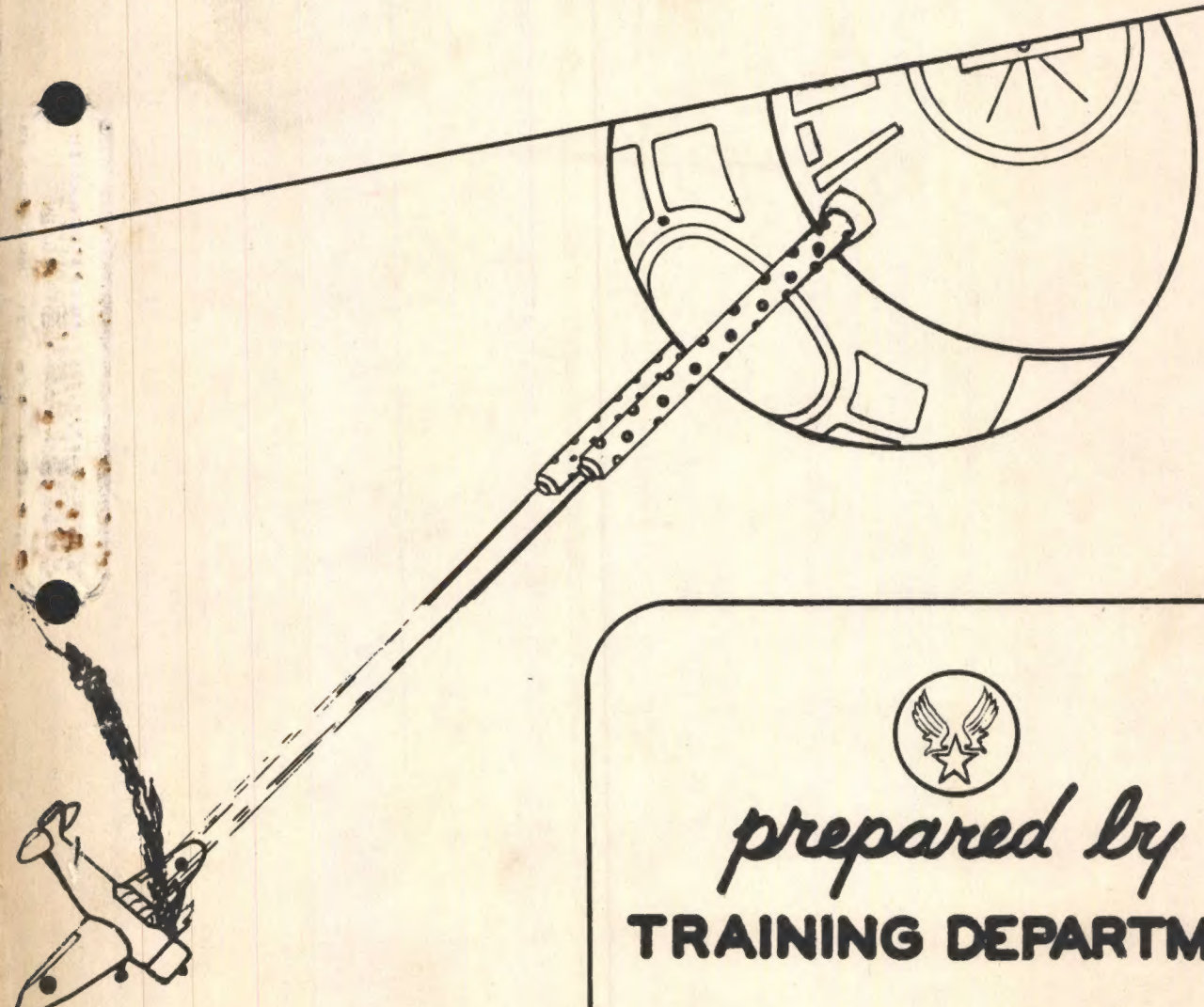
RESTRICTED

SPERRY

Lower Ball



prepared by

TRAINING DEPARTMENT

KINGMAN
ARMY AIR FIELD

TABLE OF CONTENTS

THE OLD GUNNER LOOKS WITH CONSTERNATION ON THE CARELESS STUDENT

F O R E W O R D

It is a well recognized fact that the effectiveness of a bombardment group is no greater than the combined abilities of the Crew Members. The importance and necessity of a high degree of Gunnery Training are unquestionable when one considers the high cost of a B-17 Flying Fortress - its tremendous amount of highly technical and expensive equipment and the training and size of the Air Crew.

Aerial Gunnery of the past has been largely a matter of guess work based on a few rough calculations and predictions. Bombers were easy prey for the faster pursuit type aircraft. But this is no longer the case today.

Development of Flying Fortress Bombardment Aircraft and the Sperry Turret have turned the present day bomber into a death dealing nest of defensive destruction. German and Japanese pursuit pilots have a healthy respect for B-17 Aerial Gunners. They have seen many a pursuit with the Rising Sun or Swastika on its wings plunge to the ground a flaming torch after Dr. Sperry Lower Ball reached out over a thousand yards to give them a dose of Cal. .50 medicine.

The part played by the Sperry Lower Ball and the gunner operating the turret is a large one. But there is still a tendency to be satisfied with far less than the maximum results obtainable with this turret. Operational summaries from the battle fronts daily stress the need for better trained Aerial Gunners.

Unfortunately the turret is often better than the gunner operating it. The turret is NOT automatic. It WON'T adjust itself, nor does the turret think for itself. These are the gunner's jobs. How well the gunner learns to operate and to maintain the turret will determine largely his success in guarding the lives of his fellow Crew Members - the kind of an Aerial Gunner who will inspire the confidence of his Pilot.

Learn to service the turret yourself - don't depend on others to do the work for you. You can't afford to be a "malfunction" gunner, always expecting armorers and maintenance men to solve your troubles. You may find yourself in a spot where there is nobody to help you. Always be able to do the job yourself. The maintenance men don't fly with you.

SO LEARN HOW TO OPERATE AND SERVICE THE LOWER BALL TURRET. WHEN THE TURRETS ARE NOT OPERATING CORRECTLY THE PLANE IS ALMOST DEFENSELESS AGAINST ENEMY ATTACK! THE GUNNER'S JOB IS SO IMPORTANT THAT THE LIVES OF ALL THE CREW MEMBERS DEPEND ON HIM WHEN THE SHIP IS UNDER ATTACK. REALIZE YOUR RESPONSIBILITIES EARLY, AND SPEND YOUR TIME AND EFFORTS DURING INSTRUCTION ACCORDINGLY. IT IS IMPOSSIBLE TO KNOW TOO MUCH ABOUT THIS TURRET. LITTLE MISTAKES ARE TERRIBLY COSTLY IN A COMBAT AREA ..... LEARN NOW WHILE YOU ARE NOT UNDER FIRE.

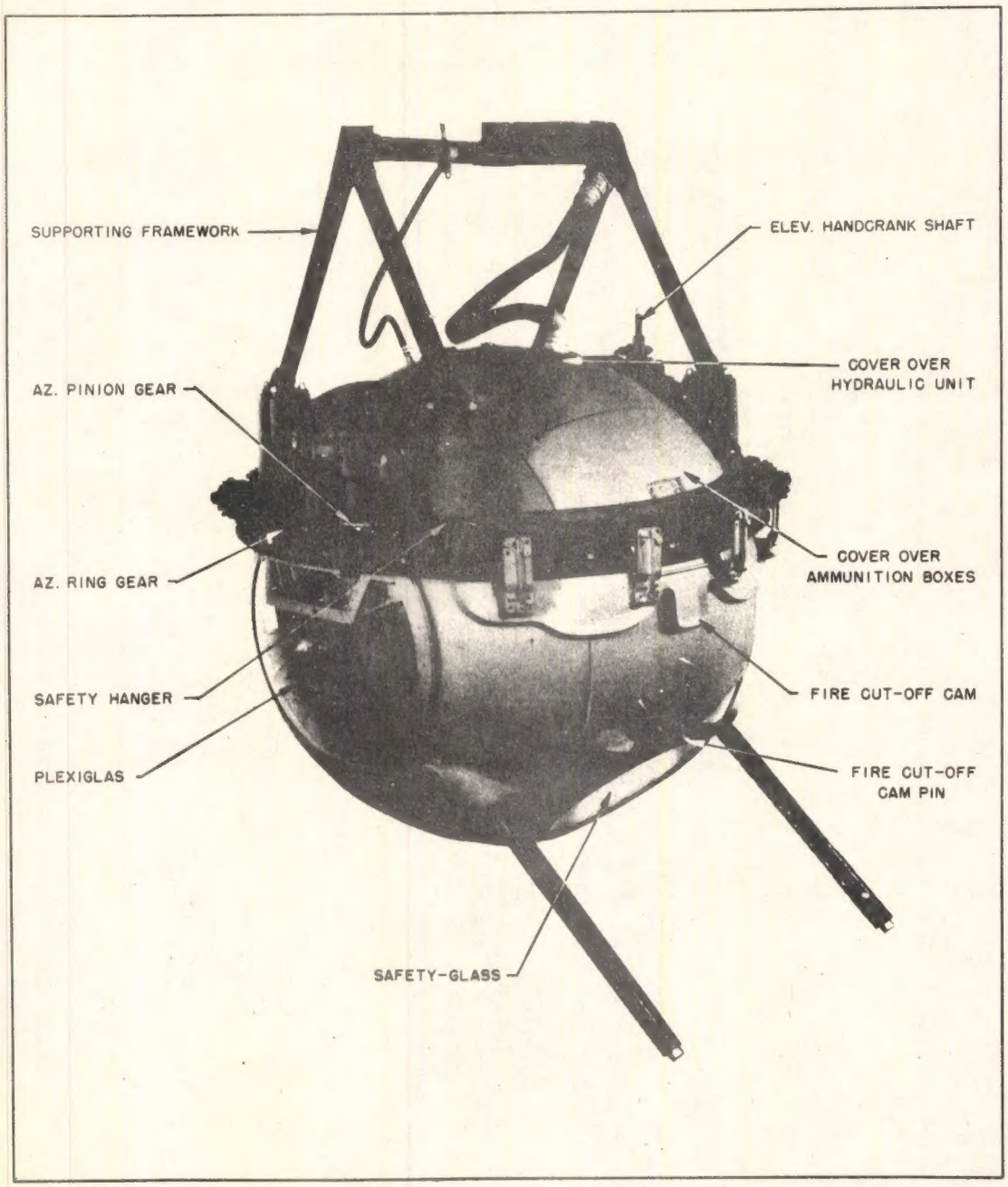


FIGURE-1

LOWER BALL TURRET

FRONT SIDE VIEW

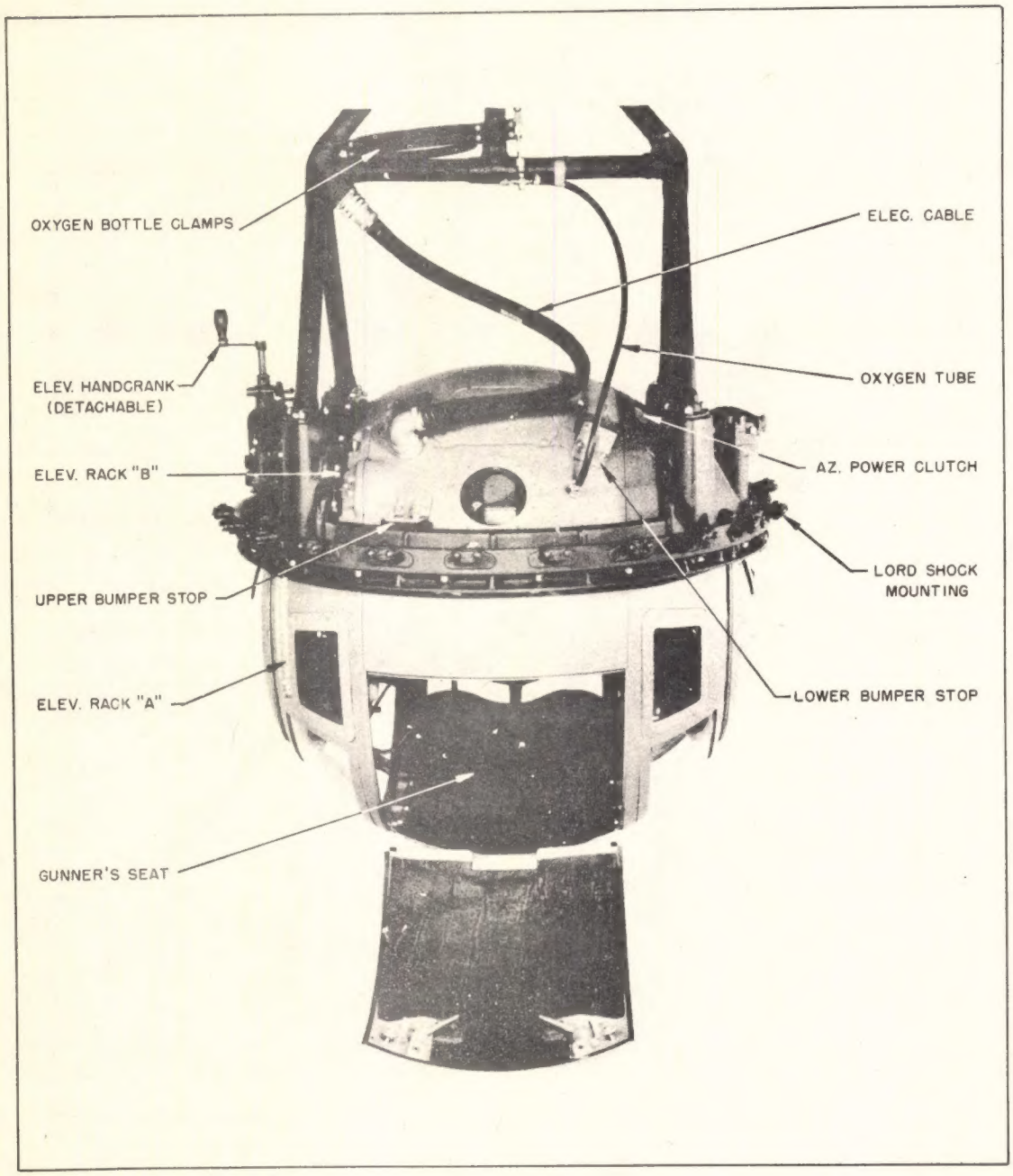
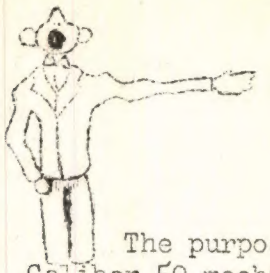


FIGURE-2

LOWER BALL TURRET

REAR VIEW



INTRODUCTION TO THE SPERRY LOWER BALL

The purpose of the Lower Ball Turret is to direct the fire of two Caliber 50 machine guns.

The Sperry Lower Ball is an Electro-Hydraulic Turret, designed for the B-17 E and F model Airplane. It is mounted behind the radio compartment. When the term "Electro-Hydraulic" is applied, we refer to the fact that Electric Energy is converted to Hydraulic Energy.

Operating under hydraulic power, the turret will turn easily in and out of the slipstream - resulting in a smooth tracking operation, free of jerk or sudden movement.

A. CONSTRUCTION

The turret weighs 1?90 pounds, and is constructed of light, durable metals, alloyed to hold weight down to a minimum.

B. METHOD OF MOUNTING

The entire weight of the Lower Ball is supported by a self-aligning bearing, bolted to the "I" Beam of the airplane. It also rides in horizontal rollers which align the turret when it is moving in Azimuth.

C. RATES OF OPERATION

Azimuth Rate: The Lower Ball will track or slew at a rate of 0-45 degrees/sec when properly regulated.

Elevation Rate: The Lower Ball will track or slew at a rate of 0-30 degrees/sec when properly regulated.

Note: A variable rate of acceleration and deceleration is set up in the Hand Control Unit.

D. LIMITS OF OPERATION

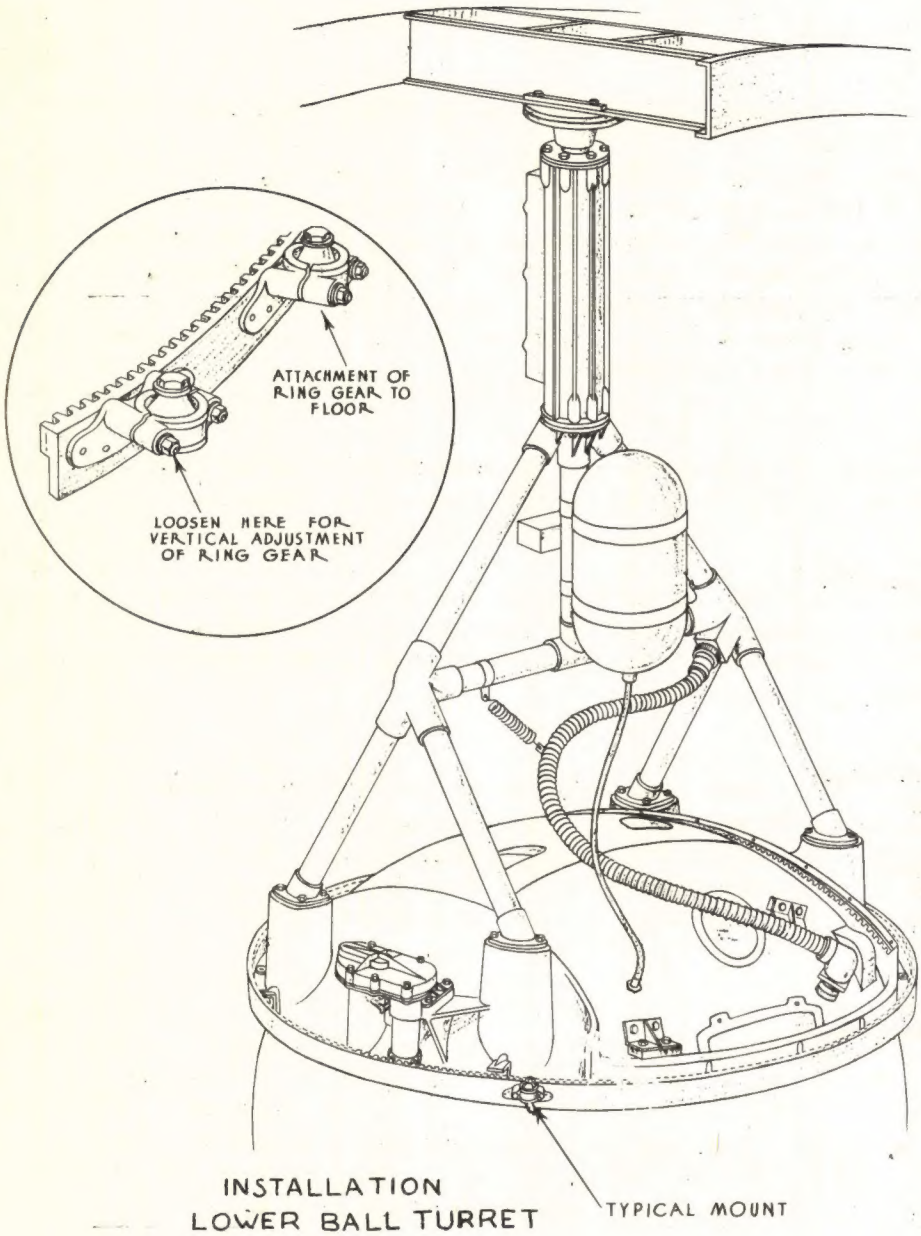
The turret is unlimited in Azimuth operation, and will operate from 0-360 degrees. The guns are rigidly mounted in the Ball, and the Ball will operate from 0 to -90 degrees in Elevation. Therefore, except when guns are pointed at a structural portion of the ship, the Lower Ball Gunner has a full field of fire throughout the lower hemisphere.

E. ARMAMENT

The turret mounts twin Caliber 50, Browning M2, Aerial Machine Guns.

F. ARMOR

The gunner's seat and back rest is constructed of steel armor plate. (The spherical shape of the Ball Turret makes it extremely difficult to get a straight-on shot into it.)



INSTALLATION
LOWER BALL TURRET

FIGURE 3.

G. COMPUTING SIGHT

The Sperry K-4 Automatic Computing Sight is standard equipment.

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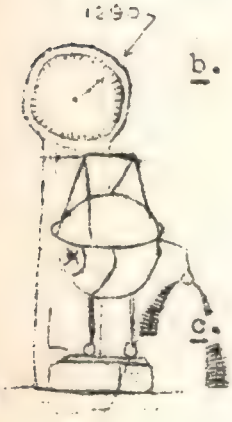
P A R T I — CONSTRUCTION, METHOD OF MOUNTING AND STRUCTURE

Before the gunner may attempt to master the mechanical operation of the turret, it is essential that he have an understanding of its method of mounting in the airplane, and a general picture of its structure in mind.

1. CONSTRUCTION AND METHOD OF MOUNTING

a. General - (1) The Lower Ball is designed for mounting in the lower part of the fuselage. The minimum opening required in the airplane is a circular hole of 46 3/4" diameter. The turret extends about 22" below the skin line of the ship, and the Cal. .50 Guns extend approx. 24" beyond the turret structure. Plexi-glass windows and shock frames are place at various positions giving the gunner a wide field of vision.



b. Construction - (1) Constructed of aluminum alloy, the turret weighs 1290 pounds, plus ammunition. Light, durable metals are employed wherever posible to hold the weight down to a minimum. 3/8" Plexi-Glass (requiring expert care) is used in windows but the sighting window, which is of two thicknesses of extra quality safety glass. The gunner's seat and back rest are made of armor plate.

c. Method of Mounting - (1) The turret is bolted at the top to a supporting "I" beam between two bulkheads on the upper portion of the fuselage by a mounting flange. To the mounting flange is rigidly attached:

(a) The Top Trunnion: The vertical pivot fitting or "axle" on which the entire turret (except the fixed Azimuth Ring Gear) rotates in Azimuth with the aid of a:

(b) Self-Aligning Bearing: This bearing is supported by the Top Trunnion and in turn supports and is a bearing surface for the entire weight of the turret.

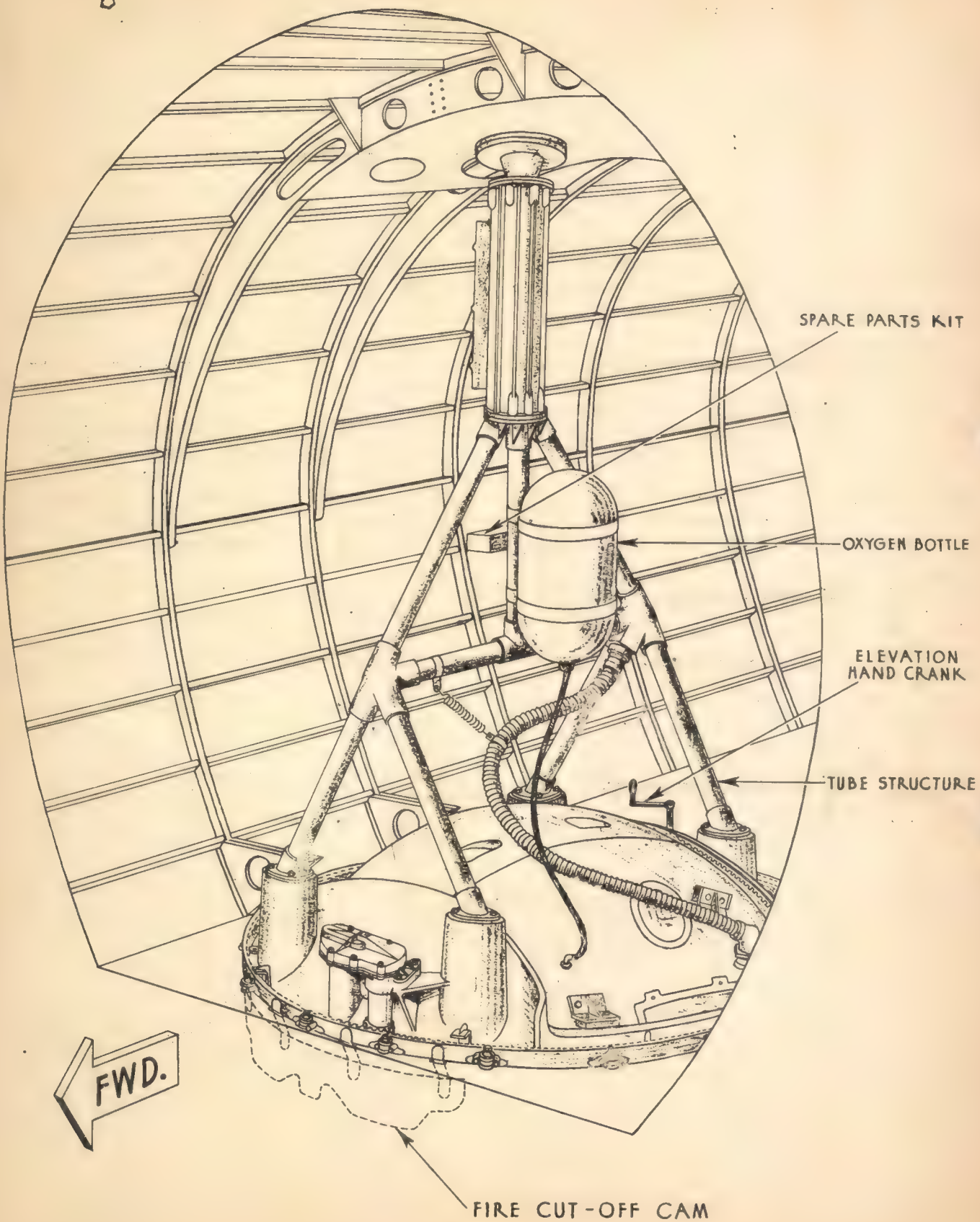

SPARE PARTS KIT
OXYGEN BOTTLE
ELEVATION HAND CRANK
TUBE STRUCTURE
FWD.
FIRE CUT-OFF CAM

FIGURE 4.

2. STRUCTURE

a. General - (1) The rotating structure of the Lower Ball Turret may be thought of as divided into two separate parts.

(a) The Azimuth Portion

(b) The Elevation Portion: which rotates in Azimuth with the Azimuth Portion, but is also movable in elevation. This portion is the ball itself.

b. Detailed Description - (1) The Azimuth portion consists of:

(a) The Centralized Column: a hollow vertical column which rides directly on the Self-Aligning Bearing, and to which is bolted:

(b) The Supporting Framework: a structural member consisting of struts and four supporting arms and to which is bolted:

(c) The Trunnion Ring Casting: a large ring-like casting which supports the Azimuth Power Gearing Assembly containing the Azimuth Pinion Gear, and to which is bolted

(d) The Elevation Trunnion Supporting Brackets: the supports for the "axle" on which the Ball Structure rotates in elevation.

(2) The Elevation portion or Ball consists of:

(a) The Left Hand End Bell: That portion of the Ball to the gunner's extreme Left.

(1) The Left Gun Trunnions: The adjustable supports holding the left gun in position bolted to the End Bell. Each gun has a rear and a front trunnion.

(b) The Right Hand End Bell: That portion of the Ball to the gunner's extreme Right.

(2) The Right Gun Trunnions: The adjustable supports holding the right gun in position.

(c) The Center Section: That portion of the Ball between the Left and Right Hand End Bells which contains:

(1) The Door: The only entrance to the turret which can be opened from the inside or the outside of turret. The door is latched with fasteners, each having a handle on the inside and the outside. When the aircraft is in-flight, the door **should not be** opened except when the guns are pointing straight down, (-90 degrees). THERE ARE SEVERAL IMPORTANT SAFEGUARDS WHICH MUST BE OBSERVED BY THE GUNNER WHEN HE ENTERS AND LEAVES THE TURRET.
The safeguards are described on page (30).

(2) Inspection Plates: To enable the gunner to load ammunition cans and reach the hydraulic unit, two inspection plates, fastened to the ball structure with Dzus fasteners are provided. IT IS MOST IMPORTANT THAT THESE PLATES BE REPLACED BEFORE TAKE-OFF.

(3) A number of items cannot neccessarily be considered to belong to either the Azimuth or Elevation portions.

(a) The Azimuth Ring Gear: A large fixed circular gear, mounted in the lower portion of the fuselage, with 20 Lord Shock Mountings, which meshes with the Azimuth Pinion Gear of the turret so that when the Pinion Gear is rotated, the turret moves in Azimuth.

(b) The Elevation Trunnion: The pivot fitting, or "Axle" on which the Ball Structure rotates in Elevation. Each turret has two - one in the Left Hand End Bell, and one in the Right Hand End Bell, each with a Ball Bearing in the End Bell.

(c) Horizontal Roller Bearings: 20 in number, mounted to the Trunnion Ring Casting, and which bear on the inside surface of the Azimuth Ring Gear to prevent lateral play of the turret.

(d) Safety Hangers: 4 of these are bolted to the Trunnion Ring Casting and will hold the Ball on the ship by hanging on the Azimuth Ring Gear if the supporting framework is severed.

The Flight Surgeon must understand the "inner workings" of the human body before he is able to keep his patient fit. Just so, the gunner must understand the "inner workings" of the Sperry Lower Ball to operate and adjust it.

1. GENERAL

All the essential units for the control and mechanical operation of the turret are contained in the Ball, itself, with the exception of the Azimuth Power Gearing Assembly, which is mounted to the Trunnion Ring Casting.

2. DETAILED DESCRIPTION

a. Introduction - (1) Mechanical operation of the turret is divided into two systems:

(a) The Power System

(1) The Azimuth Power System

(2) The Elevation Power System

(b) The Control System

(1) The Azimuth Control System

(2) The Elevation Control System

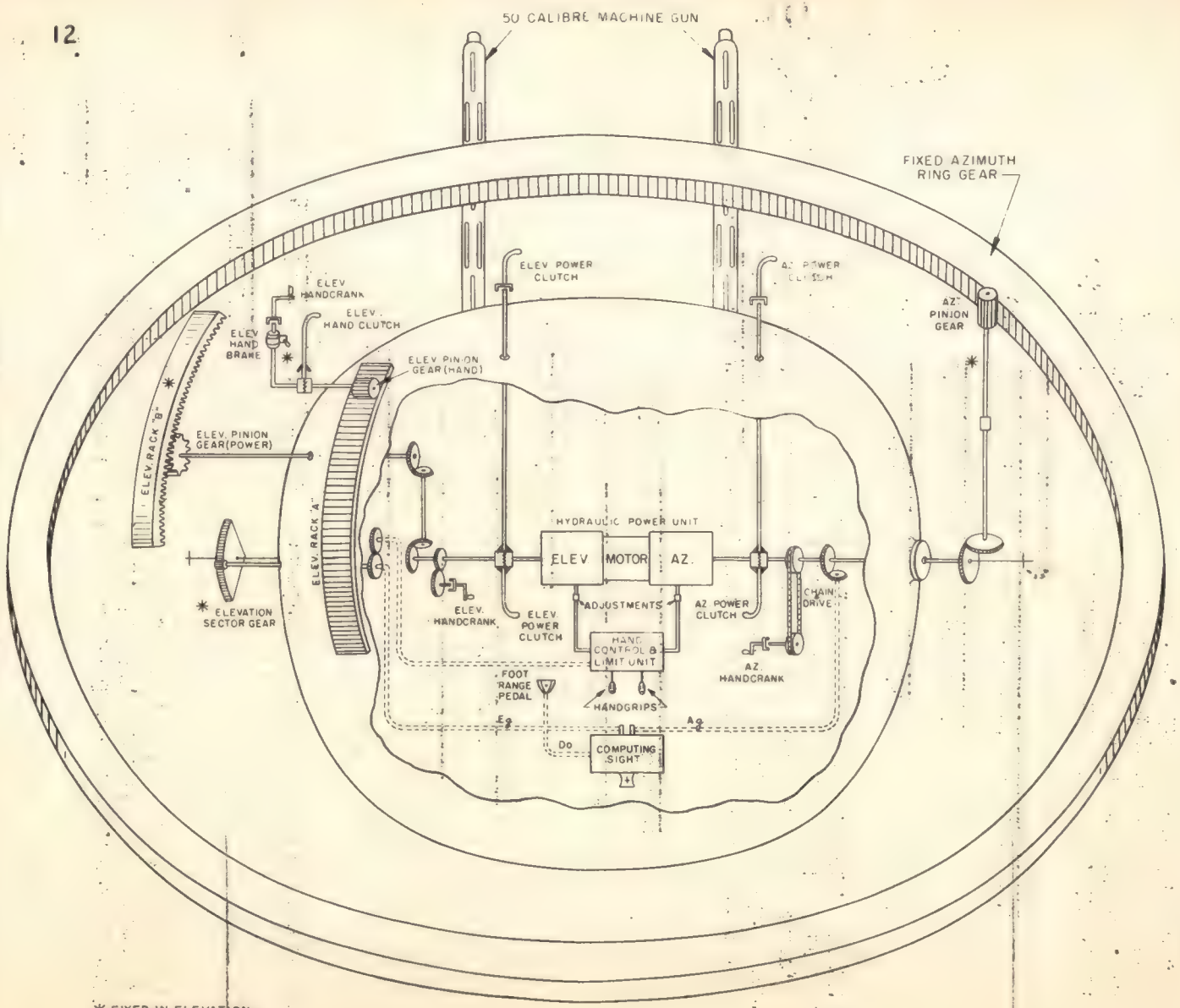
b. The Power System - (1) Power for driving the turret in Azimuth and Elevation is provided by the Hydraulic Power Unit which is mounted directly in front of the gunner, above the ammunition cans. THE HYDRAULIC POWER UNIT CONSISTS OF THREE SEPARATE ASSEMBLIES, FASTENED TOGETHER. THESE ARE:

(a) The Azimuth Vicker's Unit

(b) The Elevation Vicker's Unit

(c) The Electric Motor (constant speed common to both systems)

(2) The initial power is furnished by the 2 HP Electric Motor, rotating at a constant speed of 4000 RPM. The Vicker's Units convert the energy from the Electric Motor into Hydraulic Energy. The Hydraulic Fluid which is thus caused to flow within the unit drives both the Azimuth and Elevation Gear Trains. The speed and direction of Hydraulic Fluid is controlled by the motion of the "A" End Yoke which is displaced by movement of the turret's control system from the Hand Grips. The speed and direction of movement of the turret is thus controlled.



✱ FIXED IN ELEVATION, MOVES ONLY IN AZIMUTH

=== INDICATES FLEXIBLE SHAFT

FIGURE 5

SYSTEM OPERATION SCHEMATIC

(3) The rotating output shaft of the Azimuth Vicker's Unit drives the turret in Azimuth through the following gear trains:

(a) The Azimuth Power Gear Case: is fastened to the Azimuth Vicker's Unit, and the gears contained are driven by the Output Shaft of the Azimuth Vicker's Unit ("B" End).

(b) The Azimuth Internal Gear Box: - is bolted to the Right Hand End Bell and is driven through a 45 degree drive from the Azimuth Power Gear Case. The gears contained in this unit in turn drive a shaft through the hollow Elevation Trunnion, thus leading the Azimuth Gear Train out of the Ball. This shaft, in turn, by means of a 90 degree drive, rotates a vertical shaft up through the Trunnion Support Bracket.

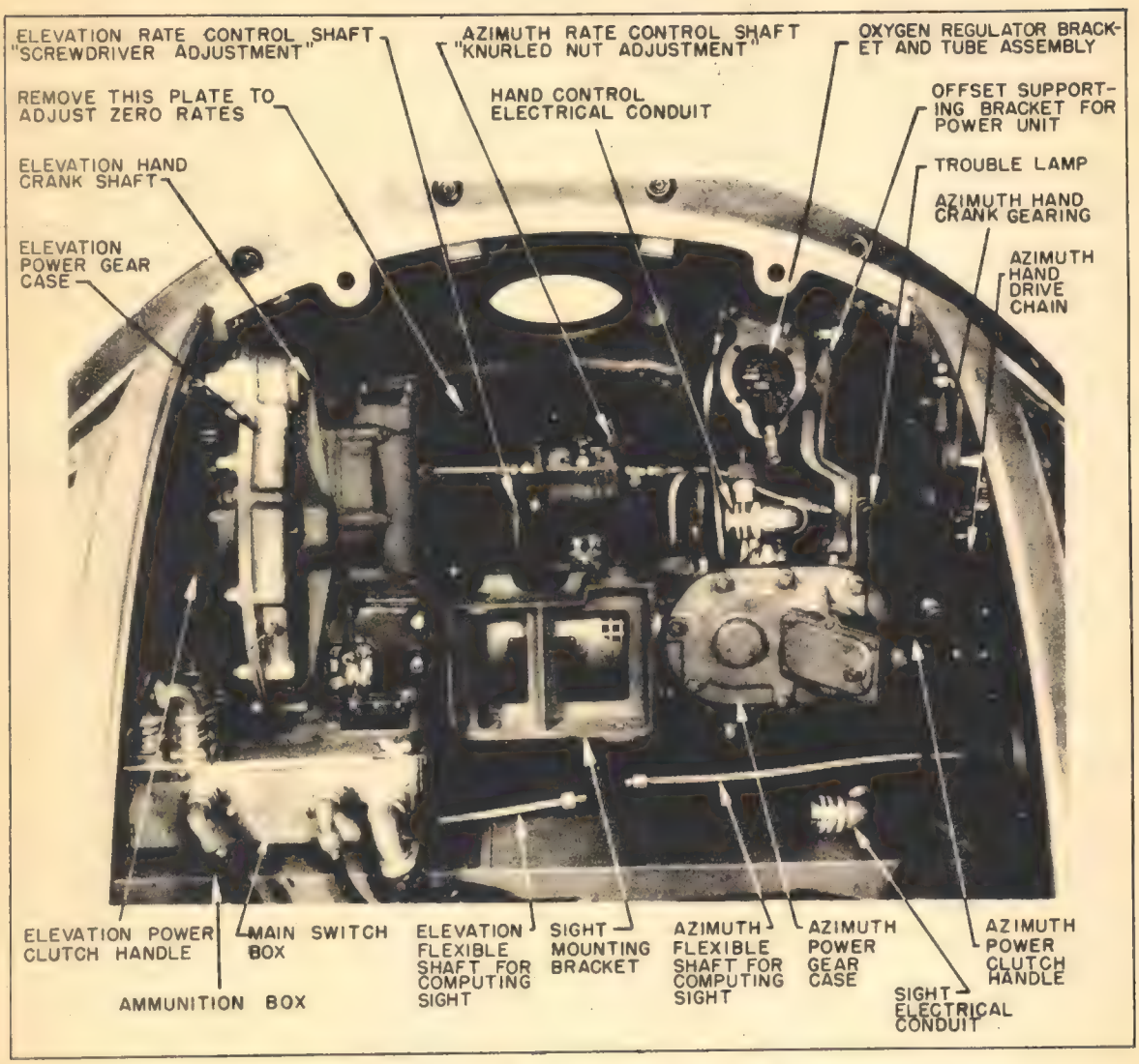
(c) The Azimuth Power Gearing Assembly: Gears contained within this unit are driven by a vertical shaft up through the Trunnion Support Bracket.

(1) The Azimuth Pinion Gear: The rotation of which within the stationary Azimuth Ring Gear causes the turret to rotate in Azimuth.

(d) The Azimuth Power Clutch: The Power Clutch can be engaged and disengaged by means of a Power Clutch, located between the Azimuth Power Gear Case and the Azimuth Internal Gear Box. The clutch consists of a shaft and two "dogs" which are engaged and disengaged by moving the Power Clutch Handle to IN or OUT positions. When the Power Clutch Handle is moved along a Spline Shaft outside of the Azimuth Internal Gear Box.

(e) The Azimuth Internal Hand Crank: In the interior of the turret, held in a clip directly above the Hand Control and Limit Unit, is the Azimuth Hand Crank used in moving the turret under hand power from the interior of the turret. THE CRANK IS ALWAYS ATTACHED TO THE HAND CRANK SHAFT, AND HELD FIRMLY BEFORE THE AZIMUTH POWER CLUTCH IS DISENGAGED.

(4) The rotating Output Shaft of the Elevation Vicker's Unit drives the turret in Elevation through the following gear trains:



INTERIOR OF TURRET WITH HAND CONTROL AND SIGHT REMOVED

FIGURE 6

(a) Elevation Power Gearing Assembly: All of the Elevation Gears, except the Elevation Pinion Gear, are contained in a single gear box, mounted to the Left Hand End Bell. The Output Shaft ("B" End) of the Elevation Hydraulic Unit is connected to the Elevation Gear train by a spline shaft, which enters the ELEVATION POWER GEAR CASE via a 90 degree drive.

(b) The Elevation Pinion Gear: The rotation of which, meshed on and turning inside of the Elevation Power Rack, causes the turret to move in Elevation. The Pinion Gear is driven by the Elevation Power Gear Case.

(c) The Elevation Power Rack: A Gear quadrant, mounted rigidly to a machined arc on the Trunnion Ring Support. The gear quadrant is sometimes referred to as a sector gear.

(d) Elevation Power Clutch: A clutch is provided to engage and disengage the gear train in the Elevation Power Gear Case, and is operated by hand. A detent arrangement holds the Elevation Power Clutch in and out of position.

(1) Interior: Operated within the turret by a fixed clutch handle.

(2) Exterior: Operated from the exterior with a removable clutch handle which fits on an extended shaft attached to the Elevation Power Clutch.

(e) Elevation Interior Hand Crank: This crank is provided to operate the turret in Elevation, by hand from the interior of the turret. The crank handle is placed in a clip above the Hand Control and Limit Unit when not in use. The crank turns a small spur gear which meshes with a large gear in the Elevation Power Gear Case.

(1) Elevation Interior Hand Clutch: The small shaft to which the crank handle is attached when the gunner is operating the turret by hand crank has a small sliding pin type clutch. This clutch must be disengaged when operating the turret under power, and engaged when operating the turret by hand crank.

(5) Exterior Elevation Hand Crank Assembly:- (Consists of a Gear Housing mounted to the Trunnion Ring Casting.) The assembly incorporates:

(a) Detachable Hand Crank: (One end of which has a specially designed screwdriver end for opening and closing Dzus fasteners on Inspection Plates.)

(b) Hand Crank Pinion Gear: Turned by the Hand Crank though the gear train, and turning the Ball in Elevation by meshing with the:

(1) Elevation Hand Rack: A sector or gear quadrant mounted on a machined arc on the Left Hand End Bell.
WARNING: DO NOT OPERATE TURRET UNDER POWER WITH ELEVATION EXTERIOR CLUTCH HANDLE ENGAGED.

(c) Hand Clutch: To engage or disengage the gearing by disengaging the pinion gear from the Elevation Hand Rack.

(d) Friction Brake: A brake to prevent the Ball from moving when the Elevation Exterior Hand Clutch is engaged.

(6) The Fixed Segment: Consists of a small gear quadrant mounted to the Left Trunnion Support Bracket. When the Ball moves in Elevation, the Fixed Segment turns a small gear leading to the Fixed Segment Gear Box. This unit is located in the Left Hand End Bell, and performs two functions

(a) Via Flexible Shaft, it sends the Elevation Rate to the Limit Stop.

(b) Via Flexible Shaft, it sends the Elevation Input Rate to the K-4 Computing Sight.

c. The Control System: (1) Most of the Control System is contained within the Hand Control and Limit Unit. Movement of the Hand Grips represents a rate control of the turret in both Azimuth and Elevation.

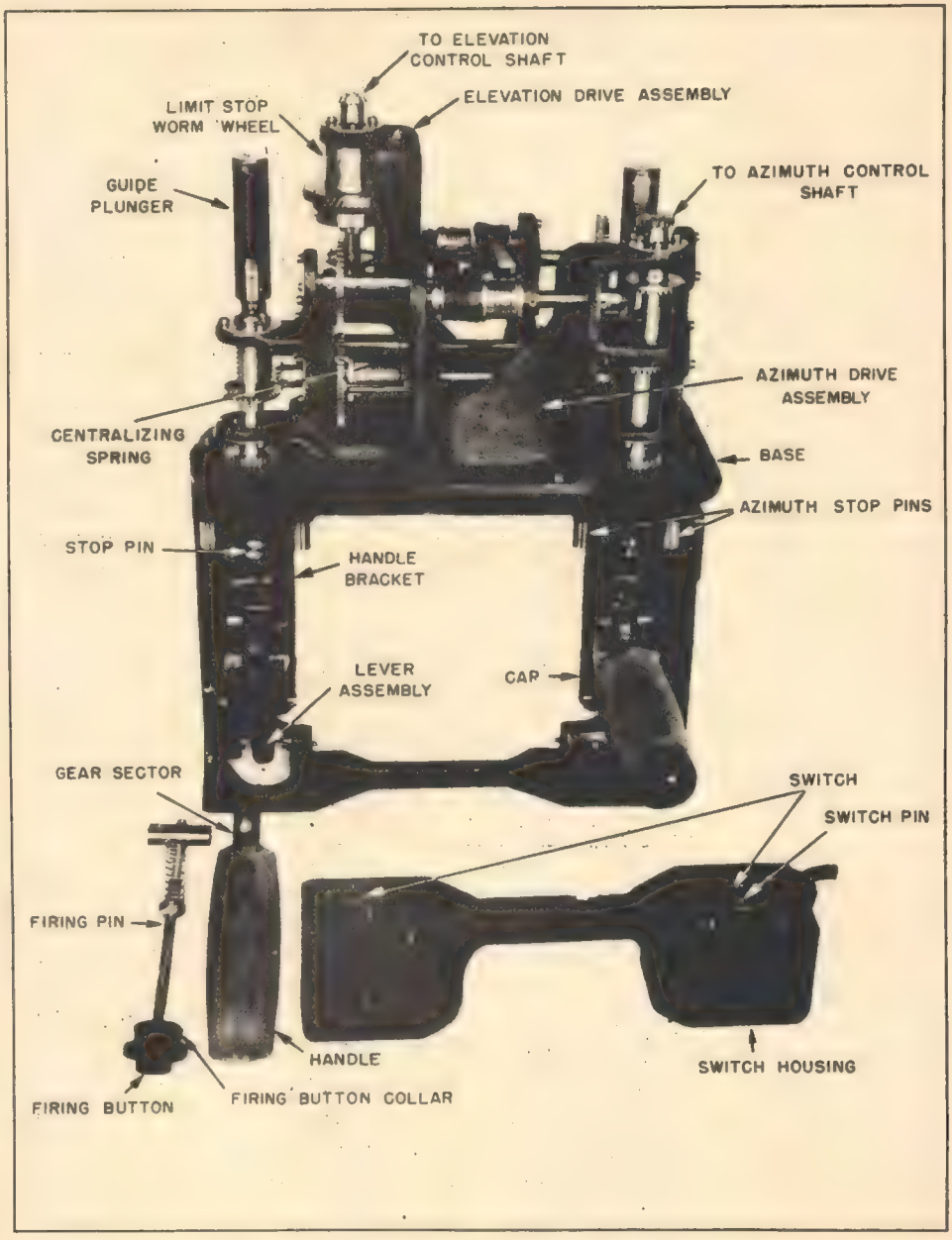
(a) Tilting the control handles to the LEFT causes the turret to move clockwise in Azimuth.

(b) Tilting the control handles to the RIGHT causes the turret to move counter-clockwise in Azimuth.

(c) Tilting the control handles towards and away from the gunner will cause the turret to move up or down in Elevation.

(2) The Hand Control and Limit Unit:

(a) The Hand Grips: The gunner operates the turret in Azimuth and Elevation by proper motion of the Hand Grips.



HAND CONTROL UNIT PARTIALLY DISASSEMBLED

FIGURE 7

(1) Elevation Movement: When the grips are tilted away or towards the gunner movement is transmitted through push rods and a rack machanism to a rotary motion via a gearing within the Hand Control and Limit Unit.

(2) Azimuth Movement: When the grips are tilted right or left, movement is transmitted through push rods to a rack mechanism via gearing to the Vicker's Unit, via the Hand Control and Limit Unit.

(b) Centralizing Springs: These are incorporated within the Hand Control and Limit Unit in both Azimuth and Elevation Gear mechanisms to bring the controls to a "neutral" position when the grips are released.

(c) Overload Springs: These are incorporated in both Azimuth and Elevation Gear mechanisms within the Hand Control and Limit Unit for two purposes:

(1) To prevent damage to the control mechanism when the Hand Grips are accidentally or suddenly jarred.

(2) To prevent damage to the control mechanism when the turret moves up against the Elevation Limit Stops, when the Hand Grips are still displaced.

(d) Elevation Limit Stops: Are a device utilized in the Hand Control and Limit Unit to bring the Elevation Control Mechanism to "neutral" (consequently the "A" End Yoke of the Elevation Vicker's Unit to "neutral") when the guns are at their limits of 0 and -90 degrees

(e) Eccentric Mechanism:- A variable acceleration rate is set up by a mechanism within the Hand Control and Limit Unit. This mechanism consists of Channel and Roller Arms, and the function they perform is identical to that function performed in the Upper Local Turret by the Eccentric Gears of the Control Box.

(3) The rate is transmitted from the Hand Control and Limit Stop Unit to the Vickers Units by rate Shafts.

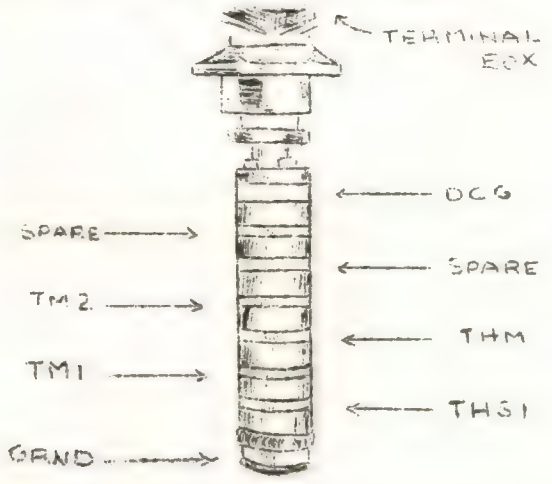
(a) Azimuth Rate: is transmitted by a connecting rod direct from the Hand Control and Limit Stop Unit, to the Azimuth Vicker's Unit.

(b) Elevation Rate: is transmitted through a unit known as the Elevation Control Box, (containing a 90° Bevel Drive) a rotating shaft and a connecting rod to the Vickers Unit.

PART III. THE ELECTRICAL SYSTEM

GENERAL:

All electrical power for the turret and Computing Sight is obtained from the airplane's power supply. The Voltage required is 27.5 Volts, plus or minus 5%. The maximum current requirement is 75 Amps.



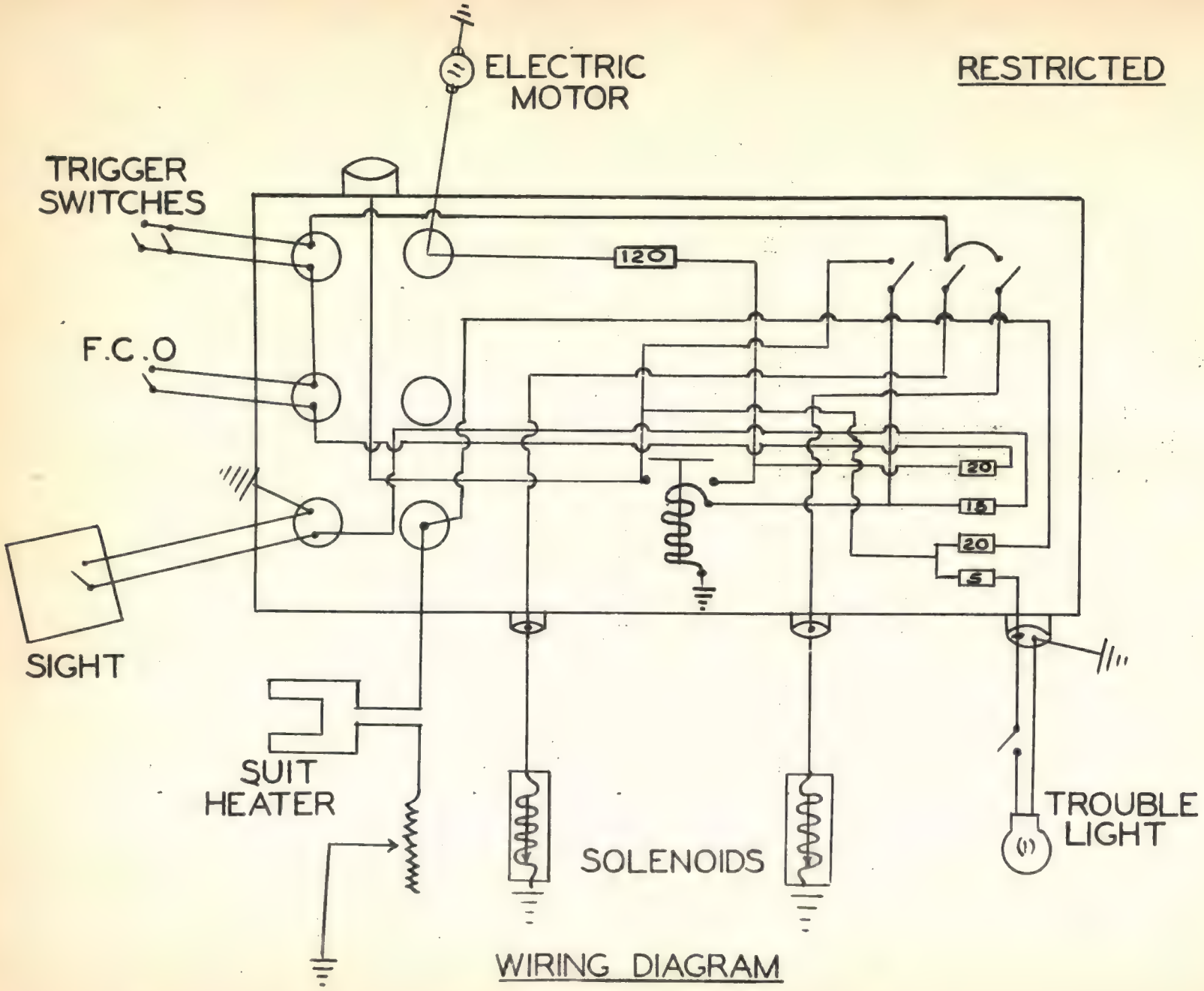
1. Method of connection between airplane and turret:- The connection from the airplane to the turret is made by means of Collector Rings, housed in the Centralized Column. The metal brushes (housed in a Brush Box in the Centralized Column make connection with the rings, regardless of the Azimuth position of the turret.

2. Terminal Box:- This unit is bolted to the Top Trunnion and remains stationary at all times. The Terminal Box acts as a conveyor between the ship's supply of current and the turret. Wires leading into the turret come through the Terminal Box and are led to the slip rings of the Collector Ring Assembly.

3. Collector Ring:- A Collector Ring is fastened to the Top Trunnion, and extends down into the hollow portion of the Centralized Column. It remains stationary at all times, and DOES NOT turn with the turret in Azimuth. The assembly consists of eight slip rings.

(a) Slip Ring for DCG (Direct Current from Generato
(b) Slip Ring for XG (Ground)
(c) 4 Slip Rings for Communications Circuits
(d) 2 Slip Rings for Spares.

4. Brush Box:- Mounted as a part of the Centralized Column, the Brush Box is rigid, and revolves as a part of the Centralized Column in Azimuth. Metallic (alloy) Brushes are held in contact with the Slip Rings of the Collector Ring Assembly By eight Brush Spring Retaining Plugs.



WIRING DIAGRAM

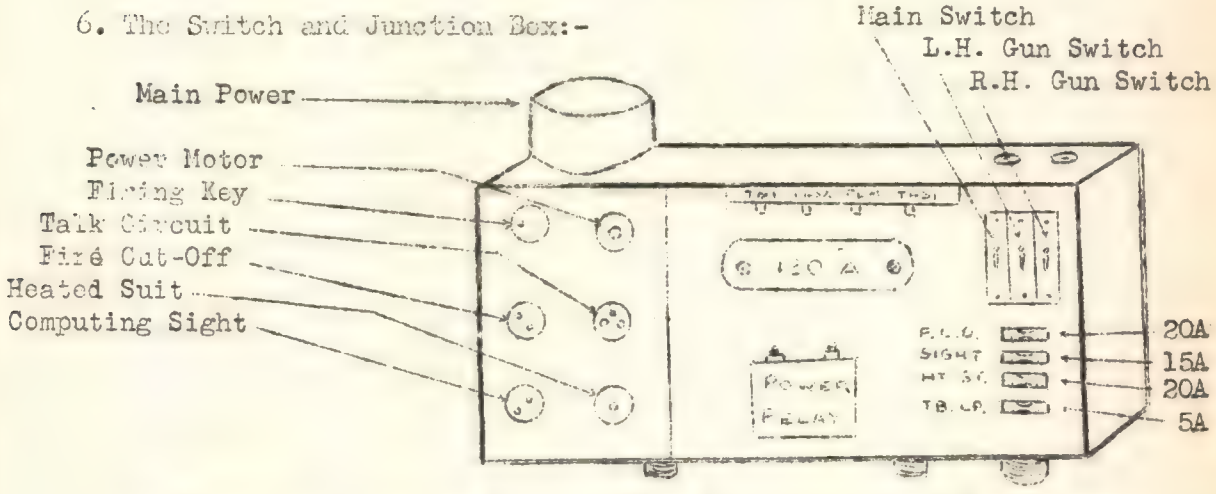
FIGURE 8

(a) Replacing Brushes:- Remove Brush Spring Retaining Plug Plate, disconnect the contact and place a new brush in the square opening from which the old brush was removed. Then reconnect the contact and replace the Retaining Plate.

(b) Brushes should be checked regularly for wear and replaced if not held up against the slip ring under spring tension.

5. Electrical and Interphone Connection from Supporting Framework to wall of turret:- DCG, XG and Interphone Wires run from positive contact with the Brushes in the Brush Box down a hollow arm of the Supporting Framework to a Cannon Plug receptacle. The Flexible Conduit Cable plugs into this receptacle, and the other end of the Conduit Cable plugs into a like Cannon Plug receptacle on the wall of the turret. Once inside the turret, the DCG, XG and Interphone wires run directly to the Main Switch Box.

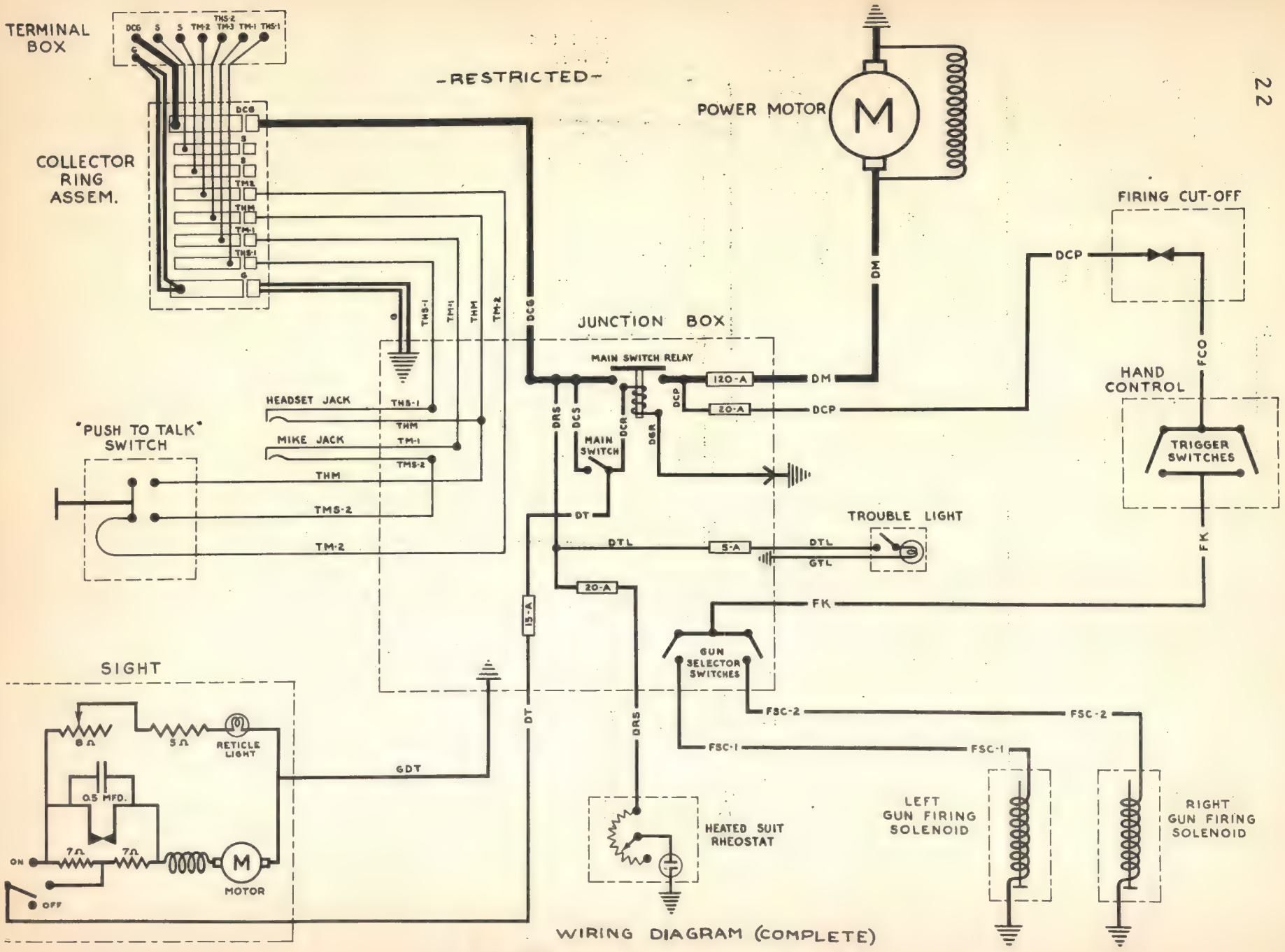
6. The Switch and Junction Box:-



The Switch and Junction Box controls distribution of The Electric Power to the various units within the turret, and is located convenient to the gunner's left hand.

(a) Switches:- There are three single pole, throw type manually operated switches within the unit. These are:

(1) Main Power Switch:- When moved to ON position, it operates the Main Power Relay, from which contacts are made to supply power to certain units. This Switch has a wire safety band to prevent accidental operation.



WIRING DIAGRAM (COMPLETE)

FIGURE 9

(2) Right and Left Gun Selector Switches
The Left Switch is connected in series with the solenoid of the left gun. The Right switch is similarly connected to the solenoid for the right gun. They can be operated independently so that either or both guns will be fired when the gunner presses a firing key.

(b) Correct order of turning on Switches:

(1) Sight Switch
(2) Main Power Switch
(3) Gun Selector Switches

(c) All connections, except those to the gunner's headset and microphone are brought into the box by means of Cannon Plugs and Receptacles.

(1) Terminal Block: This unit is found in the top of the Switch and Junction Box and has convenient posts for connecting the flexible leads from the gunner's headset and microphone. These leads should be carried through the insulated bushings provided in the top right side of the Switch and Junction Box.

(d) Fuses: The Switch and Junction Box contains five fuses. When a fuse "blows out," the gunner will make the replacement with a fuse of the SAME amperage rating. Sustituting fuses of different amperage is dangerous to the circuits. The five fuses are:

(1) 120 Amp for Electric Motor Circuit
(2) 20 Amp for Firing Circuit
(3) 20 Amp for Heated Suit Circuit
(4) 15 Amp for K-4 Sight Circuit
(5) 5 Amp for Trouble Lamp Circuit

Note: Spare Fuses are found in the Spare Parts Box.

(e) Cannon Plugs: Cannon-plugged electrical connections are used extensively throughout the turret. These provide easy means of connecting and disconnecting electrical circuits during installation or service operations.

(1) As a regular pre-flight check, the gunner will make sure all Cannon Plugs are connected and tightened.

(f) Heated Suit:- While flying in the Lower Ball turret, the gunner wears a heated suit. A rheostat and flexible electrical connections are provided for use with the suit when flying at high altitudes or during periods of low temperature. The gunner adjusts the rheostat to obtain the desired temperature of the suit.

(g) Fire Cut-Off Cam and Switch:- This unit will normally require no adjustment, although it is well to inspect periodically for dents or mars in the bracket. The function of the Fire Cut-Off Cam is to prevent firing of the guns when they point at any portion of the airplane or its accessories. Since the Ball turret is limited to firing in the lower hemisphere, the Fire Cut-Off Cam is quite simple in construction.

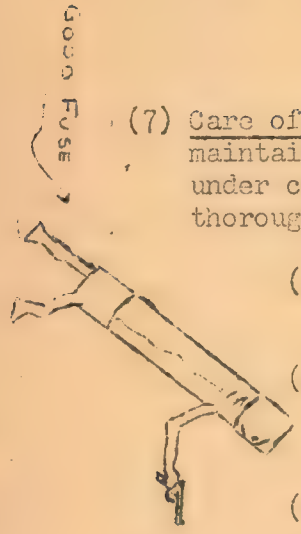
(1) The cam is a metal plate which is fastened to the flange of the Azimuth Ring Gear by four brackets, and is so constructed that it will operate a switch pin lever whenever the guns are pointed at restricted points.

(2) The switch pin projects through the wall of the turret and is normally extended to its full length. In this position of the pin, the switch is closed, and the solenoids can be operated. If the turret is moved to a position where the guns point at any part of the airplane, the pin is pushed back as it rides the cam surface, thus opening the Firing Circuit.

(3) The actual shape of the cam will necessarily depend on the particular airplane in which the turret is installed. For the B-17 E and F, the cam gives protection to the underside of the fuselage and the four propeller arcs when the wings are flexed down to the limit.

(h) Firing Keys and Firing Switches: The Firing Keys are mounted one on top of either Hand Grip. They operate Firing Switches which are wired in parallel-depressing either firing key will fire both guns, provided the Gun Selector Switches are both ON. Firing Switches are of the sealed "button" type.

(i) Trouble Lamp: A small Trouble Lamp with swivel mounting, switch and rubber cable comes out of the Switch and Junction Box to provide the gunner with a small, movable light when needed. Swivel mountings are on the wall of the turret, above and to either side of the gunner. Spare bulbs for the Lamp will be found in the Spare Parts box.



(7) Care of the Electrical System: Failure to properly care for and maintain the Electrical System can result in failure of the turret under critical conditions. The gunner MUST understand the wiring thoroughly enough to make quick repairs of simple breakdowns.

(a) Make certain all Cannon-Plugs are tightly connected before operating turret.

(b) Brushes should be changed when they are no longer held up against the slip ring under fairly strong spring tension.

(c) Do NOT run turret for test or adjustment without an auxiliary power supply (C-10 Generator) which is capable of maintaining full voltage when turret is operated under full load. LOW VOLTAGE MAY SERIOUSLY DAMAGE THE ELECTRIC MOTOR AND THE MAIN POWER RELAY.

(d) On turrets without spare fuses, tie a bag containing fuses to the Switch and Junction Box.

(e) When replacing a "blown" fuse, MAKE CERTAIN YOU REPLACE IT WITH A GOOD FUSE OF THE SAME AMPERAGE RATING.

(f) Power Motors and the Electrical System must be protected against rain water by covering the turret.

(g) Do not spill oil in the Electric Motor. Oil is the gunner's enemy when not in its proper place. Leaking Hydraulic oil may seriously damage the Electrical System.

(h) NEVER OPERATE THE TURRET ON LOW VOLTAGE.

(i) A "fluttering" or clicking Main Power Relay is a sure indication of low voltage, the result of which is great damage to the system. If this occurs, turn Main Power Switch OFF immediately.

(j) In event of Electrical malfunction, inspect the fuses. If inspection discloses the fuses to be all good, then use a Continuity Tester on the circuit in question. Use of simple logic will usually locate the trouble, since the wiring of the Lower Ball is simple and free of complication.

(k) The Circuits are labeled and can be followed through:

(1) Interphone wires are provided with labels starting with the letter "T".

(2) Direct Current from Generator is labeled DCG.

(3) Ground Circuits are labeled G.

(Note: The Lower Ball has no Safety Switches. When the Main Power Switch is turned ON, the Main Power Relay closes and energizes the Electric Motor and Firing Circuits.)

PART IV. ADJUSTMENTS AND TESTS

GENERAL:

Correct adjustments are necessary to correct operation. The Ball turret is a fine piece of precision machinery requiring expert care.

(1) Hand Control and Limit Unit:- This unit should normally need no adjustment. The handgrips should move freely without binding and should return without drag to their center positions. If the unit does not pass these simple requirements, it is probable that the centralizing springs are loose or weak, or that the unit needs grease. In such cases, the whole unit will have to be removed and serviced by a maintenance man.

(2) Setting Zero Hydraulic Rates (Creep Adjustment):- If the handgrips are centered in their "neutral" positions for Azimuth and Elevation, the turret should not move with the Main Power Switch turned ON. If movement is present, it is necessary to adjust for creep.

(a) Preparation:- Let the Hydraulic Unit warm up for 10-15 minutes before attempting to adjust for creep. When setting the zero hydraulic rates, the turret shall be moved to approximately 10 degrees in Elevation (This important precaution will be taken to prevent the guns from striking the ground if very much Elevation Creep is present).

1. Two men are required to make the adjustment. One to operate the turret, and one to make the actual adjustment.

2. Remove the inspection plate, covering the Hydraulic Unit on the wall of the turret by loosening the Dzus fasteners.

(b) Setting the Elevation Zero Rate:

1. Zero rate on the elevation unit is set by turning a screw on the control assembly, on the left side of opening.

2. Insert screwdriver in the adjustment screw on the control assembly for Elevation and with Main Power Switch on, adjust until zero rate comes.

3. Now apply full Elevation rate by moving the handgrips to their extreme positions, then releasing handgrips to see if turret still creeps in Elevation.

4. It may be necessary to make several adjustments before determining the best adjustment for zero rate.

(c) Setting the Azimuth Zero Rate:

1. Repeat the above proceedure for Azimuth making the adjustment by means of a knurled thumb screw on the control shaft, to the right of the opening.

2. When the proper adjustment has been determined, tighten the lock-nut on the shaft.

3. Recheck the elevation zero adjustment to see that it has not been disturbed during the azimuth adjustment.

4. When zero rates are both set, it should be possible to vary the speed of the turret from 0-45 degrees/sec in Azimuth, and 0-30 degrees/sec in Elevation.

(3) Elevation Limit Stop:- The limit stop prevents the turret from going beyond the prescribed limits in Elevation 0 and -90 degrees. Rubber stops are provided on the outside of the turret to prevent large over-runs. With proper adjustment of the limit stop, neither of these rubber stops should hit as the turret is driven under power to the limits. The top bumper should be set very close to the limits so that the gun bosses do not strike the underside of the airplane fuselage when the turret is driven under power, or by handcrank.

INASMUCH AS THE LIMIT STOP IS A DIFFICULT ADJUSTMENT, IT SHOULD NOT BE ATTEMPTED BY THE GUNNER UNLESS ABSOLUTELY NECCESSARY. NORMALLY, THE LIMIT STOP WILL REQUIRE NO ADJUSTMENT UNLESS THE HAND CONTROLS ARE REMOVED FOR SERVICING.

(4) Setting the Limit Stops:-

(a) Set the turret on its zero position by lining up the scribe mark on the azimuth housing of the turret with the scribe mark on the light aluminum plate which is fastened to the elevation housing of the turret.

(b) Disconnect, (at Gear Box end) the flexible shaft which connects the gear box on the left side of the turret to the left of the hand control and limit unit.

(c) Turn the flexible shaft counter-clockwise until it is stopped (due to the limit stop operating.)

(d) Carefully remesh the flexible shaft spline into the gear in the gear box end, and tighten the coupling.

(e) When in-flight, run turret up, then down under full power to check operation of the limit stop at the 0 and 90 degree extremes.

(f) It may be necessary to repeat the setting and meshing procedure several times before the best adjustment can be made.

(g) When the best adjustment has been decided upon, set the top bumper with very little clearance at the zero limit so that the gun bosses do not strike the aircraft surface.

NOTE: (The gear box and flexible shaft referred to above are most easily accessible when the plexi-glass plate on the left side of the turret is removed. They are also easily reached when the guns are not in their mountings. It will be found most convenient to make the limit stop adjustment before the guns are installed. There should be little if any need for later adjustments.)

(5) Fire Cut-Off:- The fire cut-off cam should require little adjustment since the cam is accurately fastened to the Azimuth Ring Gear at the factory.

The fire cut-off cam should not be removed from the ring gear unless absolutely necessary. If the pinion gear of the turret is properly located with respect to the ring gear, the cam is correctly aligned. The most probable cause of improper cut-off is due to the cam being dented, or the turret "sagging." A careful check should be made when the turret is installed, and approximate checks at other regular intervals to see that the guns are "cut off" by the opening of the firing circuit when pointing at restricted areas MAKE SURE THE CAM PIN DOES NOT BIND OR STICK IN THE ENTRANCE HOLE.

(a) If adjustment is necessary, set turret at exactly 22 degrees in Azimuth and adjust screw on switch so that cut off is obtained when the turret is elevated to 9 degrees, plus or minus 1/2 degree.

PART V. INSTRUCTIONS FOR ENTERING AND LEAVING TURRET

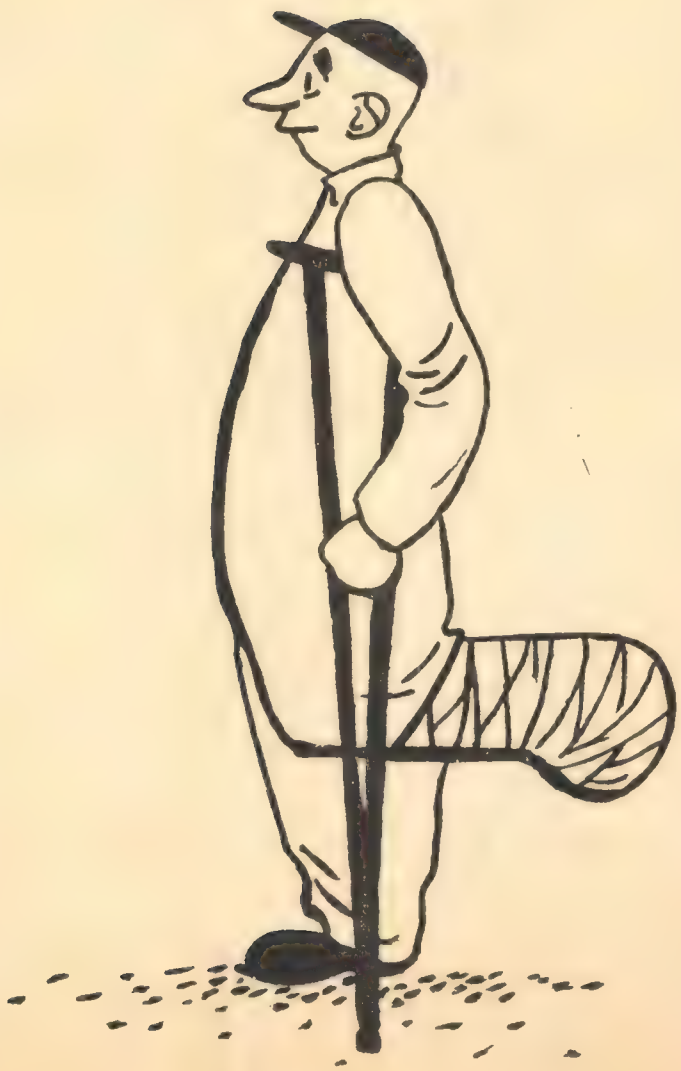
GENERAL:

It is essential that the personnel charged with the operation and maintenance of the Ball turret understand the safeguards provided, and the proper routine to be followed in operating and maintaining the turret. NO ONE SHOULD ATTEMPT TO OPERATE THE BALL TURRET WITHOUT BECOMING FAMILIAR WITH THE INSTRUCTIONS CONTAINED IN THIS BOOKLET. SERIOUS INJURY MAY RESULT FROM INCORRECT OPERATION.

INSTRUCTIONS FOR ENTERING TURRET

"I CAN'T GO IN BACKWARD..."

1. Remove Elevation Hand Crank from its clip and attach to shaft. Be sure that hand brake is locked.
2. Move Elevation Hand Clutch to IN position. (It may be neccessary to loosen hand brake and rock hand crank back and forth before hand clutch can be moved to IN position.)
3. Move elevation Power Clutch to OUT position, using clutch handle, then replace handle in its clip.
4. Loosen Elevation brake slowly while holding Elevation Hand Crank firmly.
5. Turn Elevation Hand Crank in down direction until turret revolves to low limit of -90 degrees.
6. While holding Elevation Hand Crank, open turret door, reach inside and move Elevation Power Clutch to IN position.
7. To test power clutch, step on seat with full weight bearing down on it, and jump up and down a little to make certain the Elevation Power Clutch IS ENGAGED.
8. Move Elevation Hand Clutch to OUT position, then remove Elevation Hand Crank and replace in its clip.
9. Enter turret, and close door securely. Be sure door handles are pushed all the way up and that turret door is locked before turning MAIN POWER AND SIGHT SWITCH ON.

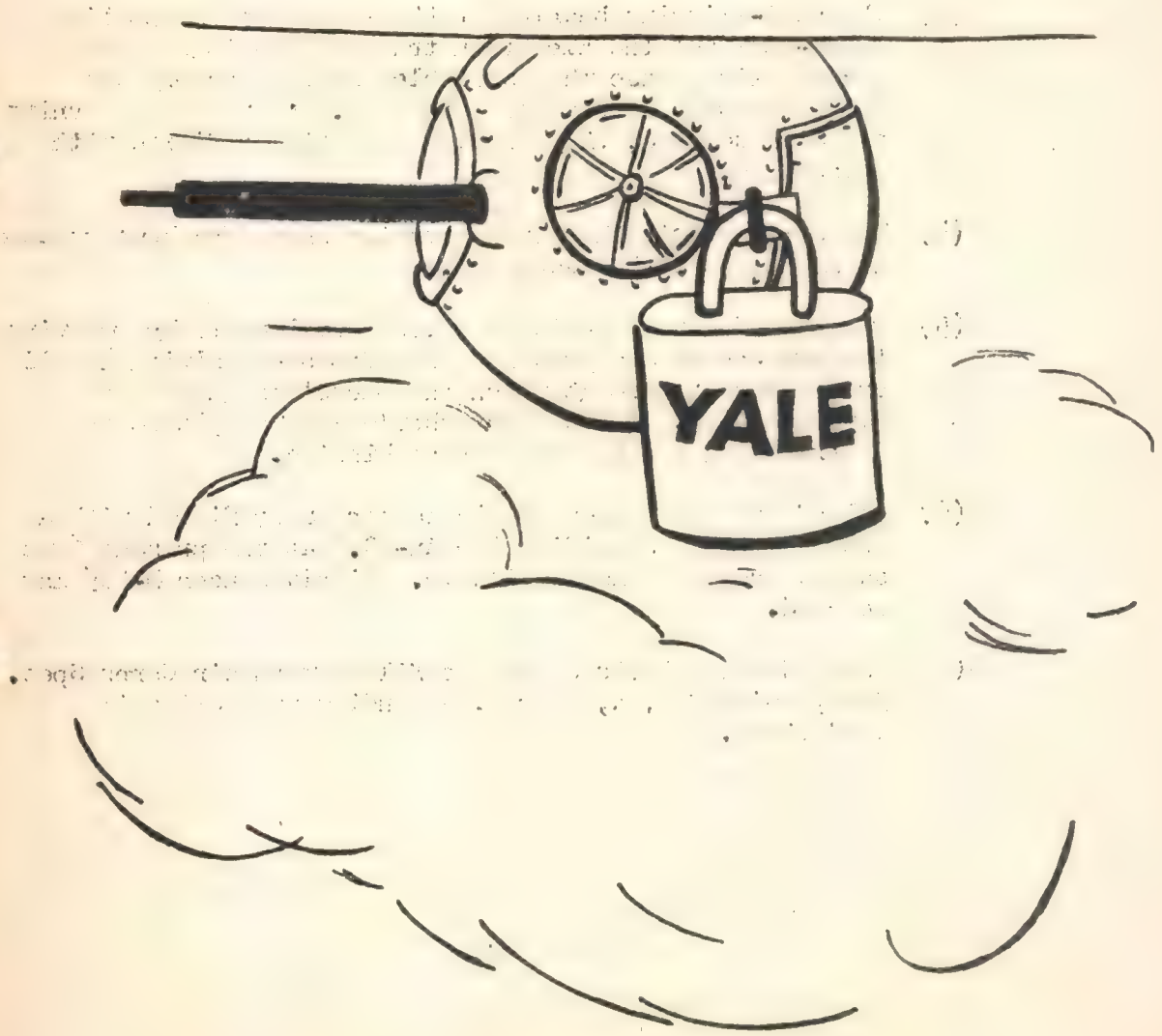


KEEP YOUR CLUTCHES ENGAGED

INSTRUCTIONS FOR LEAVING TURRET

1. Drive turret to low limit of Elevation, -90 degrees.
2. Turn Sight Switch and Main Switch OFF.
3. Open door and LEAVE turret.
4. Attach Elevation Hand Crank. (Exterior)
5. Move Elevation Hand Clutch to IN position.
6. While holding Elevation Hand Crank firmly, reach inside turret and move Elevation Power Clutch to OUT position.
7. Close and latch turret door.
8. Turn Elevation Hand Crank and elevate turret to upper limit, 0 degrees.
9. Lock Elevation Hand Brake, and Engage Elevation Power Clutch with clutch handle. The turret will then be in stowed position*.

*Stowed Position: When the guns are pointing at 180 degrees Ag and 0 degrees Eg, or straight back towards the tail, they are in stowed position. NEVER LEAVE THE GUNS POINTING DOWN. DURING TAKE OFF AND LANDING THEY WILL NOT CLEAR THE GROUND.



MAKE SURE YOUR DOOR LATCHES ARE SECURE

PART VI. LOWER BALL TURRET LUBRICATION

GENERAL: Oiling is a very necessary and important part of the maintenance of the turret. However, it should be kept in mind constantly that excess oil or grease must be guarded against.

(1) All parts of friction should be given a few drops of Univis oil #54.

(2) The Foot Range Control Assembly, Hand Elevation Drive Unit Assembly, Azimuth Gear Assembly (hand control) and Elevation to Sight Gear Assembly all require Beacon M-285 grease.

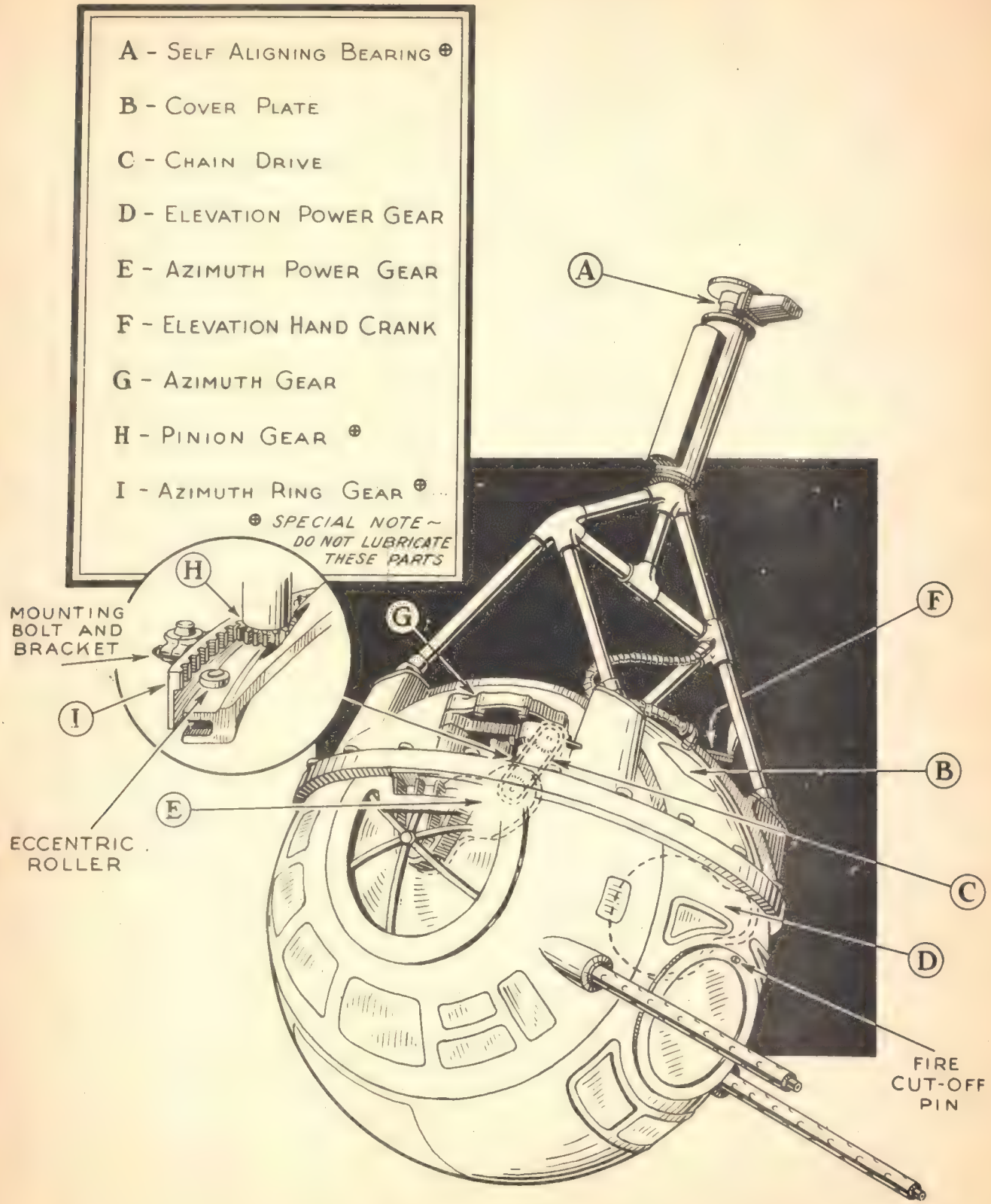
(3) The self-aligning bearing at the top of the supporting frame-work and the Elevation trunnion bearings were packed with grease when assembled at the factory and should require no regular attention. If any of the units are disassembled, they should be partially filled with Beacon 285.

(4) The exposed Azimuth spline coupling should be kept greased at all times with Beacon 285.

(5) The Hand Control should be oiled occasionally by removing the two covers and putting a few drops of Univis #48 oil on the bosses through which the Elevation gear rack plungers pass. A few drops should also be placed on centralizing springs to prevent binding.

(6) All of the gear cases should be partially filled with a grease meeting specification An-G3. At the present time such a grease is not available. Pinola Beacon M-285 may be used.

(7) The Hydraulic Units should be filled with Air Corps Spec. 3580, Color Red, A, B or C, depending upon climatic conditions.



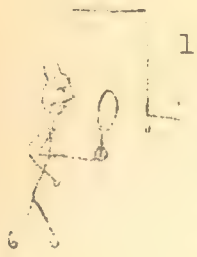
Lubrication Diagram

PART VII.

SERVICING AND CARE OF THE HYDRAULIC SYSTEM

GENERAL:

Every precaution must be taken to see that the Hydraulic Unit is filled with the proper amount of oil. Failure to service this unit may result in power failure under critical conditions in flight. Use every precaution to prevent dirt, dust, or other foreign matter from entering the turret. All cover plates must be kept in place except during service operations. These operations shall be carried out in as dust free surroundings as possible.



1. Inspecting for Leaks:- During high altitude flights, air is bled from the hydraulic units due to changes in atmospheric pressure. The oil may go down a bit, due to reduction in volume. THE GUNNER MUST CONSTANTLY BE ON THE LOOK-OUT FOR LEAKS. During normal operation, the lines will bleed one cubic centimeter of fluid during every ten minutes of flight. This is considered a normal operation. But, if excessive amounts of oil leak from the units, they must be stopped IMMEDIATELY.

2. Filling the Breather Tank: - The oil level in the Hydraulic Breather Tank, which is common to both hydraulic units, is checked before and after each flight, and filled in the following manner;

(a) Remove Cover Plate over the Hydraulic Unit after the turret has been run to 0 Eg, that is, with guns level.

(b) If fluid is not visible, then fluid must be added.

(c) Remove the two 1/8" pipe plugs from the bleeder tubes which attach to the Bleeder Tank and remove the breather plug in the tank.

(d) Stuff rags underneath the breather tank to prevent oil from dripping into the Electric Motor.

(e) Insert a safety wire, and pour CLEAN UNIVIS #40 OIL, (Air Corps Specification 3580, Color Red) until the oil level is well up on the window.

(f) Bleed the Unit as follows:

(1) Close one of the breather lines with one finger and apply slight pressure to the opening of the tank by blowing with the mouth until CLEAR OIL, FREE OF BUBBLES, runs from the open breather line.

(2) Repeat for the other breather line, adding oil, if necessary.

(3) When both Vicker's Units are completely filled, blow oil through one line or the other from the tank until the oil level is just visible at the bottom of the window.

(4) Replace the three plugs and safety wire then.

(5) DO NOT ALLOW OIL TO DRIP INTO THE ELECTRIC MOTOR.

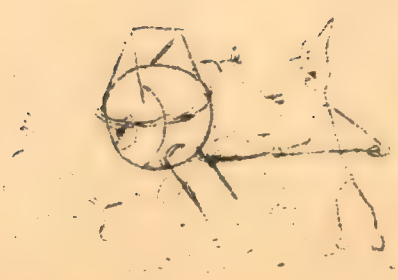
3. Hydraulic Oil: Whenever oil is added to the Hydraulic Breather tank, the unit must be bled. It is suggested that the gunne. keep a rag in the turret to use for wiping up any drippings of oil.

(a) Make sure the Hydraulic Oil used in filling the Breather Tank is clean, and of the correct type, AGS 3580, Color Red.

(b) Never dilute or mix the oil.

(c) Spilling oil on Plexiglas is harmful.

(d) Don't spill oil in the turret. Every effort must be made to keep the Lower Ball turret clean; free of dust and dirt.



PART VIII.

THE CARE AND SERVICING OF PLEXIGLASS

GENERAL:

Cleaning the surface of Plexiglass is comparable to cleaning the the finish of a fine automobile. It is just as susceptible to damage as the finish on the car if improper methods or cleaning agents are employed. Even a light coating of dust or salt spray should not be wiped dry because of the tendency of small particles, when rubbed over the surface, to cut hair line scratches.

(1) Cleaning Plexiglass:- If the surface is covered with oil or grease, clean with a small quantity of kerosene. NEVER USE GASOLINE, NAPTHA OR CARBON- TETRACHLORIDE. THESE SOLVENTS WILL DISSOLVE PLEXI-GLASS.

(a) First flush the surface with clean water or a mild soap solution, then rub it lightly with a grit free soft cloth, sponge or chamois. Cellulose sponges are excellent for this purpose.

(b) Rinse with clear water.

(c) Polish glass with Simoniz or DuPont Duco No. 7 automobile.

(d) To finish a high polish and protect the surface use a good water emulsion wax. This final application is usually done by hand. Most polishing waxes will effectively fill tiny hair scratches and make them less apparent. The wax also makes Plexiglass more resistant to dirt and dust particles.

(2) When operating the Lower Ball, take care not to rest your feet on the Plexiglass. This only results in scratches and mars which you will have to rub out by hand upon landing, not to mention the more important fact that visibility is not good through scratched windows.

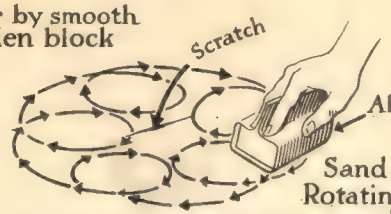
Fig. 1-A

SCRATCHES

Do not sand unless absolutely necessary to remove deep scratches

Hold Sandpaper by smooth rubber or wooden block

Avoid Excess Pressure



Sand with Rotating Motion

and over wide area to prevent optical distortions

Excess Pressure in sanding or buffing will burn Plexiglas

Fig. 1-B

FINISHING

When Buffing Wheels are available	Hand Buffing
① Coarse Sandpaper (320 A)	① Coarse Sandpaper (320 A)
Do not sand unless absolutely necessary to remove deep scratches	
② Fine Sandpaper (400 A)	② (400 A) Fine Sandpaper
③ Buff with abrasive and tallow	③ Apply Automobile body cleaner with damp pad or cloth
④ Buff with tallow only	④ Apply Automobile body polish with pad or cloth
⑤ Polish with dry buff *Avoid Grit*	⑤ Polish with dry clean cloth *Avoid Grit*

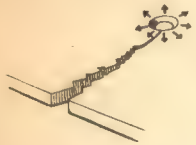
Excess Pressure in sanding or buffing will burn Plexiglas

Fig. 2-A

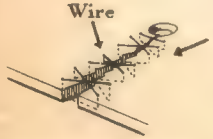
CRACKS

All the strains which originally caused crack are concentrated at this point - tending to extend crack

Therefore



Drill a small hole at end of crack to distribute strain over wider area.



Lacing a crack to relieve strain *Emergency*

Each crack occurring at any hole or tear drilled in same manner

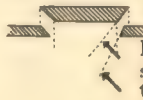
Acetone Patch *Emergency*

Fig. 2-B

PATCHES

Patch and hole should be trimmed with tapered edges

Heat edges of Patch until soft and force it in hole. Hold it in place until cool and hard to assure perfect fit. Then remove patch for cementing bath



Patch should be of thicker material Patch tapered on sharper angle than material

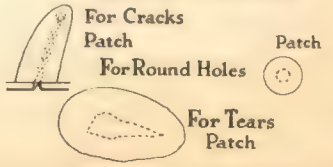
During cementing pressure need be applied only on top surface. Taper assures equal pressure on all sides.

After cement has hardened sand or file edges level with surface.

DRILLS

Drills, like all machine tools, should have a scraping rather than a cutting action on the Plexiglas

Shape of Patches



PART IX. INSTALLATION OF GUNS AND GUN ACCESSORIES

GENERAL: Before guns are installed they must be thoroughly cleaned in accordance with Ordnance Regulations, and reassembled PROPERLY. GUNS MUST BE INSTALLED CORRECTLY, AND IN PERFECT WORKING ORDER OR THE TURRET WILL BE DEFENSELESS AGAINST ENEMY ATTACK.

G-2 SUMMARY

Melbourne, Australia: B-17 Bomber ordered to return to base when guns failed to fire test bursts at high altitudes. This was traced directly to the gunner's negligence -- FAILURE to check and install guns properly during the pre-flight operation.

REQUIREMENTS: Guns must meet the following qualifications before they can be installed in the turret.

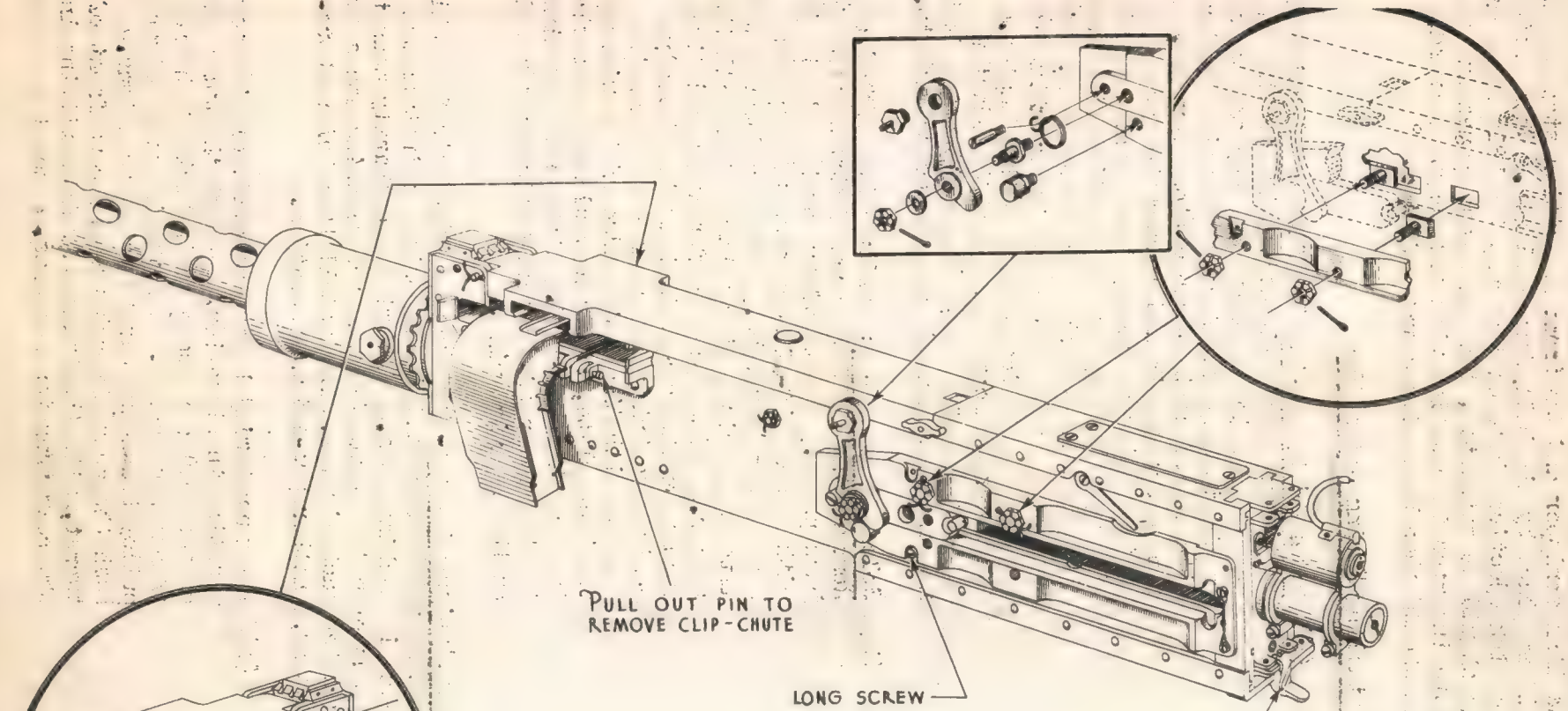
(1) Cleaned and properly serviced as required by regulations

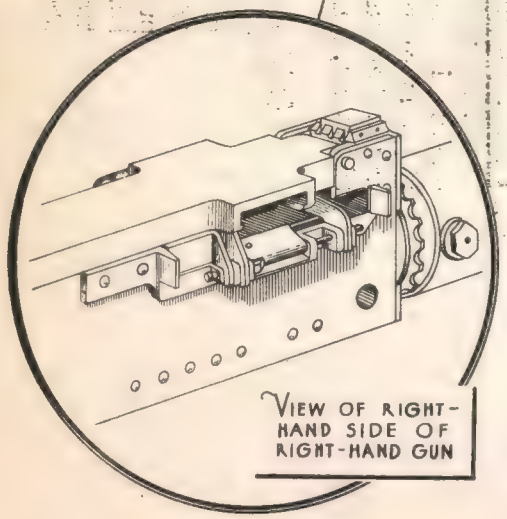
(2) The right gun must be assembled for right hand feed, and the left gun assembled for left hand feed.

(3) Edgewater Recoil Adapters:- The front trunnion assembly on each gun must be removed and the Edgewater Recoil Adapters screwed in place. If the trunnion bolts are screwed in the adapters, they should be removed so that the guns will slide into the front trunnions when being installed in the turret.

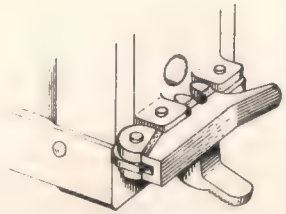
(4) Cover Latch Shaft Lever:- The gun is normally assembled with the cover latch shaft lever at either the right or left side of the gun cover. However, the lever will be attached to the side of the cover nearest the center of the turret on each gun so that the gunner can open the cover without difficulty. When a change in the position of the lever is required, move the cotter pin from the end of the latch pin, and withdraw the latch pin. Move the lever to the opposite side of the gun cover, insert the latch pin and replace the cotter pin.

(5) Manual Charger:- Each gun is normally equipped with a standard manual charger mounted on the right hand side of each gun. The charger assembly must be fastened to the side of the gun nearest the center of the turret. This requires that the charger assembly for the right hand gun be taken off and placed on the left hand side. It is necessary to mount the charger assembly in the back set of holes so that the charger cable will reach it. The wood handles on the charging levers should be removed so that the charging cable bolts can be fastened directly to the lever when the guns are installed. It is also necessary to file approx. 1/8" from the inside and upper surfaces of the charging lever so that it will not strike the cover latch shaft lever during the charging operation.

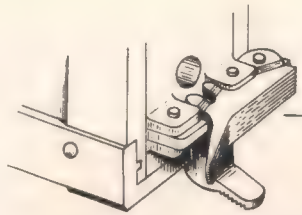




VIEW OF RIGHT-HAND SIDE OF RIGHT-HAND GUN



BACK-PLATE LATCH FOR LEFT-HAND GUN



BACK-PLATE LATCH FOR RIGHT-HAND GUN

GUN ACCESSORIES

FOR

LOWER BALL TURRET

• RIGHT-HAND SHOWN LEFT-HAND OPPOSITE •

(6) Installing Link Ejection Chutes:- A special link ejection chute is provided from the gun to the ejection passageway. The chute is mounted on the guns between the link stripper and the front ammunition stop and is held in place by the belt feed pawl pin. When installing the link ejection chute on the gun, the belt feed pawl pin should be retracted, the gun cover opened and the chute inserted in position with the tongue forward. The pin should then be replaced and safetied.

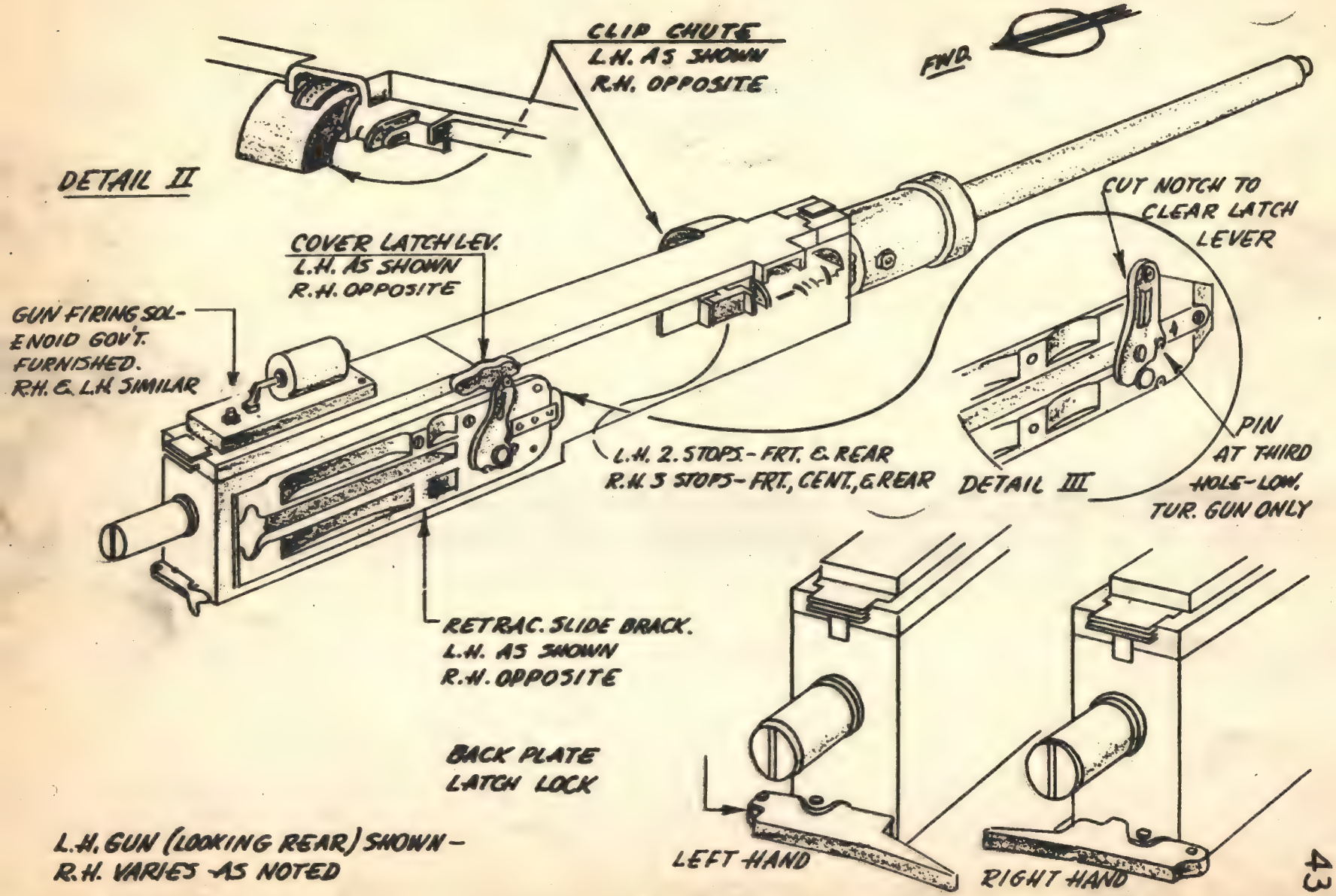
(7) Installing Firing Solenoids:

(a) Solenoid type G-4A: The firing solenoids of this type must be installed before the guns are mounted in the turret. They are mounted on the tops of the firing solenoid adapters with the electrical connections forward. First remove cotter pin and loosen the large nut on the firing solenoid, then mount the solenoid into the adapter by inserting its back lug into the rear slot of the adapter, sliding the solenoid forward until its front lug is engaged in the front slot of the adapter. Push the solenoid forward against the adapter mounting screw heads, then tighten the large nut on the solenoid and replace cotter pin.

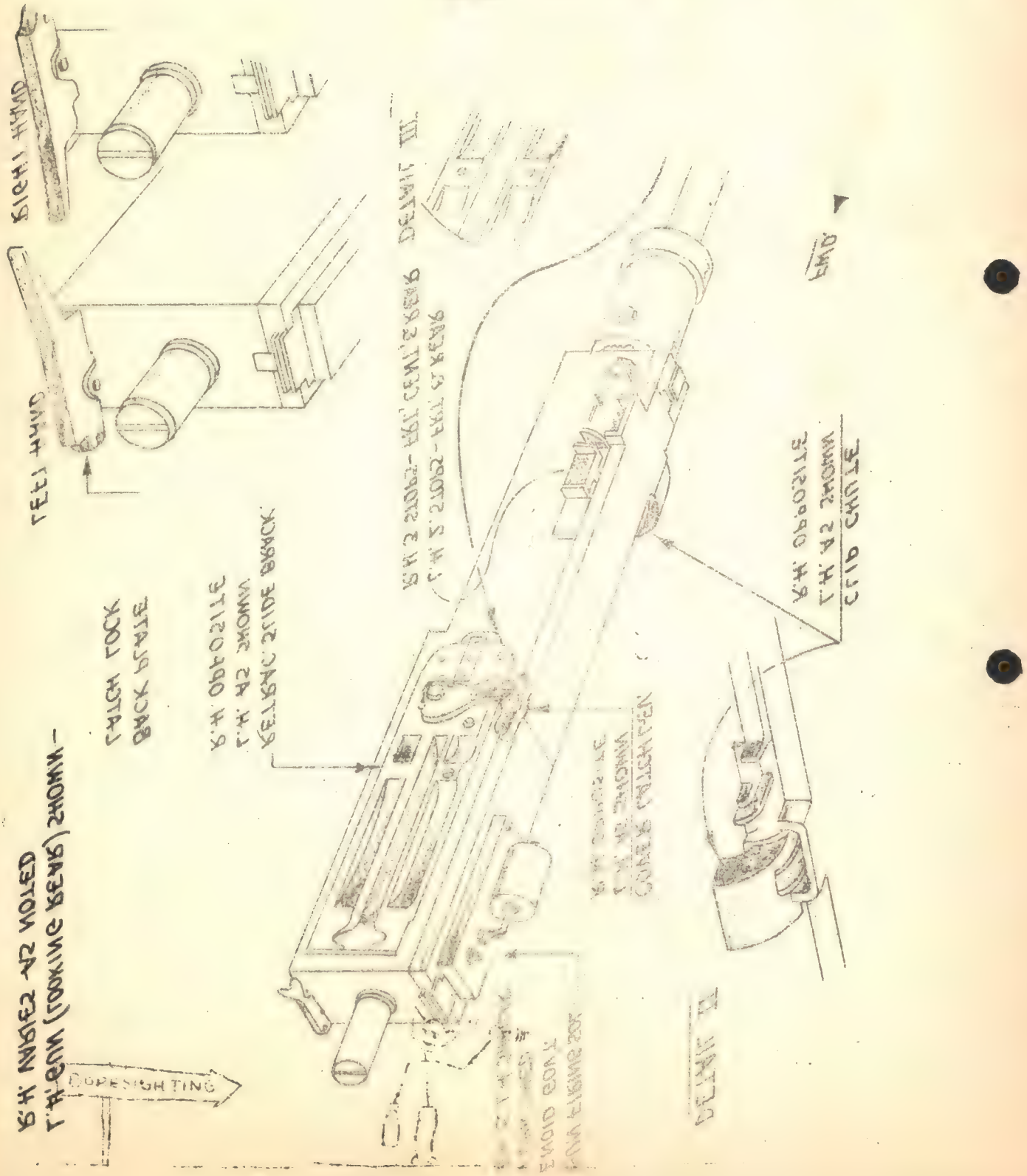
(b) Solenoid type G-11: Buffer tube mounted. Remove pin and panel from window at top of back plate. Mount safety latch on back plate with special 10-32 screws so that spring bears on buffer tube. Then depress safety latch and raise trigger bar lifter with the finger. Slide solenoid forward until the shoulder on the core (which is immediately behind the trigger bar lifter) comes in contact with the bottom edge of the window on the back plate, and safety clamp enters slot in core when released. With core approximatel in the center of the window tighten two bolts on the clamping ring.

(8) Installation of Guns:- The gunner is required by all Operational Training and Combat Units to install and clean his machine guns. This will necessarily mean that the gunner will remove the guns for cleaning and servicing after each mission, and install them before boresighting, another pre-flight operation.

(a) The turret will be in approximately its zero position in Elevation. Remove the two plates on the ball surface just in back of the rear trunnion supports. Remove the gun charger pulley brackets near the rear trunnions. Push the guns through from rear to front of turret, with the trunnion slides fitting in the rear trunnion supports. When the guns are


CLIP CHUTE
L.H. AS SHOWN
R.H. OPPOSITE
FWD.
DETAIL II
COVER LATCH LEV.
L.H. AS SHOWN
R.H. OPPOSITE
GUN FIRING SOL-
ENOID GOV'T.
FURNISHED.
R.H. & L.H. SIMILAR
CUT NOTCH TO
CLEAR LATCH
LEVER
L.H. 2 STOPS - FRT. & REAR
R.H. 3 STOPS - FRT., CENT., & REAR
DETAIL III
PIN
AT THIRD
HOLE - LOW.
TUR. GUN ONLY
RETRAC. SLIDE BRACK.
L.H. AS SHOWN
R.H. OPPOSITE
BACK PLATE
LATCH LOCK
L.H. GUN (LOOKING REAR) SHOWN -
R.H. VARIES AS NOTED
LEFT HAND
RIGHT HAND

in place, screw in place and safety wire the front trunnion bolts. (Outside bolts on front gun trunnions are accessible when small circular plates on outside of ball surface are removed.) Replace the gun charger pulley brackets and fasten the gun charger cables to the charging levers with the bolts provided on the cables, then insert cotter pins in the bolts.



PART X. LOADING AMMUNITION

1. Ammunition Boxes and Chutes: Each gun is provided with an ammunition box and properly shaped chutes for feeding ammunition to the guns and leading away the links and fired shells.

(a) The top ammunition can is for the left gun and has a maximum capacity of 675 rounds.

(b) The lower box is for the right gun and has a maximum capacity of 500 rounds.

(c) The ammunition is fed with bullet end downward from the boxes via the chutes to the guns. The ammunition is fed to the left side of the left gun, and to the right side of the right gun. New guns are normally assembled for left hand feed, so it will be necessary to modify the right gun as described on page 40.

(d) The gunner manually charges the guns by means of charger cables which are fed over two sets of pulleys and terminated in handles. The gunner grasps the handles and pulls back to "cross charge" the guns.

(e) M2 Links are used exclusively for belting. They are black in color, and are very flexible. M1 links, light in color ARE NOT TO BE USED UNDER ANY CIRCUMSTANCES.

2. Loading Instructions: Belts of ammunition must be even and free of kinks. 99% of malfunctions can be avoided by a careful check of the ammunition before loading for tight links, short rounds and deepset primers. ALWAYS CHECK THE AMMUNITION.

(a) Run turret to 0 Eg.

(b) Remove plate over the ammunition boxes by loosening the four Dzus fasteners holding it in place.

(c) Placing the SINGLE LINK END in either bottom corner of the box, belt the ammunition one layer on top of another, "accordion style", until the boxes are filled to the top.

(d) Take two short belts (one for each gun) of approximately 35 rounds each, dropping the DOUBLE LINK END of each belt down the chutes, so that the first shell is forced over the belt feed pawl by the weight of the succeeding shells. The gun cover need not be open. Two or three attempts may be required before the first shell is

YOU'LL HAVE TO DO IT YOURSELF

KEEP IT CLEAN

properly engaged. If the mouth of the feed chute is damaged or dented so that the loading cannot be accomplished in this manner, a hook made of heavy wire can be used to pull the first shell into the gun.

(e) Link the short belt for each gun to the main ammunition supply in each box.

(f) Replace cover to ammunition boxes, MAKING SURE THE FOUR DZUS FASTENERS ARE SECURELY FASTENED.

PART XI. THE COMPUTING SIGHT AND FLEXIBLE SHAFTS

GENERAL: Since there are but minor differences in the construction of K-3 and K-4 Sperry Computing Sights, the sight will be referred to as the Sperry Caliber 50 Automatic Computing Sight.

(1) The K-4 Sperry Computing Sight:- The sight is fastened to a mounting bracket located between the two guns and under the Hand Controls. The gunner sits in a seat directly behind the sight. A large circular glass window is provided so that the gunner looks through the sight directly into a large field of view outside of the turret. The sight switch is located on the front of the sight. Directly below the sight switch is the sight rheostat which is used to control the intensity of the sighting image. The target dimension and range dials are on the left side of the sight.

(2) Installation of the K-4 Computing Sight:- A mounting frame is provided in the turret for mounting the sight. Remove the mounting pin from the sight and slide the sight forward, until the mounting pin hook on the sight engages the 3/8" pin in the mounting frame and the mounting holes in the sight. When the sight is evenly and solidly mounted, snap the mounting pin lever into the spring latch. The flexible shaft and cannon plug connections are never made until the sight is mounted and the boresighting operation is completed.

(a) If the mounting pin binds before it can be inserted, lubricate the pin with Alcoa thread lubricant.

(3) Connecting the Flexible Shafts:- Serious damage to the Sight and Flexible Shafts will result if these instructions are not carried out to the letter.

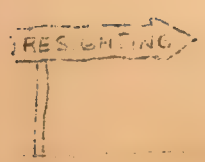
(a) Azimuth Input:- Loosen Azimuth Flexible Shaft, and pull out of Gear Box End. Then connect one end to the Azimuth Input of the Sight before installation. After installation, connect free end to gear box.

(b) Elevation Input:- Connect the free end of the Elevation Flexible Shaft to the Input in the Sight. (One end was already connected to the Elevation Gearing at the left of the turret).

(4) Connecting the Range Input:- Connect the free piece of flexible shaft to the range input of the sight (on the same side as the rectangular window) and rotate shaft until the range reading is as far above 1000 yards as it will go (Range Stop will prevent it from going too far). Then with Range Pedal

pushed ALL THE WAY DOWN, connect flexible shaft to Range Pedal Input and let Range Pedal up SLOWLY.

NOTE: Make sure the Range Flexible Shaft is routed so as to be free of kinks and sharp bends which would cause jerky action and binding of the foot pedal. Best routing of the Range Shaft is from right angle fitting on the sight, across guard to foot range pedal assembly.



PART XII. FIELD CHECK OF THE SPERRY COMPUTING SIGHTS

GENERAL: A mistaken idea exists regarding the prediction rate of the Caliber 50 Computing Sight. The prediction limitation of the sight is 200 Mils. This statement has frequently been misinterpreted to mean that the Sight will not predict correctly when the tracking rate of the turret exceeds 200 Mils per second. The tracking rate of the turret for which the sight will predict correctly varies from 150 Mils per second at 1000 yards to 870 Mils per second at 200 yards range.

RANGE (YARDS)	TIME OF FLIGHT t (SECONDS)	PREDICTION (MILS)	MAXIMUM RELATIVE SPEED (MPH) OF TARGET	TRACKING RATE OF TURRET (MILS/SEC.)
1000	1.33	200	307	150
800	1.00	200	327	200
600	.75	200	327	267
500	.60	200	341	333
400	.47	200	348	425
200	.23	200	355	870

In column one are values of range from 200 yards to 100 yards. Column two gives the corresponding time of flight for each value of range. Column three is the maximum prediction that the sight will calculate. Column four gives the maximum relative target speed that the sight will predict for at different ranges. THEREFORE, AT VERY CLOSE RANGES, THE MAXIMUM RELATIVE TURRET SPEED THAT CAN BE TRACKED IS LIMITED BY THE TURRET RATHER THAN THE SIGHT.

FIELD CHECK OF THE SPERRY COMPUTING SIGHT:

In order that the gunner may always have the utmost confidence in his equipment, it is considered a good policy to "field check" the installation and adjustments of the K-3 and K-4 Sperry Computing Sights. These checks are not absolutely conclusive, but are an excellent indication of the apparent condition of the Computing Sight.

It is not possible to check the "lead" prediction without special apparatus. However, we can check the Ballistic predictions, therefore showing Ballistic Cams are set up correctly under actual combat conditions. The checks should be made after accomplishing the boresighting procedure.

All Sight Inputs must be correctly connected, and the Sight Motor Running.

(1) Check correct reading of Elevation and Azimuth Position Dials when turret is at 0 Ag, 0 Eg.

(2) Check operation of Sight Light and Rheostat.

(3) Check operation of Range Mechanism.

(a) Target Dimension Dial operates smoothly from 20 to 60 ft.

(b) Range Dial operates smoothly from 0 to 1000 yards.

(c) Reticle lines appear approximately as an offse cross, with Range Dial reading 1000 yards and Target Dimension Dial reading 20 feet.

(d) The distance between the Vertical Reticle line should be approximately the width of one line, upper Vertical Reticle offset to the left.

(4) Check setting of Ballistic Cams, Deflection Dials should read 0 Ag, 0 Eg, under the following conditions:

K-3 Range 800 Yards.

Plus 320 Mils Elevation (To be read on Elevation Position Dial.)

0 Mils Azimuth (To be read on Azimuth Position Dial

K-4 Range 800 Yards.

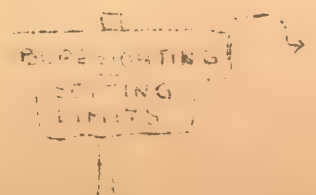
-340 Mils Elevation (To be read on Elevation Position Dial.)

3200 Mils Azimuth (Determined by lining up 0 degree Azimuth Scribe Mark on Trunnion Support Casting with 180 degree Lord Shock Mounting.)

(5) Check tension on slip clutches and pressure on differentials.

(a) Apply Azimuth and Elevation rates separately. With rates applied suddenly, Deflection Dials should snap off stationary position immediatel

(b) Stop turret suddenly, rate being fed-in ceasing, Deflection Dials should snap back towards initial setting immediately.



PART XIII BORESIGHTING THE LOWER BALL

GENERAL:

The term BORESIGHTING, as used in these instructions, is to be considered as signifying exactly what the word implies; that is, SIGHTING THROUGH THE BORES in order to correctly and exactly align each gun with the other, and so to set both guns that they are in their correct relation to the turret. Guns that are properly boresighted with the turret must meet the following conditions.

(1) Guns must be parallel with each other in the horizontal plane.

(2) Guns must be parallel with each other in the vertical plane.

(3) Guns must be in correct relation to the turret.

When these conditions are met, particularly the latter, the safety factor of the Fire Cut-Off Cam is maintained as originally set by the manufacturer within strict and precise limits. Any deviation of the guns from the three factors listed will introduce errors into the zone of Fire Cut-Off which will give unsatisfactory fire pattern that will automatically lower the accuracy and fire power of the turret. A turret incorrectly BORESIGHTED will also present the danger of shooting into the airplane structure with probably loss of life - EVEN THE LOSS OF THE ENTIRE BOMBER AND CREW.

When the guns are properly BORESIGHTED with each other, and with the turret, the K-4 Automatic Computing Sight must be HARMONIZED with the line of fire. A turret thus boresighted, in combination with a properly harmonized sight, is equipped to deliver the maximum firepower for which it has been designed.

As stated in paragraph one, BORESIGHTING indicates the alignment of gun bores produced by sighting through them, usually at a common target at a great distance, i.e., 1000 yards or more. (The convergence of fire at 1000 yards or more, is merely an apparent contradiction of the condition listed above, since reflection will show that the theoretical line of fire resulting from parallel guns will be shifted only 1½ inches each side of the point on which the guns are sighted. And this slight difference is inconsiderable at 1000 yards or more.)

ALIGNMENT OF GUNS TO TURRET: This important step must be taken to protect the fire-cut-off system, and to align the guns to each other that maximum fire power can be attained.

(1) Measure distance between gun bores. The correct distance is 28" from AOB to AOB. If this distance is correct, a horizontal adjustment will not be necessary. The Horizontal adjustment must be made first, since the vertical bolts hold the horizontal block tight until loosened.

(2) If a horizontal adjustment is necessary, loosen the vertical adjusting bolts until the desired adjustment is acquired.

I FORGOT TO BORESIGHT

(3) To test the vertical adjustment, run guns to 0 Elevation, and place a bevel protractor on top of each gun receiver (first obtaining the degree of tilt the ship is in), and adjust the gun mount up or down until the guns are at 0 Elevation in relation with the turret.

(4) Be sure gun adjustment mounts are very tight.

BORESIGHTING THE GUNS AND ALIGNMENT OF COMPUTING SIGHT TO GUNS

(1) Remove sight from turret and place on work bench.

(2) Inserting a flexible shaft into the Elevation and Azimuth Inputs, set both Deflection Dials until they read exactly zero.

(3) Inserting a flexible shaft into the Range Input, set the Range Dial to read 10. (1000 yards)

(4) Set Target Dimension Dial to read 20 Feet.

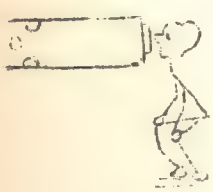
(5) Remove Sight Lamp Cover and Lamp Housing. (So artificial Light can be used.)

(6) Clean Combining and Filter glasses with optical tissue and replace in sight.

(7) Remove Plexi-glass window over deflection dials.

(8) Sight through mounting pin holes at target 1000 yards or more away. Then by means of thumb screw, adjust sight reticles UNTIL THEY ARE ON THE SAME TARGET VIEWED THROUGH THE MOUNTING PIN HOLES. Make CERTAIN the deflection dials remain at zero during this adjustment. (Inserting a flexible shaft and holding tight to the free end will prevent the deflection dials from turning)

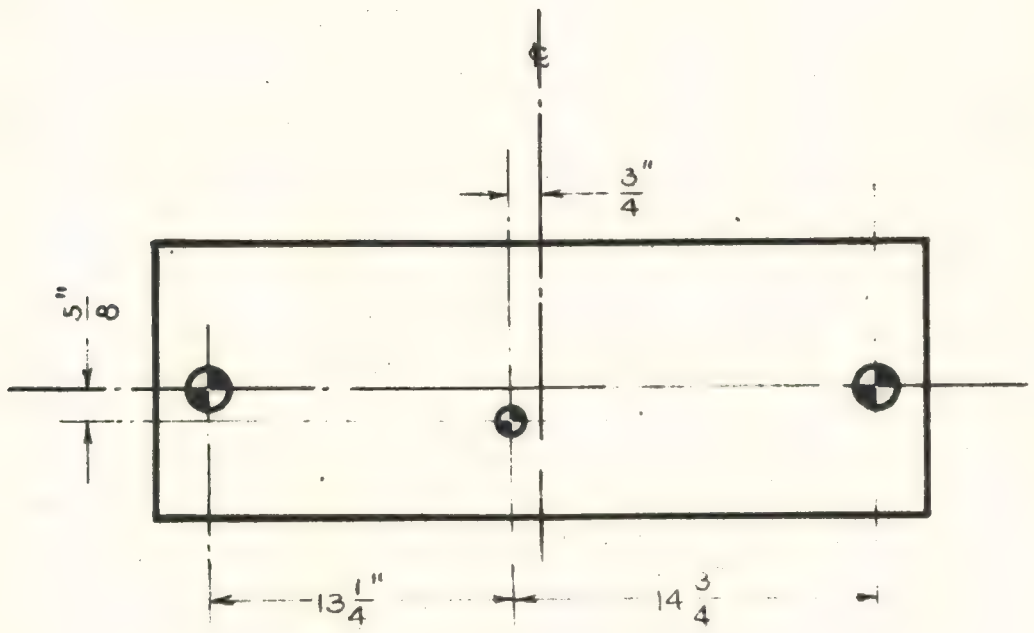
(9) Now, using the Azimuth Hand Crank and the Exterior Elevation Hand Crank, manipulate turret until left gun is bearing on a selected target 1000 yards or more away.



(10) It is necessary to remove the G-11 Solenoid, Back Plate, Driving Spring and Bolt from each gun before the above operation.

(11) As soon as the left gun is bearing on the target 1000 yards or more away, engage the Azimuth Power Clutch and set the Brake on the Exterior Elevation Hand Crank. Then look through the bore of the right gun and see if it is bearing on the same target as the left gun. If not, a SMALL ADJUSTMENT is permitted to bring the right gun to bear on the same target.

(12) When the guns are both bearing on the same target, install the computing sight in the mounting cradle. (Do not connect inputs or cannon-plug.)



BORESIGHT CHART

LOWER BALL

(13) Inserting the trouble lamp or flashlight into the Lamp Housing (that the reticles will appear on the combining glass), check to see if the reticles are on the same target 1000 yards or more away, on which the guns are bearing.

(14) If the reticles are not on the target, then they may be adjusted to bear on the target by means of the thumb screws on the shafts of the Deflection Dials, MAKING SURE THE DEFLECTION DIALS ARE NOT PULLED AWAY FROM ZERO DURING THE ADJUSTMENT. Make sure that the reticles in the sight line upon the target on which the guns are bearing with the deflection dials both reading zero.

(15) Remove Sight from turret.

ALIGNMENT OF SIGHT TO THE TURRET:

(1) Run turret to exactly OEg OAg, by lining up scribe marks, and engage the power clutches.
   (a) When the Fire Cut-Off Pin is in the notch on the Fire Cut Off Cam, the turret is at OAg.

(2) Insert flexible shaft into Elevation and Azimuth Inputs, and set Elevation and Azimuth Position Dials to read EXACTLY ZERO

(3) Turn Range Dial to read as far above 1000 yards as it will go.

(4) Mount sight in turret, connecting the Azimuth Input Shaft to the sight before mounting. Latch mounting pin securely.

(5) Connect Elevation Input into sight and Azimuth Input into gear box.

(6) Connect Cannon Plug to Sight.

(7) Connect Range Input to sight and then to Foot Range Pedal Assemby, WITH RANGE PEDAL HELD ALL THE WAY DOWN AND RANGE DIAL READING 1000 YARDS PLUS.
   (a) Range Input must be routed so as to be free of kinks, and safetied to prevent bolt stud catching it as guns are firing.

(8) Turn on Sight Switch and Main Switch and adjust sight rheosta to desired brilliance.

(9) Replace guts for each gun, back plate, bolt and driving sprin attach charging cables and replace G-11 solenoid on right gun. Then replace the guard plates and inspection windows. Solenoids should be timed and tested at this time to insure proper operation.

PART XIV. TROUBLES AND REMEDIES

GENERAL: Listed are a series of "symptoms" their probable cause and probable remedy. When malfunctions occur, the gunner must use logical reasoning to quickly locate the difficulty and repair same as quickly as possible.

Symptom	Probable Cause	Remedy
SLUGGISH OPERATION	(a) Low oil level in hydraulic unit.	Refill and blow oil through bleeder tubes.
	(b) Dirty oil in hydraulic unit.	Same as above.
DEAD SPOT IN CONTROL HANDLES	(a) Low oil level, or dirty fluid in hydraulic unit.	Same as above.
	(b) Backlash in Hand Control Mechanism.	Make sure that linkages to hydraulic unit respond to small movement of hand grips. If not, remove Hand Control Unit, take off mechanism cover and inspect for backlash.
	(c) Faulty Voltage Regulator in ship's circuit.	Report to Radio Operator, and Flight Engineer.
TURRET ROTATES IN WRONG DIRECTION WHEN HANDLES ARE MOVED.	(a) Linkages between Hand Control and Hydraulic Unit reversed.	Disconnect and reassemble correctly.
	(b) Azimuth Bevel Gearing inside Hand Control Unit reversed.	Remove Hand Controls, disassemble and reassemble gearing correctly. (The gunner should not attempt this adjustment unless familiar with the correct procedure..
GUN SOLENOID WILL NOT OPERATE WHEN FIRING KEYS ARE DEPRESSED.	(a) Main Power Switch and/or Fire Selector Switches OFF.	Turn on switches.
	(b) Guns are pointed towards restricted area.	Change position of turret.
	(c) 20 Amp fuse in Firing Circuit "blown out."	Check and replace.
	(d) Fire Cut-Off Switch stuck OPEN.	Check with Ohmmeter.
	(e) Firing Switches defective.	Check with Ohmmeter.
	(f) Burned out Solenoid.	Replace Solenoid.

Symptom	Probable Cause	Remedy
	(g) Open circuit in wiring system.	Check all connections and use Ohmmeter, if needed.
VICKER'S UNIT WHINE IN EITHER ELEVATION OR AZIMUTH OR BOTH.	(a) Low or dirty oil level in hydraulic unit.	Refill and blow out bleeder tubes
VICKER'S UNIT WHINES IN ELEVATION	(a) Limit Stops not properly set.	Reset limit stops.
MAIN POWER RELAY 'CLICKS' OR FLUTTERS.	(a) Low Voltage.	Turn Main Switch OFF IMMEDIATELY.
SLUGGISH MOVEMENT IN ELEVATION	(a) Hand Clutch (Exterior) engaged.	Disengage clutch.
	(b) Dirt or foreign matter lodged in Hand Rack.	Clean Elevation Hand Rack.

PART XV. COMMUNICATIONS CIRCUITS

GENERAL:

Although the gunner is not responsible for the servicing of the communications system, it is necessary for him to know the principles of operation and wiring that he will be able to operate his instruments.

The Lower Ball gunner is rather isolated from the rest of the airplane, and his only means of communicating with other crew members is through the Interphone. And because of this condition, it is doubly important that the gunner be able to operate the interphone correctly. Facilities are provided for connection of two way instruments for use between the gunner in the turret and the airplane personnel. The instruments are connected to the Terminal Block in the Switch and Junction Box as described in the Electrical System.

(1) Microphone and Headphone connections:- The gunner connec his instruments to the flexible rubber cables which contain a jack and a block connection. A throat type microphone is used in the turret.

(2) Press to Talk Switch:- This unit is located just in fror of the gunner's right foot rest. This switch is normally open. When the gunner wishes to talk into the microphone he depresses the spring loaded switch pin lever with the front portion of his right foot.

CAUTION: During flight, check interphone and microphone connections at regular intervals to make sure they are connected; and do not let your right foot rest o the Press to Talk Switch unless you wish to talk into the microphone.

PART XVI. THE OXYGEN SYSTEM

GENERAL: Oxygen is life at high altitudes. Learn to use it properly. The following G-2 Summary should drive this important point home.

Somewhere in Australia: Two gunners flying in a B-26, NOT USING OXYGEN PROPERLY, during a long hard mission, were over come by Anoxia and the Pilot and Navigator were forced to man the guns during the attack.

An oxygen supply with its conventional type valve and indicator is provided for use in connection with the gunner's oxygen mask, which is worn during high altitude flying.

An oxygen supply tank (500 lbs. pressure) is fastened to the outside supporting framework of the turret. Appropriate valves connect the unit to flexible tubing which runs to a fitting in the wall of the turret. Inside of the turret, rigid tubing is used to connect to the oxygen regulator which is within convenient reach of the gunner. A second connection in the regulator has two dials with points The top dial and pointer show the altitude readings which the gunner sets in manually. The gunner obtains the altitude reading over the interphone system, and when the proper setting is made, an adequate supply of oxygen is delivered to the mask. The lower dial and pointer show the oxygen pressure in the tank, thus giving a visual safeguard against insufficient oxygen in the tank.

1. Care of the Oxygen System:- The oxygen should be kept completely free of:

   (a) Oil and Grease - to avoid danger of spontaneous combustion and explosion when in contact with high pressure oxygen.

   (b) Water - to prevent freezing of oxygen equipment at low temperatures.

   (c) Other Foreign Matter - to prevent contamination of the breathing oxygen.

2. Lubrication:- No lubricant which is not approved by the Air Corps shall be used anywhere in the oxygen system.

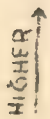
   (a) The correct lubricant is Air Corps Specification No. 40363.

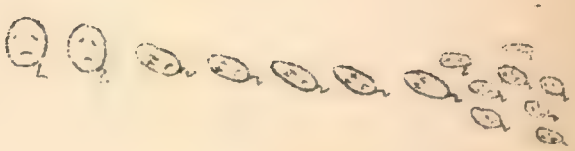
3. Sealing Compounds:- Leaks sometimes develop in the tube couplings. The couplings can be tested by putting soap suds on them and watching for bubbles.

   (a) If a leak is found, it can be sealed with Air Corps Specification Sealing Compound.

4. Installing the Oxygen Bottle:- The oxygen bottle should be mounted in the clamp rings which are fastened to the column from the bottle to the fitting on the Ball turret Be careful not to put undue strain on the couplings when handling the tubing and fittings. All couplings shall be lubricated in accordance with Air Corps Specification No. 40363.

NOTE: THE NEWEST LOWER BALL TURRET MOUNTS DUAL OXYGEN TANKS, USED IN CONNECTION WITH AN A-12 DEMAND TYPE OXYGEN REGULATOR AND MASK.





PART XVII. PRE FLIGHT AND IN FLIGHT OPERATIONS AND 50 HOUR INSPECTIONS

1. Pre-Flight Operation: The following procedure is recommended to insure satisfactory operation of the turret under actual combat conditions.

   (1) Clean all Plexi-glass and safety plate panels.

   (2) Check oil level in breather tank of hydraulic unit, and INSPECT FOR LEAKS IN THE SYSTEM.

   (3) See that all hand cranks and clutch levers are in their proper positions.

   (4) Turn Sight Switch ON.

   (5) Turn Main Power Switch ON.

   (6) Check response of Azimuth and Elevation control mechanisms by manipulating the Hand Controls. (Be careful not to drive the guns down until they strike the ground).

   (7) Adjust reticle light on Computing Sight to desired brilliance.

   (8) Work Range Foot Pedal up and down and observe if reticles move in response.

   (9) Make alignment of Sight and Guns by boresighting.

   (10) Load ammunition boxes and push ammunition down to guns

   (11) Lift each gun cover plate and pull ammunition down, feeding the first shell by hand over the belt holding pawl. Then close gun cover plates.

   (12) Warm hydraulic units and sight for AT LEAST 5 minutes before take-off.

2. In-Flight Operation:

   (1) Turn Sight Switch ON.

   (2) Turn Main Power Switch ON.

(3) Charge guns twice.

(4) Turn both Gun Selector Switches ON.

(5) When target is sighted, set target dimension dial in sight.

(6) By means of hand controls, move turret so that reticles stay on the target, "tracking the target."

(7) Operate Foot Range Pedal until reticles frame target.

(8) Close either firing key.

(9) When ammunition is used up, charge guns at least twice to make sure that no live shells are left in the guns.

(10) Turn both Fire Selector Switches OFF.

(11) Leave turret as described. Final position of the turret is stowed position 0 Eg, 180 Ag.

WARNING! During landing or take-off, guns must be in stowed position, pointing aft, and there should be no crew member in the turret.

3. 50 Hour Inspection of turret operation:

(1) Clean and polish safety glass and Plexi-glas panels.

(2) Clean slip rings and replace brushes if worn.

(3) Clean relay points with crocus cloth.

(4) Check spare parts box for fuses, tools, etc.

(5) Check for oil leaks in Vicker's Units and Gear Cases.

(6) Check oil level in hydraulic power unit.

(7) Check all electrical connections for good contact.

(8) Check oxygen system for satisfactory operation

(9) Move turret in Elevation and Azimuth, check-in for smoothness of operation.

(10) Move turret by hand cranks in Elevation and Azimuth, checking for smoothness of operation.

(11) Have guns serviced.

(12) Check guns for tightness in mounts.

(13) Check position of Azimuth Pinion Gear and Azimuth Ring Gear.

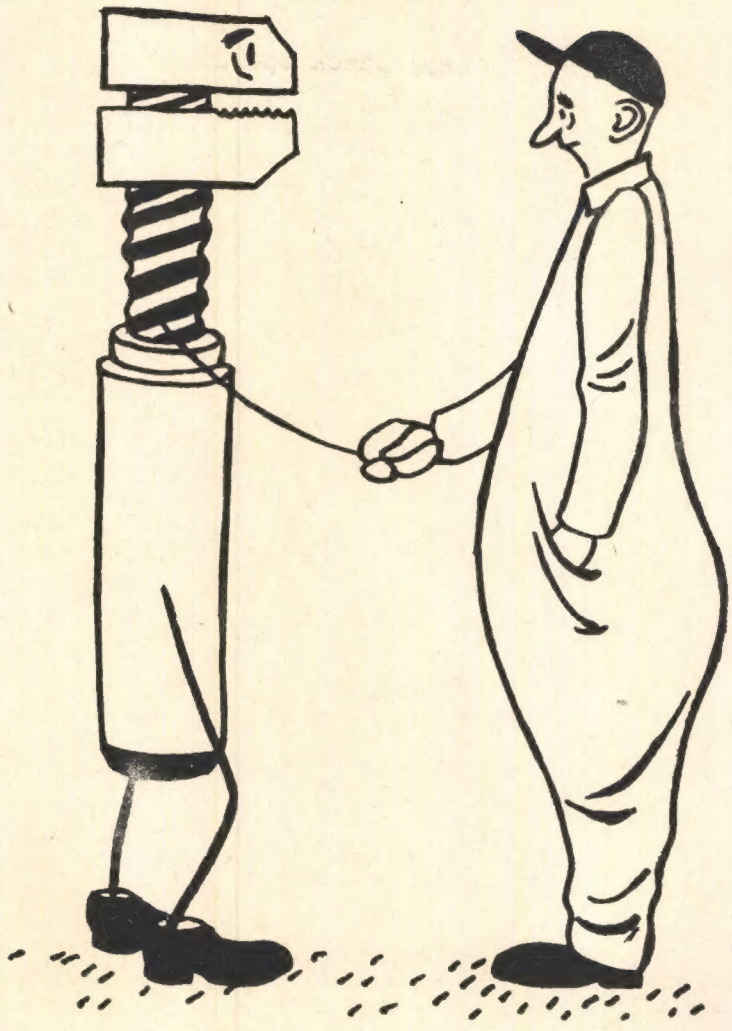
(14) Boresight.

(15) Check operation of firing solenoids.

(16) Check fire cut-off cam and switch operations.

* * *

"... AND THAT'S ALL!"



KNOW YOUR TOOLS