on its lower edge and the periphery of its inner face is fitted with an asbestos-metal-cloth-rubber gasket which is secured by an aluminum retaining strip. The outer face is fitted at seven points with bronze dog wedges. An operating cylinder bearing located in offset position on the outer face provides attachment for the piston rod of a hydraulic door operating cylinder mechanism. A bronze door frame riveted in the trunk door aperture provides hinge butts and contact flange for the door hinge pins and door gasket respectively.

13. The door locking arrangement comprises seven swinging dogs which are simultaneously operated to lock or unlock by a system of transmission rods. These are actuated by a toggle and yoke linkage which is normally operated by a hydraulic cylinder piston, but which may be alternatively operated by an emergency hand crank mechanism. These devices are shown on general arrangement drawing number 216459. Both dog locking operating mechanisms are attachable to the toggle linkage by a removable coupling pin. And both the piston and the hand operated gear link are arranged to be secured in stowed positions when either is uncoupled.

14. The main toggle link of the dog locking toggle linkage is provided with a latch lug. This lug engages a spring loaded hook of an interlock hook and arm lever when the dogs are in closed position. The arm of this lever projects into the path of the car and is actuated to release the hook (and the toggle linkage) when the ascending car is 2.5 inches from its upper unloading position. The interlock hook and arm lever when moving to unlatch the dog linkage operates an interlock switch, designated "C" on figure 53. This is a normally closed switch which when open de-energizes an interlock solenoid to prevent starting the hoist. See description paragraph 32.

15. The hydraulic control valve arrangements which control operation of the door and dog locking power operated mech-

anisms are incorporated in two valves and the port arrangements of the two operating cylinders. The valves are the manually operated door and dog operating valve, and, a door actuated quick opening valve. The manner in which these valves and the cylinder ports admit and port pressure in correct sequence for unlocking, opening, closing and locking the door, is shown on the diagram of the hydraulic circuit, figure 52.

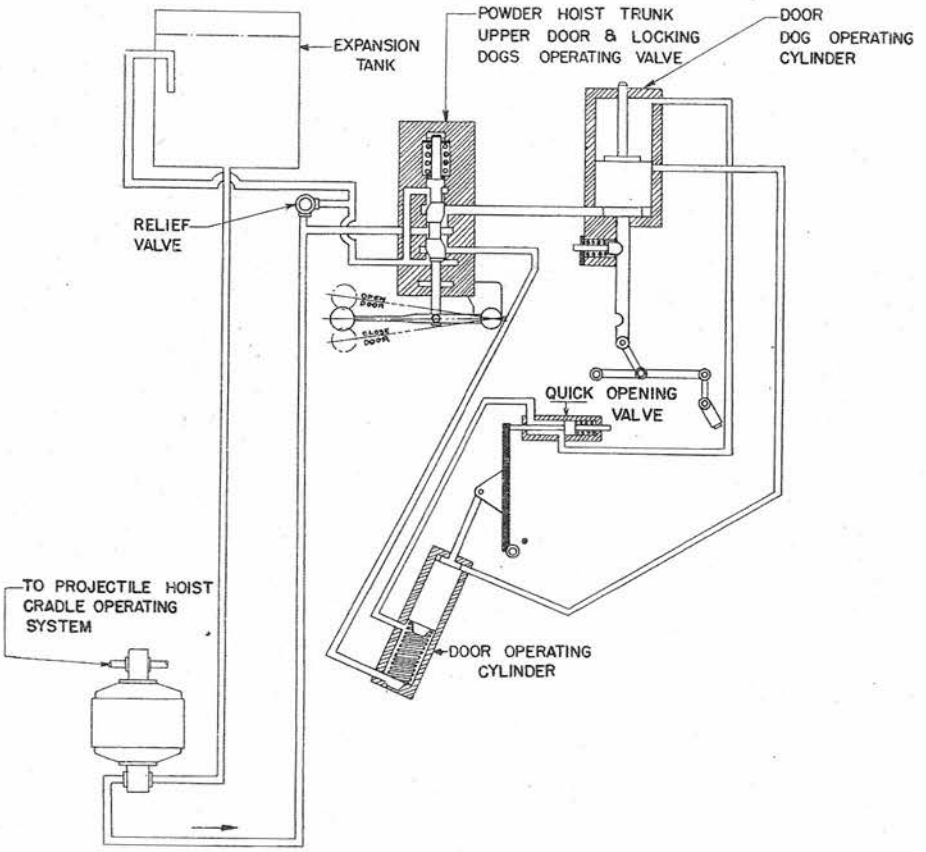

Fig. 52 - Powder Hoist Upper Door Operating System

16. In addition to the preceding described details of the upper door assembly, it is arranged with a hoist starting lever starting circuit switch which has similar arrangement and operation to the "No. 4" switch described in paragraph 10. The upper door switch is designated No. 5. It is in series with switches No. 4 (lower door) and No. 6 (starting lever) and renders the hoist control inoperable except when the door is closed or the car is at the upper unloading position. Refer to control circuit description, paragraphs 49-69 for interlocking performance of this switch.

Powder Car

17. The powder car is an assembly of a large box-shaped aluminum casting with two tiltable trays, four guide-wheels, a safety brake mechanism,* a cam bracket, safety latch stops, a switch operating bar, an upper door interlock trip and other attached devices. The car is closed at top, bottom, rear and sides. In the open front the two powder bag trays are horizontally pivoted with axes spaced 22.5 inches. Both trays have limited tilt against rubber pad stops; each is separately operated to tilt from normal position by a hand lever on one side which has detent arrangement to latch in normal or hoisting position. Completely assembled and installed in the hoist the unit weighs 1715 pounds (without service load). The design arrangements are shown on drawing number 216452.

18. The guide wheels are bracket mounted at the four rear corners of the car. The two upper and the rear lower brackets are fixed; the forward lower is pivoted and spring loaded to compress its wheel against the guide rail, its movement however is limited to approximately one-half inch.

19. The safety brake mechanism* comprises two pair of serrated arc shaped rail grabs pivoted in brackets which are located on each side at the top of the car. These grabs straddle the respective rails and are held clear as long as the car hoisting rope tension is maintained under load equivalent to approximately one-half of the weight of the car. The arrangement that accomplishes this function is a spring loaded toggle linkage, operating levers, operating bars and a rope guide block assembled at the top of the car with springs and other elements. The guide block at the center is interposed between two of the operating levers in such manner that when the rope fails the block will free the levers. The latter under spring load will than move together and will simultaneously free both pair of rail grabs. The arrangements of this car subassembly are shown on drawings number 216452, 216472 and 216475.

20. The safety latch stops are steel blocks bolted to the sides of the car at the front and arranged in pairs, two at the bottom and two 22.5 inches above. They are positioned for emergency support of the car at upper and lower unloading positions respectively when the safety latches move beneath them as the car approaches those stations.

21. The two vertical front edges of the car are cam surfaces** which function to displace the two safety latches as the ascending car approaches the upper end of the trunk. These

* Safety brakes have been removed.

** These cam surfaces have been extended upward by two weldments which are attached to the top of the car (Ordalt 1099).

safety latches are spring loaded pawls which are mounted on the inner face of the hoist trunk and have free movement on their respective shaft bearings. They are retractable (to permit the car to descend) through hydraulic control circuit arrangements described in paragraphs 49 to 69. An alternative foot pedal mechanism for retraction of the latches in emergency (power failure) is located as shown on drawing number 233133. The latch position in the trunk is shown on general arrangement drawing number 216459.

22. The cam bracket location on the car and its functional purpose is described in paragraph 9.

23. The upper door dog interlock trip pawl is located on the rear side of the car at the top. (See dr. no. 216452.) It functions to unlatch the hook described in paragraph 14.

24. The switch operating bar is located on the forward side of the car. It is a vertically positioned subassembly which includes two adjustable trip brackets. These are limit switch actuating elements which have fixed position (after adjustment) and operate together with limit switches at top and bottom to control the stopping positions (servo control) of the car at loading and upper and lower unloading positions. Their adjustment for correct cam lever contact (which throws the limit switches) is as shown on drawings number 233136 and 233137. The control performance provided is described in paragraphs 49-69 (refer switches 7, 8 and 9).

25. A trip cam (234051-13 or 14) on the rear side of the car is one of the actuating elements of the lower door, car and control lever mechanical interlock. See description of the "Control Lever Interlock," paragraphs 30 and 31.

Hoist Rope

26. The car is raised from the loading station to the upper unloading station by means of a five-eighths inch diameter wire rope, a sheave under the turret top plate, and a hoist drum driven by a hydraulic transmission and electric motor. The car is lowered by gravity (there is no downhaul). From the single sheave (a 15-inch diameter wheel) the rope extends forward to the hoist machine through a hollow bronze rope guard. This guard is mounted in the front plate of the hoist trunk. The hoist machine is located next to the hoist trunk within the box gun girder.

Car Buffers

27. At top and bottom of the hoist trunk an installation of car buffers provides emergency stopping devices to deceler-

ate and stop the car. When the hoist assembly is correctly adjusted and when operation is normal the car is stopped by the controls before striking the buffers.

28. The lower buffer is an assembly of two identical spring and hydraulic buffers. These are mounted at the bottom of the trunk with a sealed expansion chamber midway between them and with pipes connecting the cylinder of each buffer to the common reservoir of the expansion chamber. The design and arrangement is shown on drawing number 216457. The installation is so placed that the car, when at the loading station, (its automatic stopping position) is one-half inch above the buffers. The equipment permits a maximum buffing stroke of 5.75 inches.

29. The upper buffer is an arrangement of four rubber pads located immediately below the hoist sheave and attached to the rear plate of the hoist trunk. The design is shown on drawing number 216456. Clearance between the pads and the top of the car when the car is in its automatic stopping position at the upper unloading station is one and one quarter inches.

Control Lever Interlock

30. A mechanical interlock* arranged as shown on drawing number 237938 operates to lock the control lever under certain conditions and under other conditions restrains the lock element. Thus when the lower door is open the lever is locked in its neutral position. But when the ascending car arrives at the upper end and the control lever is returned to neutral the lock detent is prevented from locking the lever. These movements of the interlock are caused in the first instance by a system of levers, rope, sheaves and rods which are actuated by the lower door, and in the second instance by a trip lever linkage actuated by a trip cam on the rear side of the car. The latter action by making the lock detent inoperative, permits operation of the car from upper unloading to lower unloading and loading positions.

31. The lock elements which thus block the control lever (when the lower door is open) and which restrain the lock (when the car is at the upper end) are:-

A detent retaining disk which rotates with the control lever movement and at neutral aligns a socket with a *detent and plunger*.

An *operating lever* which has three lever arms radiating from a central pivot and has one arm

* Not installed initially. To be added later by Ordalt.

engaged with the detent, one arm coupled to a spring plunger coupling and the third arm positioned in the path of movement of

A cam lever. This lever is actuated by the rope and rod linkage that extends to the lower door.

A *translating arm* which has the same pivot axis as the operating lever. It has connection to the operating lever through the spring plunger coupling, and has bearing at the end of its arm on a roller mounted on one of the door locking dog linkage pins.

A *slide detent* which is actuated to move in the way of the third arm (see above) of the operating lever. This movement is caused by the car trip cam and the trip lever linkage. It is the upper end action that restrains the detent from locking the control lever in neutral.

32. *Starting lever interlock.* - An electrical interlock system that is entirely independent of the preceding described mechanical interlock and the system of "servo-electrical" control interlock (pars.49-69) is arranged to lock the starting lever (par. 33). The system as shown by figure 53 operates for all methods of hoist operation. It includes the following electrical elements shown on the figure.

Starting lever solenoid "B". - The plunger of this solenoid locks the lever at neutral under the circuit operating arrangements which actuate the three switches described below.

Lower door switch "A". This is a normally closed switch which opens whenever the lower door is undogged (which can only occur when the car is at the loading station). When the circuit is thus open solenoid "B" is de-energized and the starting lever is locked.

Upper door dog locking interlock switch "C". - This is also a normally closed switch. It is operated to open the starting lever interlock circuit when arrival of the car trips the dog locking latch lug. Refer paragraph 14. Sole-

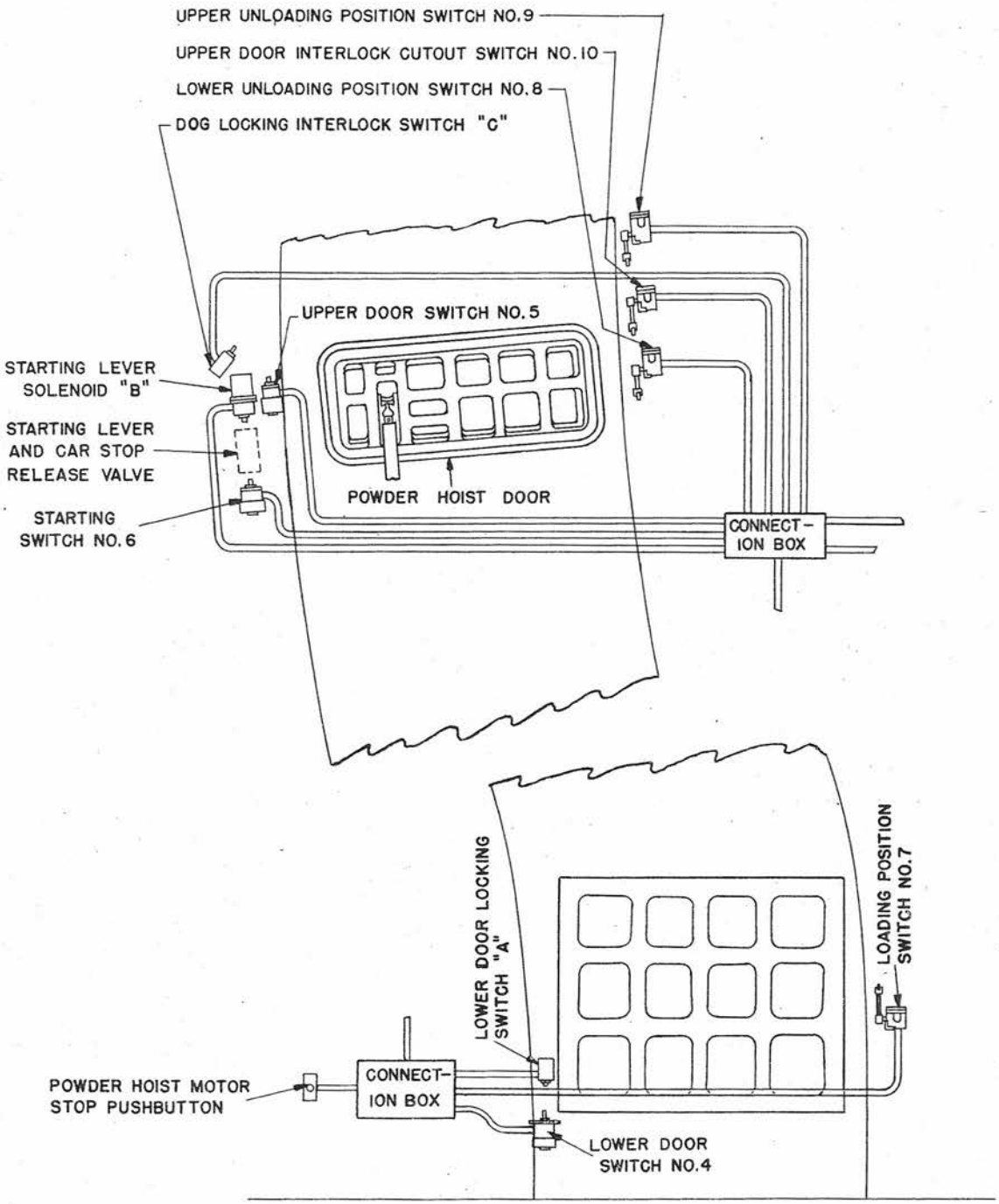

Fig. 53 - Powder Hoist Interlock System.
Diagram of Circuit "QC".

noid "B" however is not de-energized by the opening of this switch due to the circuit arrangement of switch #10.

Switch #10. - This switch functions as a "cut-out" switch for the starting lever interlock circuit. It is a normally open switch which is closed by the car while the car is at the upper unloading station. Thus as switch "C" opens, switch #10 is closed and the solenoid plunger does not move to lock the lever.

The "cut-out" thus permits operation of the car from the upper unloading station to the lower unloading station with the door open. It prevents starting the hoist to move the car away from the lower unloading station until the door is closed and dogged.

Note: The preceding circuit (designated "QC") comprises only the four units described. It has no mechanical, electrical or functional interconnection with the circuit that embraces switches numbers 4, 5, 6, 7, 8, 9 and solenoid #1.

Hoist Controls

33. The hoist control arrangements located at the hoist operator's station (at the upper end immediately in the rear of the trunk) include an installation of three levers. These are designated the starting lever, the control lever, and the selector control lever. Their general arrangements mechanically are as indicated in the subparagraphs below and as shown on drawings number 230762, 233133, 234060, 234062, right hoist, and 233134, 233135, 234063, left and center hoists. Full details as to their control functions are described in the text on the power unit, paragraphs 49 to 69 inclusive.

(a) *Starting lever.* - The starting lever is bracket mounted on the rear of the trunk rear plate. It is connected to operate a safety release valve and one of a series of starting circuit switches (designated #6). It is interlocked with the lower door and the upper door dog locking latch through a solenoid operated detent. The circuit in which this solenoid is arranged with switches at the lower door and at

the dog locking latch (upper door) is the interlock system described in paragraph 32.

(b) *Control lever.* - The control lever is bracket mounted adjacent to the starting lever. It is interlocked as described in paragraphs 30 and 31 and is arranged with a quadrant designating three position movement:- to "Hoist," to "Lower," and "Stop." It is keyed to shafting and levers extending forward to the A-end tilting plate controls and to the B-end control cams.

(c) *Selector control lever.* - This hand lever is located below the starting and control levers. It is arranged so that it can be positively held (by pin) in either of its selective positions. (Designated, "Servo Electrical" and "Servo Mechanical and Manual.") The shaft to which it is keyed extends forward to the hoist machine and is provided with lever linkage connected to a brake release valve, a venting valve and a control lever shaft latch.

Through these control levers and other arrangements in the A-end, the hoist has three selective types of control. These are designated, "Servo Electrical," "Servo Mechanical" and "Manual." The first and second control the A-end displacement through power operation (servo pressure) of the pump yoke. The third method is without control pump pressure and manually positions the pump yoke. All methods are described in the circuit descriptions, paragraphs 49 to 69. Manual control is an emergency selection. It should not be used for extended periods, and then only at reduced speed, because of operating limitations as explained in paragraphs 64, 65 and 75.

ELECTRIC HYDRAULIC DRIVE

34. Each hoist machine is an electric hydraulic drive which includes the following principal parts.

Electric motor
Hydraulic pump (A-end)
A-end valve block assembly
Hydraulic pump, auxiliary
Hydraulic motor (B-end)
Hoist drum
Drum brake assembly
Limit stop cam mechanism
Latch and vent valve
Safety latch operating cylinder
Limit switch assembly

Starting circuit electrical interlock
Control lever dashpot
Safety latch release valve
Oil filters
Motor-starting interlock

35. The installed arrangement of each such power plant (but not those elements located in the hoist trunk and at the operator's station) is as shown on drawings number 216453, 216454, for the right and center hoists, and drawings number 230757 and 230758, for the left hoist. In these assemblies the electric motor is mounted with its rotor shaft vertical and direct coupled to the A-end pump. The auxiliary pump is driven through a reduction gear by the motor. Both pumps are supplied from the same tank. Leads connect the main pump with the hydraulic motor (B-end) and elements of the A-end valve block. The auxiliary pump is arranged in a system of leads so that it replenishes the A-end supply, provides control circuit pressure to the brake operating cylinder, the safety latch release valve and operating cylinder, the latch and vent valve, and elements of the A-end valve block. The control lever dashpot is a closed hydraulic element that is independent (hydraulically) of the main and control circuits.

36. The purpose of the preceding indicated arrangement is to provide hydraulic power for hoisting and lowering the car and for controlling those movements in conjunction with an interlocking system for the trunk doors. The arrangements include devices to limit the rates of acceleration and deceleration of the car and other provision to prevent falling of the car in event of power failure or of rupture of pipe lines. These and other features of the drive are provided by the following design arrangements.

(a) The electric hydraulic drive is designed to be normally controlled by a "Servo" system. This system controls the offset of the A-end pump with pressure operated piston. Pressure is derived from a control and supercharging pump located in the top of the A-end. This auxiliary functions for two methods of "Servo" operation, designated SERVO ELECTRICAL and SERVO MECHANICAL. Normal operation of the drive is through "Servo Electrical" control.

(b) *Servo electrical control* is a system utilizing car limit switches, door actuated switches and a starting lever switch to open and close a circuit which shifts an operating valve of the hydraulic system to initiate servo piston stroke. Car acceleration, high speed and de-

celeration, in this method of control, are controlled by an arrangement of cams located in the B-end assembly.

(c) *Servo mechanical control* is a system in which all switches are inoperative and the operating valve (which is solenoid actuated in servo electrical) is manually shifted to initiate servo piston stroke. Car acceleration, high speed and deceleration are controlled by the same B-end cams as in servo electrical control but stopping is controlled by a latch and vent valve. This method of control is selected by shifting the "Selector Control Lever," paragraph 33-c, to position designated "Servo Mechanical and Manual."

(d) The powder car may be started or stopped at any time during the cycle, by the manipulation of the control lever, paragraph 33-b. The acceleration and deceleration rates are limited to less than 16 ft. per sec. per sec. by the dashpot cylinder attached to the operator's control shaft. This device prevents rapid shifting of the pump yoke. The hoisting deceleration and the lowering acceleration rates are limited by the cams in the B-end to a value of less than 16 ft. per sec. per sec.

(e) *Manual control.* - In event that the control pump circuit becomes inoperative, means have been provided to permit control of the unit manually. This phase of operation is designated as the "Manual Mechanical" control. The controls are set for "Manual Mechanical" operation by moving the control selector lever to the "Mechanical" position, and shifting a control pump by-pass valve and servo valve locking lever to the "Manual" position. When operating in this control, the pump yoke is shifted off its center position by manual effort, which requires greatly increased effort at the control lever as compared to the effort required with servo. Furthermore, in as much as the main circuit lines are not supercharged, cavitation will occur with resultant noise and vibration in the equipment. Also the stopping variation at the loading and unloading stations is greatly increased. In order to obtain as accurate stopping as possible, and to obtain the least amount of noise and vibration for

continuous operation, it is necessary to operate the equipment at a much slower speed, than when using "Servo Electrical" or "Servo Mechanical" control.

In order to train the crew in this method of operation, a control pump by-pass valve has been provided. This permits the control pump to be by-passed to the tank to simulate a control pump failure.

Shifting to "Manual" is accomplished by moving the control selector lever to the "Mechanical Control" position and then the control pump by-pass valve and servo valve locking device lever to the "Manual" position. See further reference in the description of the control circuit.

(*f*) *Power failure.* - Means have been provided to apply brake and stop the hoist regardless of the position of the control levers, if power fails.

Detail Description of Power Units

37. Mechanical arrangements and specification data for the power units which provide the above indicated operation and control are as described below, paragraphs 38-48.

38. *Electric motor.* - The electric motor is a power unit of commercial design and manufacture (Louis Allis Co.). It is a vertical shaft type with downward output centered in a flange mounting pad located on top of the box gun girder immediately over the A-end shaft. The two shafts are coupled with a short connecting shaft and two flexible couplings (Fast type). Motor specification and performance data are as follows.

Motor Data

Type: - - - - -	Squirrel cage induction; 440 volts, 60 cycle, 3 phase; vertical mounting; fan-cooled; waterproof enclosure.
Horsepower- - - - - - - - -	-75 (overload rating 135)
Speed -	Constant
R.P.M., full load - - - - - - - - - - - - - - - -	-1760
Amperes, full load- - - - - - - - - - - - - - - -	90
Weight, pounds- - - - - - - - - - - - - - - - -	-1525
Lubrication - - - - - - - - - - - - - - - -	Grease cups
Manufacturer's type designation - - - - - -	RX-505-C
General arrangement drawing - - - - - - - -	231701

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39. *Controller.* - The controller is an across-the-line, magnetic motor starter of shockproof design, semiautomatic operation, waterproof enclosure, arranged with an externally operated door interlock disconnect switch. It is an assembly of commercially manufactured parts (Ward Leonard Elec. Co.), providing control and protection for the above described motor. The cabinet units for each hoist are mounted in the machinery space of the upper projectile flat. Their starting circuit push-button stations are located at the upper end of the hoist at the hoist operator's station. Each circuit includes a "Stop" push button at the lower end door operator's station. These arrangements and other details of the controller are shown on the diagram and data of drawing number 231703. The protective features there indicated comprise undervoltage, short circuit and overload devices of the following types.

(a) *Short circuit protection.* - Adjustable automatic trip circuit breaker which operates to open the motor supply at settings between 1100 to 1200 amperes.

(b) *Undervoltage protection.* - A contactor drop-out arrangement which functions at potentials of 110 volts or less; sealing voltage approximately 360.

(c) *Overload protection.* - The motor overload protection is of the inverse time limit thermal type with magnetic reset mechanism actuated by closing the starting circuit. Starting overload is prevented by arrangement of the starting circuit to include an interlock switch (#13 on pls. 7-14) in the A-end. This is only closed when the pump yoke is at neutral.

40. The controller is arranged with a "power-on" circuit connected to a solenoid of the A-end control. This circuit is closed when the main line contactors are closed and when this circuit is closed the solenoid (#28 on pls. 7-14) is energized to position a "power-failure" valve of the control system. See references in the circuit description.

41. *A-end assembly.* - The A-end assembly of the power plant (dr. no. 274247) is a unit of commercial design and manufacture (Vicker's). It operates to provide pressure oil to drive and control the B-end and its coupled hoist drum (also of Vicker's manufacture). The unit includes a variable delivery, seven cylinder, piston type of pump, which is mounted in a steel housing. On the top of this housing is located a train of gears and a mounting face for the control and supercharging pump. The centering spring assemblies, which return

the variable delivery pump to a position slightly offset towards the hoisting position, are located on the top of the pump housing. A limit switch is also mounted on the upper housing, to prevent the starting of the electric motor, unless the pump has been returned to its centered position. The splined input shaft of the pump is at the top of the pump housing and is arranged with connecting shaft coupling to the motor as described above. Other elements of the A-end are as indicated in the subparagraphs below.

(*a*) Mounted on the side of the upper housing is the valve block and control levers. This is a subassembly which consists of a "Servo Controlled" pump yoke operating piston, and solenoid and lever operated valves for controlling the various phases of the cycle. The piston is linked to the pump yoke, so as to provide means for offsetting the pump yoke either by "Servo" power, or by a direct mechanical connection to the operator's control lever.

(*b*) The pump housing is assembled to a welded steel galvanized storage tank for oil. Access to the tank is through openings, covered by removable inspection plates mounted on the ends of the tank.

(*c*) Mounted on the side of the storage tank is found the oil filter assembly. This consists of two filter units mounted in removable containers. A valve is also in the assembly, which when in its centered position allows control pressure oil to be pumped through both filters. When the lever is turned either to the right or left, one of the filters is cut out of the circuit. Filters may be removed for cleaning without interfering with the normal operation of the hoist.

(*d*) The storage tank provides the mounting feet through which bolts are used for securing the unit in the turret. A drain plug is located on the end of the tank to provide for draining the A-end. The oil filler cap is located on the side of the steel housing and oil level pet cocks are provided for determining the correct oil level.

(*e*) The complete assembly of the A-end is such that it can be dismantled in order that its component parts may be passed through an

18 by 24 inch hatch. The dismantling procedure is described in the disassembly instructions at the end of this chapter.

(*f*) Right and left hand A-end units are identical except different control levers are assembled to the control shafts.

42. *B-end assembly.* - The B-end assembly includes a nine cylinder constant volume hydraulic motor, a hoisting drum, a drum brake and a cam and cam housing unit. This group of parts and their arrangement is shown on drawing number 274249. The unit is located above its associated A-end, adjacent to the electric motor and mounted on the same plate as the motor. Two large hydraulic leads connect the like valve plate ports of the A and B-ends. The assembly has design features and details of mechanical arrangement as described in the following subparagraphs.

(*a*) The rotating parts of the hydraulic motor are mounted in steel housings, which in turn are mounted on a welded steel base, which forms the mounting feet for the complete assembly. The rotating parts of the hydraulic motor consist of an output shaft, pistons and rods, a cylinder block, and universal link assembly. The steel pistons oscillate in the bronze cylinder block and the universal link assembly maintains a correct relationship between the output shaft and the cylinder block. The cylinder block rotates in contact with a hardened steel valve plate through which pressure oil is supplied to drive the pistons. The cylinder block is held in contact with the valve plate by the action of a spring and also by oil pressure.

(*b*) In the hydraulic motor head are located the main circuit relief valves and a check valve. The latter functions to prevent excessive pressure build up at the start of the lowering cycle.

(*c*) Mounted on the output shaft of the hydraulic motor is the hoisting drum, and the brake drum. The cable from the powder car is secured to the hoisting drum by cable clips. Built into the brake drum and hoisting drum is a mechanical ratchet, which permits overrun of the hoisting drum in instances of power failure during a hoisting cycle.

(d) On the end of the output shaft is located the steel cam housing. This provides a mounting for the outboard bearing of the output shaft. It includes reduction gearing which drives a cam support assembly. This cam support is geared to the output shaft so that it turns less than one revolution for a flight of 53 feet of the hoist. There are four cams which are secured to the cam support and they control the hoisting and lowering, acceleration and deceleration rates. These cams are adjustable for positioning the flight, and also for controlling the length of the flight.

(e) At the lower end of the cam housing are located a rocker arm and shaft unit which transmits motion limited by the cams, to the control rod to the A-end. This motion is in turn transmitted to the A-end through the control linkage, and limits the amount that the pump may be offset. This determines the maximum speed of the hoist. Access to the cams and gears is obtained by removing the large steel inspection cover on the face of the cam housing.

(f) The brake operating linkage is secured to the welded steel base, and consists of a pressure operated cylinder, links and levers to release the brake band. The brake is applied by venting the brake cylinder, which allows the spring in the brake cylinder to move the piston and linkage to tighten the brake band. When the brake is released, the steel band is forced out to rest against five adjustable stops, which hold the band away from the brake drum, to prevent excessive wear.

(g) A foot valve assembly is mounted on the inlet flange face of the hydraulic motor. The control linkage for the foot valve is mounted on the base plate. The foot valve functions to prevent the car from lowering at the start of a cycle, while the brake is released and the main circuit pressure is building up sufficiently to support the load. Also when stopping, after the main circuit is vented, the foot valve holds the load until the brake has had time to apply. The foot valve functions only at beginning and the end of the cycle, as its control linkage is mechanically connected

to the linkage which controls the offsetting of the pump. As the pump is moved away from its center position, the foot valve linkage opens a valve which by-passes the foot valve. During a hoisting cycle the foot valve is by-passed through a check valve, as well as the by-pass valve.

(*h*) The B-end assembly consists of exactly the same component parts for both right and left hand installations, but the parts are assembled differently to make up the desired unit. Method of changing from one hand to the other is outlined in the disassembly instructions at the end of this chapter, see subtitle "Change of drive to opposite hand."

43. This A-end B-end power transmission assembly and its control circuit operates at speeds and pressures according to the following tabulation of data.

Oil specification	O.S. 1113
Total oil volume in system	32 gals.
Relief valve settings:-	
Control circuit	160 P.S.I.
Main circuit	2100 P.S.I.
Normal operating pressures:-	
Hoisting	1400 P.S.I.
Lowering	1000 P.S.I.
Accelerating pressures:-	
Hoisting	1900 P.S.I.
Lowering	1500 P.S.I.
Decelerating pressures:-	
Hoisting	1000 P.S.I.
Lowering	1900 P.S.I.
Idling pressures:-	
Control circuit	40 to 45 P.S.I.
Main circuit*	20 to 25 P.S.I.
Drum speed:-	
Hoisting	168 R.P.M.
Lowering	178 R.P.M.
Normal B-end torque (1275 P.S.I.)	2400 lb.ft.
Flight length adjustable limits	35 to 56.5 ft.
Cycle time (longest hoist):-	
Servo electrical control**	12.5 sec.
Manual, hoisting	15 sec.
Manual, lowering	12 sec.

* When control is neutral the pump yoke is slightly offset toward hoisting.

** Speed will decrease with oil temperature increase above 120° F.; however, maximum time should not exceed 18 seconds.

44. *Safety car stop release valve.* - Located at the hoist operator's station is a small separate assembly, which functions to start the cycle, and to withdraw the safety car stop device from the path of the powder car. It is connected to the rest of the equipment by copper tubing. The assembly consists of a steel valve in a cast bronze housing. The valve is linked to a starting handle, assembled to a cover on the body. At the other end of the body is located a bracket, to which is secured an electrical switch. When the starting handle is moved to the "Start" position, the valve is shifted and in turn closes the switch to start the cycle. The valve is spring operated to return to the "Stop" position, when the starting handle is released. Drawing number 274260 shows the arrangement of this valve unit.

45. *Latch and vent valve.* - The latch and vent valve functions only during a "Mechanical" controlled cycle. It is connected to the control selector linkage. The latch is mechanically held out of the notch on the cam when the controls are set for "Servo Electrical" operation. The assembly consists of a steel valve in a cast bronze housing. The valve is pressure operated to withdraw the latch and is spring and pressure operated to return the latch. The valve is used to vent the main circuit during a "Mechanical" controlled cycle, and also allows the brake to apply. The latch is used to prevent the moving of the operator's control lever, until the starting valve is moved to the "Start" position. This prevents the powder car being lowered inadvertently on to the safety car stop device. Drawing number 274263 shows the arrangement of this unit which is located forward, adjacent to the A-end.

46. *Safety car stop device.* - The safety car stop device consists of a steel housing and a steel plunger with oil seals. This plunger is attached to a lever, which is assembled to the control shaft and linkage. The unit operates a pair of safety car stop device latches which are mounted on free bearings in the trunk below the upper door. The latch is in the path of the powder car, when the car is at either the upper or lower unloading station. The latch is withdrawn hydraulically when the starting handle is moved to the "Start" position, but after the car has moved a few inches, the starting handle is released, and the latch is spring operated to return into the path of the powder car. This latch prevents the powder car from falling from either unloading station in event of cable breakage. Drawing number 274258 shows the design of this hydraulic device.

47. *Control linkage.* - Drawing number 274251 shows the control linkage elements that are located forward of the hoist trunk and provide interconnection between the A-end controls and the control lever control shaft. The linkage consists of a steel bracket and shaft, to which are secured levers and

adjustable control rods. Needle bearings are used at all moving parts to eliminate friction and lost motion. This linkage connects the cam rocker arms in the B-end to the "Hoist and Lower" operating lever at the A-end. The linkage transmits the motion of the cams in the B-end to the A-end pump yoke, to limit the acceleration and deceleration rates of the hoist.

48. *Dashpot.* - The dashpot (dr. no. 274265) consists of cast bronze body, into which are assembled steel valves and a piston. The assembly is mounted on a gun girder, forward of the hoist trunk, near the A-end and by means of a clevis on the end of the piston it is attached to the hoist and lower control shaft. This valve functions, during mid cycle, to prevent rapid shifting of the operator's hoist and lower control lever. The valve is adjustable and is to be set to permit movement of the operator's control lever to give acceleration and deceleration rates of the hoist not to exceed 16 feet per second per second, nor less than the rates which are determined by the cams in the B-end.

Power and Control Circuits

49. The mechanical and circuit arrangements indicated above for car operation and control are shown on the circuit diagrams of plates 7 to 14, inclusive. These show the position of all elements under the following conditions. Control actions indicated are described in paragraphs 50 to 69.

Servo Electrical control:-
- Stop position (pl. 7)
- Controls set ready to hoist (pl. 8)
- Hoisting (pl. 9)
- Power failure (pl. 10)

Servo Mechanical control:-
- Stop position (pl. 11)
- Controls set ready to hoist (pl. 12)
- Hoisting (pl. 13)
- Power failure (pl. 14)

50. *Stop position - Servo Electrical control.* - The diagram of plate 7 shows the circuit with the main circuit lines 23 and 41 by-passed and the control circuit by-passed. Both are vented to the tank. The venting of the main circuit allows the centering plungers 21 and 22 to center the pump 20 in a slightly offset position towards hoisting, which is maintained by the centering plungers. The venting of the control circuit removes the pressure in the brake line 16, and the brake 15 is applied by spring pressure. Restriction 44 maintains a low supercharging pressure in the main circuit lines 23 and 41 when the control circuit is vented.

51. *Controls set ready to hoist - Servo Electrical Control.* - The diagram of plate 8 shows the circuit with the controls unlocked ready to hoist, using servo electrical control. This is accomplished by moving the starting lever 32, which closes switch 6 and shifts valve 30. If the door interlock switches 4 and 5 are closed, the solenoid 1 will be energized to shift the venting valve 2, which closes the main circuit vent and by-pass and also closes the control circuit vent. As solenoid 28 is always energized whenever there is power on the electric motor 3, valve 27 will remain in the position shown. The closing of the control circuit vent allows the pressure to build up to release the brake 15 and withdraw the safety car stop device 19. Pressure in the control circuit causes valve 37 to shift, which ports pressure oil to the small end of the stroke control piston 35, but as valve 33 is in the center position, the oil at the large end of piston 35 is trapped, which prevents movement of the piston. As pump 20 is held slightly offset towards the hoisting position, the closing of the main circuit vent and by-pass allows pressure to build up in the main circuit lines to the hydraulic motor, to retract the centering plungers 21 and 22. The powder car is prevented from dropping, after brake 15 is released, by foot valve 48. This valve functions thus by reason of back pressure in line 55, caused by the weight of the car (making the hydraulic motor act as a pump). The spring in valve 48 is strong enough to hold pressure in the motor sufficient to support the loaded car. Line 55 is trapped by check valve 59 and by the position of by-pass valve 60. Thus the hydraulic motor cannot rotate.

52. *Hoisting - Servo Electrical Control.* - The diagram of plate 9 shows the unit hoisting. This is accomplished as follows:- The control lever 31 is moved towards a hoisting position which moves the cam lever roller 26 to take up the lost motion and ride on the hoisting acceleration cam. The lost motion at the cam is enough to allow the servo control valve 33 to be shifted by the linkage 34. The shifting of valve 33 opens the chamber at the large end of the stroke control piston to the tank, and the control pressure in the opposite end moves the stroke control piston and the attached pump yoke to the hoisting position. Servo control valve 33 is mechanically connected to stroke control piston 35 through linkage 34. As long as valve 33 is held open by the movement of the operator's control lever 31, the stroke control piston will move to offset the pump. If movement of the control lever is stopped, the stroke control piston will continue to move until valve 33 is closed by the action of linkage 34. This functioning of the valves and linkage in conjunction with the limit switches and solenoids constitutes the "Servo Electrical Control." As soon as the car raises slightly, switch 7 will be closed and starting lever 32 must be returned to the neutral

position. This opens switch 6 and shifts valve 30 to vent the safety car stop device and allow it to return into the path of the car. As the unit hoists, the acceleration rate is controlled by the roller 26 riding on the hoisting acceleration cam. The hoist will continue to raise at a constant speed until the cam roller 26 rides on the hoisting deceleration cam, which will move valve 33 in the opposite direction, to port control pressure to the large end of piston 35, to force the pump yoke towards center and decelerate the hoist at the top of the flight. As the car reaches the upper unloading position, switch 9 is opened by the car. This de-energizes solenoid 1 and allows valve 2 to shift to vent and by-pass the main circuit and to vent the control circuit. The latter action applies brake 15, while main circuit venting allows the centering plungers to position the pump to a position slightly offset towards hoisting. Switch 9 is designed to close by spring as the car is lowered. However, its position is such that a few inches of car downward movement is necessary before the switch closes. This prevents car oscillation at the upper unloading station in the event the car should settle slightly before the brake applies. Foot valve 48 has no function when hoisting - high pressure flows freely through check valve 59.

53. To lower from the upper unloading to the lower unloading station, the starting lever 32 is moved to close switch 6, as in the hoisting cycle. (Refer pl. 9.) The control lever 31 is moved to the lowering position until the cam roller 18 contacts the lowering acceleration cam, which will shift valve 33 to cause stroke control piston 35 to move the pump yoke towards lowering. At the start of the lowering movement high pressure in line 41 is by-passed through check valve 40. This prevents excessive pressure build-up to blow the B-end relief valves before brake release. As soon as the brake releases, pressure caused by the load is delivered by the B-end into line 55 and check valve 40 closes. This prevents main circuit by-pass and enables oil delivery through line 41 at a sufficient pressure to overcome the difference between the spring setting of foot valve 48 and the pressure necessary to hold the load from dropping. The hydraulic motor will then rotate in a lowering direction. In this action the A-end does not tilt so far as to permit by-pass valve 60 to open, in consequence oil is pumped over foot valve 48 as the car lowers to the lower unloading position. Low pressure oil is in line 23 and the system is replenished through check valve 61. The centering plungers are held out by pressure delivered through check valve 62. Acceleration and deceleration of the hoist from the upper unloading to the lower unloading station is controlled by the end portion of the lowering acceleration cam. The car will lower during this part of the cycle with the upper door open. Descending three inches enables switch 9 to snap close. The starting handle should be returned to stop

position to permit the safety car stop device 19 to move into the car path. However with the door open the car will stop at the lower unloading station even though handle 32 is held in the starting position. The car will lower, controlled by the lowering acceleration cam, until switch 8 is opened by the movement of the car. This vents the system and applies the brake. Switch 8 opens only when lowering.

54. To lower from the lower unloading station to the loading station, the door interlock switches 4 and 5 must be closed. Moving the starting lever 32 to the start position closes switch 6 and vents the system as in the hoisting cycle. As the car starts to lower foot valve 48 functions the same as when lowering from the upper unloading station. However as the A-end pump moves farther off center, controlled by the lowering acceleration cam, control linkage 39 opens by-pass valve 60. The car then lowers by gravity controlled by the B-end cams which change the A-end tilt to limit the acceleration and deceleration rates. As the pump is thus returned toward center at the end of the cycle (by the lowering deceleration cam) by-pass valve 60 closes and the load is taken on the foot valve. At this stage high pressure is again pumped into line 41 to overcome the foot valve spring (as at the start of lowering). When the car trips open switch 7 the system is vented and the brake sets. Foot valve 48 prevents the car from settling until the brake has had time to apply. During this lowering cycle the main circuit is replenished through valve 63 whenever by-pass 60 is open, and the centering plungers are withdrawn by pressure delivered through valve 64.

55. During either a hoisting or lowering cycle the hoist may be stopped and the direction changed by the manipulation of control lever 31. Acceleration and deceleration are limited by the action of a dashpot assembly 65, a unit mechanically linked to the control lever shaft. This unit is hydraulically independent of the rest of the system. It functions to retard control lever movement from neutral to either hoisting or lowering positions. This occurs through transfer of dashpot cylinder oil from one side of piston 66 to the other through the small feed control valves 67, the restrictions 68 and check valves 69. If the lever (and the piston) is moved slowly, oil will pass freely through the feed control valves and the restrictions. If the movement is rapid pressure causes the feed control valves to close and prevent rapid piston displacement. When such action occurs, pressure will drop on the area above the feed control valve (through the restriction), which will allow the valve to open again. A balance between the pressure build-up and the rate of motion of the piston will be established, by the action of valves 67 and the restrictions, to limit the rate of travel of the control lever. Piston rate of travel is dependent on the size of the adjustable orifice in the re-

striction. The limits of adjustment permit hoist acceleration and deceleration greater than the rates as determined by the B-end cams but not in excess of one-half gravity. Dashpot reservoir 70 supplies oil to take care of the differential area of the piston and to replace seepage loss.

56. *Power failure - Servo Electrical.* - The diagram of plate 10 shows the circuit during power failure when operating with servo electrical control. If power should fail during servo operation, both solenoids 1 and 28 will be de-energized, which vents the brake cylinder and applies the brake, and also positions valve 2 to by-pass the main circuit lines. However, with the pump in hoisting position, line 24 is open to line 25 only through restriction 49 until the pump is near its centered position. Restriction 49 is small enough to prevent a pressure drop in line 23 which would permit the car to drop due to a slack cable (power failure when hoisting), but is sufficiently large to prevent hoisting when the car is at the lower unloading station with door open. At occurrence of power failure the pump continues to drive the B-end carried on by electric motor inertia. The brake under these conditions is engaged, but the free wheeling device 11 allows overrun of the drum and the B-end. Thus the car gradually decelerates, without cable whip, and as it comes to rest the load is taken by the brake. Simultaneously pressure falls off in line 23 and centering plunger 22 restores the pump yoke to its center position. The electric motor cannot be started until the pump yoke has been returned to near the center position. At this position neutral switch 13 (in the motor starting circuit) is closed.

57. If power failure should occur during a lowering cycle (servo electrical control), solenoids 1 and 28 will be de-energized to by-pass and vent the main circuit, and to vent the control circuit. Venting the latter applies the brake to decelerate and stop the hoist. Centering plunger 21 is vented and moves to return the yoke to centered position.

58. *Stop position - Servo Mechanical.* - The diagram of plate 11 shows the circuit in the stop position with the controls set for servo mechanical operation. The arrangement shown provides for hoist control and operation in event that the electrical control circuit is inoperative. The controls are set for servo mechanical operation by shifting the selector control lever 12 to "Servo Mechanical" position. This movement shifts the brake release valve 14, the venting valve 2 and releases latch 52. The latter drops into the notch on cam 53 (provided lever 31 is at neutral). This allows latch valve 54 to shift to vent the main circuit and the control circuit to the tank. Main circuit lines 23 and 41 are vented to the tank through check valves 62 and 64 and thence around the power

failure valve, through the brake release valve, back to the power failure valve, through line 17, around the latch and vent valve, through line 29 to car stop release valve 30. If the latter is in stop position oil will flow around the valve and through line 57 to the tank. This main system oil flow receives supercharging from the control circuit through valves 61 and 63. Venting of the system through the latch and vent valve applies the brake (venting through line 38) and releases the centering plungers and thus holds the car and positions the A-end at its neutral position (slightly offset towards hoisting). The electrical control switches and solenoids are inoperative (valve 2 is held in the unvented position by lever 12). The shifting of valve 2 to its unvented position closes the main circuit by-pass but the circuit is vented as explained above through valve 54.

59. *Controls set ready to hoist - Servo Mechanical Control.* - The diagram of plate 12 shows the circuit with the controls set "ready to hoist," using servo mechanical control. The starting lever 32 has been moved to the "Start" position, which shifts valve 30 and closes the main circuit vent. With the main circuit vent closed, pressure will build up in the system (as pump 20 is offset slightly towards hoisting) to pump enough oil to overcome the leakage and hold the load from falling. This oil pressure withdraws the safety car stop device 19 from the path of the car, withdraws latch 52, by hydraulically shifting valve 54, releases the brake 15, and retracts the centering plungers 21 and 22, to permit free movement of the pump. Control pump delivery supercharges the main circuit and supplies servo pressure for operating the stroke control piston, as in servo electrical control. Foot valve 48 functions the same in servo mechanical control as in servo electrical control.

60. *Hoisting - Servo Mechanical Control.* - The diagram of plate 13 shows the circuit in the hoisting position when using servo mechanical control. The control lever 31 has been moved into the hoisting position. The car is controlled by the use of lever 31 and the cams in the B-end. The starting lever 32 is shown in the stop position, because just as soon as the hoist starts to move, the safety car stop 19 must be released into the path of the powder car, as in servo electrical control. Valve 30 is shown in a position to vent line 56 to the tank, which vents the safety car stop device cylinder 19, and also the latch and vent valve 54, to allow the latch 52 to ride on the cam 53. The latch 52 will not fall into the notch in the cam 53 until the control lever 31 is moved to its "Stop" position, either by the operator, or by the deceleration cams in the B-end. The latch 52 is pressure operated by the plunger 58 to drop into the notch on the cam, and is spring operated to complete the latching operation after the main

circuit is vented. The venting of the main circuit allows the brake 15 to apply, and the centering plungers 21 and 22 to hold the pump in the "Stop" position. The control lever cannot be moved again until the starting lever 32 is moved to the "Start" position. It is evident that the stopping of the car is controlled by the latch valve 54 in servo mechanical control, and not by the limit switches at the car as in servo electrical control. Dashpot 65 functions to limit acceleration and deceleration if the car is stopped and started in mid flight (as in servo electrical control).

61. *Power failure - Servo Mechanical Control.* - The diagram of plate 14 shows the circuit during power failure, when operating with servo mechanical control. When electrical power fails the solenoid 28 will be de-energized, which will allow valve 27 to shift to vent the brake cylinder and apply the brake. If power fails when hoisting, the main circuit by-pass will open through restriction 49 only until the pump has been returned to neutral. (With the pump at neutral or offset toward lowering, line 24 is open to 25.) The pump continues to raise the car carried on by the inertia of the electric motor. Brake and free wheeling units function the same as in servo electrical control.

62. If power fails during a lowering cycle (servo mechanical) the main circuit by-pass opens as soon as the solenoid 28 is de-energized to shift valve 27. The brake applies immediately to decelerate and stop the loaded car and the B-end. The pump driven by the inertia of the electric motor will only circulate the oil through the main circuit by-pass and valve 40. Switch 13 makes it necessary for the operator to allow the control lever 31, and the pump to return to center before the electric motor can be started upon resumption of power.

63. *Manual control.* - If the control pump becomes inoperative, which will be indicated during "Servo Electrical" control, by the failure of the brake 15 to release, or during "Servo-Mechanical" control by the increased effort required to shift the hoist and lower control lever 31, means have been provided to permit manual operation of the hoist. This phase of operation will be designated as the "Manual Mechanical" control. The controls are set for this method of operation by moving the control selector lever 12 to the "Mechanical" position. The equipment functions the same when using "Manual Mechanical" control as when using "Servo-Mechanical" control except, due to the lack of control pump pressure, the A-end pump must be shifted by manual effort instead of "Servo" power. The servo control valve 33 is locked in the center position without any lost motion, by the locking device 47. Valve 37 is spring returned, due to lack of control pressure to open the pressure supply lines of the stroke control piston 35 to the

tank, to permit manual shifting of piston 35. The main circuit lines 41 and 23 are not supercharged, but the system leakage is replenished by suction through the replenishing check valves 45.

64. *Limitations, manual control.* - When operating the hoist using "Manual Mechanical" control, the manual shifting of the pump yoke 20 greatly increases the effort required on the operator's hoist and lower control lever 31 to shift the pump off center, and in the same manner greatly increases the loads on the cam mechanism and linkage to return the pump yoke 20 to its center position. This loaded condition in conjunction with stopping on the latch and vent valve 54, and the stretching of the hoisting cable greatly increases the stopping variation at the loading and unloading stations. The main circuit lines 23 and 41 will not be supercharged, which will result in cavitation in the system, and will cause gasification of the oil in the system to increase the noise and vibration if the equipment is operated at high speeds. If continuous high speed operation is attempted, the oil may become so gasified as to prevent proper operation of the brake, and also will cause very slow starting of the hoist.

65. *Operation with manual control.* - In order to obtain as accurate stopping as possible and to obtain the least amount of noise and vibration for continuous operation, it will be necessary to operate the hoist at much slower speeds than when using "Servo Electrical" or "Servo Mechanical" control. This is accomplished by moving the hoist and lower control lever 31 only partially towards the hoisting and lowering positions. For the most satisfactory operation using "Manual Mechanical" control it is recommended that the cycle time be increased to 12 to 15 seconds for hoisting and 10 to 12 seconds for lowering. This method of operation should be considered as an emergency condition due to malfunctioning of the control pump, which should be corrected as soon as possible after its failure.

In order to permit training of the ship's personnel in this method of operation, a control pump by-pass valve has been provided, whose only function is to by-pass the control pressure to the tank to simulate a control pump failure. This valve is actuated by the same lever which shifts the servo valve locking device 47, when the lever is shifted to the "Manual" position. This valve cannot be shifted inadvertently to the "Manual" position if the control selector lever 12 is in the "Electrical" control position. This is prevented by linkage, which permits the shifting of the valve only when the control selector lever 12 is in the "Mechanical" control position. If the valve has been shifted to the "Manual" position, the moving of the control selector lever 12 from the "Mechanical"

to the "Electrical" control will mechanically return the valve to the "Servo" position through the action of the control linkage. The by-pass valve and the locking device 47 operating lever is maintained in the "Servo" position by a positive detent, and in the "Manual" position by a non-positive detent.

When lowering from the upper unloading station, during "Manual Mechanical" control with the control pump inoperative, the A-end pump is moved by the operator's control lever from a position slightly offset towards hoisting, through the neutral position, to the lowering position. As the pump passes the neutral position, the pressure in the system will drop momentarily, and will tend to permit the centering plungers to engage and the brake to apply. However at this time the main circuit vent is closed, which will permit the centering plungers to engage and the brake to apply only by oil leaking from the system. The time required for the pump to pass the neutral position will be very short in comparison to the time required for the brake and the centering plungers to engage by leakage. If the operator should hold the pump in the neutral position long enough to permit the centering plungers to retract and the brake to apply, it will still be possible to shift the pump towards lowering and compress the centering spring without building up excessive loads on the control lever.

66. *Failure in the hydraulic system.* - The brake will be applied either when operating with servo electrical, or with servo mechanical control, in the event of rupture of the pipe lines, as follows: Rupture of the main circuit low pressure line 41 will vent the control pump pressure, when operating with servo electrical power, through line 42 and check valve 43, and engage the brake. Rupture of the main circuit high pressure line 23, when operating with servo electrical power, will vent the control pump pressure through B-end check valve 40, and engage the brake. Rupture of any of the control pump pressure lines will engage the brake. When operating with servo mechanical control, the rupture of any pressure lines will engage the brake, as the brake is released by main circuit pressure.

67. *Oil filters.* - The oil filters 36 are mounted in parallel in the control pump pressure lines and are arranged so that one filter at a time may be removed and cleaned while the unit is operating. This is accomplished by shifting the filter control valve 50 which cuts out one of the filters, depending upon the direction the valve is shifted. With valve 50 in the center position both filters are in the system.

68. *Buffers and overtravel action.* - In event of overtravel of the car at the upper unloading station it will stop against the upper buffers at a low rate of speed. The safety

relief valve in the B-end will open to by-pass A-end pressure. If overtravel occurs at the lower unloading station and the car comes to rest on safety stop 19, check valve 40 will open to by-pass motor lines 23 and 41 and thus prevent B-end rotation and unwinding of the cable. In such contingency, before lowering can be attempted it is necessary to hoist the car slightly in order to withdraw the safety stop. If the car overtravels at the loading station and comes to rest on the lower buffer, check valve 40 will by-pass the main circuit lines.

69. *System vents.* - Air vent 71 enables bleeding of air from the stroke control cylinder when the unit is started after it has been drained and refilled. Vent 72 bleeds the brake cylinder. Vent 73 bleeds air from the dashpot assembly.

MAINTENANCE INSTRUCTIONS

70. The powder hoist assemblies are to be operated and maintained, including periodic exercise, adjustment and lubrication, in accord with the regulations of the Ordnance Manual, the general instructions as to installation and maintenance as given in chapter XV, and the specific instructions below.

71. *Operating precautions.* - Before operating the hoist under load and before attempting to pass powder bags inspect and service the hoist assembly as follows:

(*a*) Observe oil level in the power circuit supply tank. Replenish if necessary. Use oil specified in paragraph 72.

(*b*) Check oil level in the supply tank for the upper door and dog locking operating system. Use oil specified in paragraph 72.

(*c*) Check liquid level in the lower buffer liquid system. Use liquid specified in paragraph 74.

(*d*) Verify all lubrication.

(*e*) Inspect the loading trays, car trays and upper door, for burr or other deformation that might tear powder bags.

(*f*) Inspect the hoist drum. Remove burrs.

(*g*) Inspect the condition of the hoist rope and its fastenings.

(*h*) Start the motor and operate the car and doors through a full cycle in servo and then in man-

ual control. Observe the accuracy of car stopping positions, functioning of all interlock facilities, operation of the brake, the free wheeling device and the car safety latch.

72. *Hydraulic oil.* - The oil to be used in the power plant system, the dashpot and the door operating system is that designated in Ordnance Specification No. 1113. All oil when inserted must be strained through a fine mesh wire strainer of at least 120 wires to the inch. The use of cloth strainers is not desirable since such material tends to cause an accumulation of lint in the system. New assemblies should be drained after fifteen hours operation and should then be thoroughly flushed clean and refilled with fresh oil. The system must be inspected and analysis of oil sample must be performed at least once monthly. If there is evidence of sludge, water or acidity, trace source, drain, flush and refill with fresh oil. The amount of oil required for one power plant system is 32 gallons. The system requires venting as indicated in paragraph 69.

CAUTION: When filling the system with oil for the first time, or after the system has been completely drained, the following procedure is to be used. Remove the filler plug from the top of the B-end and fill the hydraulic motor case with oil. Next fill the A-end through the oil filler to the top oil level petcock. After the equipment has been run for a short time additional oil will have to be added in the A-end to bring the oil level to a point between the two oil level petcocks.

73. *Lubrication.* - The powder hoist assemblies must be lubricated with the lubricants and according to the frequencies specified on the four lubrication charts appended.

74. *Buffer fluid.* -The liquid to be used in the buffers at the foot of the trunk is standard recoil cylinder liquid as specified in the latest revision of Ordnance Data No. 1914.

75. *Speed limitations - Manual Control.* -In manual control operation, without the control pump, air is drawn into the main circuit. This causes vibration of pipe lines and considerable noise, the amount of air and resultant vibration and noise depending upon the speed that the powder car is hoisted or lowered.

In order to reduce the amount of air entering the system, the control should not be positioned to more than one-third of its full stroke movement (for both hoisting and lowering). Con-

tinuous operation at such reduced speed should be limited to a period of one hour (vibration, noise and adverse effects will vary for different hoists).

In emergency, the drive may be operated in "Manual" control with full speed throw of the control lever. But such high speed operation should be limited to twenty-five or less complete cycles.

For drill and training purposes always limit "Manual" control speed as specified above.

ADJUSTMENTS

76. *General.* - Adjustment of the various elements of these powder hoists is principally confined to adjustment of the power plants and their control linkage and the interconnection of the latter with the hoist control and interlock system. Adjustments of the car hoist cable attachment, safety brakes and switch actuating cams are apparent from the general arrangement drawings. The positions of parts of the upper door dog locking mechanism, the lower door latch and latch release and the hoist indicator device are prescribed by design; they should be set as shown on the general arrangement drawings and should subsequently be adjusted and fitted (if required) so that they will perform their functional purposes.

Adjustments of the power units and controls are divided into stages:- Preliminary adjustment of the assembly as prescribed in paragraph 77, and detail adjustment of specific units as outlined in paragraphs 79 to 88, inclusive. The first stage is only applicable in the installation of a new hoist or a dismantled and reassembled hoist.

77. *Preliminary adjustments.* - The hoisting cable must be disconnected from the B-end hoisting drum, and the complete assembly of the cams and cam support are to be removed from the B-end, until all of the preliminary adjustments and preliminary tests have been made.

The cam assembly in the B-end (see 274249) is made accessible by first removing the large inspection cover 274320-2. The lock nut 271731-3 and the lock washer 200074-8 are to be removed from the end of the hydraulic motor shaft. The cam support 274322-1, with the cams attached, can now be slipped off the shaft. This permits the B-end to be operated in a hoisting direction only, which will permit the preliminary tests to be made, after the preliminary adjustments have been completed.

The first step in the preliminary adjustment is the adjusting of the control selector linkage.

(a) With the control selector lever in the "Electrical" position, the latch on the operator's control shaft is to be held out of its notch, and is to clear the cam when the operator's control lever is moved to either the "Hoist" or the "Lower" position. With the control selector lever in the "Mechanical" position, the latch on the operator's control shaft is to drop into the notch on the latch cam, when the operator's control lever is in the neutral position.

The next step is to adjust the adjustable rods to provide for the correct angular position of the control selector levers at the A-end (see 274239, installation - A-end), as follows:-

(b) *To adjust the brake release valve lever.* -

(1) The control selector lever is to be in the "Electrical" control position.

(2) The brake release valve lever is to be placed in the "Electrical" control position as shown on the installation drawing of the A-end (see 274239). The correct position of this lever is determined by turning the lever in an "Electrical" control direction, manually at the A-end, as far as the lever can be moved.

(3) The adjustable rod is to be lengthened or shortened, and assembled to the brake release valve lever, and to the rocker shaft to maintain this position of the lever.

(c) *To adjust the venting valve lever.* -

(1) Place the control selector lever in the "Electrical" control position.

(2) The venting valve lever is to be moved manually at the A-end toward the mechanical position. The lever is then to be allowed to return to the electrical position by the spring action of the valve. The lever is to be moved approximately 1° farther in the "Electrical" control direction, and the adjustable rod is to be lengthened or shortened and assembled to the venting valve lever to maintain this position. The lever can be moved manually farther than the 1° past

the "Electrical" control position as determined by the spring action of the valve, but this additional movement is used to provide lost motion, when the venting valve is operated by the solenoids, during "Servo Electrical" control.

(3) The next step in preliminary adjustments is the adjusting of the connecting rods for proper lengths to give the correct angular position of the hoist and lower operating lever at the A-end.

(d) *To adjust the hoist control lever.* -

(1) First disconnect the adjustable rods 274254-2 or 274251-2 (see 274251, installation and assembly of the control linkage) from the A-end, and also the control rod 274330-3 that connects from lever 274253-1 to the B-end.

(2) The control selector lever is to be placed in the "Mechanical" position to allow the latch to register in the notch in the cam on the main control shaft. The control pump by-pass valve and servo valve centering lever is to be placed in the "Manual" position to correctly center the servo valve.

(3) The hoist and lower control lever, which is mounted in the control compartment is to be adjusted to its neutral position, when the latch is in the notch of the latch cam.

(4) The adjustable universal link, which connects the lever on the main control shaft to lever 274253-3 (see 274251), is to be correctly adjusted for length. This link when connected to lever 274253-3 must hold lever 274253-3, so that its center line makes a 90° angle (approx.) with the center line of bracket 274252-1. This may be determined by measuring the distance from the center line of the shaft 274253-2 to the lower side of the gun girder cap; then adjust the universal link, so that the center line of the end of lever 274253-3 is the same distance from the lower side of the gun girder cap.

(5) Now adjust the length of the rod (274254-2 for the L.H. installation, or rod 274251-2 for the R.H. installation) to just fit between the lever on the control linkage and the lever on the A-end.

(6) Now adjust the control rod 274330-3, which connects lever 274253-1 on the control linkage to lever 274327-2 on the B-end, to maintain a distance of 1.25 inches between the lower edge of clevis 274253-5 and the top of the B-end base. (See 274249.)

(e) *To adjust the servo control valve centering lever and the pump by-pass valve lever.* -

(1) Place the control selector lever in "Electrical" control position.

(2) Place the servo control valve centering lever and the pump by-pass valve operating lever in "Servo" position.

(3) Shorten or lengthen the adjustable control rod to fit between the lever on the A-end and the lever on the control selector rocker shaft. The rod is to be adjusted to prevent movement of the lever on the A-end when the control selector lever is in "Servo" position but will permit shifting of the lever when the control selector lever is in "Mechanical" position.

78. *Preliminary tests.* - It is imperative that the hoist shall receive functional tests after reassembly in the mount and following the preliminary adjustments of paragraph 77. These tests are for purpose of verifying correct assembly. They are slow speed tests that are absolutely essential to prevent serious malfunctioning and loss. During these tests, the hoist cable and the cam support unit are disassembled. The tests should be made with controls at "Servo Mechanical" and subsequently with controls at "Servo Electrical." In each case they comprise verification of:- motor rotation, brake action, safety car device action, latch and vent valve action, movement of the centering plungers to permit control lever movement, hoist drum direction, correct interlock and limit switch action, door and locking dog operation and interlock of those movements with the starting lever and correct venting action in the A-end when any one of the limit switches or the door interlock switches is actuated.

79. *Adjustment for flight length.* - After all of the preliminary tests have been made and the equipment is functioning correctly, both hydraulically and electrically, the electric motor is to be stopped. The cable is to be attached to the B-end hoist drum. The drum size will permit one extra coil more than is required for maximum lift (53 ft.). Adjustments of limit switch car stopping positions as described below are made without the B-end cams and the car is operated at slow speed into the limit switches. (Note: "Slow" speed desired is car movement of six inches per second.)

(a) *To adjust upper limit switch #9.* - With car at bottom, motor on, doors open, switches #4 and #5 blocked closed, move the starting lever to "Start" and the control lever to *slow hoist* As soon as #7 switch closes release starting lever. Permit the car to run into switch #9. Verify car position and adjust the cam on the car to give the desired position (for six-inch per sec. speed).

The limit switches are adjustable for opening or closing by varying the position of the switch operating lever. This is accomplished by loosening the lock nut on the lever clamp bolt. Turn the clamp bolt until the desired position of the lever is obtained, and then tighten the lock nut. The adjustment on the cam and the adjustment on the switch may be used in conjunction, to give a correct switch setting.

(b) *To adjust the lower unloading station switch #8-* After switch #9 has been adjusted, the starting handle is to be moved to the "Start" position, and the control lever is to be moved slightly towards the "Lower" position. After the car has lowered a few inches, or just enough to close switch #9, the starting handle is to be released, to return to the stop position, before the car reaches the lower unloading station. The car is to be lowered at a speed of approximately six inches per second into the #8 switch. The position of the stopped car is to be checked in relation to the intended stopping position. The switch lever and operating cam are to be adjusted to give the desired stopping position, in the same way as for the #9 switch.

(c) *To adjust the loading station switch #7.* - After switch #8 is adjusted the powder car is to

be lowered at a rate of six inches per second, in the same manner as when lowering from the upper unloading station, to contact switch #7 to stop the hoist. The stopping position of the car is to be checked in relation to the intended stopping position and the switch lever and cam are to be adjusted to correct any error in stopping.

80. *Adjustment of B-end cams.* - Adjustment of the cam assembly of the B-end unit involves positioning of the elements listed below. (Shown on dr. no. 274249.) These parts are located in the oil reservoir space of the cam housing. They are fully exposed for adjustment, after draining the housing, by removing cam housing cover, 274320.

Name of Part	Piece No.
Hoisting Acceleration Cam	274323-1
Hoisting Deceleration Cam	274323-3
Lowering Acceleration Cam	274324-4
Lowering Deceleration Cam	274324-1
Lowering Cam Arm	274328-1
Hoisting Cam Arm	274329-2

These parts are identical in all hoists but have varying arrangements as to position of cams in the cam support and clamping rings with respect to the two arms. The latter have the same position in all assemblies while the positions of the cams vary according to the height of lift and hoist location, left hand hoists having the cams turned over from the right and center arrangement. Compare figures 55, 57 and 56, 58.

The objectives to be accomplished in the adjustments are:

(*a*) To position the cams exactly in synchronization with car stopping positions as obtained by limit switches 7 and 9, and

(*b*) To position the cam arm rollers with respect to the adjusted positions of the cams so that the arms (and the hoist control lever) have precise limit of movement from neutral when the cams are at limit stop positions.

In order to obtain requirements (a) and (b) it is essential that the switch actuating cam plate on the car is adjusted to the positions shown on drawings 233136, 233137; that the hydraulic oil is at normal operating temperature; that the system is full and vented; and that the control lever with its shaft linkage to the A-end, B-end controls is easily and ac-

curately positioned from neutral. Excessive friction in the control shafting will make accurate adjustment impossible. The effort required to shift the control lever from neutral, in servo control, must be less than fifty pounds.

The car hoist cable attached to the drum as shown on drawing number 274249, must be adjusted at the car attachment fitting to position the car at the trunk lower door loading position as shown on drawing 233137.

The cam support assembly should be removed from the B-end cam housing and scribe marks should be made on the outer faces from the profile points indicated below toward the cam shaft center. Their location and reference numbers are shown on figure 54.

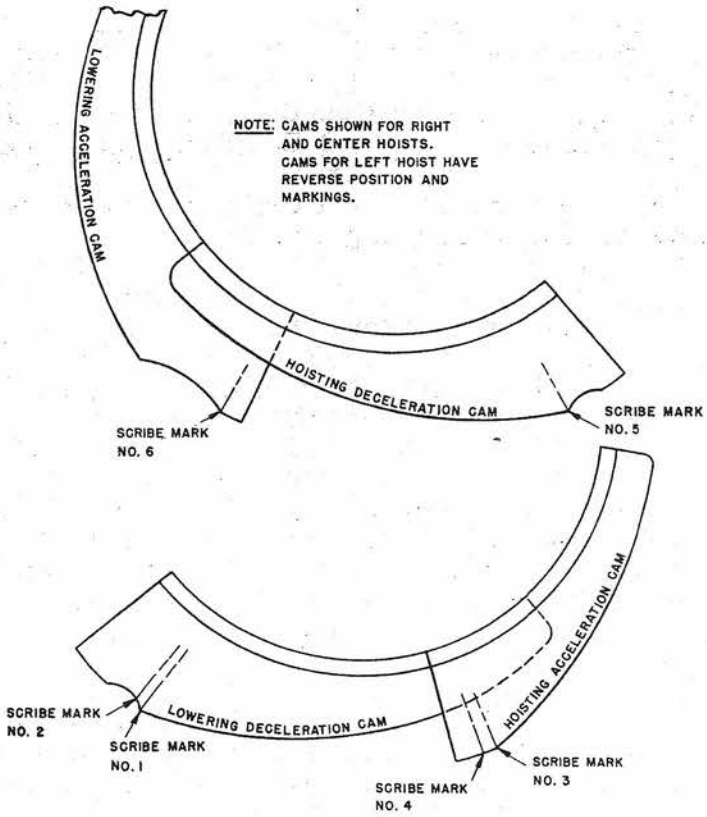

Fig. 54 - Cam Adjustment Marks

Lowering deceleration cam. - Mark #1, from the high point of the cam profile.

Mark #2, from a point on the cam profile 9/64 inch beyond mark #1. (Scribe mark #2 will thus be located in the stopping position notch.)

Hoisting acceleration cam. -Mark #3, from the high point of the cam profile.

Mark #4, from a point on the cam profile 9/64 inch beyond mark #3.

Hoisting deceleration cam. - Mark #5, from the high point of the cam profile.

Lowering acceleration cam. Mark #6, from the high point of the cam profile that is nearest the end of the cam. (This point of the cam is the upper unloading position, slow stop point.)

On the outer rim of the hoist drum, at approximately equal intervals, provide 12 chalk marks. These marks are for purpose of stop watch timing of the slow hoisting speed required in the adjustment routine prescribed below. Each chalked space is closely equivalent to six inches of the hoist cable.

With the preceding preparations completed the adjustments are made according to the following routine.

(1) Start the motor and set controls for servo electrical operation.

(2) Operate the controls to hoist the car at slow speed. Stop at a point 10 or 12 feet up the trunk.

(3) Using a stop watch and observing the drum chalk marks, operate to lower at a speed of six inches per second. Permit the car to run until switch #7 functions to stop the hoist.

(4) Stop the motor.

(5) Reassemble the cam support unit. Mesh the cam drive gearing so that the lowering deceleration cam is located with scribe mark #1 adjacent to the lowering cam arm roller (274328-1).

(6) Verify that the hoist control lever is at the neutral detent.

NOTE: A further check for ascertaining that the control linkage and A-end yoke is at neutral is readily made by verifying the 1.25-inch dimension shown on section K-K, drawing number 274249.

(7) Unclamp the cams so that they may be positioned by light tapping with copper or lead mallet.

(8) Align a straight edge from the cam shaft center to the center of the lowering cam arm roller.

(9) Move the lowering deceleration cam until mark #1 aligns with the straight edge. Secure the cam.

(10) Align the straight edge from the cam shaft center to the center of the hoisting cam arm roller.

(11) Move the hoisting acceleration cam until mark #3 aligns with the straight edge. Secure the cam.

(12) Using 1/16 space gauge verify the gap between each roller and the cams as positioned. Reset the arms as required. It is important that the controls shall be as checked in operation (6). Refer to figures 55 and 57 for arm adjustments.

(13) Start the motor. Controls set for servo electrical operation.

(14)*Raise the car at slow speed 20 or 25 feet up the trunk and lower at full speed into switch #7.

(15) Stop the motor. Place controls as in (6).

(16) Repeat operation (8) and observe position of mark #2. This mark should align with the straight edge. If it has overtraveled, the car has overtraveled from #7 station and cam deceleration is late. An extremely small advancement of the cam will give correct retardation of car approach to switch #7. At high speed stop at that station mark #2 should align precisely with the straight edge. This cam position is essential in order to permit roller starting motion; i.e., when the control is shifted from neutral the roller should have full bearing in the notch. Figures 55 and 57 show the correct positions in left and right hoists respectively.

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* The dashpot must be connected and adjusted before operating thus.

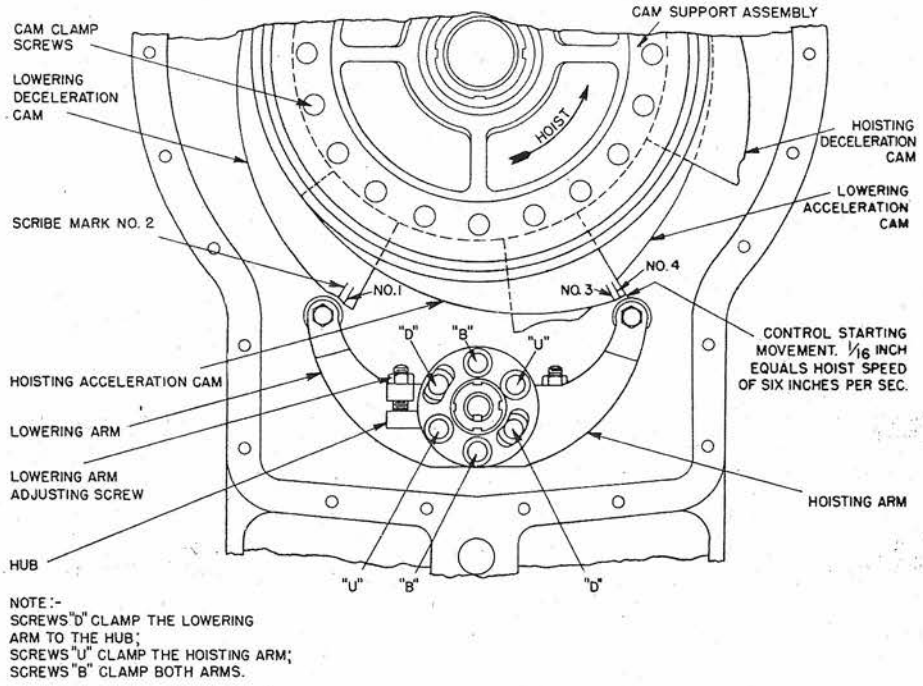

Fig. 55 - Cam positions for Left Hoist.
Car at Loading Station. Control Neutral.

(17) Repeat operation (10) and observe position of mark #4. This mark should align with the straight edge.

(18) Repeat operation (12).

(19) Start the motor. Operate to hoist at slow speed. Time the speed as in operation (3). Permit the car to run until switch #9 functions.

NOTE: If operations (12) and (18) have been correctly performed, the hoist will operate at exactly six inches per second with the control held at the limit of starting movement, i.e., 1/16-inch cam roller movement.

(20) Stop the motor and set control at neutral.

(21) Repeat operation (10).

(22) Move the hoisting deceleration cam until mark #5 aligns with the straight edge. Secure the cam.

(23) Repeat operation (8).

(24) Move the lowering acceleration cam until mark #6 aligns with the straight edge. Secure the cam.

NOTE: Cam positions obtained by operations (22) and (24) will provide correct high speed synchronization with respect to switches #9 and #8. At high speed stopping through action of switch #9, marks 5 and 6 will have overtraveled but the car should be at the upper unloading station. See positions of marks #5 and #6 on figures 56 and 58. If the car is out of position, very slight adjustment of the hoisting deceleration action, will give the required stopping position. The lowering acceleration cam must be reset a like amount.

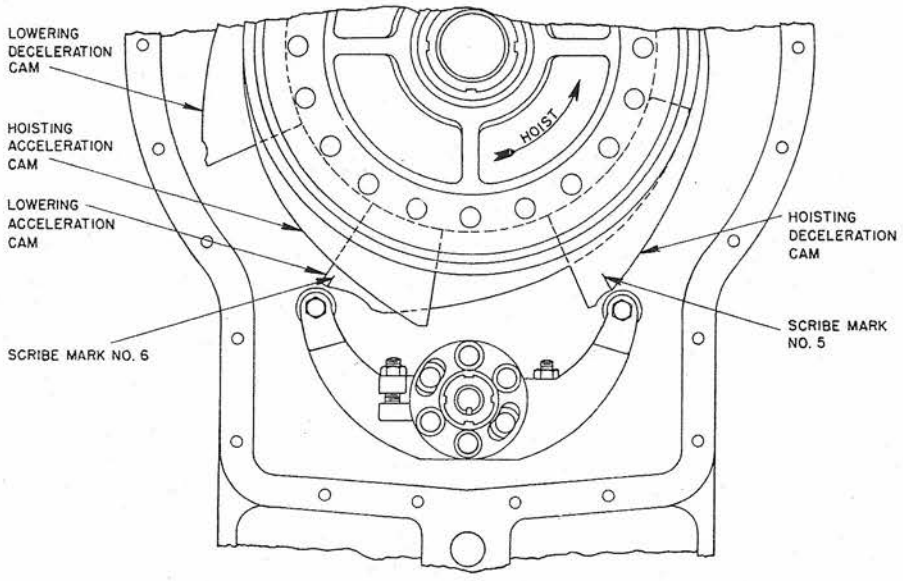

Fig. 56 - Cam positions for Left Hoist. Car at Upper Unloading Station. Control Neutral.

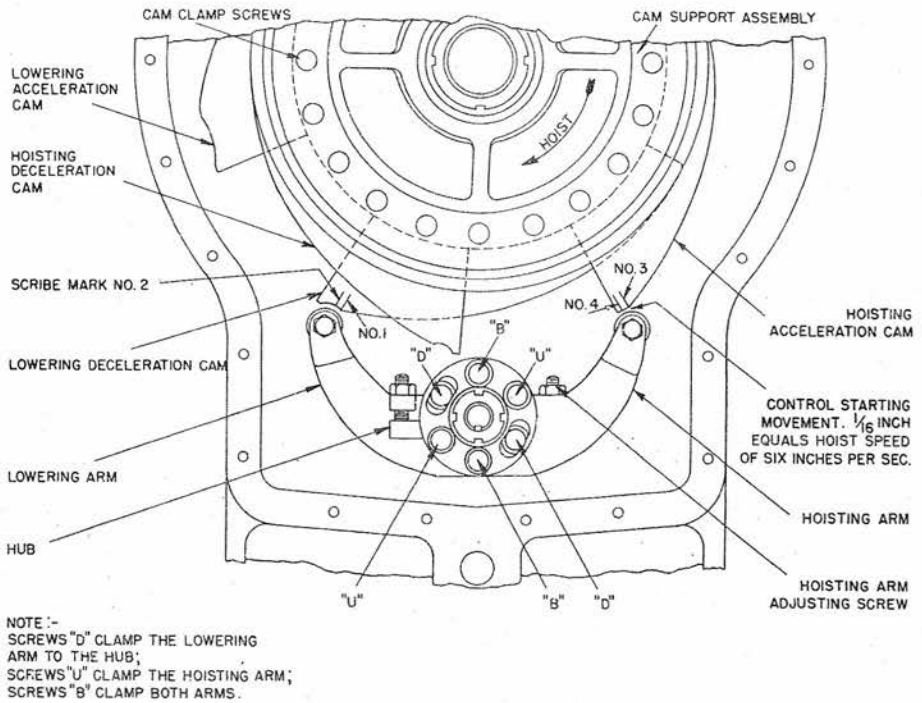

Fig. 57 - Cam positions for Right Hoist. Car at Loading Station. Control Neutral.

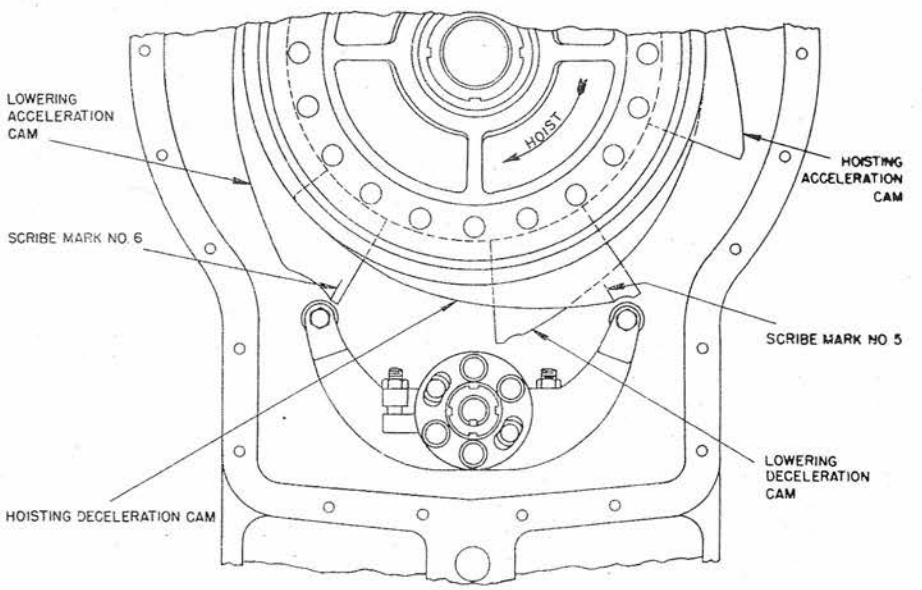

Fig. 58 - Cam positions for Right Hoist. Car at Upper Unloading Station. Control Neutral.

81. *Adjustment of the A-end centering plungers.* - The reference drawings for this adjustment are number 274247, A-end assembly, and number 274251, control linkage assembly. The centering plunger assemblies have been adjusted at the factory to maintain the pump yoke at a slight offset towards the hoisting position. The pump is offset enough to supply oil to overcome the leakage of the system and to build up enough pressure to retract the centering plungers and to release the brake and operate the safety car stop device. No adjustment is necessary until the parts of the equipment have worn enough to permit increased leakage and prevent the proper functioning of these devices.

The adjustment of the centering plungers is made by shimming the complete centering plunger assemblies to the desired position. When this adjustment is made it will be necessary to readjust the control rod 274254-2 or 274251-2 which connects between the control linkage rocker shaft and the A-end control lever. The procedure is as follows:

Remove the pipe flanges 271724-4 from both centering plunger housings 274304-1. Remove the six long screws 274340-2 from each assembly and the centering plungers can be removed from the unit. Next disconnect clevis 274253-5 from the control rod lever 274254-1. Now remove .010 inch of shim stock from shim 274305-9 under centering plunger housing (long plunger 274306-1). This will shift the pump yoke farther towards the hoisting direction. Next add the same amount of shim stock under the opposite centering plunger. Replace the centering plunger assemblies and the pipe flanges. Control rod 274254-2 or 274251-2 is to be adjusted for length as explained in the preliminary adjustments. If the .010 inch adjustment is not enough to make the above units function properly, additional shims must be removed from centering plunger 274306-1 and added to the other until proper functioning is obtained. After adjustment of the centering plunger it may be necessary to readjust limit switch 231705, located on the top of the A-end. See paragraph 82.

82. *Adjustment of the A-end neutral interlock switch.*- Refer drawing number 231705. The limit switch has been adjusted at the factory to just close when the operator's control lever is in the "Stop" position, to prevent starting the electric motor until the pump yoke is returned to its centered position. A change in the adjustment of the centering plungers may affect the limit switch, which is adjustable as follows:

Remove the two screws 196825-7, and the conduit connections, and the limit switch may be removed, which will expose the adjusting screw 274300-4. If the electric motor would not start, with the control lever in "Stop" position, turn the adjusting screw 274300-4 "out" about 1/2 turn, and tighten lock nut 180226-11. To accomplish this easily, the complete assembly of the limit switch mounting and plunger may be removed by first removing the screws 180226-7. Next remove the roller 274304-5, and its retaining screw 274304-3. This will permit the plunger 274303-3 to be withdrawn from the housing. Reassemble the parts after the adjusting screw has been adjusted and check to see if electric motor will start.

83. *To adjust the control pump relief valve.* - This relief valve is located in the valve block assembly (see dr. 274272). It was adjusted at the factory for a pressure of 160 P.S.I. and should not require adjusting unless the valve block is completely dismantled. To adjust, loosen acorn nut 274280-8, and lock nut 221525-4. To increase the pressure, turn adjusting screw 274277-8 "in", and to decrease the pressure "back" screw out. To check the pressure, a pressure gauge is to be screwed into the discharge flange 274289-3 at the control pump. A 1/4 inch brass plug 191329-9 is to be removed to permit the use of the pressure gauge. After the pressure is adjusted to 160 P.S.I. the lock nut and acorn nut is to be replaced.

84. *Adjustment of the main system relief valve.* - Refer to drawing number 274249. The relief valves are found in the hydraulic motor head, but only one is used for venting excess pressure from the main circuit high pressure line. The relief valve on the same side of the motor head 274316-1 as the #1 flange connection is used for the left hand installation to control the high pressure. The relief valve on the same side as the #2 connection is used to control the high pressure for a right hand installation. Both relief valves have been adjusted at the factory for 2100 P.S.I. and it should not be necessary to readjust them, unless the hydraulic motor head is completely dismantled. If adjustment becomes necessary, the relief valve in the high pressure line of the main circuit is the only one which needs adjusting, as the relief valve in the low pressure line will act as a check valve.

To adjust the relief valve it is necessary to move the control selector lever to mechanical position to cut out the electrical control. A pressure gauge is to be attached to the air vent which is on the same side of the hydraulic motor head as the relief valve (see 274241). The electric motor is to be

started. The starting handle is to be held in the "start" position, and the car is to be hoisted slowly until it contacts the upper buffer. The car will be stopped by the buffer, but the starting valve held in the start position prevents venting the main circuit lines. The pressure reading shown on the gauge indicates the setting of the relief valve. The relief valve is to be adjusted to crack at 2100 P.S.I., by removing cap 274311-2, loosening lock nut 274319-3, and screwing "in" or "out" on the adjusting screw 274324-5. Screwing "in" on the adjusting screw will increase the pressure. An approximately correct setting of the relief valve will be obtained by screwing in the adjusting screw as far as possible, and then "back-out" 1-1/2 turns.

85. *Brake adjustments.* - Refer drawing number 274249. The brake is adjustable to provide for wear, at the brake band end 274318-3, and at the four eccentric stop pins 274307-2, and the two adjusting stop screws 274328-10. A maximum dimension of three inches, and a minimum dimension of 2-3/4 inches locating the end of the brake cylinder piston 274318-1 from the face of the cylinder cap 274317-2 is shown on the drawing. The brake is to be adjusted to the three inch dimension, this will provide 1/4 inch of piston travel to provide for wear before it becomes necessary to readjust the brake.

CAUTION: The distance from the end of the brake cylinder piston to the cylinder cap should never be allowed to become less than 2-3/4 inches. This should be checked at frequent intervals.

With the hoist in the "Stopped" position (brake applied) and the controls set for a "Servo Controlled" cycle, the two lock nuts 274339-4 are to be loosened, and the upper adjusting nut 206522-3 is to be backed off. Tighten the lower adjusting nut 206522-3 until the three inch dimension is obtained.

Now place the starting handle in the "Start" position, which releases the brake, and check with a .010 inch feeler gauge to see if there is clearance all around the band. This clearance can be maintained by adjusting the stop screws 274328-10 which are located on the top of the brake cylinder, and also by the eccentric stop pins 274307-2. Remove the cotter pins 274341-3, and loosen slightly the slotted nuts 274339-5. Use a wrench on the flats, provided on the ends of the stop pins, and turn the pins until clearance is obtained all around the brake band. After clearance has been obtained, hold the stop pins with a wrench, and secure the slotted nuts 274339-5. Replace the cotter pins.

86. *To adjust the foot valve control linkage.* - With the A-end held in its center position by the centering plungers,

and the control rods between the A and B-ends correctly adjusted, the clevis 274334-9 is to be adjusted so that the center line of the lever 274331-7 lines up with the center line of the valve 274335-4 in the foot valve body. Clevis 274335-2 is next to be adjusted, so that there is .020 to .025 inch deflection of the spring 274334-2 when the valve 274335-4 is seated against its seat 274335-7. This adjustment is to be made when the center line of the lever 274331-7 lines up exactly with the center line of valve 274335-4.

87. *Dashpot adjustments.* - Refer drawings number 274249, 274251 and 274265. The external coupling of the piston to the control shaft lever and the internal restrictions of this device require adjustment.

The coupling adjustment at the adjustable clevis is important in order to assure full control movement of the control lever and the cam arms. It is made by adjusting the connection so that the piston does not "bottom" ahead of either extreme movement of the control lever. The piston has total possible movement slightly greater than that imparted by full control lever movement.

The restriction adjustments are made to limit the time of full piston stroke to three seconds.

Adjustments #1 and #2 control the speed of shifting the control lever. Adjustment #1 controls the speed of depressing the piston and #2 controls the speed of withdrawing the piston.

88. *Latch and vent valve cam adjustment.* - Automatic stopping action is obtained in servo mechanical control to stop the hoist at the loading and unloading stations, by the venting action of the latch and vent valve. Such valve movement is controlled by the adjusted positions of the edges of the notch formed by the two segments of the latch and vent valve cam. Refer drawing 236578.

The adjustments are made by positioning cam segment 234058-1 to permit latch movement when mark #1, figure 57, is aligned as in paragraph 80, operation 9, and, positioning cam segment 234058-2 similarly when mark #5, figure 58, is aligned as in paragraph 80, operation 22.

TROUBLE DIAGNOSIS

89. This section of the text covers a series of possible operating troubles, together with suggestions for locating

their source and making corrections. The instructions are based on normal operation of the hoist (Servo Electrical Control). The various symptoms of imperfect functioning are indicated by separate subheadings, under each of which is listed the possible causes and the procedure to follow in restoring the equipment to normal. The order of arrangement under each subheading is designed to isolate the source of the trouble by a process of elimination and if the same sequence is followed in practice a minimum amount of work will be required. Where further instructions are required for removing parts, refer to "Disassembly Instructions".

90. *No electric power.* - If electric motor fails to start, current is probably not available due to one of the causes mentioned below.

(*a*) Circuit breaker being open in the controller box.

(*b*) Pilot circuit fuse in the controller box is blown.

(*c*) Neutral interlock switch on the A-end incorrectly connected or adjusted. (See instructions to adjust limit switch.)

(*d*) Main line fuses blown.

91. *Circuit breaker opens.* - This would indicate a direct short in the main circuit supply lines to the electric motor.

92. *Overload relay open.* - If the electric motor tends to start, but the overload relays in the controller box open, the trouble will probably be a damaged A-end or control pump causing a locked rotor. The pumps are to be checked for damage by attempting to rotate the electric motor shaft manually. If a binding condition exists remove the control pump to check whether the binding condition is in the control pump or in the A-end pump.

(*a*) *Control pump binding.* - If a binding condition is found to exist in the control pump, the loosening of the screws in the pump head must not be considered a sufficient correction. The pump head must be removed, and an inspection made to see whether the pump has been damaged by the starting action. The rotor should be removed and an inspection made to

see whether the faces of the bronze bushings in the pump body and head have been scored. An examination should be made of the rotor vanes to see that no sheared particles of brass have become lodged beneath them. When the head is replaced the flange screws should be tightened, while rotating the shaft manually.

(b) *Main pump binding.* - If a binding condition exists in the A-end first check the gears which drive the control pump to insure that no foreign matter has become wedged in the gear teeth. If binding still exists the A-end is to be dismantled for inspection as explained in the instructions of paragraphs 128, 129.

93. *Hoist inoperative due to pressure failure when the controls are set for a hoisting cycle.* -

(a) *Failure of electrical control circuit.* - With the electric motor operating and the controls correctly adjusted and positioned for a hoisting cycle, using servo electrical control, pressure should build up in the system as soon as the starting handle is moved to the "start" position. If pressure does not become available immediately, it is probably due to the failure of the electrical control circuit. This may be checked by shifting the control selector lever to the servo mechanical position. If the hoist then functions correctly and requires only a normal effort to shift the control lever, the trouble is in the electrical controls, and may be caused by one of the following reasons:

(1) The solenoid fuse, in the controller box, blown.

Check fuse and if blown replace with the proper fuse.

(2) The door interlock switches open.

Check to see if doors at the top and bottom of the hoist are closed. If closed check the switches to see if they are closed and the contacts in good condition.

(3) The solenoids in the valve block assembly do not function to shift the venting valve or the power failure valve.

Remove the inspection cover from the solenoid housing and examine the solenoids to see if they operate to shift the venting valve, when the starting handle is moved to the "Start" position. Also check to see that the power failure valve shifts when the electric motor is turned off and on.

(4) The venting valve or the power failure valve stuck.

Operate the valves manually by moving their operating levers inside of the solenoid housing to insure that no friction exists in the valves, and the valve springs function correctly.

(5) The starting switch fails to close or make contact.

Remove the cover of the starting switch and check to see if the contacts close when the starting handle is moved to the "Start" position.

(6) The loading and unloading position limit switches fail to close or make contacts.

Remove the covers of the switches which are not held open by the powder car and check to see that the switches are closed, and the contacts in good condition.

(7) The wiring may be ruptured or a short circuit may exist.

Check the wiring for rupture or short circuit.

(b) *Failure of control pump circuit.* - If pressure builds up to operate the hoist with the control selector lever positioned for a "Servo Mechanical" controlled cycle, but considerable effort is required to operate the hoist and lower control lever, the control pump has failed. The trouble may be caused by one of the following reasons:-

(1) The control pump relief valve adjusted too low to provide enough pressure to operate the hoist.

Install a pressure gauge in the inlet flange of the control pump, and check the pressure to be 160 lbs. per square inch. Adjust relief valve if necessary as explained in paragraph 83.

(2) Control pump relief valve stuck open.

Remove the acorn nut and adjusting screw. Reach into the opening and check the valve to see if it is free from binding.

(3) The oil filter on the A-end clogged. The pressure may seem to be correctly set at the pump but the filter may prevent the flow of oil to the control pump circuit.

Remove the filter cores from the A-end filter assembly and clean.

(4) The control pump damaged.

Remove the control pump, dismantle and check for worn or damaged parts.

(5) Restriction #44 is clogged.

Remove pipe plug 196826-11 from the top of the valve block assembly and remove the restriction plug for inspection.

(6) The by-pass valve 274283-3 in the valve block assembly 274272 may be stuck in its vented position.

Dismantle the valve block and check the valve to be free from binding. (See "To Dismantle Valve Block".)

(c) *Failure of main circuit.* - If the pressure does not build up to operate the hoist when the control selector lever is positioned for a "Servo Mechanical" controlled cycle the trouble will be in the main circuit, and will probably be caused by one of the following reasons:-

(1) The main circuit relief valves in the B-end hydraulic motor head set too low.

Adjust the relief valves.

(2) Relief valves stuck open due to binding or foreign particles.

Dismantle the relief valves and check for dirt or scored valves. See "Dismantle Relief Valves".

(3) The check valve 206639-5 in the B-end hydraulic motor head stuck open, omitted, or assembled for opposite rotation.

Remove the pipe plugs in the motor head and check for foreign matter. Check location of the valves and plugs. (See dr. no. 274249.)

(4) Pipe plug 200075-16 in the hydraulic motor head omitted or incorrectly assembled.

Correct in same manner as for (3).

(5) Insufficient clearance between the rocker arm rollers 274328-4 and B-end cams.

Check adjustment for rocker arms and cams as explained in instructions.

(6) The supercharging check valves and the by-pass check valves 274285 and 274286 may be stuck open. These valves are located on the inlet and outlet flanges of the A-end and the by-pass checks are assembled to the top of the valve block.

Remove the small covers 274285-2 from the bottom of the check valve assemblies. Examine the valve for binding or foreign matter.

(7) The replenishing check valves 274284 stuck open. These valves are located inside of the A-end storage tank.

To inspect these valves see "Disassembly".

(8) Excessive leakage in the system due to scored cylinder blocks or pistons in the A or B-ends.

This may be checked by increasing the clearance between the rollers and the cams, which should allow the pressure to build-up in the system.

Remove the drain pipe which connects the drain flange on the top of the B-end to the top of the A-end. Install a temporary drain from the B-end to a separate container and check the leakage out of this drain pipe. If the leakage is in excess of 1/2 G.P.M. with the oil at a temperature of 100 degrees, a scored B-end piston or cylinder block is indicated. If the B-end will operate at a slow speed, but the rotation of the hoist drum is erratic and uneven, a scored piston is indicated. If the leakage at the B-end drain is not excessive and more than the normal offsetting of the pump is required to build up pressure, a damaged A-end cylinder block or piston is indicated.

94. *Hoist inoperative due to pressure failure when the controls are set for a lowering cycle.* -

(a) If the powder car fails to lower at either the upper or lower unloading stations the probable cause is that the powder car is being blocked by the safety car stop device. This condition may occur if the starting handle is alternately placed in the "Start" and "Stop" positions several times before starting to lower the car. This improper operation of the hoist controls releases and applies the brake each time the starting handle is depressed and may allow the car to catch on the safety car stop device. The car can be lifted off the safety car stop device by moving the control lever to the hoisting position before starting to lower.

(b) The above condition may also occur if the cable has stretched in excess of the two inches provided for on the cams in the B-end. Improper adjustment of the cams or the unloading station limit switches may also cause this condition.

The cable is to be taken up, or the cams and limit switches are to be adjusted.

(c) If the car is not resting on the safety car stop device, and pressure fails to build up in the system, the equipment is to be checked in the same manner as for pressure failure with controls set for hoisting. (See par. 93.)

95. *Stopping inaccurate.* -

(a) When operating with the controls set for a "Servo Electrical" controlled cycle, and the car fails to stop within one inch of the intended stopping position the trouble will probably be one of the following reasons:-

(1) The starting handle is held down when the car is approaching the loading or the upper unloading stations which will cause the hoist to overtravel and strike the buffers.

This is improper controlling of the unit, by the operator, as the starting handle is to be released as soon as the car has moved a few inches.

(2) The hoisting cable has stretched in excess of the two inches allowed for on the B-end cams.

Adjust the cams or shorten the cable if the cams have been dowelled in place.

(3) The limit switches are not properly adjusted.

Readjust the limit switches.

(4) The brake improperly adjusted to hold the load.

Readjust brake.

(5) Brake band worn, oil soaked, or glazed to permit brake to slip.

Check brake band. If worn or oily, remove and clean, or install a new band.

(b) During "Servo Mechanical" control or "Manual" control, the stopping will not be as accurate

as when using "Servo Electrical" control, however if the stopping is not normal for these methods of operation the probable causes will be the same as when using "Servo Electrical" control, except for the limit switch adjustments. An additional reason for inaccuracy, will be an improperly adjusted latch and vent valve cam. This will prevent the brake from applying, and the circuit from venting, when the powder car reaches the loading or unloading stations.

96. *Ratchet slips when hoisting.*

(a) This will be recognized by a clicking sound in the B-end, while the unit is hoisting or starting to hoist. The reason for this is that the brake is slow in releasing due to one of the following causes.

(1) Too much travel of the brake cylinder piston.

Check the location of the end piston 274318-1 to be 3 inches from the face of the brake cylinder head.

(2) Too little clearance between the brake band and the brake drum when the brake is released.

Check the clearance between the brake band and the drum to be .010 inch.

(3) Insufficient control pump pressure.

Check the control pump pressure with a gauge to be 160 lbs. per sq. in. See reasons for control pump pressure failure in paragraph 93.

97. *Rail grabs operate.* - If the rail grabs operate during a normal "Servo Electrical" controlled cycle, the trouble will be in the setting of the rail grab controls and springs, as the cams in the B-end are machined to prevent hoisting deceleration and lowering acceleration rates in excess of 16 ft. per sec. per sec., if the cams are properly adjusted. However, if the rail grabs function when stopping or starting the car in the middle of the cycle, the dashpot cylinder assembly is improperly adjusted.

98. *Slow starting of the hoist.* - If the hoist requires excessive time to start after the controls are set for "Hoist-

ing" or "Lowering" the trouble will probably be insufficient clearance between the rocker arm rollers and the cams in the B-end.

99. *Excessive drop of the powder car when the brake is released.* - The normal drop of the powder car, when the brake is released should be from 1/2 to 3/4 of an inch. This is due to the compression of the oil in the main circuit. If the drop is excessive the probable reason is leakage in the foot valve assembly which is mounted on the B-end hydraulic motor head. This leakage will be caused by one of the following reasons:-

(1) The by-pass valve 274335-4 in the foot valve assembly is improperly adjusted.

See instructions "To adjust Foot Valve Control Linkage", paragraph 86.

(2) The check valve 274331-2 in the foot valve assembly is binding or stuck open due to foreign particles.

Remove the cover 274330-5 and check the valve for cleanliness or binding (see dr. no. 274249).

(3) The relief valve ball 274341-15 held off its seat by foreign particles.

Remove the cover 274330-9 and check the ball 274341-15 and plunger 274331-9 for cleanliness or binding.

100. *Excessive heating.* - If the unit gets excessively hot, it will probably be due to one of the following causes:

(1) Insufficient oil in the system.

Check oil level in the A-end tank.

(2) Mechanical bind in the equipment or the powder car.

Check pressures with gauge in the main circuit lines at the pressure gauge connections on the B-end. (See par. 43.)

101. *Unusual noises and their causes.* -

(a) When operating using "Servo Electrical" or "Servo Mechanical" control the unit will function with only the normal amount of noise and

vibration for equipments of this type. However when operating using "Manual" control, the noise and vibration in the equipment will increase. This will be caused by the failure of the control pump circuit which no longer supercharges the main circuit lines. The noise is caused by cavitation in the oil, but no harm will occur in the equipment if it is operated slowly as explained in paragraph 65.

(b) *Popping and sputtering* are caused by air entering the control pump through the intake lines, and may be caused by leaking gaskets in the suction line of the pump or damaged oil seal on the control pump drive shaft.

(c) *Grinding noises* are usually caused by dry bearings, or gears, or foreign matter in the oil.

(d) *Hydraulic chatter or hammer* is caused by the vibration of a spring actuated valve, long pipes not securely fastened with clamps, or air in the system.

(e) *Squeals* are caused by the head on the control pump being clamped too tightly against the pump rotor.

102. *Leakage* either inside or outside of the system may be the result of any of the following causes:

(a) Threaded fittings improperly tightened. Tinning the threads of fittings or pipe plugs will usually aid in preventing leakage, when they are correctly tightened.

(b) Crossed threads in fittings.

(c) Improper fitted or torn gaskets.

(d) Distorted, scored or worn oil seals, sealing rings, or packing. A single scratch or cut on the working surfaces may cause a slow steady leak.

(e) Flanged joints not seating squarely.

(f) Worn or scored valves.

(g) Worn or scored pistons in the motor or pump.

(*h*) Scored valve plates or cylinder blocks in the hydraulic motor or pump.

(*i*) Scored bushings or worn vanes in the control pump.

DISSASSEMBLY AND ASSEMBLY

103. Disassembly and reassembly of most elements of the powder hoist are apparent from the general arrangement drawings. Accordingly, no instructions are included here as to dismantling the hoist doors, door operating mechanisms, door dog locking mechanisms, the indicator device or the car or any of its attached devices. However, because of the installed positions of the power units and the necessity for dismantling in order to pass through the gun girder access hatches, complete instructions are compiled in the remaining paragraphs of this chapter as to disassembly and assembly of all parts of one A-end and B-end mechanism. Instructions as to A-end parts are given in paragraphs 104 to 131; B-end parts are covered in paragraphs 132 to 161, inclusive.

104. *To remove the control pump* (dr. no. 274269). - The control pump can be removed without draining the oil from the system by first removing the screws 180226-7 and 220718-2 from the inlet and outlet flanges of the pumps. Next remove the four screws 196825-6 from the pump mounting flange 274269-2. By springing slightly the inlet and outlet tubing, the pump shaft can be slipped out of its drive gear 274294-3, and the complete control pump removed.

105. *To dismantle the control pump*(refer dr. no. 274269). After the control pump has been removed from the A-end, the lock wire through the screws 274270-2 is to be broken and the screws removed. The pump head 274269-5 can now be removed, which will permit the removal of all of the internal working parts but the drive shaft 274269-4 and bearing 164474-10. The drive shaft is removed by loosening the screws 196780-4 and removing the mounting flange 274269-2. The shaft 274269-4 and its bearing can be slipped out of the pump housing.

106. *To reassemble the control pump.* - It is impossible to assemble these pumps for opposite hand rotation, and care should be taken upon reassembly, to check the rotation which is stamped on the pump body. It should be noted that there are arrows on both bushings, and the rotor, and when properly assembled all three of these arrows will point in the direction of the desired rotation. The chamfer on the vanes is on the trailing edge. When replacing the pump head 274269-5, care should be taken to tighten the screws that are diametrically

opposite. It is good practice to turn the pump shaft manually while these screws are being tightened to insure that the rotor is not binding. It is essential before reassembly that all parts of the pump are carefully washed in a non-acid cleaning fluid to insure absolute cleanliness.

107. *To remove the centering plunger assemblies* (refer dr. no. 274247). - The centering plungers can be removed without draining the oil from the A-end tank by first removing the screws 196780-4 from the pipe flanges 271724-4 which are secured to the centering plunger assemblies. Next remove the six long screws 274340-2 from each of the housings and the assemblies can be lifted off the A-end case. Care must be taken when removing these assemblies to mark the parts to insure that the proper centering plunger assembly and its mating shim 274305-9 are kept together, as the shims are of different thickness to insure the proper setting of the plungers.

108. *To dismantle the centering plunger assembly.* - After the assemblies have been removed from the A-end, the short screws 180226-6, which secure the cover 274305-8 to the body 274304-1 are to be removed. Spring 274305-7 is a 100 lb. spring, and it is advisable to use longer screws as jack screws while removing the cover 274305-8, to prevent the spring from flying out when the cover screws 180226-6 are removed. The plungers 274306-1 and 274306-4 can now be slipped out of the housings.

109. *To reassemble the centering plungers.* - All parts are to be washed in a non-acid cleaning fluid to insure cleanliness before the parts are reassembled. Make sure that the correct centering plungers are installed in the bodies and that the same shims are installed as were removed. If new shims are required, see centering plunger adjustments.

110. *To remove the neutral interlock switch.* - (See dr. no. 274247.) This can be removed without draining the oil by first shutting off the electric power supply and removing the terminal connections. Next remove the two screws 196825-7 and the limit switch 231705 can be lifted off. Next remove the four screws 180226-7 and the plunger assembly can be moved from the A-end. Switch dismantling and reassembly are apparent.

111. *To remove the solenoids.* - (Refer dr. no. 274272.) First open the electric power disconnects, and then remove the 14 screws 196825-6 from the cover 274277-1, which will give access to the solenoids 274233. Disconnect the terminal wires and remove the screws 206446-3 and the solenoids can be lifted out of the case 274279-1.

112. *To reassemble the solenoids.* - The solenoids are to be reassembled in the same location as when removed as they

have been fitted individually over the dowel pins 196732-8. If a new solenoid is to be installed the solenoid case 274279-1 is to be removed by first loosening the clamp bolts 196780-4 in the solenoid operating levers 274273-3 and 274273 (see 274272 valve block), then remove the levers. Next remove the 14 solenoid housing mounting screws 196780-4 and the case 274279-1 can be removed. Next remove the 196826-9 pipe plugs located on the back of the solenoid cases, and drive out the dowel pins 196732-8. The solenoid is to be mounted in place and secured with its mounting screws. Now use a 19/64 inch drill and with the dowel holes as a guide drill thru the solenoid mounting flanges. Care must be taken not to drill too deep and injure the solenoid coils. Ream the holes for the 5/16 inch dowel pins 196732-8, and assemble the pins and the pipe plugs 196826-9. Remove the solenoid and reassemble the case 274279-1 to the valve block cover 274275-1. Reassemble the solenoid operating levers, and both solenoids. Connect the terminal wires and then replace the cover.

113. *To remove the air breather assembly* (dr. no. 274286-2). Grab the lower hexagonal portion of the breather assembly with a wrench and screw the breather assembly out of the elbow 206447-4.

To dismantle the air breather. - Grab one of the hexagonal portions of the breather in a vise, and screw off the other cover with a wrench. Take precautions against losing the small needle valve when dismantling the assembly.

114. *To remove the control pump gear case assembly.* - (Refer dr. no. 274247.) First disconnect the tubing from the #7 flange connections and disconnect and remove the coupling between the electric motor and the A-end shaft. Remove the 14 screws 206829-5 and then insert three 3/8"-16 jack screws in the 1/2 inch drilled holes and remove the assembly by turning the jack screws evenly. Care must be taken not to injure the oil seal 274338-7.

115. *To dismantle the control pump gear case assembly.* - After the assembly has been removed from the A-end remove the two screws 180226-6 remaining in the cover 274295-1. Insert jack screws in the three 3/8"-16 tapped holes in the cover 274295-1, and remove the cover by turning the jack screw evenly until the cover slides off the dowel pins. The gear 274298-1 can now be lifted out of the case 274296-1 and the gear 274298-5 can be removed from the drive shaft 274300-1.

116. *To reassemble the control pump gear case assembly.* - Wash all parts in a non-acid cleaning solution. The assembled gear case can be reassembled to the A-end, however for ease

of assembly and to minimize the danger of injury to the oil seal it is advisable to reassemble the parts as follows: First assemble the gear 274298-5 on to the shaft 274300-1 and next reassemble the gear case 274296-1 to the A-end. Replace the gear 274298-1, and the two shims 274300-2. Before replacing cover 274295-1 with its oil seal 274338-7 slip the oil seal leader 274350-2, which will be found in the spare parts boxes, over the end of the drive shaft 274300-1. The oil seal is to be slipped over the end of the leader and the cover is to be pushed down on to the case. Make sure that the bronze spacer 274303-4 is correctly assembled over the pins 206457-6. To aid in assembling this spacer, it may be stuck on the gear case cover with grease, to hold it in place until the cover is reassembled. The hold down screws 206829-5 and 180226-6 are to be reassembled and tightened and the coupling and tubing are to be replaced.

117. *To remove the filter assembly.* - The oil must be drained from the tank. The tubing subassembly 274289-2 which connects from the control pump to the filter assembly, and the tubing subassembly 274256-2 which connects from the filter assembly to the by-pass valve 274256 are to be disconnected. Remove the four screws 196825-11 and the complete assembly can be removed.

118. *To dismantle the oil filter assembly.* - The six screws 180226-6 are to be removed from each filter retainer 274303-2. This permits the removal of the filter cores 274306-3 and the springs 229026-10. Next remove the three screws 196780-4 from the oil seal retainer 274296-3, and the valve 274296-4 can be removed from the body 274293-1. Next drive out the pin 274341-5 and the lever 274395-4, spring 199993-5 and the detent plunger 274297-4 can be removed.

119. *To reassemble the filter assembly.* - The parts are to be washed with a non-acid cleaning fluid, and reassembled by reversing the dismantling procedure. The completed assembly is to be checked to permit free movement of the valve, and then the tubing assemblies are to be replaced.

120. *To remove the control pump by-pass valve.* - (Refer dr. no. 274256 and 274272.) The oil is to be drained from the A-end tank. The linkage is to be disconnected from the lever 274257-2. The tubing assemblies 274256-2 and 274256-4 are to be disconnected. Next remove the six screws 274340-3 and the by-pass valve can be removed from the valve block assembly.

121. *To dismantle the control pump by-pass valve.* - (Refer dr. no. 274256.) First remove the clamp bolt 196780-4 from the lever 274257-2, and the lever can be pried off the valve 274256-5. The key 196716-3 is to be removed, and the valve

can be withdrawn from the body. The pin 274341-6 is to be driven out which will permit removal of the detent plunger 274257-3, and the spring 180233-6.

122. *To reassemble the control pump by-pass valve.* - Refer dr. no. 274256. The parts are to be thoroughly cleaned and reassembled by reversing the dismantling procedure. The assembled valve is to be checked to permit free movement of the valve, and then the tubing and linkage is to be replaced.

123. *To remove the valve block assembly* (dr. no. 274272). The A-end tank is to be drained. The air vent and breather, the control pump gear housing, with the control pump attached, the filter assembly, and both solenoids are to be removed as explained above. All tubing and linkage are to be disconnected from the valve block flanges and levers. Next remove the large pipe plug 274341-11 from the A-end pump housing 274292-1. Reach into the opening at the top of the pump housing and remove the slotted nut 274339-2. (See 274272 assembly drawing of the valve block.) The pin 274273-11 can be kept from turning by inserting a large screw driver through the pipe tapped hole in the pump housing. The pin 274273-11 can be removed through the same opening. The valve block assembly is a very heavy unit, and a block and tackle or a chain fall must be used for ease in handling the unit, when it is being removed from the A-end. The venting valve control lever shaft 274281-5 assembly is to be removed by loosening the four screws 196825-6. Next remove the two solenoid operating levers 274273-3 and 274273 by removing their clamp bolts 196780-4. Next remove the fourteen solenoid housing mounting screws 196780-4, and the housing can be lifted off. With the chain fall or block and tackle secured to the eye bolts in the valve block assembly, loosen the nineteen valve block mounting screws 206590-7. Insert jack screws in the two 1/2 inch tapped holes in the pump housing 274292-1. Turn the jack screws evenly and the valve block can be slipped off the dowel pins 271727-11.

124. *To dismantle the valve block assembly* (dr. no. 274272). - In order to remove the internal parts from the valve block assembly, the valve block must be removed from the A-end as explained above. For ease in assembling and dismantling, it is advisable to remove the block to a work bench. The parts are to be removed as follows:

(a) *To remove the valve block servo linkage.*- First loosen the slotted nut 274339-2, and remove the screw 274273-6 from the stroke control piston 274280-1. Next loosen the slotted nut 206513-6, and remove the screw 274273-10 from the "S" valve (servo valve) 274283-1. Now turn the control lever 274272-1 or 274336-1, so that

the end of the short lever 274276-4 projects out of the block and remove the nut 206513-6 and the screw 274252-5.

(b) *To remove the stroke control piston.* - (Refer dr. no. 274280-1.) Remove the five mounting screws 196780-4 from the stroke control piston retainer 274278-1. The piston and retainer can now be pulled out of the valve block. Care must be taken not to injure the oil seal leather 274273-8. When reassembling these parts, first assemble the piston in to the block, and then assemble the retainer.

(c) *To remove the "S" valve (servo).* - (Refer dr. no. 274283-1.) First remove the control pump by-pass valve and the servo valve can be withdrawn from the block. The servo valve can be removed from the valve block, without removing the block from the A-end. This is accomplished by draining the A-end and removing the A-end inspection covers 274298-2. Reach up through the inspection openings, and remove the nut 206513-6 and the screw 274273-10, which secures the servo valve 274283-1 to the servo control link 274275-3. Now remove the control pump by-pass valve. Next remove the servo valve end cover 274280-5, and the servo valve can be pushed out of the valve block. When a new valve is to be assembled, the valve will have to be ground to agree with drawing number 274283-1. The outside diameter of the valve will be 0".010 oversize and will have to be ground to fit the valve block to give a clearance of 0".0005 to 0".0007 inches. The 45° chamfer, and the 1/8" side slots are to be ground on the lands of the valve in accordance with drawing number 274283-1. The lines of seal on the valve are to be determined from each individual valve block as follows:

(1) Assemble the valve in the valve block, with the control pump by-pass valve in place. The large end cover 274275-1 must be off. With the valve installed and the cam on the end of the by-pass valve turned so as to permit practically no movement of the valve, the distance from the end of the valve to the valve block cover face 274275-1 is to be accurately measured with a depth micrometer.

(2) Now remove the valve and then accurately measure the distance from the valve block face to the inner grooves in the servo valve bore in the valve block.

(3) From these dimensions, the valve can be accurately laid out, and the seal lines determined.

(4) The lines for the 45° chamfers and the ends of the 1/8 inch wide slots are to be scribed on the valve.

(5) The valve is to be set up in a grinding machine, and the slots and chamfers ground to the scribed lines.

(d) *To remove the "BP" (by-pass) valve.* - (Refer dr. no. 274283-3.) First loosen the screws 180226-6 from the end cover 274284-1 and remove the cover. The valve 274283-3 can be pulled out of the block.

(e) *To remove the valve block cover.* - (Dr. no. 274275-1.) First remove the small end cover 274284-1 which exposes the "V" (venting) valve plunger stop 274282-5. Next remove the pins 274341-7 from the plunger stops on both the "V" valve and the "PF" (power failure) valve. Next remove the 15 cover mounting screws and the 4 screws from the servo valve end cover. Insert jack screws into the two 1/2"-13 tapped holes, and the cover can be removed by turning the jack screws evenly. Care must be exercised when removing this cover, as the "BR" valve, the "PF" valve and the "V" valve are assembled to the cover, and will pull out of the valve block while the cover is being removed. After the cover is removed from the valve block the valves which are assembled to the cover are to be removed by loosening the slotted nuts and removing the screws. The removal of the cover makes accessible the control pressure relief valve 274280-3 and the check valve 196788-10.

(f) *To remove the "V" (venting) valve, the "BR" (brake release) valve, the "PF" (power failure) valve, the "REL" (relief) valve and the check valve,* see instructions "To Remove the Valve Block Cover". Further dismantling is apparent.

125. *To reassemble the valve block* (dr. no. 274272). - Wash the parts in a non-acid cleaning fluid to insure cleanliness and assemble the parts in reverse of the dismantling instructions. Extreme caution must be exercised to not injure the valves which are assembled to the valve block cover 274275-1 when the cover is reassembled to the valve body 274274-1. The valves are to be inserted into the body and the cover slowly pushed towards its mounting face, making sure that no binding of the valves exist as the cover approaches its mounting face. Make sure that the small check valve 196788-10, its spring 271702-1, and the relief valve stop washer 274277-9 have been installed in the valve block before tightening the cover mounting screws.

126. *When reassembling any new sliding valves* in the valve block the outside diameters will have to be fitted to the valve block bores by grinding the .010 inch oversize stock off the valves. The valves are to be ground and polished to give a clearance fit of .0005 to .0007 inch clearance.

127. *To remove the check valve assemblies.* - (See dr. 274247.) The check valves 274285 and 274286 which are assembled on the top of the valve block can be removed without draining the oil from the A-end, but the check valves 274286 which are assembled to the inlet and outlet flanges 274297-1 of the A-end will require draining of the oil before their removal. Disconnect the tubing assemblies from the check valves, and remove the check valve mounting screws, and the check valves can be lifted off the A-end assembly. Dismantling the valves from the cover is apparent.

128. *To remove the A-end pump assembly.* - First drain the oil from the A-end assembly. Disconnect the A-end from the control linkage. Next remove all tubing from the A-end. Disconnect the electric motor coupling, and remove the A-end mounting bolts. Next slide the A-end under the access hatch to provide room for using a chain fall or block and tackle for removing the heavy portions of the unit. Now remove the control pump gear housing, the filter assembly, the centering plunger assemblies, the limit switch assembly and the valve block assembly as explained previously. Now remove both inspection covers 274298-2 from the ends of tank 274291-1. Reach in through the inspection openings and remove the 21 screws 206513-1, which will permit the pump housing 274292-1 to be separated from the storage tank 274291-1. The pump housing is to be lifted off using a chain fall for ease of handling. Now remove the gear 274298-5 from the drive shaft 274300-1. Next remove the two keys 200066-6, the spacer 274303-7, and the split rings 274300-5. Now turn the pump housing assembly over, and set it on wood blocks so that the pump shaft 274300-1 points down. Now block the pump yoke 274301-1 in a centered position and remove the

pipe plug 206701-6, and the screw 196780-4 from the pump head 274302-1. Next remove the pump head mounting screws 206701-7 and 271730-12, and the pump head 274302-1 can be removed. The valve plate 274299-5, the cylinder block 274299-1, and the universal link assembly can be lifted out. The pump shaft 274300-1 with the pistons and bearings assembled can now be lifted out. Next remove the pintles 274298-3 from the end of the pump housing and the pump yoke 274301-1 can be removed.

129. *To dismantle the pump shaft.* - First remove the screws 271678-4 from the piston rod retainers 271692-4. Make sure that these parts are marked to insure reassembly in the same location. The piston rods 271690-4 can now be removed from the shaft. The pistons are further dismantled by straightening out the lock washers 271691-4, and then removing the bearing retainers 271690-3. The bearings 274337-16 and 274337-15 are next to be removed. Bearing 274337-16 is a light push fit on shaft 274300-1, and can be removed easily by tapping on the edge of the inner race of the bearing. The bearing 274337-15 is a press fit on the shaft 274300-1, and can be removed only by inserting pins of equal length in the 3/8" diameter holes in the piston rod bores in the shaft, after the piston rod bearings 271691-6, have been removed. The shaft and pins are to be placed under a press and the bearing 274337-15 forced off. When installing a new bearing 274337-15, the new bearing is to be heated in an oil bath to a temperature of 175° F. and is to be assembled quickly on to the shaft, before the bearing cools. The bearing support on the shaft 274300-1 is to be coated with "Micronized Graphite", a product of the Dixon Graphite Co. to permit easy disassembly of the bearing. The spring retainer 271692-2 can next be removed by loosening the locking screw 220718-1 from the shaft, and removing the universal link retainer 271692-5. The cylinder bearing pin 274296-5 can be removed from the cylinder block by tapping lightly on the end of the shaft, which will drive out the universal link retainer 271691-3.

130. *To reassemble the A-end,* all parts are to be washed in a non-acid cleaning fluid, to insure cleanliness, and the parts are to be reassembled by reversing the dismantling procedure. When assembling the pistons in to the cylinder block, the pump yoke is to be tilted to one side, and the pistons and the universal link are to be fed in to their bores one at a time. All moving parts are to be checked to be free from bind. When assembling new oversize pistons into a worn cylinder block, the cylinder bores are to be remachined to make the bores true and round. The 0.010 oversize pistons are to be ground and polished to fit the bores with a clearance tolerance of .0008 to .0014 inches.

131. *To remove the replenishing check valves* (dr. no. 274284). - It is not necessary to remove these assemblies for

inspection purposes. The oil is to be drained from the A-end tank and the inspection covers 274298-2 are to be removed. Reach in through the opening and remove the screws 196825-6 from the cover 274284-6. The cover and the valve 274284-7 can be removed for inspection. Make sure that the valve is free from bind when reassembled by checking the valve movement through the opening in the lower end of the valve body.

132. *The B-end* (dr. no. 274249) is built up of several subassemblies, some of which may be removed without completely dismantling the B-end. The removal and dismantling of these subassemblies will be described separately.

133. *To remove the cam support assembly.* - Remove the large portable plate at the cam end of the powder hoist compartment. Next drain the oil from the cam housing. Remove the inspection cover 274320-2, which will expose the cams. Remove the lock washer 200074-8 and the lock nut 271731-3 from the end of the drive shaft 274313-1. Mark the cam support 274322-1 and the gear 274328-9 to insure the reassembly of the parts in the same location. Slip the cam assembly off the end of the drive shaft.

134. *To dismantle the cam support assembly.* - The hoisting cams are removed by loosening the screws 180226-6, the heads of which project slightly above the surface of the clamp ring 274323-4. The lowering cams are dismantled by removing the screws 220718-2 from the clamp ring 274323-2. Remove the screw 180226-6 from the face of the gear 274327-5 and the gear can be forced off the dowel pins 206485-14.

135. *To reassemble the cam support assembly.* - All parts are to be thoroughly washed in a non-acid cleaning fluid and are to be assembled in the reverse of the dismantling procedure. The cams are to be adjusted as explained in paragraph 80.

136. *To remove the rocker arm assembly.* - Loosen the lock nut 271665-3 and the lock washer 196733-14. Use bearing lock nut wrench 220720-2, which may be found in the spare parts box #1. Tap on the end of the shaft 274327-3, and the rocker arm assembly can be forced off the shaft.

137. *To dismantle the rocker arm assembly.* - First remove the two screws 220718-2 and the two screws 180226-7 which project out of the rocker arm, and the hoisting arm 274329-2 can be removed from the hub 274329-1. Next loosen the remaining two screws 180226-7 and the lowering rocker arm 274328-1 can be dismantled from the hub 274329-1.

138. *To reassemble the rocker arm assembly.* - The parts are to be thoroughly cleaned, and are to be reassembled in

reverse of the dismantling procedure. After the parts have been reassembled, they are to be adjusted as explained in paragraph 80.

139. *To remove the brake band assembly* (dr. no. 274307). First block the powder car at the loading station. Loosen the lower lock nuts 206522-3 and 274339-4 on the adjustable brake band end 274318-3. Next remove the two clamp bolts 196825-9 from the upper bosses of the brake support bracket 274321-2. The shaft 274331-1 can be pushed out of the brake band end 274320-4, the lever 274321-1, and the bracket 274321-2. Next remove the slotted nuts 274339-5 from the four eccentric adjusting screws 274307-2. Turn the adjusting screws so that the flat on the screw heads will slide past the hoisting drum, and then remove the adjusting screws 274307-2. Next loosen the two lock nuts 180226-12, which are located on top of the brake cylinder housing 274315-1. Screw "in" on the adjusting screws 274328-10 as far as they will go. The brake band can now be removed by springing it slightly. Care must be exercised to keep the spring of the band to a minimum to prevent injury to the band by forcing it out of round.

140. *To remove the brake cylinder assembly.* - First remove the brake band assembly 274307 as explained above. Remove the tubing assemblies which are connected to the #4 and #5 connections on the brake cylinder. Next loosen the slotted nut 220743-4 and remove the screw 274328-5, which connects the lever 274321-1 to the link 274322-3. This permits the removal of the lever 274321-1. Now loosen the four brake cylinder mounting screws 274340-9. Pry up one end of the cylinder assembly until it clears the key 274319-7 and the brake cylinder can be removed.

141. *To dismantle the brake cylinder.* - First remove the slotted nut 220743-4 and the screw 274328-5 which connects the link 274322-3 to the brake cylinder piston 274318-1. Now remove two of the cover screws 220806-7 from the flange #4 end of the brake cylinder. Insert jack screws or threaded rods and nuts in the two tapped holes to prevent the 500 pound spring from forcing the piston out of the housing when all of the four screws 220806-7 are removed. Further dismantling is evident by examining the assembly drawing 274249.

142. *To reassemble the brake cylinder.* - The brake cylinder is to be reassembled in reverse of the dismantling procedure except the oil seal leader 274347-4, which is to be found in the spare parts box #1, is to be slipped over the end of the piston 274318-1, while the piston is being assembled through the oil seal 274338-10. All parts are to be throughly cleaned before assembling.

143. *To reassemble the brake band assembly.* - The brake band assembly is to be reassembled in reverse of the dismantling instructions. Extreme care must be exercised to prevent oil or grease from getting onto the brake band or brake drum while reassembling the parts. The brake is to be adjusted as prescribed in paragraph 85.

144. *To remove the relief valves* from the B-end motor head, loosen the acorn nuts 274311-2 and the lock nut 274319-3. Back out the adjusting screw 274324-5, and the relief valves and springs 274312-6 and 274312-3 can be removed. After the parts have been cleaned and reassembled the relief valves are to be adjusted as prescribed in paragraph 84.

145. *To remove the cam housing assembly* (dr. no. 274326-1). Block the powder car at the loading position to take the load off the cable if the unit is assembled in the turret. Remove the cam support assembly as explained previously. Using the bearing lock nut wrench 274346-2, which may be found in the spare parts box #1, loosen the lock nut 274339-6 on the drive shaft 274314-1. Next remove the gear 274328-6 and the spacer 274335-6. Next remove the clamping screw 196825-7 from the upper end of the link 274335-8, which connects the rocker arm operating lever 274327-2 to the foot valve linkage (see dr. no. 274249). Drive out the link pin 274334-8. Loosen the two lock nuts 274339-8 on the control rod 274330-3, which connects the B-end to the control linkage, (dr. no. 274251). Remove the screw 274272-5 from the upper end of the link 274253-4, which connects the control rod 274330-3 to the lever 274253-1 on the control linkage. Next screw the control rod 274330-3 out of the clevis 274253-5 at the B-end. Remove the eight mounting screws 229123-7 from the mounting face of the cam housing 274326-1 and drive out the dowel pins 274319-4. The cam housing can now be slid along the mounting base until it clears the drive shaft and can be removed. As this is a heavy assembly a chain fall or block and tackle should be used for ease in handling.

146. *To dismantle the cam housing* (dr. no. 274326-1). - The rocker arm assembly is to be removed as explained previously, which will permit the rocker arm shaft to be slipped out of the bearings 274337-9 and the oil seal 274338-10. Next remove the small cover 274321-5, and loosen the lock nut 271665-7. Tapping on the end of the shaft 274324-3 will force the shaft out of the gear 274327-1, and the outer bearing 196827-9. The shaft 274324-3, assembled to the inner bearing 196827-9, and the gear 274328-9 can be removed. Loosen the key 200148-6 and the gear and bearing can be forced off the shaft 274324-3. Next remove the large cover 274324-2, and the oil seal 274338-8 and the bearing 274337-11 can be removed.

147. *To reassemble the cam housing* (dr. no. 274326-1). The parts are to be washed in a non-acid cleaning fluid and are to be reassembled in reverse of the dismantling procedure. Part 274334-13 is to be assembled into the oil seal 274338-8 and the bearing 274337-11 before the cam housing assembly is slipped over the drive shaft. Make sure that the gasket 274329-4 is in place before the housing is assembled to the shaft. After the parts are reassembled, they are to be adjusted as explained in the instructions.

148. *To remove the hoisting drum* (dr. no. 274325-1). - First remove the cam housing assembly. Next disconnect the cable from the drum by removing the slotted nut 274339-1 and the collar 274328-11. Remove the cable clamps and pull the cable out of the slotted holes in the drum. Remove the hoisting drum from the shaft 274314-1.

149. *To dismantle the hoisting drum* (dr. no. 274325-1). After the drum has been removed, the screws 200075-6, which secure the ratchet 274317-4 to the drum are to be removed. The ratchet can now be forced off the dowel pins 206664-6.

150. *To reassemble the hoisting drum* (dr. no. 274325-1). The parts are to be reassembled in reverse of the dismantling procedure except that the hoisting cable may be attached to the hoist drum, if desired, after the cam housing has been reassembled. Before assembling the drum on the shaft, wire hooks are to be formed which will hook over the edge of the brake drum and into the holes on the ratchet dogs 274317-5, to hold the dogs clear of ratchet 274318-2. After the drum has been assembled far enough on the shaft to permit the dogs to engage, the wire hooks are to be removed and the drum pushed up against its retaining face.

151. *To remove the brake drum* (dr. no. 274320-1) - First remove the cam housing and hoisting drum 274325-1 and then the brake band assembly 274307, as explained previously. The brake drum can now be slipped over the end of the drive shaft 274314-1.

152. *To dismantle the brake drum* (dr. no. 274320-1). - Remove the slotted nuts 274339-7, and the ratchet dog support pins 274322-2 can be driven out of the brake drum. The springs 274317-7 can be disconnected from the ratchet dogs.

153. *To reassemble the brake drum* (dr. no. 274320-1). - The parts are to be washed in a non-acid cleaning fluid and are to be reassembled in reverse of the dismantling procedure.

CAUTION: Be sure that all oil has been carefully cleaned off the brake drum and the brake band assembly while assembling these parts.

154. *To remove the oil seal* (dr. no. 274338-9). - The oil is to be drained from the B-end case by removing the drain pipe plug 200075-16 located on the lower side of the hydraulic motor housing 274310-1. The cam housing, hoisting drum and brake drum are to be removed as explained previously. The removal of the oil seal retainer screw 271666-9 will permit the removal of the retainer 274318-4. The oil seal 274338-9 can then be forced out of the retainer.

155. *To remove the foot valve control linkage* (see dr. no. 274249). - Dismantling of the control linkage is evident by examining the reference drawing.

156. *To remove the foot valve assembly.* - This assembly can be removed without completely draining the oil from the system if a drip pan is placed under the valve when it is being removed. If the unit is to set any length of time after the foot valve is removed the oil in the B-end case is to be drained by removing the drain plug located on the lower side of the hydraulic motor case 274310-1. The drain flange 274287-6 is to be disconnected from the body of the foot valve. The screw 274334-11, which connects the foot valve clevis 274335-2 to the foot valve control linkage link 274331-4, is to be removed. The main supply line flange 274330-1 is to be disconnected from the foot valve body 274332-1. The removal of the four mounting screws 274340-10 will allow the foot valve assembly to be removed.

157. *To dismantle the foot valve.* - Any one or all of the valves in the foot valve assembly may be removed without removing the assembly from the B-end. However, for ease in dismantling it is advisable to remove the assembly.

(a) *To remove the by-pass valve* (dr. no. 274335-4). First loosen the lock nut 180247-8, and remove the clevis 274335-2. Next remove the screws 180226-6 from the cover 274331-8. By alternately pulling and pushing on the valve, the cover 274331-8, the bushing 274334-1, and the valve 274335-4 can be pulled out of the valve body. Next remove the cover 274331-6, and tap on the inside face of the bushing 274335-7 with a fiber or rawhide block, and the bushings 274335-7 and 274334-12 can be removed.

(b) *To remove the check valve* (dr. no. 274331-2). First remove the four screws 196825-11 from the cover 274330-5. This will permit the cover 274330-5, spring 274329-5, and the check valve 274331-2 to be removed.

(c) *To remove the foot valve, relief valve, ball* (dr. no. 274341-15). - First remove the screws 206590-7 from the lower cover 274330-9, which will permit the removal of the cover 274330-9, the spring 274330-6, the spring guide 274330-11, the plunger 274331-9, the washer 274327-7 and the ball 274341-15. Next remove the cover 274330-9 from the opposite side and the ball seat 274330-2 can be removed.

158. *To reassemble the foot valve.* - The parts are to be washed with a non-acid cleaning fluid and are to be reassembled in reverse of the dismantling procedure. When a new by-pass valve is to be installed the outside diameter, which is 0".010 oversize, will have to be ground and polished to give a clearance fit of 0".0005 to 0".0007 clearance with the bushings. When a new check valve 274331-2 is installed the valve will have to be ground to give a clearance fit of 0".005 to 0".006 with the body. When assembling the relief valve ball be sure that the washer 274327-7 and the spring guide 274330-11 are in place.

159. *To remove the hydraulic motor assembly.* - Block the powder car in the loading position to take the load off the hoisting cable. The oil is to be completely drained from the B-end. The cable is to be disconnected from the hoisting drum, and all of the piping and control linkage is to be disconnected from the B-end. For convenience in working, the B-end is to be removed from the turret as a chain fall hoist or crane will be required for handling the heavy parts.

160. *To dismantle the hydraulic motor assembly.* - The cylinder block 274312-1 and its associated parts can be removed from the B-end without completely dismantling the B-end. If it becomes necessary to remove the shaft 274314-1 the complete B-end will have to be dismantled.

(a) *To remove the cylinder block* (dr. no. 274312-1). The B-end assembly is to be blocked and securely fastened in a position, so that the center line of the cylinder block 274312-1 and the hydraulic motor head 274316-1 is in a vertical plane. The foot valve assembly is to be removed as explained previously. The two screws are to be removed from the cap located on the hydraulic motor head 274316-1. The twelve motor head mounting screws are to be removed. Using a chain fall or crane the motor head is to be lifted off. Next replace the small cover 274312-9 and the screws 274319-2, and clamp a four or five inch long piece of 1/2 inch square steel stock between the cover 274312-9 and the

cylinder bearing pin 274319-1 to provide means for attaching a rope sling for lifting the valve plate 274311-1 and the cylinder block 274312-1 out of the motor case 274310-1. Care must be taken not to injure these parts while they are being removed. The universal link 274313-6 and the knuckles 274314-4 can be lifted out. Remove the cover 274312-9, and tap lightly on the end of the cylinder bearing pin 274319-1 with a rawhide or fiber hammer, and the universal link retainer 274313-5 can be removed from the cylinder block.

The 12 hex. nuts 274339-3 are to be removed from the mounting face of the motor housing 274310-1, and the housing is to be removed. The spring retainer 274329-3 can next be removed. Insert a 1/2"-13 screw or rod into the tapped hole in the universal link retainer 274313-1 and the retainer can be pulled out of the shaft 274314-1. The piston rods 274313-8 can be removed by loosening the screws 180226-6 in the bearing retainers 274313-2. The bearing 274318-6 and 274313-7, the piston rod 274313-8 and the retainers 274313-2 are individually fitted to the bores in the shaft 274314-1, and care must be taken to reassemble these parts in their respective locations.

(b) *To remove the drive shaft* (dr. no. 274314-1). The cam housing assembly, the hoisting drum, the brake drum, the brake band assembly, and the foot valve and its control linkage are to be removed as previously explained. Now dismantle the cylinder block end of the hydraulic motor, as explained above, and the drive shaft 274314-1 can be removed from the drive shaft housing 274309-1. To aid in the removal of the bearing 274338-1 from the shaft three 33/64" diameter holes have been provided in the bearing bores of the shaft 274314-1; 1/2 inch dowel pins of equal length are to be inserted in these three holes. The shaft is to be placed in an arbor press, and bearing 274338-1 is to be forced off the shaft. When the bearing is being reassembled or a new bearing installed, it is to be heated in an oil bath to a temperature of 175° F., and is to be quickly assembled on to the shaft 274314-1, before the bearing cools. The bearing surface on the shaft 274314-1 is to be coated with "Micronized Graphite", a product of the Dixon

Graphite Co., to permit easy disassembly of the bearing. The drive shaft housing 274309-1 is removed by loosening the eight hex. nuts 206522-3. Jack screws are to be inserted in the two 3/4"-10 tapped holes. The jack screws are to be turned evenly, which will lift the drive shaft housing 274309-1 off the dowel pins 274319-4 and the key 274312-2. Further dismantling of the hydraulic motor and the B-end is evident by examining the assembly drawing 274249.

161. *To reassemble the hydraulic motor.* - All parts are to be washed in a non-acid cleaning fluid to insure cleanliness and they are to be reassembled by reversing the dismantling procedure, except that the motor housing 274310-1 is to be assembled after the cylinder block 274312-1 and the valve plate 274311-1 are assembled. When assembling the pistons 274314-2 into the cylinder block, the block is to be tilted to one side and the universal link 274313-6 with the knuckles 274314-4, and the pistons 274314-2 are to be fed into their respective bores one at a time. All moving parts are to be checked to be free from bind. When assembling new oversize pistons into a worn cylinder block, the cylinder bores are to be remachined to make the bores true and round. The 0.010 oversize pistons are to be ground and polished to fit the cylinder bores with a clearance tolerance of .0008 to .0015 inches. The face of the cylinder block is to be spot scraped flat and smooth to provide a sealing and bearing surface at the valve plate 274311-1. Before assembling the motor head 274316-1, make sure that the small copper gasket 274312-11 is in place around the cylinder bearing pin 274319-1. After the B-end is completely reassembled and installed, the unit is to be adjusted and tested as explained in the instructions to adjust the B-end.

162. *Disassembly and assembly instructions for valve assemblies and control linkage.* - The valve assemblies and control linkages are separate small assemblies which are mounted in the turret and are connected to the A and B-ends with copper tubing or linkage. The removal, dismantling and reassembling of each of these units are explained for each subassembly in the paragraphs below.

163. *To remove the safety car stop release valve* (dr. no. 274260). - It will not be necessary to drain the oil in the system if a pan is used to catch the small amount of oil lost from the system when the pipe connections are broken. The electrical disconnects are to be opened and the terminal leads are to be disconnected. Remove the screws in the flanges 274263-1 and 271697-7. The tubing at the #5 flange connection

is to be sprung far enough to permit the removal of the four valve mounting screws. This will permit the removal of the complete assembly for convenience in dismantling the valve assembly 274260.

164. *To dismantle the safety car stop release valve* (refer dr. no. 274260). - The switch 231707 is removed by loosening the two switch mounting screws 196780-7. Next remove the three hex. nuts 191000-2, and the lever 274262-1 and the link 274262-5 can be dismantled. Loosen the lock nut 220718-7 and insert a pin in the hole on the valve 274262-10 which will permit the clevis 274262-6 to be turned off the valve. Next remove the four cover screws 180226-6, and the cover 274262-4 can be dismantled. The valve 274262-10 can now be pulled out of the body 274261-1. Next remove the four screws 180226-6 from the opposite end, and the cover 274262-2, washer 274262-8 and the spring 274263-2 can be dismantled.

165. *To reassemble the safety car stop release valve.* - The parts are to be washed in a non-acid cleaning fluid and reassembled in reverse of the dismantling instructions. When assembling the oil seal 274338-3 over the valve 274262-10, slip the oil seal leader 274349-2 over the thread end of the valve to prevent injury to the oil seal packing. This oil seal leader will be found in the #1 spare parts box. All parts are to be free from bind, which will permit the valve to return to the "Stop" position, when the lever 274262-1 is released. When assembling new valve in the body the 0"010 oversize valve are to be ground and polished to give a clearance fit of 0"0004 to 0"0008, and the sharp edges are to be stoned to break the sharp edges.

166. *To remove the latch and vent valve* (refer dr. no. 274263). - It will not be necessary to drain the oil in the system if a pan is used to catch the small amount of oil which will be lost from the system, when the pipe connections are broken. First remove the screws 190958-3 and 206829-3 from the flanges 271697-7 and 274263-1. The tubing at the #6 and #7 flanges is to be sprung far enough to permit the removal of the four valve mounting screws. The linkage which connects the valves to the latch mechanism is to be disconnected. The valve assembly can be moved for convenience in completely dismantling the valve.

167. *To dismantle latch and vent valve* (dr. no. 274263). First remove the four cover screws 180226-6 from the stem end cover of the valve assembly, and the cover 274263-3 can be removed. The valve 274263-4 and the bushing 274266-1 can be withdrawn from the valve body 274264-1. Remove the four screws

220718-2 from the opposite end cover and the cover 274265-5, washer 274265-3, spring 274265-1, and the valve plunger 274265-2 can be removed.

168. *To reassemble the latch and vent valve* (dr. no. 274263). - The parts are to be washed in a non-acid cleaning fluid and reassembled in reverse of the dismantling instructions. When assembling the oil seal 274338-3 over the valve 274263-4 slip the oil seal leader 274349-2 over the thread end of the valve to prevent injury to the oil seal packing. This oil seal leader will be found in the #1 spare parts box. When assembling a new valve 274263-4 into the body, the .010 inch oversize valve is to be ground and polished to give a clearance fit of .0004 to .0008 inch clearance and the sharp edges of the valve are to be removed by stoning the valve. All parts are to be checked to be free from binding to permit the valve to be spring returned to its normal position. After the valve has been installed in the turret the linkage is to be adjusted to hold the latch just clear of its notch when the control selector lever is placed in the "Electrical" control position.

169. *To remove the safety car stop device cylinder and lever assembly* (refer dr. no. 274258). - It will not be necessary to drain the oil from the system if a pan is used to catch the small amount of oil lost from the system when the pipe connections are broken. First remove the screw 274258-2 which connects the piston 274259-9 to the safety car stop device mechanism. Next remove the screws 190958-3 and 206485-16 from the pipe flanges 274259-2 and 274259-3. Remove the four valve mounting screws and the valve assembly can be removed from the turret for convenience in completely dismantling the assembly 274258.

170. *To dismantle the safety car stop device cylinder and lever assembly* (dr. no. 274258). - First remove the cover screws 206590-7 from the flange end of the assembly and the cover 274259-4 will be removed. Care must be taken when removing this cover as the spring 274260-3 will force the piston rod 274259-9 out of the body 274258-1 with a force of approximately 65 pounds. Next remove the four cover screws 196825-11 from the opposite end of the assembly, and the cover 274259-10 can be dismantled. This will permit the removal of the Garlock Chevron packing 274260-2, and its retainer 274260-4. Further dismantling is evident by examination of the assembly drawing 274258.

171. *To reassemble the safety car stop device cylinder and lever assembly* (dr. no. 274258). - The parts are to be washed in a non-acid cleaning fluid, and reassembled in reverse of the dismantling instructions. When assembling the oil seal 274338-2 over the piston rod 274259-9, slip the oil seal leader

274349-4 over the end of the rod to prevent injury to the oil seal packing. The oil seal leader will be found in the #1 spare parts box. When assembling new Garlock packings 274260-2 the packings are to be fitted to hold the friction of the piston rod in the oil seal and packing to a maximum of 20 pounds pull on the piston rod. This can be determined approximately by lifting the valve assembly by the end of the piston rod 274259-9. The piston rod is to slide in its packing and oil seal by the weight of the body and its attached parts.

172. *To remove the control linkage assembly* (dr. no. 274251). - First disconnect the control rod, which connects onto the lever 274253-3. Remove the screw 274252-5 which connects the link 274253-4 to the B-end control rod, which passes through the gun girder cap. Next remove the screw 274252-6 from the clevis 274253-6, which connects to the A-end control lever. Remove the four bracket mounting screws, and the assembly can be forced off the dowel pins and can be removed from the turret to facilitate further dismantling.

173. *To dismantle the control linkage assembly* (dr. no. 274251). - Remove the screws 274252-5 and the control rod 274254-2 or 274251-2, and the link 274253-4 can be dismantled. First loosen the clamp bolt 220718-2 from the inner lever 274253-1 and slide the lever along the shaft 274253-2 until the two keys 274252-4 can be removed. Next remove the clamp bolt from one of the end levers, and remove the lever and its keys from the shaft. The shaft 274253-2 with the other lever attached may be forced out of the inner lever and the bracket 274252-1. Further dismantling is evident by examination of the assembly drawing 274251.

174. *To reassemble the control linkage assembly* (dr. no. 274251). - The parts are to be thoroughly cleaned and are to be reassembled in reverse of the dismantling instructions. All parts are to be checked to be free from binding and after the assembly is reinstalled in the turret the control rods are to be readjusted as explained in the "Preliminary Adjustments".

175. *To dismantle the dashpot cylinder assembly* (dr. no. 274265). - The assembly is to be drained by removing the filler cap 274266-7 and turning the assembly upside down to drain the oil from the reservoir 274266-9. Loosening the screws 196780-4 and the cover 274267-7 will aid in draining the oil. Remove the lock nut 274339-9 and the clevis 274266-5. Inserting a pin through the hole in the piston rod 274266-13 will prevent the rod from turning. Remove the cover 274267-7 and the piston rod 274266-13 can be pushed out of the body 274268-1. Remove the screw 180226-6 from the upper cover 274267-11, and the cover, washer 274267-5 and the packing 274266-10 can be dismantled. The feed control valves 274267-1 and the spring

274267-9 can also be removed. The removal of the small pipe plugs 196826-9 from the ends of the body 274268-1 will permit the removal of the ball checks 196701-9, the springs 274266-4 and the spring retainers 229060-9. Removal of the acorn nuts 206482-11 and loosening the lock nuts 274267-10 will permit the removal of the adjustable needle valves 274266-11.

176. *To reassemble the dashpot cylinder assembly* (dr. no. 274265). - The parts are to be thoroughly cleaned in a non-acid cleaning fluid and are to be reassembled in reverse of the dismantling instructions. When assembling the piston rod 274266-13 through the oil seal 274338-4 and the packing 274266-10, slip the oil seal leader 274349-3 over the thread end of the piston rod to prevent injury to the oil seal and packing. The oil seal leader may be found in the #1 spare parts box. The assembly is to be filled with oil and adjusted as explained.

METHOD OF CHANGING EQUIPMENT FROM RIGHT HAND TO LEFT HAND

177. The remaining paragraphs of this chapter are disassembly and assembly instructions which apply to alteration of a right hand power plant for purpose of converting it for left hand installation. Elements of the A-end, the B-end, the control linkage and the safety car stop device require conversion as described. All other parts are assembled the same for both right and left hand installations.

Conversion from left hand to right hand is made in exactly the same manner as described except the parts are to be mounted in the R.H. locations and the R.H. levers are to be used.

178. *B-end change-over from R.H. to L.H.* requires the following changes (see assembly drawing of B-end, 274249).

(*a*) The foot valve and its control linkage are to be assembled on the opposite side of the base and the hydraulic motor head.

(*b*) The complete brake cylinder and brake band are to be assembled to the opposite side.

(*c*) The ratchet dogs and springs are to be assembled to the opposite hand.

(*d*) The cams in the B-end are to be turned over.

(*e*) The check valve 206639-5 and the pipe plug 200075-16 are to be assembled in the opposite side of the hydraulic motor head 274316-1.

(*f*) Thereafter proceed as follows:- Disconnect clevis 274335-2, which connects the foot valve to the foot valve control linkage. Remove the four screws which secure the foot valve to the hydraulic motor head. Remove the foot valve assembly. Remove the screw from the link which connects lever 274331-5 to lever 274327-2. The connecting pin 274334-8 can be removed. Remove the screw from the brackets 274333-1 and 274333-5 and the foot valve control linkage can be dismantled.

(*g*) To remove the cam housing 274326-1: Remove the inspection cover 274320-2. Remove the lock nut 271731-3 and the lock washer 200074-8. The complete cam and cam support assembly may be slipped off the drive shaft. Next remove the lock nut 274339-6, the gear 274328-6, the keys 200148-6, and the spacer 274335-6 can be dismantled. The cam housing 274326-1 can then be slipped off the drive shaft, after the mounting screws 229123-7 have been removed, and the dowel pins 274319-4 driven out. Remove the hoisting drum.

(*h*) To remove the brake cylinder and band assembly it is necessary to remove the four brake band stop pins 274307-2, by removing the cotter pins 274341-3, and the slotted nuts 274339-5. Next loosen the brake band assembly 274307, by removing the lock nuts 274339-4 and the adjusting nuts 206522-3. Next remove the link pin 274328-5, which disconnects the brake lever 274321-1 from the brake cylinder assembly. Remove the screws 220806-7 from the brake lever bracket 274321-2 and drive out the dowels 274329-9. The brake band and bracket can now be removed. Remove the four screws 274340-9 and the brake cylinder assembly can be removed. Next remove the lower brake band stop pin bracket 274318-7, by loosening the screw 196825-11. The bracket is to be reassembled on the opposite side of the mounting face. (Provided for the L.H. installation.)

(*i*) The brake cylinder assembly must be altered before reassembly to the L.H. mounting position. The flange 271697-7 is to be removed, and the pipe plug 196826-10 in the flange mounting on the body is to be removed, and reassembled in the opposite flange mounting.

The brake cylinder is then to be secured to the mounting base in the left hand position.

(*j*) The three ratchet dogs 274317-5 assembled to the brake drum 274320-1 are to be dismantled, by removing the slotted nuts 274339-7, and the pins 274322-2. The ratchet dogs are to be turned over and reassembled with the springs 274317-7 hooked over the opposite pins. For convenience in changing the ratchet dogs the brake drum may be removed from the drive shaft and is to be replaced as soon as the change is made.

(*k*) The brake band, lever and bracket assembly are to be reassembled to the L.H. mounting position, and are to be secured by the screws and dowels. The brake band stop pins are to be reassembled in their respective places and are to be secured by the slotted nuts.

(*l*) Before the hoisting drum can be assembled it will be necessary to form hooks of heavy wire, which will hook into the spring retaining holes of the ratchet dogs and hook over the edge of the brake drum. These hooks are to be made short enough to hold the ratchet dogs clear of the ratchet when the hoist drum is being assembled. When the hoist drum is far enough on the shaft to permit the ratchet dogs to ride on the ratchet, the wire hooks are to be removed and the hoist drum slid completely on the drive shaft.

(*m*) When the cam housing is ready for assembly make sure that the spacer 274334-13 is assembled into the bearing 274337-11 and into the oil seal 274338-8 before sliding the cam housing over the drive shaft. Also make sure that the gasket 274329-4 is in place on the drive shaft. Secure the housing to the base with the dowels and screws provided. Reassemble the spacer 274335-6, gear 274328-6, keys 200148-6, and the bearing lock, nuts and washers.

(*n*) The brake cylinder piston is to be reassembled to the brake operating lever and the brake band end is to be reassembled through the block. The brake band is to be adjusted in accordance with the adjustment instructions.

(o) Before assembling the cam support 274322-1, it will be necessary to reposition the cams for L.H. rotation. This is accomplished by removing the screws 180226-6 and 220718-2 from the clamping rings 274323-4 and 274323-2. The cams are to be removed from the grooves, turned over 180°, and reassembled in the same grooves as before. They are to be secured in place by the screws and retaining rings. The screws need not be tightened securely until the cam adjustments have been made. The cam assembly is to be reassembled to the drive shaft, and is to be secured by the bearing lock nut and washer. If the cams are correctly assembled for the left hand installation, the designation L.H. will appear on the outside of the cams. After the cams have been adjusted and the hoist is operating correctly, the inspection cover 274320-2 is to be replaced and the case filled with oil in accordance with the oil instruction plate.

(p) Before the foot valve can be reassembled to its left hand location on the B-end motor head, it must be changed to a left hand assembly. This is accomplished by first removing the large pipe plug 274334-16 from the bottom of the valve body 274332-1 and reassembling it in the opposite side. Next remove the two covers 274330-9 from the top and bottom of the valve body 274332-1. Remove ball seat 274330-2, spring 274330-6, plunger 274331-9, spring guide 274330-11, sleeve 274334-5 and ball 274341-15. Reassemble these parts in the body on the opposite side, so that when the foot valve is assembled to the hydraulic motor head, the ball seat 274330-2, is at the top of the valve body 274332-1. The foot valve assembly is then to be secured to the opposite flange of the hydraulic motor head with the four mounting screws 274340-10. Make sure that the Neoprene seal 274297-2 has been installed between the foot valve and the motor head.

(q) To reassemble the foot valve control linkage to the left hand position it is necessary to disconnect the link 274335-3 from the lever 274331-5. Levers 274331-5 and 274335-9 are next to be removed by removing the pin and the nut. The key in the long shaft 274335-1 is

to be removed. Care must be taken not to injure the bronze bushing with the key when lever 274335-9 is being dismantled. The bracket 274333-1 is to be slipped off the end of the shaft and reassembled in the opposite direction. The above parts are to be reassembled for a left hand installation; mount on the base as shown on assembly drawing 274249. The assembly is to be checked to insure that all parts are free from binding. The control linkage is then to be reassembled to the foot valve clevis 274335-2 and to the B-end control lever 274327-2. The linkage is to be adjusted as explained in the adjustment instructions.

(r) The check valve 206639-5 located in the hydraulic motor head is to be changed for the L.H. installation as follows:- Remove the two 3/4 inch pipe plugs 196826-11, which are located directly below the relief valve acorn nuts. Remove the spacer 274312-5, the spring 206639-1 and the check valve 206639-5. Reassemble these parts in the opposite side and replace the 3/4 inch pipe plugs. Next remove the 1/2 inch pipe plug from the end of the hydraulic motor head. One of the holes is plugged with a 3/8 inch pipe plug. Remove the plug and reassemble it in the other 3/8 inch tapped hole, and then replace both of the 1/2 inch pipe plugs.

179. *A-end change over from right hand to left hand.* - (See assembly drawing of the A-end, dr. no. 274247.) The R.H. assembly is identical with the L.H. assembly except for the three external levers, mounted on the valve block assembly. Remove all three of the levers, by first removing the clamp bolts, and replace them with the proper levers as shown on drawing 274272.

274336-1 Lever L.H. Replaces 274272-1 Lever R.H.
274336-3 Lever L.H. Replaces 274272-2 Lever R.H.
274336-2 Lever L.H. Replaces 274272-2 Lever R.H.

180. *Control linkage change over from R.H. to L.H.* - (See dr. no. 274251.) The control linkage is identical for right and left hand installations, except for the control rods and lever which connect to the A-end. The lever 274251-1 on the R.H. assembly is to be removed, by first removing the clamp bolt 220718-2. It is to be replaced by L.H. lever 274254-1. The R.H. control rod 274251-2 is to be replaced by L.H. control rod 274254-2.

181. *Safety car stop device cylinder change over from R.H. to L.H.* (see 274258). - The assembly is identical for both R.H. and L.H. installations except for the pipe flange 274259-2. The flange can be mounted on either side of the cylinder, but it will be necessary to remove the pipe plug 196826-9 from the side of the cylinder to which the flange is to be mounted. The pipe plug is to be replaced in the opposite flange mounting.

Chapter XIII

16-INCH SIGHT, MARK IV AND MARK IV, MOD. 1

General Description

1. Turret fire control and the arrangements for control of the elevating and training gear speed gears are substantially different arrangements from previous main battery gun positioning control systems. These arrangements are utilized in whole or part in each of three basic systems of fire control. Designated "Primary," "Auxiliary" and "Local" control,* these systems provide control according to the following brief description of each.

Primary control is director control from forward or after main battery director through plotting room instruments and gun mount indicators. In this system of control the guns are laid and the turret is trained by gun layers and a gun train operator who match pointers in their respective indicators by operating conventionally arranged handwheel control units of their respective speed gears. The gun layers and gun train operator are at stations remote from sight stations.

Auxiliary control is an alternative emergency director system. It is director fire control employing auxiliary fire control facilities within the control tower or turret 2, transmitting director orders through auxiliary switchboard in turret 2 and thence to the gun mount indicators. The guns are laid and the turret is trained from the same stations as in Primary control.

Local control, in its basic plan, is independent direction of own turret fire using own turret sights, rangefinder and auxiliary computer. The system is capable of variations, i.e. using plotting room instruments, other rangefinder. The guns are positioned in elevation by the gun layers according to mechanically or electrically transmitted gun elevation order from the sight pointer's station. The turret is trained by direct control from the sight trainer's handwheels to the training speed gear; the gun train operator does not function.

* A fourth method, "Remote Control," is to be added.

2. Thus turret sights are part of local fire control arrangements and do not function in primary or auxiliary control methods (except as a correction factor as explained in paragraph 4).

3. Gun elevating, turret train and sight control stations as indicated in the above comprise the following personnel station arrangements.

> Three gun layers, one for each independently driven elevating speed gear control, are located on the electric deck.
>
> One gun train operator is also located on the electric deck, adjacent to the training gear A-end unit.
>
> Two sight trainers are located in right and left sight stations. (One at each station.)
>
> Two sight pointers are located similarly, in right and left sight stations. (One at each station.)
>
> Two sight setters are located similarly, in right and left sight stations. (One at each station.)

4. When the guns are being controlled by director (Primary or Auxiliary Control) the sight trainers and sight pointers are not required. However, this method of control necessitates continuous operation of one sight setter's indicator in order that sight angle will be transmitted mechanically to the gun elevation indicators where it is used as a function of correction for erosion. The other sight setter and the pointers and trainers "stand-by."

5. Similarly, when the guns are being controlled by "Local" control, the gun train operator is not required. From his station this operator controls a positive clutch permitting handwheel control of the train speed gear to be shifted to the sight trainer manning the controlling telescope. Local control operating arrangements and their variations include sight station assignments as indicated in the following description of the sight.

TURRET SIGHTS

6. Turret sight installations are identical in all turrets of ships of the class. They are director type telescope sights (a new type), lack slide movement input and their

design arrangement and method of gun movement control are distinctive new features. Each installation comprises duplicate sight stations located right and left, respectively, of the wing guns, above the shelf plate and enclosed in sight station compartments which provide flameproof isolation from the gun compartments and other turret divisions. Each sight station includes sight pointer's telescope, sight trainer's telescope and sight setter's indicator. These are arranged in a system of sight movement indicating and transmitting shafts and sight handwheel drives that positions the lines of sight, interconnects the like elements of the two sight stations and extends to indicators at each gun layer and gun train operator station. The shaft system of brackets, gearing, shafts, clutches and connected parts and the elements of the right sight station comprise one assembly, designated 16-inch Sight, Mark 4; the elements of the left sight station comprise 16-inch Sight, Mark 4, Mod. 1. The schematic diagram of plate 15 shows the arrangement. Symbols used on the diagram are standard fire control symbols as defined in O.D. 3447.

7. The arrangement of these assemblies is such that the elements of either station when clutched to the shaft system comprises a complete sight. The elements of the other station, disconnected from the shaft system, comprise a standby station which may be quickly synchronized to take over sight operation. Both stations function alike, directly in train and by gun order in elevation, positioning the guns with reference to the target. This is accomplished by sight setter movement of the lines of sight according to sight angle and deflection orders and by pointer and trainer handwheel manipulation holding cross-wires on the target.

8. The arrangement of the sight within the turret corresponds generally to the location of the telescope objective. The components of the duplicate arrangement are practically symetrical about the longitudinal center line of the turret, the center of telescope objectives being right and left of the center line of the turret, pointer's 231.25 inches and trainer's 225.25 inches. The center of the pointer's telescope is 44.0 inches above the shelf plate and 5.0 inches above the center line of trunnions. The center of the trainer's telescope is 80.0 inches above the shelf plate and 36.0 inches above the center line of trunnions. The fore and aft location of the center lines of the telescopes is, trainer's 32.0 inches forward, and pointer's 24.0 inches rearward of the transverse center line of the turret. Shafts from these stations extend through the shelf plate to brackets on the circular girder above the pan floor; thence obliquely forward to cross shafts running transversely through the turret to connect the two sight assemblies. From cross shaft brackets, shafts extend into the

gun layer's and turret train operator's compartments to connect to elevation indicators and the turret train operator's handwheel bracket respectively. The couplings connecting these shafts to the elevation indicators and turret train operator's handwheel bracket are the extent of the mechanism covered in the sight design.

9. Specification and performance data of lines of sight movement and the optical characteristics of sight telescopes are as tabulated below.

Specification and Performance Data

Depression of line of sight (includes 20° of roll)	-50°
Elevation of line of sight (for 20° of roll)	-20°
Left deflection of line of sight	-100 mils (5° 43' 47")
Right deflection of line of sight	-175 mils (10° 1' 37")

Telescope Mark 66, optical characteristics:

Magnification	11.8 X
True field	4° 15'
Exit pupil	5.0 mm
Eye distance	32.0 (approx.)
Eyepiece adjustment limits	2 to -4 diopters

10. The component parts of the sights are shown on general arrangement drawings number 231150-231176, 232423, 232424. The main divisions are pointer's station and trainer's station with all parts associated bearing this designation. Other parts are known by the sight function transmitted as: sight angle, elevation order, sight deflection, and train order. In the description that follows the components have been grouped under the heading of pointer's station; trainer's station; turret train order selector clutch; elevation order, train order, and sight angle shaft, gear brackets, and bearing brackets; sight hood assemblies; and sight setter's clutch warning circuit. Separate paragraphs also deal with the sight setter's warning circuit, telescope Mark 66, sight setter's indicators Mark 3 and Mark 3, Mod. 1, gun elevation order transmitters Mark 2 and Mark 2, Mod. 1, gun elevation indicators Mark 33 and Mark 33, Mods. 1 and 2, turret train indicators Mark 33, and multiple turret train indicators Mark 11, Mod. 1.

11. The right and left pointers' and trainers' stations being of opposite hand, but otherwise identical, the description of one applies equally to the like parts of the other station.

POINTER'S STATION

12. The pointer's station is shown on drawings number 231153, 231155, 231156, 231158 and 231159 for the right hand station and drawings number 231167, 231169, 231170, 231172 and 232423 for the left hand station. Components of the pointer's station are the following parts and subassemblies, telescope holder, elevation bracket, deflection pinion and sector, sight deflection worm and worm wheel, sight elevation worm and worm arc, pointer's station differential, handwheel and order shaft gearing, pointer's station synchronizing clutch, dials, and gearing, handwheel bracket, synchronizing dial housing, pointer's station housing cap, pointer's station housing, and pointer's station housing support. These parts and assemblies are described in the paragraphs that follow.

13. *The telescope holder assembly* holds the telescope and provides vertical trunnions for deflection movement of the telescope. One face of this phosphor bronze casting mounts a sector gear which acts with a pinion to cause telescope holder deflection. The trunnions of the telescope holder have trunnion bearings in the elevation bracket.

14. *The elevation bracket* supports the telescope holder and with its hollow horizontal axis shaft element, ball bearing fitted, supplies elevation movement to the telescope holder. The hollow shaft section of the bracket encloses and supports the deflection pinion shaft and is the axis shaft of the elevation worm arc with provision for clamping and adjusting this part.

15. *The deflection gear sector and pinion* constitute the mechanism directly connected to the telescope holder that functions to deflect the telescope. It consists of a 24 tooth pinion and a sector of a 240 tooth bevel gear. The pinion is connected to a shaft from the deflection worm wheel and the phosphor bronze sector is bolted to the telescope holder.

16. *The sight deflection worm and worm wheel* operate to set the deflection angle of the telescope holder. The worm is connected to a shaft from the trainer's station sight deflection worm and the worm wheel is connected to the telescope deflection pinion shaft. The worm is a left hand quadruple thread steel worm and shaft and is matched with the worm wheel of bearing bronze.

17. *The sight elevation worm and worm arc* set the elevation bracket in elevation. The worm arc, made of bearing bronze, is connected to the elevation bracket and the worm, a quadruple thread worm and shaft of carbon steel, is connected to the shaft from the sight angle bevel gears. The sight angle

bevel gears are shaft connected to the pointer's station differential. A shaft from the worm also connects through an adjustable coupling to the trainer's station elevation worm.

18. *The pointer's station differential* consists of a planetary arrangement of a spider, two idler bevel gears, a combination bevel gear, and a combination spur and bevel gear shown on drawings number 231158, 231159, 231172 and 232423. The spider is a crossed shaft arrangement combining the rotating axis for the idler bevel gears with a shaft from the sight setter's indicator. The spider axis of the idler bevel gears rotates in a plane perpendicular to the sight angle shaft. The spider mounted bevel gears are meshed with a combination spur and bevel gear. The combination bevel gear is connected through a bevel gear shaft, and bevel gear train to the sight elevation worm and arc. The combination bevel and spur gear is meshed with the handwheel and order shaft gear train. This all functions to combine sight setters sight angle and pointer's handwheel elevation to position the telescopes in elevation and supply gun elevation orders.

19. *The handwheel and order shaft gearing* is composed of two bevel gears at the handwheel shaft, a pair of bevel gears connecting the handwheel shaft to the elevation order shaft, and a spur gear connecting the handwheel shaft to the spur bevel gear of the differential. These gears and shafts, as all others in the sight, are ball bearing mounted. The handwheel shaft and handwheel order transmission shaft are supported by the handwheel bracket. The elevation order shaft is mounted in the shaft upper bearing sleeve and lower bearing sleeve. The elevation order shaft is interrupted between the handwheels and the lower bearing sleeve by the synchronizing clutch and its related indicator gearing.

20. *The pointer's station synchronizing clutch, clutch dials, and clutch gearing* are combined in an assembly for synchronizing the pointer's station with the gun elevation order indicators. The clutch is a positive engagement pin type and is designed for only one engagement position for every 360° of relative shaft rotation. With the dials matched the clutch engagement position should accurately synchronize the station and the indicators. In detail the clutch upper jaw is located on the splined section of the elevation order shaft just below the upper synchronizing dial bevel gear. The clutch lower jaw is a combination jaw, containing holes to receive and match the different diameter pins of the upper jaw, and a double bevel gear. One side of the double bevel gear is for the synchronizing dial mechanism and the other side is for the gun elevation order transmitter. The matching dial bevel gears are shaft connected to worms and worm wheels which rotate their respective matching dial of the synchronizing clutch matching dials.

21. *The handwheel bracket,* a phosphor bronze casting, functions to support the handwheel shaft and handwheel bevel and spur gear shaft. The handwheel bracket is attached to the station housing and provides for a cover to enable inspection and assembly of the gears.

22. *The synchronizing dial housing,* a phosphor bronze casting, contains elements for the support and enclosure of the synchronizing dial mechanism. It provides for inspection covers and a bezel and is attached to the station housing support.

23. *The pointer's station housing cap,* a steel casting, encloses telescope elevation bracket, sight deflection gearing, and sight elevation gearing. The cap is fastened to the pointer's station housing and has provision for the elevation arc inspection cover.

24. *The pointer's station housing* is a steel casting containing elements for the support and enclosure of the handwheel, deflection, elevation, and sight angle shafts and gearing. Fastened to this housing are the housing cap, housing support, handwheel bracket, elevation order shaft bearing sleeve, eyepiece cover support, and various covers used in connection with the support, inspection, and lubrication of the contained mechanism.

25. *The pointer's station housing support* is a steel casting which functions to support the pointer's station housing, the synchronizing dial housing, and the gun elevation order transmitter. It provides an inspection cover and encloses the clutch, gun elevation order shaft bearings, elevation order transmitter gears, and synchronizing dial gears.

TRAINER'S STATION

26. The trainer's station is shown on general arrangement drawings number 231154, 231155, 231157, 231168, for the right hand station and drawings number 231168, 231169, 231171, and 232424 for the left hand station. The components of the trainer's station are the following parts and subassemblies: telescope holder, elevation bracket, deflection pinion and sector, sight deflection worm wheel, sight elevation arc, sight deflection worm, sight elevation worm, compensating differential and spur gear train, handwheel and order shaft gearing, housing cap, housing, housing support, pedestal, and shaft guard. A description of these components is contained in the following paragraphs.

27. *The telescope holder,* shown on drawings number 231639 and 231640, is similar to the pointer's station telescope

holder except that there is provision for the telescope to rotate within the holder about its longitudinal axis. This rotation is limited by two bumpers mounted on the holder. The telescope can be locked against rotation relative to the holder by a locking pin mounted on the holder cap. The holder is pinion and sector connected to the deflection worm wheel shaft, is supported by the elevation bracket, and provides ball bearing mount for the telescope (line of sight elevating movement).

28. *The elevation bracket* is similar to that of the pointer's station, there being only a slight difference in the shape of the arm skirts and length of the shaft portion of the bracket. The skirt is cut away to allow for motion of the telescope in elevation independent of the elevation bracket motion.

29. *The deflection pinion and sector, sight deflection worm wheel, and sight elevation arc* are identical in every respect to the same parts on the pointer's station. However, the *sight deflection* and *elevation worms* differ in that the deflection worm, 231647-3, is made separate from the shaft while the elevation worm, 231669-6, differs in minor details of the shaft.

30. *The compensating differential and spur gear train* function to compensate for the deflection of the telescope due to planetary action of the telescope holder deflection sector and pinion. This arrangement, drawing number 231160, is made up so that the worm shaft bevel gear meshes with two spider mounted idler bevel gears; the spider mounted idler bevel gears mesh with a rivet joined spur bevel gear; this in turn meshes with the idler spur gear and elevation shaft spur gear. The spider is splined to a bevel gear which meshes with a bevel gear on the deflection input shaft.

31. *The handwheel and order shaft gearing*, enclosed and supported by the cast phosphor bronze handwheel bracket, connects the handwheels to the train order shaft. This gear system is simply two sets of bevel gears with a handwheel and connecting shaft ball bearing mounted on the handwheel bracket.

32. *The housing cap, housing, housing support, pedestal, and shaft guard* function to support and enclose the various elements of the trainer's station, synchronizing clutch, and sight setter's indicator. With the exception of the shaft guard, which is a bronze casting, these parts are steel castings arranged in the order mentioned from top to bottom of the trainer's station. The shaft guard fastens to the housing and also to the pedestal by means of a bracket. Also fastened on the pedestal are the seat pedestal and foot rests.

33. *The sight angle synchronizing clutch,* drawings number 231161 and 231166, functions to allow the gun elevation indicator and cross shaft system to be clutched in or out and synchronized to the sight setter's indicator, trainer's and pointer's stations. This is accomplished by means of a 180 degree engagement jaw type clutch and bevel gears, shafts and worm driven synchronizing dials attached. Also, in the assembly are two bevel gears meshing with a bevel gear connected to a shaft from the pointer's station elevation and sight differential. One of these two bevel gears is connected to a shaft from the sight setter's indicator while the other is connected to the sight angle cross shaft and elevation indicator system. This assembly is attached to the back of the trainer's station housing and pedestal with the clutch handle extended through a roof girder to the sight setter's station.

ELEVATION ORDER, TRAIN ORDER, AND SIGHT ANGLE SHAFTS, GEAR BRACKETS AND BEARING BRACKETS

34. *The gun elevation order bevel gear brackets,* drawing number 232401, are identical right and left units. Each functions as shaft bearing, bevel gear housing and bracket at the extreme right and left rearward ends of the gun elevation order cross shaft. These assemblies are connected by universal joints and shafts to the pointer's stations and by flexible couplings to the gun elevation order bearing brackets. These cast phosphor bronze brackets are fastened to a plate welded to the circular girder.

35. *The gun elevation order bearing brackets,* drawing number 232402, are identical right and left assemblies which function to support the rear to forward sections of the gun elevation order cross shaft. These cast phosphor bronze brackets contain a bearing mounted shaft which connects by flexible couplings to shafts from the gun elevation order bevel gear brackets and sight angle, gun elevation and turret train order bevel gear housings.

36. *The sight angle, gun elevation, and turret train order bevel gear housings,* drawing number 231163, being of opposite hand but otherwise identical, function as a combined bevel gear bracket for the three cross shafts at the point where their rear to forward direction is changed to transverse. The shafts from this phosphor bronze cast housing connect with flexible couplings to a sight angle and elevation order cross shaft bracket, a turret train order bearing bracket, a gun elevation order bearing bracket, turret train order upper bevel gear bracket, and sight angle bevel gear bracket. Each housing (dr. no. 231163) is mounted right and left, respectively, on the outboard gun girders.

37. *The sight angle bevel gear brackets,* shown on drawing number 231683, are identical right and left except for a grease hole on opposite sides. Each is a phosphor bronze casting which combines a bevel gear housing and bracket in the function of connecting the vertical sight angle shaft to the rear to forward section of the sight angle cross shaft. The brackets are mounted on an extension of the sight setter's roof girder at pan floor level and are connected by flexible couplings to shafts from their respective sight angle, gun elevation, and turret train order bevel gear housings, also by universal joints to shafts from their respective sight angle bearing brackets and sight angle synchronizing clutches.

38. *The turret train order upper bevel gear brackets,* drawing number 232403, are identical right and left assemblies. Each consists of a phosphor bronze housing bracket, covers, shafts, and bevel gears. Each functions to connect the vertical section of the turret train order shaft to the rear to forward section of the cross shaft. They are fastened to a plate on the circular girder and connect by a flexible coupling to a shaft from the sight angle, gun elevation and turret train order bevel gear housing and by a universal joint to a shaft from the turret train order bearing bracket and trainer's station.

39. *The sight angle and gun elevation order cross shaft brackets,* drawing number 231164, are three identical assemblies each serving in the combined function of a bracket, bevel gear housing, and cross shaft bearing for the sight angle and gun elevation order shafts. These cast phosphor bronze brackets are mounted on a beam suspended between the gun girders above the pan floor, right and left and on a support plate bracket center.

TURRET TRAIN ORDER SELECTOR CLUTCH

40. *The turret train order selector clutch,* drawing number 231162, a combination of two jaw type clutches and a bevel gear arrangement, functions to provide for selecting control from either right or left trainer's station. The jaw type clutches are each composed of a movable jaw, spline mounted on its train order cross shaft, and a combination jaw and bevel gear, bearing mounted on this same train order shaft and geared to the shaft from the turret train order lower gear bracket. The two movable jaws are fork positioned, the forks being connected and controlled together by a sector gear and spur gear on a shaft from the control lever over head at the train operator's station. This shaft, positioned by a lever and detent, provides adjustment for the clutch by means of an adjustable coupling.

TURRET TRAIN ORDER LOWER GEAR BRACKET

41. *The turret train order lower gear bracket,* shown on drawing number 232404, functions to transmit turret train order from the vertical shaft from the turret train order selector clutch to a horizontal shaft to the turret train operator's handwheel bracket. The coupling connecting this gear bracket shaft to the handwheel bracket is this extent of the sight design. This bracket is connected to the left gun girder at the turret train operator's station and consists of a phosphor bronze casting, ball bearing fitted to support the spiral bevel gears.

SIGHT HOOD ASSEMBLIES

42. The sight hood assemblies, drawings number 231173 to 231176, are all similar. The like parts of each hood are identical except the sight hoods which vary as to pointer's, trainer's, opposite hand, and as to provision of space for larger right than left deflection of the telescope. There is also different arrangement of door operating mechanism in that it is above the telescope at the pointer's station and below the telescope at the trainer's. The parts of the sight hood are the sight hood, sight hood door, bloomer, bloomer collar and frame, and door operating mechanism. The sight hood, a special steel casting, is mounted on the turret armor over the sight ports. Hinged to the sight hood is a bulletproof steel door operated by a double screw and link door operating mechanism which functions to open and close the door, retain it open, and clamp it shut. The sight hood bloomer is fastened to the sight hood by a frame and to the telescope by a collar and lashing. This bloomer provides a weather and gas seal for the opening and is designed with a slit to permit wiping of the objective lens.

SIGHT SETTER'S CLUTCH WARNING CIRCUIT

43. The sight setter's clutch warning circuit shown on sketch no. 95204 consists of an arrangement of two switches and two signal lights functioning to indicate to each sight setter the position of the other sight setter's sight angle synchronizing clutch. The switch is mounted on the clutch case with a plunger in the way of and actuated by the clutch control lever. The switch is a normally open single throw type switch and each switch is in circuit with a signal light in the opposite sight setter's compartment so that the light is on when the clutch is engaged.

TELESCOPE, MARK 66

44. The Telescope, Mark 66, shown on drawing number 217427, is used at all sight stations. It is of the fixed prismatic, fixed power, single eyepiece type, containing a

90° adjustable head prism, a compound objective lens, a crossline lens (in focal plane of the objective), an erecting lens system 90° eyepiece prism, and eyepiece. The line of sight is truly perpendicular to the telescope bearings. The objective lens is mounted on a double eccentric to provide for adjusting the optical axis of the telescope to correspond with the axis of the bearings. Other optical features are ray filters introduced between the eyepiece and the focal plane of the eyepiece (red, yellow, polarizing plates, and clear glass), illuminated crosslines and the focusing eyepiece, adjustable from plus two to minus four diopters. Mechanically the telescope comprises an assembly to appropriately enclose and support the optical elements of the telescope, gas tight except for the eyepiece and filter housing, and designed to be accurately supported in a telescope holder bracket. Used in connection with the crossline illumination is Lamp Socket, Mark 9 shown on drawing number 134834. Correct illumination requires a two candle power Mazda lamp No. 64 or equal (6-8v.).

SIGHT SETTER'S INDICATOR, MARK 3 AND MARK 3, MOD. 1

45. The Sight Setter's Indicator, Mark 3, right hand, and Mark 3, Mod. 1, left hand, are located on the forward side of the respective trainer's stations. They function to receive sight angle, sight deflection and battle orders; and to transmit sight angle and sight deflection mechanically to the pointer's station, trainer's station, and gun elevation indicators. The instrument receives sight angle at 6 and 216 speed from the plotting room computer, deflection at 270 mils per revolution from the plotting room computer and battle orders, "Fire," "Cease," "Local," "Automatic," "Indicating," "Circ Brok," from plotting room battle order transmitter. The instrument is provided with hand cranks for setting values of sight angle and deflection into the sights. These values are set by follow-the-pointer orders in "Primary" and "Auxiliary" control but in "Local" control are set in response to oral orders from the local computer. Dials are provided for indicating sight angle, deflection, and battle orders. Follow-the-pointer dials indicate against a fixed scale the amount and direction of sight angle and deflection adjustment of the lines of sights and indicate against electrical dials when the sights are set in accordance with orders received. Dial graduations and limits are, for sight angle, 2000 to 4800 minutes and, for deflection, 350 mils to 600 mils. Mil calibrations are spaced at two mils. Zero sight angle is 2000 minutes; zero deflection 500 mils.

GUN ELEVATION INDICATOR, MARK 33 AND MARK 33, MODS. 1 AND 2

46. The gun elevation indicator, located at each gun layer's station, functions to give orders for the gun layer and provide correction to the gun response before it is indi-

cated as elevation on the dials. It is designed to receive gun elevation orders electrically at 2 and 36 speed from the controlling director and from the pointer's gun elevation order transmitter and to receive gun elevation order mechanically at 2 and 36 speed from pointer's stations. Indicated by the instrument as a zero reader at 2 speed, as follow-the-pointer at 36 speed, and as a direct reader on a suitable scale at 2 and 36 speed is the relation of gun position to gun elevation order on the first two dials and the actual elevation of the gun on the latter dial, corrected for erosion and roller path compensation in each case. B-end response to the indicator is disproportionate to the elevation of the gun because of the circular path of the upper end of the elevating screw and is therefore corrected by a mechanism within the indicator. Provision is made for computing and indicating mechanically a correction for difference in equivalent service rounds fired. This correction is based on the quantities "sight angle" and "difference in velocity loss" and is set by knobs and indicated on dials. Values of sight angle are set mechanically by shafting from the sight setter's indicators. A mechanism is also provided for introducing the proper correction for inclination of roller path. Scales are provided to permit setting the inclination of the roller path from zero to a maximum of one degree and to permit setting the bearing of the high point. A window provides a means by which this setting may be checked. These corrections are all introduced between gun response and the follow-the-pointer dial and also before the motion appears at a stub shaft for supplying these values to a receiver regulator. The speed of this total correction is stepped up by means of an electrical follow-up with provision for hand matching in case of failure of the follow-up.

GUN ELEVATION ORDER TRANSMITTER, MARK 2 AND MARK 2, MOD. 1

47. The Gun Elevation Order Transmitters, Mark 2 right hand and Mark 2, Mod. 1 left hand are located at the pointer's stations and function to transmit at 2 and 36 speed, for local control, gun elevation order to the gun elevation indicators described in paragraph 46. The order is equal to the depression of the pointer's sight which in turn equals sight angle set plus selected value of level (director correction). Thus the pointer's sight acts as a local director transmitting gun elevation order to the gun layer's gun elevation indicator. Switching arrangements are provided so that in auxiliary control the local gun elevation order transmitter in turret 2 can transmit gun elevation order to turrets 1 and 3 as well.

TURRET TRAIN INDICATOR AND TRANSMITTER, MARK 37

48. The Turret Train Indicator and Transmitter, Mark 37 is located at the turret train operator's station in each turret and functions to indicate the required angle of

train, to indicate that the turret is trained to this angle, to transmit corrected train angle, and to supply the necessary correction to turret train to give the correct train angle. Indicated also is the actual turret train with parallax subtracted. The parallax mechanism receives a function of range from a transmitter in the plotting room computer. This function of range (inverse range) is received by a synchro with a dial mounted on the rotor shaft. The dial is graduated in range from 3400 yards to 50,000 yards with a mark for infinity range. Although the dial is not graduated below 3400 yards, the scale is such that operation from 2102 yards to infinity yards results in one complete revolution of the dial. This function of range is set into the parallax mechanism by hand, matching the dial described above. Provision is made for reading the base length setting through a window without removal of the cover. It is provided with a stub shaft for transmitting to the train receiver regulator the value of the function of range. The 6-G synchro transmitters transmit, at 1 and 36 speed, values of turret train with turret parallax subtracted for use in the multiple turret train indicators and in case of turret 2 for use in transmitting turret train order in auxiliary control.

MULTIPLE TURRET TRAIN INDICATOR, MARK 12, MODS. 5 AND 6

49. The Multiple Turret Train Indicators, Mark 12, Mod. 5 in officer's booths of turrets one and two and Mark 12, Mod. 6 in the officer's booth of turret three, function to indicate as a direct reader and as a zero reader that the turret has been trained in accordance with orders received. The direct reader dial indicates the train of the mount at one speed and is attached to an indicating synchro. The zero reader dial at 36 speed is attached to indicating synchros and when pointing to zero (vertical position) indicates that the turret is trained on the same target as the controlling director.

BATTLE ORDER INDICATOR, MARK 28

50. The Battle Order Indicators, Mark 28 are located one in each turret booth and function to indicate the range, deflection and battle orders transmitted by the battle order transmitter in the plotting room computer. Range is indicated by increments of 50 yards from zero to 39950 yards by means of two motors; one high speed synchro, 1 rev. = 1000 yards and a low speed synchro, 1 rev. = 4,000 yards. Deflection in increments of one mil from 325 to 600 mils is indicated by means of two motors; one high speed synchro, 1 rev. = 20 mils and a low speed synchro, 1 rev. = 300 mils. Indicated also are the following battle orders: commence firing as "Fire", cease firing as "Cease," director fire automatic as "Auto", director fire indicating as "Ind", local control as "Local," circuit broken as "Circ Brok."

OPERATION

51. The relation of the sight to other fire control equipment is shown by its function in local control. Starting with values of compass course, turret train, two values of ship speed, target angle, target speed, wind angle, wind speed, present range, range spot, deflection spot, nominal velocity, and initial velocity, the auxiliary computer supplies values of sight angle and sight deflection by oral order to the sight setter. The sight setter, (either station) by setting dials on the sight setter's indicator, transmits sight angle and sight deflection mechanically to his respective pointer's and trainer's stations. One sight setter, receiving orders electrically or orally, operates in every control to supply sight angle to the gun elevation indicators as a function of erosion correction. The pointer and trainer lay their sights on the target and combine, mechanically, sight angle and sight deflection to supply gun elevation order and turret train respectively. The trainer controls the turret training gear directly to train the turret. The pointer transmits elevation orders electrically by means of gun elevation order transmitters or mechanically through shafts and gears to the gun elevation indicator of each of the three gun layers. At the gun elevation indicators, factors are added for erosion correction, roller path compensation, and elevating screw angularity to indicate elevation order and gun elevation on follow-the-pointer dials. Each gun layer then operates the elevating gear to lay the gun by matching dials (gun elevation indicator). Under the other fire control operation methods, pointers and trainers are not required, the guns being controlled in elevation by the gun layers and controlled in train by the turret train operator. All operate by matching pointers in their respective indicators.

52. The sight function can be accomplished by the sight setter, pointer and trainer on the same side of the turret, by combinations using the sight stations on both sides of the turret, or by the sight stations in turret 2 acting through transmitters and indicators to turrets 1 and 3. Using the sight stations on either side of the turret the sight setter, pointer, and trainer of one side perform the sight function entirely independent of the other side. The pointer can either follow the target continuously, causing the trainer's telescope to follow his telescope in elevation, or fire on selected level, making it necessary for the trainer to unlatch his telescope and use his headgear to position his telescope in elevation. The pointer on one side can operate with the sole purpose of keeping his trainer on the target in elevation while the pointer on the other side is fixed in elevation for selected level firing. Any of the telescopes not being used in the sight operation can be used for checking. However, in

all combinations where both sides are used, both sight setters indicators must be in operation. Under sight control from turret 2 the sights of turret 2 are used as in local control except that gun elevation orders and turret train orders are transmitted to turrets 1 and 3 by either sight station elevation order transmitter and turret train transmitter.

53. All of these various selections and combinations of control are made by use of the synchronizing clutches, (sight angle and pointer's elevation order,) the turret train order selector clutch, and the turret train operators selector clutch. There is a synchronizing dial in connection with each of the synchronizing clutches which must be matched before engagement of the clutch. It is not intended to have the two synchronizing clutches of the same system engaged during operation. All clutch engagement combinations are evident from the operation. However, it should be observed that sight angle is supplied to the elevation indicators by the sight setter on the side where the pointer is firing, in all combinations.

54. The details of the sight operation are shown schematically on plate 15. The differential at the pointer's station operates to combine pointer's handwheel and sight angle line of sight inputs to elevate and depress the telescope lines of sights. The differential at the trainer's station operates to compensate for movement of the telescope in deflection due to the planetary rotation of the deflection sector around the pinion when the telescope is rotated in elevation. For each revolution of the elevation bracket the compensating differential and gear trains add one revolution to the deflection pinion in the same direction. This adds to or subtracts from sight setter's deflection input resulting in compensated deflection.

ADJUSTMENTS

55. The sights are adjusted to cause the telescope lines of sight to be parallel to each other, to elevate and depress in planes perpendicular to the center line of the trunnions, to deflect in planes parallel to the center line of the trunnions, to correspond to all readings of sight angle and gun elevation dials, and correspond to all deflection settings. This is accomplished by the general methods described in O.P. 762. "Alignment of Sights," through the use of Boresight, Mark 75 or Mark 8, Mod. 6, Bore Sight Telescope Holder and Muzzle Disk, Mark 2, and by the adjustment provisions within the sight.* The elements providing adjustment are tapered liners between the station housings and the gun girder cover plates, shims at shaft and gear brackets, and adjustable couplings on the sight shafts.

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* Also see Appendix III, "Sight Alignment."

56. Either bore sight telescope Mark 75 or Mark 8, Mod. 6 can be used in connection with the Mark 2 bore sight telescope holder and muzzle disk. The Mark 75 bore sight telescope differs from the Mark 8, Mod. 6 principally in that the relation of the optical to the mechanical center is not adjustable. Characteristics of the Mark 75 are: Magnification 8, true field 3° 30', exit pupil 2.5 mm, eye distance 18 mm, focus adjustment from 10 ft. to infinity, adjustable eyepiece, adjustable direction of line of sight. The Mark 2 bore sight telescope holder is fastened to the breech screw box liner and positions the bore sight at the center of the open breech of the gun. The bore sight is then adjusted by means of the adjusting screws to cause the line of sight to extend through the center hole in the muzzle disk.

57. The sight is adjusted to cause all elements to have correct relation to each other and to the gun. The stations are adjusted to cause the axis of the elevation brackets to be parallel to the gun trunnion axis by shifting the station and adjusting the tapered liners on the gun girder cover plate. Adjustment between the trainer's station and the sight setter's indicator deflection dial is made by setting the trainer's telescope at a certain elevation using the pointer's handwheels or sight setter's sight angle crank, then setting the telescope at a certain deflection using the sight setter's deflection angle crank. The sight deflection dial is then set at the angle corresponding to the trainer's telescope deflection by means of a micrometer coupling under an adjustment cover of the sight setter's indicator. The adjustable coupling on the sight deflection shaft on the rear side of the trainer's station and the adjustable coupling on the sight angle shaft on the forward side of the pointer's station are then adjusted to cause the line of sight of the pointer's telescope to be parallel to that of the trainer's. The sight angle dial of the sight setter's indicator is then made to correspond with the angle of the telescopes by adjusting the micrometer coupling under the sight angle adjustment cover. The elevation indicators are then adjusted (using the corresponding adjustable couplings adjacent to the sight angle and gun elevation order cross shaft brackets) to show zero gun elevation order and the sight angle of the controlling sight setter's indicator. The other sight station is adjusted similarly. Then the two sides are synchronized by adjusting the synchronizing clutches (sight angle and gun elevation order) to have their pointer's matched when synchronization exists. The sight angle synchronizing clutches are adjusted by removing the dial cover, loosening the inner dial clamping plate and, with the stations and indicators synchronized, matching the pointers and reclamping. The turret train order selector clutch shifting lever is adjusted to match the detents when the clutch is in the proper engagement position. This adjustment is made by means of an

adjustable coupling immediately above the pan floor on the clutch shifting shaft.

MAINTENANCE INSTRUCTIONS

58. *General.* - Mechanisms of the class of the sight assemblies, comprising principally an elaborate system of mechanical signal transmission, require high mechanical accuracy and must have exacting care. Accurate transmission of input movements has been attained by design arrangements and exceedingly high standards of manufacture. If the units are maintained in alignment, are periodically checked for accuracy and are lubricated and otherwise serviced as prescribed, they will retain their design features.

59. *Lubrication.* - All points of shaft support, all gear brackets, gearing and all moving elements of signal transmission and telescope mounting have been provided with means for lubrication. In many instances correct lubrication will only be obtained provided the lubricants prescribed on the charts are used. This is particularly important with respect to the internal mechanisms of the housings at trainer's and pointer's stations, - oil is required at certain fittings, grease must not be substituted. Lubricants should be applied sparingly but regularly.

60. *Disassembly and assembly.* - Disassembly and reassembly of all units of the sight, optical instruments, attached indicators and transmitters excepted, are apparent from the drawings. All such work should be performed by experienced personnel only, with the special tools provided and only after mating parts are marked at couplings, gears, etc., to provide for correct reassembly.

Equipment attached to the sight assemblies may be dismantled only by authorized personnel familiar with such optical and fire control instruments.

Chapter XIV

RANGE FINDER STAND, MARK 46

General Description

1. The range finder mount in each main battery turret is Range Finder Stand, Mark 46. This assembly, located at the rear of the turret officer's compartment, provides horizontal, transverse, carriage mounting for a 43 foot base length range finder (Mark 46 or 47) and encloses the outboard ends of the instrument within large protective hoods which are attached at the rear upper corners of the turret. The design includes operating mechanisms for limited azimuth and elevating movements, seats for the operating personnel, hood shutters and shutter operating mechanisms, and provision for future attachment of an automatic range finder stabilizer.

2. The principal elements of the assembly are the parts listed below which are arranged as shown on general arrangement drawing number 217223.

(*a*) Structual foundation
(*b*) Two rail brackets
(*c*) Carriage assembly
(*d*) Altitude mechanism
(*e*) Hoods.

Structual Foundation

3. The structual foundation comprises right and left steel plate weldments built into the turret structure in the arrangement shown on drawing number 217211. These structures are right and left pedestals upon which the two rail brackets are leveled, aligned and bolted.

Rail Brackets

4. The rail brackets are large cast steel platforms providing identically arranged right and left roller path segments and holding-down tracks for the roller and pinion brackets of the carriage. They mount concentrically positioned rack arcs on each inner face, provide limit stop lugs for limiting carriage deflection movement, and provide locking seats for plungers of the deflection locking device and the shutter interlock (par. 12). Each bracket has four tram marks, one on the edge of each side of the bottom flange, centered to register with longitudinal and transverse alignment lines

scribed on the structual foundations. These alignment marks are for purpose of initial installation and realignment check.

The Carriage

5. The carriage is a large assemblage that is mounted on the roller paths of the two rail brackets. It includes two large bearings in which the range finder instrument is supported by radial and thrust roller bearings. The bearing centers are spaced twenty-five feet. Each bearing consists of a bearing bracket, a bearing cap and a roller bearing cage. These have rigid mounting on the top surface of the respective right and left roller and pinion brackets. The latter brackets include roller path rollers and holding down rollers which ride on the arc-shaped rail surfaces of the rail brackets. The two bearings, thus arranged, are transversely connected by a beam weldment of box-section (15 inches square), 19 feet 11.50 inches long, which spans the space between the rail brackets and is bolted at each end to integrally cast flange seats in the bearing brackets.

6. On this carriage assembly are mounted the deflection operating mechanism, the deflection locking device and the altitude mechanism. Bearing rings on the range finder seat in the bearings so that the instrument has rotative mounting on eight large rollers in each bearing cage. Each bearing cap has two rollers which bear on the upper sector of the instrument to hold it down. The left bearing cap has one roller, centered at the top of the cap, in thrust position between two lugs on the instrument bearing ring. The arrangement of this left bearing is shown on drawing number 217224.

Altitude Mechanism

7. Rotation of the range finder in the bearings to give altitude adjustment to the instrument is performed by means of an altitude mechanism. This device, shown on drawing number 217228, is a system of two handwheel altitude adjusting inputs which respectively drive two sides of a differential gear. The output of the differential is a pinion meshed with an arc rack that is attached to the instrument near the left bearing ring. One handwheel, located at the range finder pointer's station, provides altitude adjustment at 120 speed, the other handwheel is located at the range finder operator's station and functions for fine setting at 182 speed*. Total altitude movement is 30 degrees, 15 degrees above and below horizontal line of sight. The movement has no provision for locking at mid-position. However, the design of the system worm worm-wheel drive and the balanced arrangement of the instrument precludes overhaul so that altitude settings remain as set.

* These handwheel speeds equal output pinion speed of eight and instrument rotation of approximately one.

8. The altitude mechanism as initially installed will be modified when an automatic stabilizer for the elevating motion is added. The alterations will involve attachment of an appropriate lever or other device on the pinion shaft, addition of a clutch element between the handwheels and the driven shaft, and removal of the altitude limit stop device. (Limit stop will be provided within the stabilizer mechanism.)

Deflection Mechanism

9. The range finder is positioned in azimuth by rolling the carriage on the rail brackets with center of motion pivoted at the center of the carriage beam. This movement is performed by a handwheel actuated deflection setting mechanism which is arranged as shown on drawing number 217227. Positioned horizontally near the center and on top of the beam, the handwheel drives a deflection bevel gear and thence, right and left, pinions, shafts, and worm wheels; integral pinions of the latter are meshed with the rail bracket rack (each side). The arrangement gives equal, simultaneous traverse for the two bearings. Deflection stops at each end of the carriage limit the movement to four degrees thirty minutes each side of a line normal to the turret longitudinal center line. A deflection indicator dial, located in the top of the handwheel gear box and moving against a fixed index, is graduated in mils to show range finder azimuth position.

10. At zero degree deflection (100 mil calibration on the indicator dial) plungers at each end of the beam register with holes in the respective rail brackets. This locking arrangement for securing the carriage is actuated by a hand lever, an eccentric shaft and connecting shafts coupled to the two plungers. In addition to this locking device, the design of the deflection setting worms and worm wheels is such as to prevent drift or overhaul. Deflection settings thereby remain as set.

Hoods

11. The right and left hood assemblies comprise cast steel hoods, cover plates, shutter frames of phosphor bronze, and screw mechanisms operating bronze shutters which are manually operated from the inside of the turret. The design includes fitted fabric sleeves secured to the range finder and closing the hood apertures in the armor to provide weather and gas seal. The shutters, when closed, wedge against ground seats to provide weather seal.

12. The range finder objectives are fitted with cylindrical shades which move into the open hood ports at limits of azimuth movement. Because of this design arrangement the

shutter operating mechanism in each hood is arranged with an interlock linkage and plunger which operates to lock the carriage at mid-azimuth position when the shutters are closed. This device functions to prevent instrument damage by blocking shutter closure when the shades are not clear of the shutters. It also blocks carriage azimuth movement until the shutters are open.

Care of the Range Finder Stand

13. The range finder stand should be thoroughly cleaned, inspected and exercised at least once weekly. Whenever so exercised and before range taking, the deflection gear and altitude mechanism should be operated to the limits of their movements; locking devices and shutter mechanisms should be operated through a complete cycle. Observe that all parts have normal movement and adequate lubrication. Perform the lubricating schedule as prescribed on the lubricating chart.

Chapter XV

HYDRAULIC EQUIPMENT - INSTALLATION AND MAINTENANCE

General Instructions

FOREWORD. - The information and instructions of this chapter are specific directions as to the care and operation of hydraulic power equipment. Much of this material has been derived from operating experience with receiver regulator equipment where the fine clearances of valves and the small initial power of pilot valves necessitates extreme care in maintenance, and particularly has shown the value of daily exercise. The lessons learned with operation of receiver regulator equipment concern all hydraulic equipment, for the oiltight surfaces of the power drive units are as readily scored or are otherwise just as susceptible of fault producing deterioration - the difference is a matter of degree of sensitiveness in response. Control units which build up from the power received from a single synchro motor are sensitive to the most minute interferences; whereas manually operated power units do not respond to such interferences for their sensitiveness is the reaction of the operator, - to whom sluggish, leaking valves or other cause of lost efficiency is rarely apparent. That such faulty conditions will develop in all hydraulic power equipment is evidenced by overhaul experience of equipment from older ships. The remedies are the extreme precautions prescribed for installation and during subsequent maintenance as given below.

1. Hydraulic drives of ordnance equipment are rugged, proven machines, of a type manufactured, inspected and tested with such care that service problems of operation are virtually all due to faulty assembly, installation or maintenance. These factors govern those qualities of power output, speed and accuracy of control which are essential to accurate gun laying and retention of the mount's designed rate of fire with good patterns. A correctly installed hydraulic system, exercised daily and serviced constantly with extreme care will not only retain design characteristics of power, speed and control but will eliminate expensive dismantling and replacement costs (as well as mount personnel labor). Thus adherence to instructions as to installation, operation and maintenance is a prerequisite to mount gunnery efficiency.

INSTALLATION

2. A new hydraulic unit when delivered from the Naval Gun Factory spares or from the manufacturer has all openings into the system closed with wooden or metal shipping covers or plugs. These must be retained in place until *immediately prior to connection* with their complementary parts of the system. Such connections may be made only when all dirty work on or adjacent to the mount has ceased and when the air is free of dust, fumes which may condense, or any other foreign matter which may foul freshly opened leads. The maximum possible effort must be exerted to prevent entrance of foreign matter.

3. Similarly, when an overhauled, reassembled unit is installed in the mount every precaution must be taken to exclude foreign matter from the system. Such unit before mounting should be flushed clean, air dried and all openings should be appropriately closed until immediately prior to connection to the complementary parts of the system.

4. If when installing a unit, special fitting of pipe connection is necessary at an exposed, unsealed port, exercise extreme care to prevent entrance of metal slivers, filings or dust; thoroughly inspect the seat and the opening before closing the port. When drilling, tapping, welding or soldering is being performed on or near the equipment keep all openings closed or covered.

5. New pipe is shipped with metal disc or other plug insert to exclude dirt. It has been factory inspected and although presumably clean must be recleaned before assembly in the system. Such cleaning is performed as follows:

(a) *Copper pipe.* -

(1) Treat machined faces or threads of end fittings with hot paraffin wax.

(2) Dip, and remove immediately, in acid bath solution of 2 parts sulphuric acid, 1 part nitric acid and 4 parts fresh water.

(3) Wash in fresh cold water.

(4) Immerse for one minute in a neutralizing bath of 1-1/2 pounds of Magnus #2-1/2 per gallon of fresh water.

(5) Soak in boiling water for 10 minutes.

(6) Pass frayed wire rope, according to size of pipe, through pipe.

(7) Wash with stream of fresh, cold water at high pressure.

(8) Dry thoroughly, being careful not to leave threads of rags, towelling or waste in the pipe. Seal both ends until ready to install.

(b) *Steel pipe.* -

(1) Treat machined faces or threads of end fittings with hot paraffin wax.

(2) Dip and remove immediately in acid bath solution, 1 part sulphuric acid, 15 parts water.

(3) Wash in fresh cold water.

(4) Immerse for one minute in a neutralizing bath of 1-1/2 pounds of Magnus #2-1/2 per gallon of fresh water.

(5) Soak in boiling water for 10 minutes.

(6) Pass frayed wire rope, according to size of pipe, through pipe.

(7) Wash with stream of fresh, cold water at high pressure.

(8) Dry thoroughly, being careful not to leave threads of rags, towelling or waste in the pipe. Seal both ends until ready to install.

(9) Oil to prevent rusting.

Cleaning as above is particularly applicable whenever lead or other material has been used in bending pipes.

6. When making up connections, tubing should not ordinarily be welded, brazed or silver soldered, as proper cleaning is impossible in such cases. (There are exceptions to this rule, necessitated by design.)

If the joint is gasketed, the inner diameter of the gasket must be cut back slightly to prevent gasket material fraying into the system.

Threaded joints which require cement must be partially seated (at least three turns) before applying cement, sparingly.

The tinning of male threads of fittings gives a hydraulic connection superior to a connection made with sealing compounds. Such compounds should not be used when tinning is possible.

Sealing sleeves must be seated with careful initial alignment, with the connection drawn-up evenly and without canting. A distorted or marred sleeve will leak, may produce a burr as it seats.

7. When fittings have been newly secured to pipes (particularly flanges) they should be given a hydrostatic test at a pressure substantially higher than that to which they will be subjected in service.

8. Tubing must be accurately bent and fitted so that it will not be necessary to spring it into place.

High pressure tubing which has length greater than 100 diameters between fittings, and particularly those pipes which are subject to rapid variations of pressure, must have pipe clamp, or bracket, or other similar support adjacent to each bend. Vibration in such tubing will affect the uniform smooth operation of the system and will cause crystallization at the terminal fittings.

9. When a new unit or an overhauled unit has been assembled into a system (or if a new or replacement pipe or pipe fitting has been installed), fill the system with the prescribed hydraulic oil, using a 120 mesh screened funnel* (never use cloth for filtering), and draw off the oil at the drain point through a second filtering screen. Observe the latter screen and continue flushing until assured that the system is clean. Draw off oil and pass it through a Briggs clarifier, close the drain aperture and refill according to the routine prescribed for the particular system.

Do not operate the unit when flushing to remove foreign matter.

10. When a new or overhauled replacement unit has been installed in a system and has been flushed clean as prescribed above and has been refilled with fresh oil or clarified oil, set all controls on neutral and start the electric motor. Build up response pressure and for ten minutes permit such circulation to take place as will occur with controls at neutral. This circulation will be small, comprising in most systems the oil leakage through valve block ports and past valve surfaces. However it is an important effort to remove particles at or near contact surfaces which otherwise might produce scoring. It is essential that no valves or other parts having very fine clearances be moved even the slightest amount until the system is as clean as it is possible to make it.

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* For receiver regulator systems use a 200 mesh screened funnel.

After this period of operation examine the screens or filters (if any) in the system and if any evidence of foreign matter is found draw off all oil, clarify and refill.

When filters remain clean, and only then, start moving the controls, creeping very slowly and gradually building up speed and power. During such operation watch for symptoms of valve sticking, for evidence of binding of parts, and for leaks. At the first sign of such conditions stop operations, diagnose the trouble and correct. *Do not attempt to "work-out" stiffness, lag, vibration, etc. Always stop the machine, locate and correct the trouble.*

MAINTENANCE

11. After a hydraulic system has been thoroughly cleaned, has passed a dynamic test, and is filled with clean hydraulic oil of the proper specification it should perform satisfactorily, indefinitely and without serious trouble, provided: that the simple instructions and precautions prescribed below are observed.

12. *All hydraulic mechanisms should be exercised daily.* It is not necessary to train or elevate guns to their limits, nor to put other gear to the limits of their cycles. It is sufficient, if after oil has been raised to proper temperature and response pressure throughout the system has been obtained, to move parts relative to each other. This will prevent residue from forming and galvanic action from starting with consequent sticking of valves. Operate the machine with control at slow and then at high speed: - if it has selective control operate it similarly in each. Such daily exercise not only benefits the mechanism as indicated, but equally important, it trains personnel to observe the quickness of response, the general performance, and to locate trouble. The value of daily exercise cannot be overstressed.

13. The hydraulic oil must be kept clean, neutral and free of residue. The oil of all hydraulic systems should be checked at least twice monthly* for evidence of acidity and sludge formation. When drawing test samples at drain points inspect for water or evidence of rust formation. Evidence of acidity, sludge or rust necessitates immediate draining of the system, flushing with acid free cleaning fluid, and thorough drying with compressed air. All oil added to the system must be carefully strained or filtered, or both, and salvaged oil must always be clarified. Filters in the system must be opened, examined and cleaned at regular periods (not less than once monthly). Foreign matter in filters shall always, if possible, be identified as to source, and the parts producing the particles shall be dismantled and corrected, - making replacement

* New installations daily.

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if necessary. Furthermore whenever such filter evidence is apparent, the system must be drained and flushed clean.

14. Hydraulic systems which are not self-venting must be vented periodically. Air in a system is invariably apparent as the cause of noise in pump, motor or pressure pipe line; and, as the cause of irregular operation.

15. Hydraulic systems which perform satisfactorily and which show no evidence of sludge, rust, etc., should not be opened; - all cover nuts should be kept tightly secured to discourage removal without good reason.

16. Systems which are operating unsatisfactorily and for which the trouble and correction cannot be ascertained, must not be operated, except in emergency, until replacement can be made or until a representative of the manufacturer can be obtained to make correction. In the event that it is deemed advisable to request a service engineer from the manufacturer, it is essential that the request be accompanied by complete report as to the abnormal characteristics; if parts are damaged, explain the phase of operation in which the casualty occurred. Such report will facilitate restoring equipment to service.

17. When ordering replacement parts for hydraulic equipment give the manufacturers piece number (from the piece), the Ordnance number (from the drawing), and the name of the part or a description of it. Inspect mating or attached parts for evidence of damage; order replacement parts, similarly, if they are required.

Chapter XVI

LUBRICATION INSTRUCTIONS

FOREWORD. - The ordnance assemblies described in the preceding chapters include virtually every class of mechanical engineering device. These range from heavy duty machines to exceptionally light duty instruments; from slow to very high speed oscillating and rotating mechanisms. They include electric, pneumatic and hydraulic power and service units of varying size and purpose. It is obvious that these many types of mechanisms require equally varied lubrication and that regular application of appropriate lubricants is imperative. Furthermore, although most units can be operated alone, all units must perform efficiently if the mount is to perform at its best. It is therefore important that all parts, no matter how difficult of access, shall at all times have adequate lubrication. No points requiring lubrication may be ignored or indifferently serviced without impairing operation of the mount.

Design Provisions for Lubrication

1. All ordnance mechanisms are designed to give lubricants access to bearing surfaces and wherever practical the design includes provision for retaining the lubricant. These arrangements comprise grease and oil fittings, grease cups, oil leads and grooves, wipers, oil and grease reservoirs and sufficient clearance in each case to give the desired penetration, provided the correct lubricant is used. Many pedestal fixtures, limit stop mechanisms, oscillating bearings and control screw devices, such as those included in the subject assemblies, have self-contained lubricating systems and all hydraulic transmissions provide self lubrication by immersion of moving parts in hydraulic oil. These systems as well as manually lubricated mechanisms include packing rings, bearing cages, oil bath sumps, wicks, gear cases, cover plates and other devices, to retain the lubricant. Position and movement of parts and ambient temperature also influence design and the effectiveness of design arrangements.

2. *Selection of lubricants.* - The selection of lubricant for each bearing surface has been based on design and on the service to which the part is subjected; in some instances selection has only been made after extensive tests. It is therefore important that lubricants specified shall be used consistently and that substitution of lubricants having other char-

acteristics shall not be made. It should not be presumed that a pressure grease fitting implies the use of cup grease. Ordnance designs frequently employ zerk fittings at points which require light oil for proper distribution at internal bearings.

Lubricating Frequency

3. The frequency of lubrication is dependent upon the use of the mechanism. The schedule given is required when the outfit is used daily. Lubrication may be less frequent for less frequent use but in no case shall the maximum period between regular inspections of the parts for proper lubrication on ships in commission exceed one month.

4. The parts lubricated should be exercised after lubricating.

Lubricants

5. All lubricants specified are based on classifications, definitions and the symbol designations of the Federal Standard Stock Catalogue*, except for special lubricants which are designated by the applicable ordnance specification or by special note.

6. Lubricant symbols listed in the schedules are oils and greases of the following designations:-

Stock Name	Symbol
Ice machine oil	2075
Light mineral oil	2110
Medium mineral oil	2135 or 3050
Heavy mineral oil	2190
Extra heavy mineral oil	2250
Transmission lubricant	5150 or 5190
Hydraulic oil	O.S. 1113
Breech block lubricant	O.S. 1165
Petrolatum	14P1
Ball bearing grease, soft	14L3-A
Ball bearing grease, medium	14L3-B
Cup grease, soft	14G1-I
Cup grease, medium	14G1-II

Lubrication Charts

7. Lubrication instructions for all elements of all ordnance assemblies included in 16-inch Turret Assemblies Nos. 66 to 83, inclusive, are given on drawings number 243608 to 243628, inclusive. Lithoprint copies of these charts are appended (Appendix V). These charts, as listed below, include

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* For a more comprehensive treatment of lubrication and of selection, use and care of lubricants, refer to Bu. Eng. "Manual of Engineering Instructions, Chapter 10."

separate drawings for Slides, Mark 4 and Mark 5; Elevating Gears, Mark 4 and Mark 4, Mod. 3; Training Gears, Mark 1 and Mark 1, Mod. 1. The folio of lubrication charts for any one turret will therefore comprise seventeen of the drawings and not all of the items listed.

Lubrication Chart for:-	Dr. No.
16-in. Breech Mechanism, Mk. 3, Mod. 1	243608
16-in. Slide, Mk. 4	243609
16-in. Slide, Mk. 5	243610
16-in. Deck Lug, Mk. 6	243611
16-in. Elevating Gear, Mk. 4 and Mk. 4, Mods. 1 and 2	243612
16-in. Elevating Gear, Mk. 4, Mods. 3, 4 and 5	243613
16-in. Training Gear, Mk. 1, Electric Deck	243614
16-in. Training Gear, Mk. 1, Pan Floor	243615
16-in. Training Gear, Mk. 1, Mod. 1, Electric Deck	243616
16-in. Training Gear, Mk. 1, Mod. 1, Pan Floor	243617
16-in. Rammer, Mk. 4 and Mk. 4, Mod. 1 and 2	243618
16-in. Projectile Ring, Mk. 1	243619
16-in. Projectile Hoist, Mk. 7 and Mods.	243620
16-in. Powder Hoist, Mk. 8 and Mods., Powder Car and Indicator Mechanism	243621
16-in. Powder Hoist, Mk. 8 and Mods., Motor and Speed Gear Assembly	243622
16-in. Powder Hoist, Mk. 8 and Mods., Upper Door Operating Gear	243623
16-in. Powder Hoist, Mk. 8 and Mods., Control Station	243624
16-in. Sight, Mk. 4	243625
16-in. Sight, Mk. 4, Mod. 1	243626
16-in. Sight, Mk. 4 and Mk. 4, Mod. 1	243627
Range Finder Stand, Mk. 46	243628

8. *"Check-off" lubricating routine.* - The lithoprint copies of the above listed charts are available for ship-board use as check-off sheets. These are issued as, "Appendix V, O.P. 755". Gunnery Officers should address requisitions to the Commandant, Naval Gun Factory, Washington, D. C.

NAVY DEPARTMENT
BUREAU OF ORDNANCE
December, 1941.

W. H. P. BLANDY,
Chief of Bureau.

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Appendix I

16-inch Turret Assembly No. 66			
Turret No. 1 - U.S.S. NORTH CAROLINA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4	4-1	4-2
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8	8-1	8-2
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder	——	47	——
Sight Telescope	66	——	66
Periscope	29	——	29
Periscope Mount	5-10	——	5-10
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 67			
Turret No. 2 - U.S.S. NORTH CAROLINA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4	4-1	4-2
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-3	8-4	8-5
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37-1	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 68			
Turret No. 3 - U.S.S. NORTH CAROLINA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4	4-1	4-2
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-6	8-7	8-8
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37-2	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-6	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——
Range Finder Train Corrector	——	1	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 69			
Turret No. 1 - U.S.S. WASHINGTON			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4	4-1	4-2
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8	8-1	8-2
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder	——	47	——
Sight Telescope	66	——	66
Periscope	29	——	29
Periscope Mount	5-10	——	5-10
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 70			
Turret No. 2 - U.S.S. WASHINGTON			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4	4-1	4-2
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-3	8-4	8-5
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37-1	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 71			
Turret No. 3 - U.S.S. WASHINGTON			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4	4-1	4-2
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-6	8-7	8-8
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37-2	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-6	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——
Range Finder Range Corrector	——	1	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 72			
Turret No. 1 - U.S.S. SOUTH DAKOTA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-9	8-10	8-11
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder	——	47	——
Sight Telescope	66	——	66
Periscope	29	——	29
Periscope Mount	5-10	——	5-10
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 73			
Turret No. 2 - U.S.S. SOUTH DAKOTA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-12	8-13	8-14
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37-1	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 74			
Turret No. 3 - U.S.S. SOUTH DAKOTA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-15	8-16	8-17
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33	33-1	33-2
Turret Train Indicator and Transmitter	——	37-3	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-6	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——
Range Finder Train Corrector	——	1	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd)

16-inch Turret Assembly No. 75			
Turret No. 1 - U.S.S. INDIANA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-9	8-10	8-11
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder	——	47	——
Sight Telescope	66	——	66
Periscope	29	——	29
Periscope Mount	5-10	——	5-10
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 76			
Turret No. 2 - U.S.S. INDIANA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-12	8-13	8-14
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37-1	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 77			
Turret No. 3 - U.S.S. INDIANA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-15	8-16	8-17
Sight	4	——	4-1
Training Gear	——	1-1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37-3	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-6	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——
Range Finder Train Corrector	——	1	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 78			
Turret No. 1 - U.S.S. MASSACHUSETTS			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-9	8-10	8-11
Sight	4	——	4-1
Training Gear	——	1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder	——	47	——
Sight Telescope	66	——	66
Periscope	29	——	29
Periscope Mount	5-10	——	5-10
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The Transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 79			
Turret No. 2 - U.S.S. MASSACHUSETTS			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-12	8-13	8-14
Sight	4	——	4-1
Training Gear	——	1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37-1	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 80			
Turret No. 3 - U.S.S. MASSACHUSETTS			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4-1	4-1	4-1
Yoke	4-1	4-1	4-1
Slide	5	5	5
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-15	8-16	8-17
Sight	4	——	4-1
Training Gear	——	1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37-3	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-6	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——
Range Finder Train Corrector	——	1	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 81			
Turret No. 1 - U.S.S. ALABAMA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-9	8-10	8-11
Sight	4	——	4-1
Training Gear	——	1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder	——	47	——
Sight Telescope	66	——	66
Periscope	29	——	29
Periscope Mount	5-10	——	5-10
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 82			
Turret No. 2 - U.S.S. ALABAMA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-12	8-13	8-14
Sight	4	——	4-1
Training Gear	——	1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37-1	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-5	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix I (cont'd.)

16-inch Turret Assembly No. 83			
Turret No. 3 - U.S.S. ALABAMA			
Ordnance Assembly Classification	Ordnance Mark		
	Right	Center	Left
Gun	6-1	6-1	6-1
Breech Mechanism	3-1	3-1	3-1
Firing Lock	14-5	14-5	14-5
Gas Ejector	4	4	4
Yoke	4-1	4-1	4-1
Slide	4	4	4
Deck Lug	6	6	6
Elevating Gear	4-3	4-4	4-5
Rammer	4	4-1	4-2
Projectile Hoist	7	7-1	7-2
Powder Hoist	8-15	8-16	8-17
Sight	4	——	4-1
Training Gear	——	1	——
Projectile Ring (Upper and Lower)	——	1	——
Range Finder Stand	——	46	——
Fire Control Equipment:-*			
Range Finder (Stereo)	——	46	——
Sight Telescope	66	——	66
Periscope	28	——	28
Periscope Mount	5-11	——	5-11
Sight Setter's Indicator	3	——	3-1
Gun Elevation Indicator	33-3	33-4	33-5
Turret Train Indicator and Transmitter	——	37-3	——
Gun Elevation Order Transmitter	2	——	2-1
Auxiliary Computer	——	3-1	——
Battle Order Indicator	——	28	——
Multiple Turret Train Indicator	——	12-6	——
Gun Elevation Receiver Regulator	10	10	10
Turret Train Receiver Regulator	——	8	——
Range Finder Train Corrector	——	1	——

* The transmitters and indicators and their system arrangements are described in chapter XIII. The ship's main battery fire control system, of which the turret equipment is part, is fully described in O.P. 810, "Gun Director, Mark 38." For descriptions of the receiver regulators refer to O.D. 3508, Gun Elevation Receiver Regulator, Mark 10, and O.D. 3860, Turret Train Receiver Regulator, Mark 8.

Appendix II

The lists below are cross-reference compilations of symbols and piece marks covering all of the principal parts that are indicated by symbol in the circuit diagram descriptions of this textbook.

Chapter V references.

Symbol	Name of part	Piece number
V1	Power-off valve	268501-22
V2	Servo supply cut-out valve	268518-36
V3	Control valve	268518-33
V4	Power-off control valve	268559-13
V5	Replenishing valve	268501-20
V6	Constant horsepower valve	268518-17
V7	Shuttle valve	268554-3
V8	Directional valve	268530-49
V9	Main relief valve	268554-16
V10	Main relief valve	268544-16
V11	Pilot valve	268409-13
V12	Cut-out valve	268554-21
P1	Servo piston	268546-9
P2	Pressure measuring piston	268530-7
P4	Clutch shifting plunger	268508-21

Chapter VI references.

V3	Control valve	268414-33
V4	Power-off control valve	268559-13
V5	Neutral return valve	268433-189
V6	Constant horsepower valve	268414-19
V7	Shuttle valve	268410-7
V8	Directional valve	268414-33
V9	Main relief valve	268409-1
V10	Main relief valve	268409-1
V11	Pilot valve	268409-13
P1	Servo piston	268402-8
P2	Pressure measuring piston	268415-7
P3	Brake release plunger	268441-22
P4	Clutch shifting plunger	268508-21

Chapter VII references.

A	Servo-pilot valve	290279-3
B	Constant horsepower control valve	290279-3
C	Selector valve	290288-1
E	Constant horsepower pilot valve	290280-5

Chapter VIII references.

Symbol	Name of part	Piece number
A	Servo-pilot valve	290279-3
B	Constant horsepower control valve	290279-3
C	Selector valve	290288-1
E	Constant horsepower pilot valve	290280-5

Chapter IX references.

A	Decelerate valve	265831-38
B	Striker pin	265836-61
C	Gear 81T-10P	265836-41
D	Drive shaft	265822-7
E	Make-up pump	265783
F	Valve plunger	265809-20
G	Valve plunger	265810-28
H	Valve plunger	265810-28
I	Neutral lock roller	265815-29
J	Control arm	265813-4
K	Adjustment eccentric	265816-40
L	Neutral lock spring	265815-41
M	Control shaft	265812-2
N	Control pipe	265847-14
S	Suction and discharge adapter	265809-2
T	Suction and discharge adapter	265809-2
W	Suction and discharge adapter	265830-18
X	Suction and discharge adapter	265830-18
DD	Pipe adapter	265805-25
EE	Control shaft	265812-2
FF	Control shaft	265812-2
GG	Control pipe	265847-13
II	Control pipe	265847-13
JJ	Control shaft	265812-2
KK	Valve plunger	265810-14
LL	Valve piston and plunger	265810-3,4
MM	Restrictor body	265810-18
NN	Valve plunger	265810-14
PP	Reverse check valve	265832-69
QQ	Decelerate valve	265831-38
SS	Valve plunger	265810-32
ZZ	Valve plunger	265810-32
YYY	Valve core	265831-5
ZZZ	Valve core	265831-5

Chapter X references.

25	Starting valve	271702-6
28	Interlock valve	271700-5
31	Control valve	271700-6
37	By-pass valve	271702-5

Chapter XI references.

Symbol	Name of part	Piece number
C	Pilot and shut-off valves	
K	Pawl operating valve	
H	Tube pawl operating piston	231121-3
J	Tripping mechanism piston	231122-3

Chapter XII references.

BR	Brake release valve	274282-1
PF	Power failure valve	274282-7
V	Venting valve	274282-11
SC	Stroke control piston	274280-1
S	Servo control valve	274283-1
BP	By-pass valve	274283-3
REL	Relief valve	274280-3
54	Latch and vent valve	274263-4
30	Safety car stop release valve	274262-10
48	Foot valve	274341-15

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Appendix III

Alignment of 16-inch Sight, Mark 4 and Mark 4, Mod. 1

1. The following procedure is recommended for use in aligning the subject sights after installation aboard ship, which is assumed to be in dock.

(a) Determine tilt of axis of trunnions of center gun with reference to the true horizontal plane.

(b) With the sight telescope removed from the holder bearings, adjust position of the telescope holder (231639-1, 231659-1) in deflection to bring the center line of the telescope bearings in the holder into alignment with the axis of rotation of the elevation bracket (231646-1, 2; 231668-1) so that the two are coaxial.

(c) Align sight station assembly in a vertical plane to bring the axis of rotation of the elevation bracket parallel to the center line of the gun trunnions. Shim bearing pads of the pedestal (231656-1, 2; 231666-1, 2) and housing (231661-1, 231655-1, 2) as required.

(d) Rotate elevation bracket in its bearings (about the horizontal axis of rotation) so that the axis of telescope bracket trunnions lies in a vertical plane. This is the position for zero elevation of line of sight.

(e) Clamp operating shafts to prevent any change in alignment before dials are set.

(f) Place telescope in its bracket.

(g) Loosen holding down bolts for the pedestal and housing. Adjust the complete station assembly, sliding the pedestal and housing on their respective bearing pads so that the horizontal coaxial center lines of the elevation bracket and telescope are parallel to the axis of the gun trunnions. This adjustment can be made by bringing the line of sight of the telescope to bear in azimuth upon the designated outside bore sight target. Care should be taken to see that no undue strain or binding action is placed on shafting or gears as a result of the foregoing operations. Adjustment should not be made by attempting to reset the telescope bracket alone. This will disturb the alignment resulting from the adjustments of item 1(b) and will introduce reflection errors later on when the sight is put into use. Tighten bolts and dowel parts as required.

(h) Adjust micrometer couplings to bring dials to zero. Loosen clamps on operating shafts.

(i) Check zero elevation by means of a leveled transit sighted into the window of the sight telescope (Mk. 66). Reset dials as required.

2. The adjustment and alignment processes previously outlined can be made as follows:

(a) Determination of trunnion tilt (item 1(a)) for center gun. Remove top bolt of the trunnion bearing cover plate (216343-1) for clearance purposes. Back out remaining bolts so that four equally thick spacer blocks may be inserted between the cover plate and the outer bearing seat (216343-1). Insert blocks previously machined to a thickness of about 5/8 inch and space same at equal intervals. Tighten bolts on spacer blocks. On the accurately finished 30.247 inches diameter, temporaily exposed surface of the cover plate bearing, place a V-block bearing which acts as the base for a vertical bar provided with means for leveling so that it can be set truly vertical. Set up and level a transit so that there is an unobstructed view of both trunnions of the center gun. Sight transit on the leveled vertical bar which rests upon the cover plate bearing. Locate, either by marking the vertical bar or by sliding an attached pointer, the position where the line of sight of the leveled transit cuts the bar. Move bar to opposite trunnion of the same gun. Train transit to sight on the bar in its new position, and again mark position of line of sight. Measure difference in heights of marks. Compute trunnion tilt, based upon the separation of the two positions of the bar. Adaptations of this procedure may be worked out.

(b) Alignment of axis of telescope bearings (item 1(b)). - Mount a substantial steel tubing (approx. 2 ins. dia., 36 ins. long), truly round and of a uniform diameter, in two truly round discs which will fit inside the sight telescope ball bearings. This unit should be of such workmanship that, when assembled, the rod is centered accurately in the several discs, and is free from any eccentricity when the discs are rested on V-blocks and the unit is rotated 360°. Mount discs in a pair of ball bearings of the same type and accuracy as those carrying the telescope in its holder. Assemble unit in telescope holder so that it occupies the position normally taken by the sight telescope. Mount a dial indicator on some rigid base free of the moving sight parts, and place spindle end against the cylindrical surface of the rod, as close as practicable to the outboard or free end of the rod. Rotate the telescope bracket to a position corresponding to that required

for maximum elevation, then to that required for maximum depression. Note movement of indicator dial, indicating eccentricity. Adjust as indicated in 1(b) until movement of indicator dial is brought, not necessarily to zero, but to a minimum. Lock operating shafts feeding into the subject mechanism.

(c) Vertical alignment of sight station assembly (item 1(c)). Mount a gunner's quadrant on a metal base which is fitted on its under side with two V-block bearings, and on the top side with an alignment slot into which the quadrant can be placed and secured. Scrape V-block bearings so that when the unit is placed on a truly round bar of uniform diameter, with the quadrant index set at zero, the level bubble is at the center of its run. Mount a small cross-level bubble on the V-block bearing base for correctly positioning the gunner's quadrant in the vertical plane. Set quadrant scale index to the angle corresponding to the slope or tilt of the gun trunnion axis, and place the quadrant assembly on the extended portion of the rod which was mounted previously in the telescope bearings in accordance with item 2(b). Bring bubble to center of its run by carrying out instructions in 1(c).

(d) Alternate methods of alignment for items 2(b) and 2(c). This method requires the use of a collimator, similar to that shown on drawing 164343, which should be carefully centered (optically) after being assembled in a pair of ball bearings of the same type and accuracy as those used to mount the telescope in the telescope holder. Set telescope holder trunnions to as nearly a vertical position as possible. Place collimator unit in the telescope bearings. Set up a transit in front of and looking into the collimator objective. Level the transit. Bring vertical wire in transit to vertical crossline in telescope. Elevate or depress line of sight of the transit telescope so that the vertical circle reads the same as the measured tilt of the gun trunnion axis. Sight thru transit and align sight station assembly vertically in accordance with item 1(c), so that the collimator crosslines are in coincidence with those in the transit. Rotate telescope bracket to give maximum elevation and depression. The crossline intersection in the telescope should remain on that of the transit, or within reasonable limits. Corrections, if deemed necessary, may be made.

(e) Common alignment of sights. - Check common alignment of sights when set for maximum deflection. Set center line of each sight on its properly bore sighted and not too near target, with elevation zero. Set lines of sight of the telescopes 10° to right. Train turret 10° to left. Each line

of sight should cut the target within the limits of accuracy of the roller path. In any case, each telescope crossline intersection should occupy the same relative position with respect to its own designated target, and angle of train should correspond to that of sight deflection. Set line of sight 5°40' to left, turret 5°40' to right. Check.

(f) Bore sighting. - Check bore sighting of guns and sights, if practicable, on several celestial targets at different elevations. Check elevation dial settings by means of simultaneous readings taken on same target with a transit.

Appendix IV

Reference drawings of the descriptive text are as listed below:

Chapter II.

Gun	204093
Projectile "A"	199144
Projectile "B"	204205
Screw box	216317
Breech mechanism	53771
Breech mechanism	53965
Breech mechanism	53858
Hinge lugs & bearings	54982
Hinge lugs & bearings	233198
Holding down latch	233710
Counterbalance & closing cylinder	233708
Counterbalance & closing cylinder	233709
Foster valve	179766
Mason valve	50266
Salvo latch	215998
Firing mechanism	59295
Firing lock	118488
Gas ejector	216388
Yoke	233703

Chapter III.

Trunnion bearing	216341

Chapter IV.

Slide Mark 4	215656
Slide Mark 4	215657
Slide Mark 5	231074
Slide Mark 5	231075
Gun cover	216398
Recoil mechanism (Mk. 4)	215632
Recoil mechanism (Mk. 5)	231086
Counterrecoil mechanism (Mk. 4)	215645
Counterrecoil mechanism (Mk. 4)	215646
Counterrecoil mechanism (Mk. 5)	231089
Counterrecoil mechanism (Mk. 5)	231090
Counterrecoil mechanism instructions	215247
Air charging pipes	235345

Chapter V.

Schematic diagram	230774
Pan floor assembly	230772
Electric deck assembly	230773
Motor & speed reduction gear	230778
Motor & speed reduction gear	231603
Motor & speed reduction gear	230779
Wiring diagram	230450
Electric motor	268377
Reduction gear	268473
Pump	268463
A-end	268461
B-end	268462
Oscillating bearing	216429
Control gear (hand gear)	268468
Servo control	268466
Response gear	231604
Limit stop	268468
Elevating stops	217204
Elevating stops	233700
Elevating stops	233701
Elevating stops	230775
Danger zone cutout mechanism	233706
Danger zone cutout mechanism	238870
Danger zone cutout mechanism	238871
Control valve	268470
Power-off solenoid & control valve	268347

Chapter VI.

Reduction gear	230780
Electric motor	231539
Controller	230495
Wiring diagram	230496
Speed reducer	228471
Pumps	268336

Chapter VI (cont'd.).

A-end	268332
B-end	268333
Power-off brake	268346
Control gear (hand gear)	230789
Differential screw & control valve gear	268340
Servo control	268339
Response gear	230787
Response gear	230788
Limit stop	268341
Training stop	274927
Training stop signal switch	238870

Chapter VII.

Schematic diagram	231630
Pan floor assembly	231622
Electric deck assembly	231623
Power unit	231626
Power unit	231629
Power unit	231627
Pump cluster	221534
Control pump	221533
Replenishing pump	221531
Motor	231593
Controller	231594
Speed reducer	231593
Pump	221530
A-end	268100
B-end	268153
Response	231604
Oscillating bearing	216429
Control gear (hand gear)	268147
Follow-up device	268103
Servo control	268102
Automatic cut-off	268106
Danger zone cut-out mechanism	233706
Danger zone cut-out mechanism	238870
Danger zone cut-out mechanism	239000
Danger zone cut-out mechanism	239001
Hand gear pump	221538
Hand gear pump	221541
Interlock switch	268109

Chapter VIII.

Power unit	231628
Motor	231540
Controller	231592
Speed reducer	228471
Pump	268170
A-end	268157
B-end	268177
B-end	268180
Power-off brakes	268179
Power-off brakes	268206
Control gear (hand gear)	232113
Servo control	268159
Response gear	230787
Response gear	230788
Follow-up control	268160
Automatic cut-off	268163
Constant horsepower device	268161
Constant horsepower device	268164
Training stops	274927
Training stops	275045
Input shaft assembly	268165
Pedestal input gearing	268175
Auxiliary pump cluster	221531

Chapter IX.

Rammer assembly	216402
Rammer assembly	216403
Chain head link	216407
Control gear	232124

Appendix V

The attached folio of lithoprint copies of lubrication charts prescribes lubricating maintenance for all ordnance units of the main batteries of Battleships 55 to 60, inclusive. The drawings applicable to the turrets of the differently equipped ships are as listed below.

BB55-56	BB57-58	BB59-60
243608	243608	243608
243609	243609	243609
243610	243610	243610
243611	243611	243611
243612	243613	243613
243616	243616	243614
243617	243617	243615
243618	243618	243618
243619	243619	243619
243620	243620	243620
243621	243621	243621
243622	243622	243622
243623	243623	243623
243624	243624	243624
243625	243625	243625
243626	243626	243626
243627	243627	243627
243628	243628	243628

Check-off lubrication:- Additional copies of these prints are available for "check-off" routine lubrication. Requisitions should specify "Appendix V, O.P. 755"; address the Commandant, Naval Gun Factory, Washington, D. C.