The

LOWER BALL TURRET

MODELS
A-2, A-2-A, A-13

BRIGGS MANUFACTURING COMPANY
AIRCRAFT TURRET MAINTENANCE SCHOOL

THE
LOWER BALL
TURRET

MODEL A-13—RETRACTABLE
MODEL A-2—NON-RETRACTABLE
MODEL A-2-A—NON-RETRACTABLE

SECTION I

INTRODUCTION

The "Lower Ball" turret, so-called because of its shape and location in the airplane, provides protection for the under side of the bomber in which it is mounted. The need for such protection is readily apparent. Lack of maneuverability is inevitable in the heavy bombardment type of aircraft and, until the advent of the "Lower Ball," the under portion of such planes was a choice target for enemy fighters.

The Lower Ball Turret was originally designed by the Sperry Gyroscope Company, and it is manufactured in three models by the Briggs Manufacturing Company of Detroit, Michigan.

The first model, the A-2, has been in active use for many months on the B-17-E and B-17-F models of the Boeing Flying Fortress.

The second model, the A-13, is similar to the A-2 model. It was designed especially for use in the Consolidated Liberator B-24. Because of the small ground clearance on this plane, it was necessary that the turret be retracted into the fuselage during take-off and landing. This model is called the Retractable Ball Turret because of this additional feature. Also, the retraction of the turret into the ship, when it is not needed in the combat or extended position, results in a considerable decrease in wind resistance with a resultant increase in speed and a saving in fuel consumption.

The third model, the A-2-A, is of the non-retractable type. It is used on the Flying Fortress, and its operation is identical to that of the earlier A-2 model. The A-2-A was developed to allow a greater degree of interchangeability of parts between the retractable and non-retractable models.

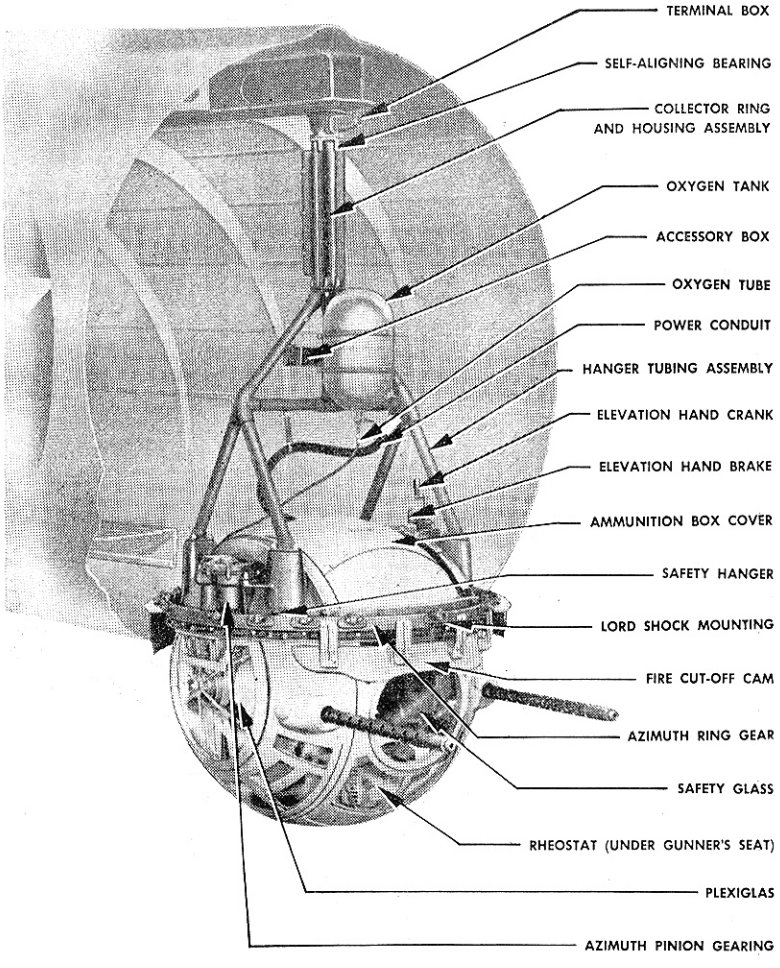


FIGURE 1—Model A-2 Complete Turret Installation

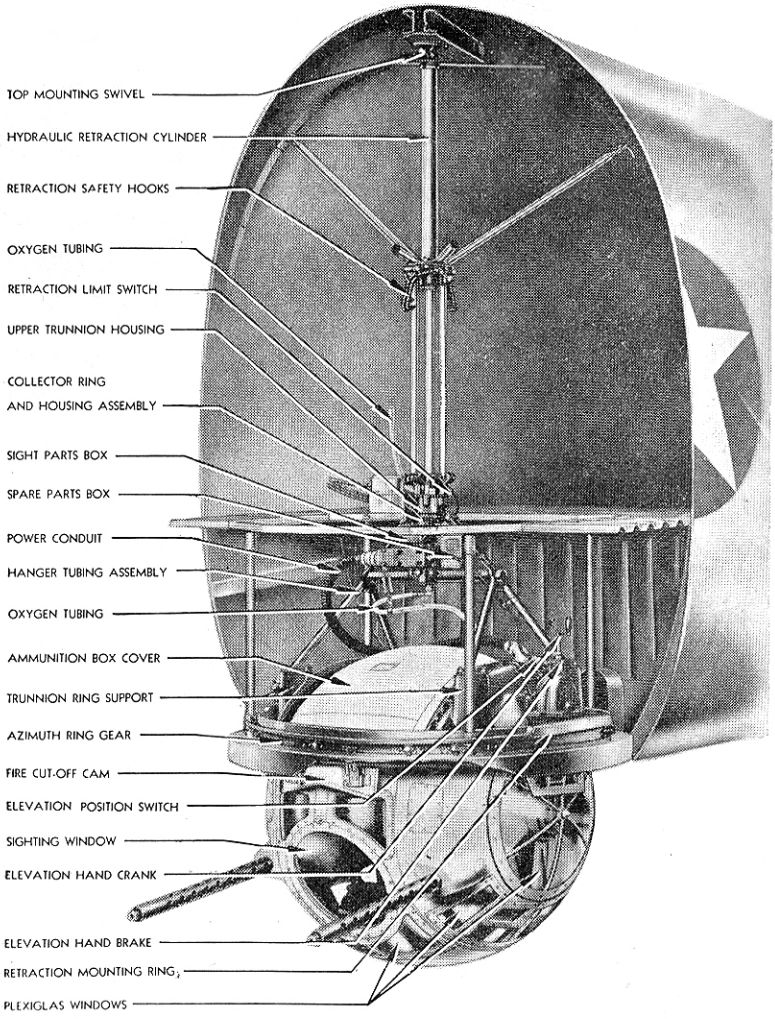


FIGURE 2—Model A-13 Complete Turret Installation—Extended

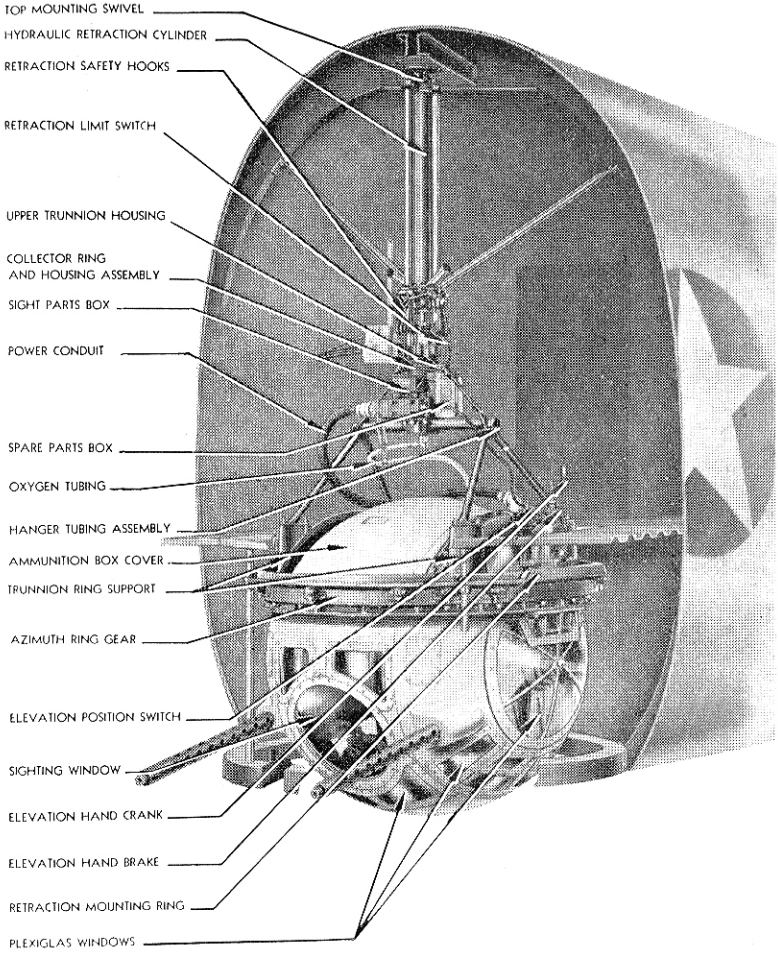


FIGURE 3—Model A-13 Complete Turret Installation—Retracted

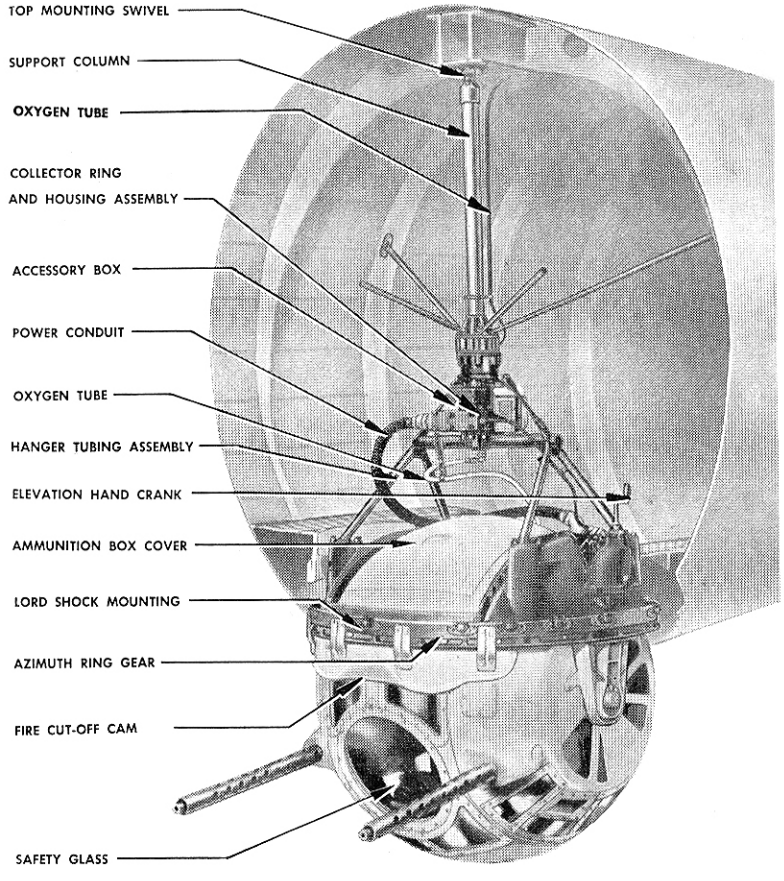


FIGURE 4—Model A-2-A Complete Turret Installation

SECTION II

DESCRIPTION

A. SIZE, SHAPE AND MATERIALS

The Lower Ball Turret is a spherical metal structure mounting two calibre .50 machine guns and containing equipment needed by a gunner in accurately directing the fire of the guns (see Figures 1, 2, 3 and 4).

The gunner rides within the spherical part of the turret or ball (see Figure 5), which rotates on both vertical and horizontal axes in order to aim the guns.

The ball is 44 inches in diameter, being an assembly of aluminum alloy castings and armor plate with transparent Plexiglas windows, giving the gunner a wide field of vision. The circular sighting window is made of laminated glass.

B. DISPOSITION

The Ball Turret is designed for mounting in the lower part of the fuselage of an airplane. Models A-2 and A-2-A are used in the B-17 Boeing Flying Fortress (see Figure 6). Model A-13 is used in the B-24 Consolidated Liberator (see Figure 7). The opening required is a circular hole 46¾ inches in diameter, through which the ball extends approximately 24 inches beyond the skin line of the airplane.

Models A-2 and A-2-A remain in this extended position. Provisions are made on Model A-13 for retraction of 28 inches, bringing the ball and guns within the skin line of the ship.

The guns extend 24 inches from the ball, and may be fired in practically any direction in a hemisphere below the airplane fuselage.

C. TURRET STRUCTURE

Figures 8, 9, and 10 are diagrams to show the relationships of the essential component assemblies of the turret structures of the three models.

1. Hanger Assembly

The supporting framework, or Hanger Assembly, is a tubular structure supported in the airplane by a thrust bearing which permits rotation of the hanger laterally about a vertical axis (rotation in azimuth).

The hanger assembly is bolted to the Ball Trunnion Ring Support which in turn sustains the turret ball.

In the model A-2 turret the hanger assembly is bolted to a self-aligning bearing which in turn is secured to the aluminum framework at the top of the fuselage section. In the model A-2-A turret, the hanger assembly is supported by a thrust bearing (located within the Collector Ring and Housing Assembly) which is attached to a Support Column which is in turn fastened to the upper portion of the fuselage.

In the model A-13 turret, the azimuth trunnion bearing or thrust bearing is secured to a piston which is actuated by a special hydraulic system so that the hanger assembly and ball may be retracted or extended through a distance of 28 inches. Guide rods prevent rotation of the piston, while the trunnion bearing permits rotation of the hanger and ball in azimuth.

In general, the turret may be considered as consisting of two operating assemblies: (1) Hanger and Trunnion Ring Support, moving in azimuth, and supporting (2) the turret ball which moves in azimuth and in addition rotates in elevation. Figures 8, 9 and 10 indicate the relative motion of the component assemblies.

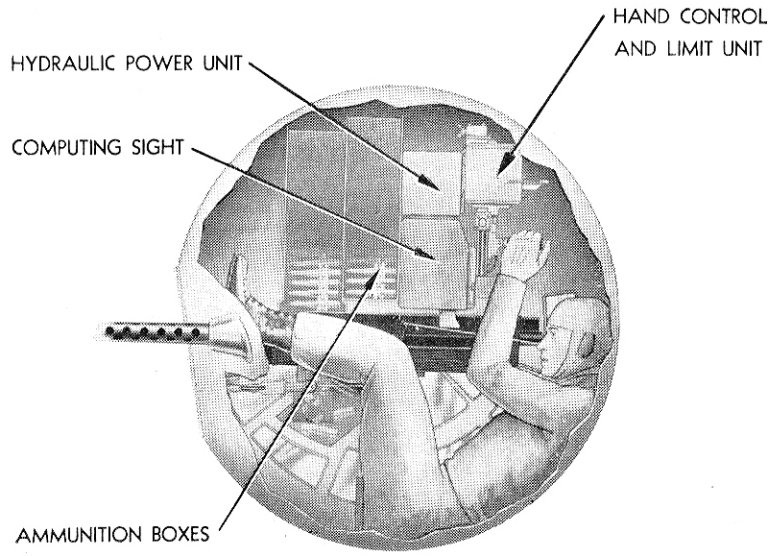


FIGURE 5—Turret Ball—Cut-away Drawing

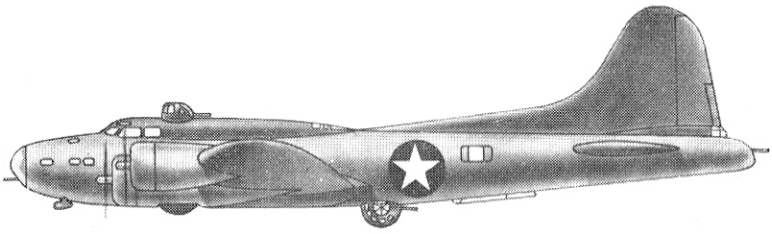


FIGURE 6—B-17 Boeing Flying Fortress

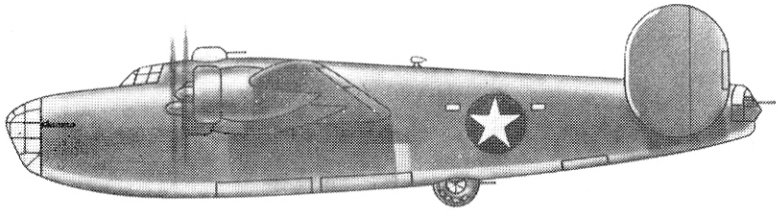


FIGURE 7—B-24 Consolidated Liberator

2. Trunnion Ring Support

The Trunnion Ring Support Assembly supports the turret ball by means of two brackets extending downward and containing two elevation trunnion bearings which permit the ball to rotate so that the guns may be moved in elevation from 0 degrees (horizontal) to —90 degrees (straight downward).

The trunnion ring support assembly rotates with the ball in azimuth and includes an Azimuth Pinion Gearing Assembly containing the pinion which drives the turret in azimuth, being meshed with a large ring gear secured to the airplane fuselage.

The trunnion ring support assembly also includes a Hand Elevation Drive Unit permitting the turret ball to be moved in elevation from outside the ball. The trunnion ring support mounts the gear sector necessary for power and inside hand movement in elevation.

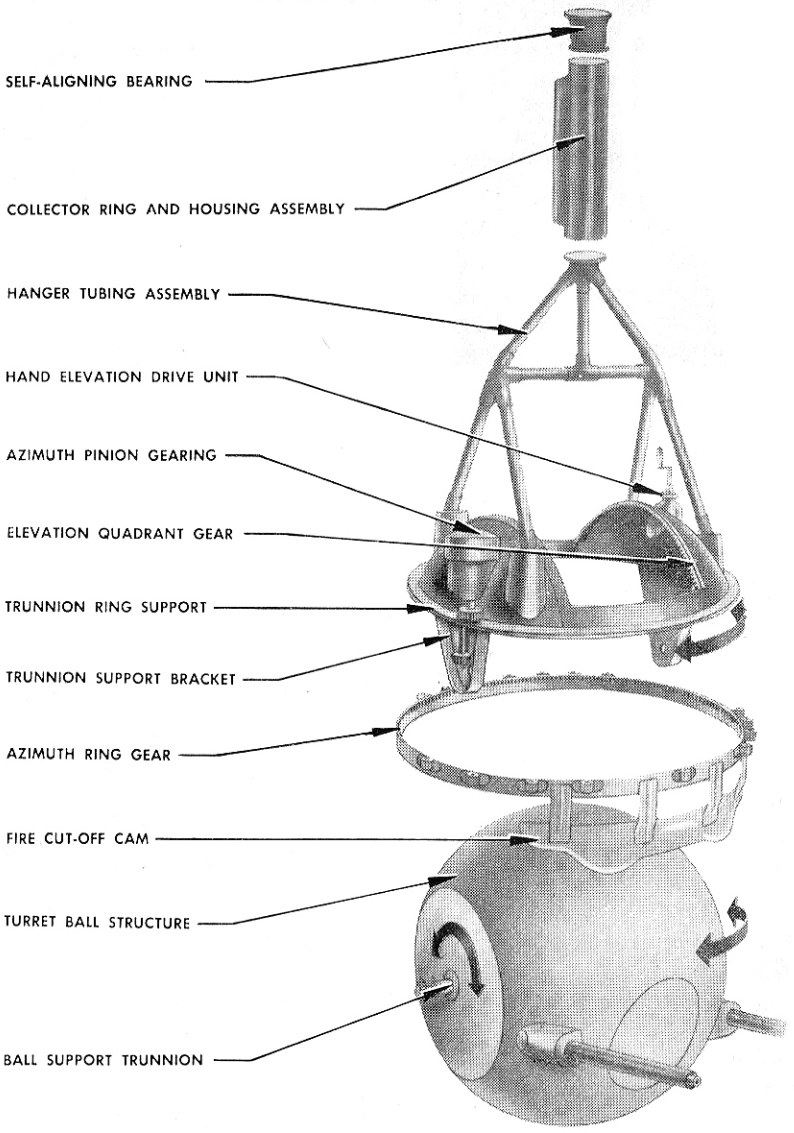


FIGURE 8—Model A-2 Component Assemblies Diagram

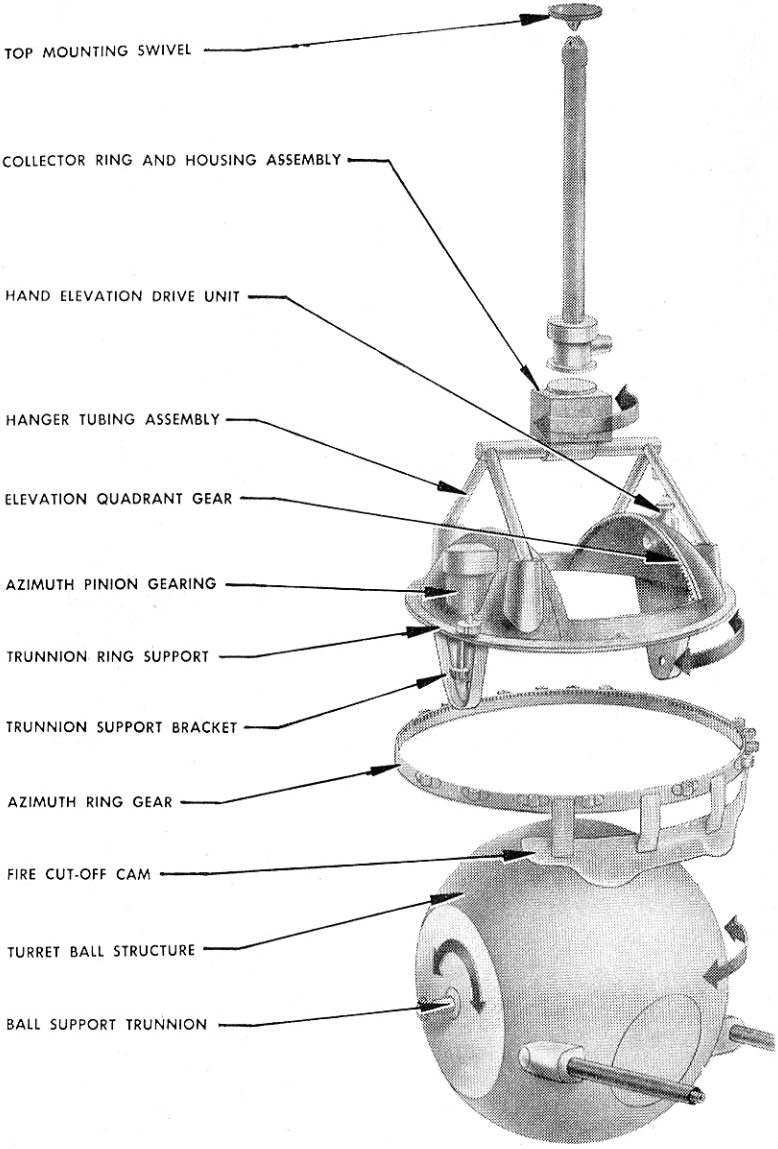


FIGURE 9—Model A-2-A Component Assemblies Diagram

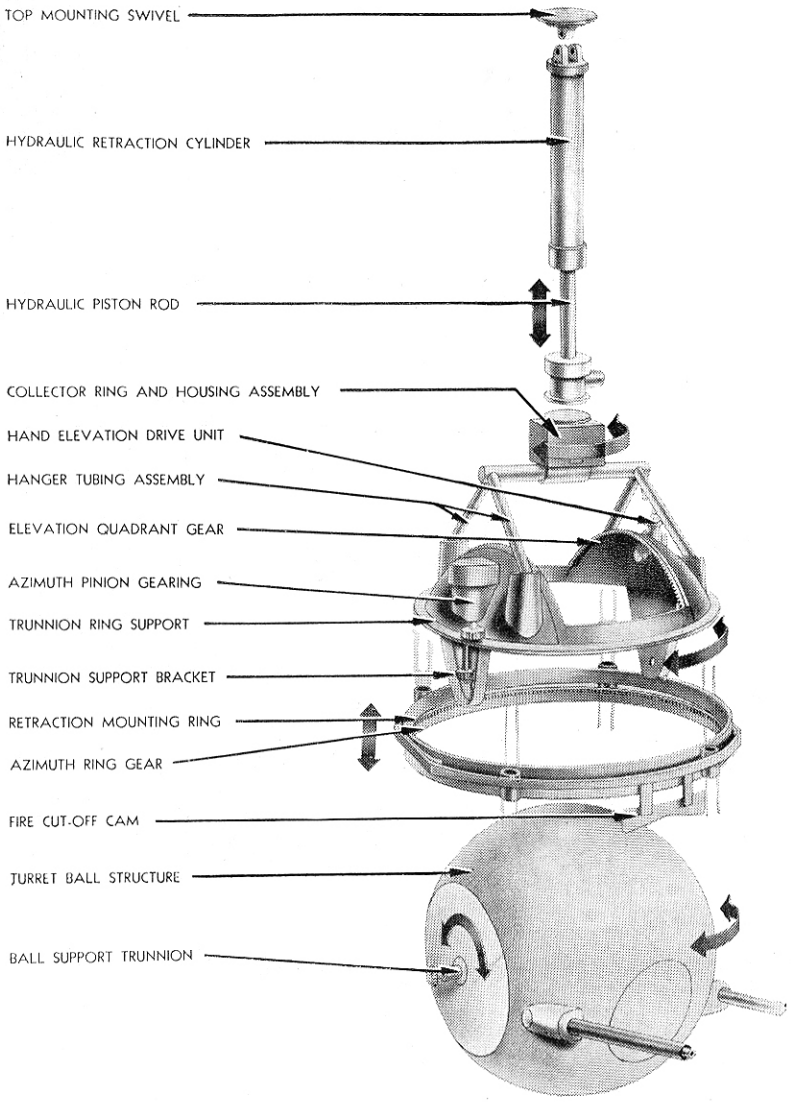


FIGURE 10—Model A-13 Component Assemblies Diagram

On Models A-2 and A-2-A (non-retractable) there are four safety hangers attached to the trunnion ring support. These hangers extend over the top of the ring gear and, in the event of failure in the supporting framework, would prevent the turret from dropping out of the plane.

In the case of the retractable model (A-13), the vertical rollers which support the azimuth ring gear assembly provide this protective feature (see Figure 11).

Figure 11 also shows the location of the Azimuth Eccentric Rollers which are mounted on the trunnion ring support on all three models. When properly adjusted, these rollers ride against the inside surface of the azimuth ring gear, thus providing proper mesh between the azimuth pinion gear and the ring gear and also eliminating lateral sway of the turret as the plane banks.

3. Ball

The spherical turret structure (or ball) itself is comprised of three main sections: the right and left hand end-bells, in which the

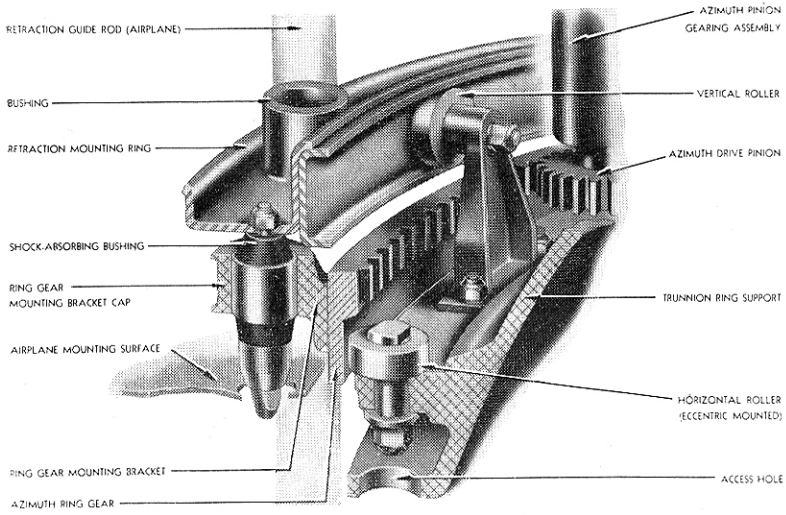


FIGURE 11—Section Through Ring Gear and Associated Parts

guns are mounted, and the center section. The center section is made up of five sub-sections:

(a) The front center section
(b) The armor plate section
(c) The door
(d) The rear center section
(e) The ammunition box cover

Attached to the top exterior of the ball are two emergency bumper stops. These stops prevent accidental over-travel of the turret in its elevation movement, should the elevation limit stops fail to operate properly while running the turret under power. They also serve as the only elevation stops when the turret is operated under hand power.

Contained within the ball are:

(a) Two calibre .50 machine guns and two ammunition boxes.
(b) Electric-hydraulic power unit and necessary gearing.
(c) Hand control and elevation limit stop unit. This unit simultaneously controls the speed, direction and extent of turret travel.
(d) Sperry Model K-4 Computing Sight which automatically calculates the prediction and ballistic deflections necessary to aim the guns properly.
Foot range pedal. This pedal is operated by the gunner's left foot to control the range-finding mechanism of the computing sight.
(e) Associated electrical equipment necessary to control the guns, operate the power unit, etc.

4. Azimuth Ring Gear

The Azimuth Ring gear is fastened to the airplane fuselage so that rotation of a pinion on the trunnion ring support causes a rotation of the turret in azimuth.

In the A-13 model, retraction necessitates vertical movement of the ring gear. To accomplish this, the ring gear is fastened to a steel mounting ring (known as the Retraction Mounting Ring) which, in turn, is supported by eight vertical rollers riding in a track formed by the mounting ring. These rollers are mounted on the trunnion ring support (see Figure 11). Fourteen "Lord" shock mountings are used to fix the ring gear to the retraction mounting ring. Four tubular Retraction Guide Rods extending through the retraction mounting

ring are secured to the floor of the plane and lower fuselage. These serve to allow the ring gear to move vertically and to prevent it from moving in azimuth.

In models A-2 and A-2-A the ring gear is fixed directly to the floor of the plane by means of 20 "Lord" shock mountings.

D. MOTIVATING POWER

The ball turret is driven by the Vickers Double Power Unit (see Figure 20) which consists of two variable-speed hydraulic transmission units mounted at the two ends of a single constant-speed electric motor driven by the airplane current supply. This assembly is contained within the turret ball.

One hydraulic transmission ("Vickers Unit") drives the turret in elevation and the other drives the turret in azimuth.

Both Vickers Units are reversible and independently controlled over a wide range of speeds by the gunner within the turret ball.

All Lower Ball turrets must attain a speed of at least 800 mils (45 degrees) per second in azimuth and at least 500 mils (28 degrees) per second in elevation.

E. CONTROL

Turret operation is controlled by means of the Hand Control Unit (see Figure 12) which includes two handgrips mechanically connected and moving together in directions corresponding to directions of gun movements in elevation, and opposite to turret movements in azimuth.

Control movements are similar to those employed in operating an airplane by means of a "joystick." Direction of handle movement determines direction of turret movement. Amount of handle movement determines speed of turret movement.

The control handles return to neutral or "zero rate" position upon release by the gunner.

A Gun Firing Button is mounted in the end of each handgrip. Two switches are connected in parallel so that the guns will be fired when the gunner's thumb depresses either button.

An Elevation Limit Stop mechanism is contained within the hand control unit assembly to restrict turret movement in elevation so that the gun bosses will not strike the airplane fuselage.

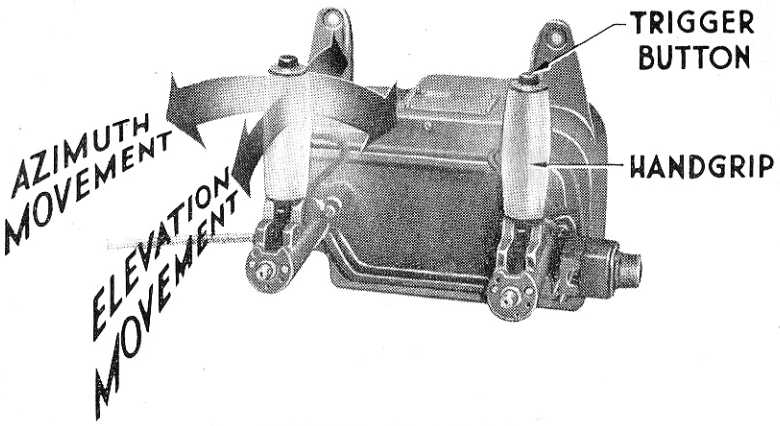


FIGURE 12—Hand Control

F. SPERRY COMPUTING SIGHT (Type K-4)

The Sight is mounted within the turret ball in front of the gunner so that enemy aircraft or target is viewed through the optic head of the sight and through a large circular window provided in the turret ball.

The sight continuously computes ballistic and prediction corrections for accurate gun fire at ranges up to 1000 yards. These corrections take into account the varying position and rate of movement of the turret and the varying range.

The sight is mounted rigidly to the turret ball but the sighting reticles which appear in the optic head, moves in proportion to the computed corrections. The gunner must maintain an alignment of the reticles with his target.

In "tracking" the target with the sight reticles, the gunner controls the turret to move the sight. He thereby moves the guns in an amount required by the movement of the target plus or minus ballistic and prediction corrections computed by the sight. The guns are thus pointed in a direction including corrections for accurate fire.

G. ARMAMENT

Two calibre .50 M-2 aircraft type machine guns constitute the turret's armament. Ammunition for these guns is carried in two separate cans within the ball. The left gun has a total firing capacity

of approximately 600 rounds and the right gun approximately 450 rounds. Spent cases and links feed through ejection chutes into the slipstream. Spare ammunition for the turret is carried in the plane and the cans may be readily filled from within the plane by running the turret to 0 degrees elevation and removing the ammunition box cover. This cover is secured by four Dzus fasteners to insure speedy removal and replacement.

The two guns are manually charged. The charging cable hand grips are located at the inside of the operator's feet. Due to limited space it is customary for the gunner to charge the guns by pulling cross-handed on these hand grips.

The guns are fired electrically by means of type G-11 solenoids which are mounted on the buffer tubes.

A Fire Cut-off Switch is mounted in the turret ball to prevent firing of guns into any portion of the carrying aircraft. This switch, moving with the turret, is actuated by a Fire Cut-off Cam fixed with respect to the airplane and having contours of correct shape for the airplane model in which the turret is installed.

In the case of the B-17 airplane (turret models A-2 and A-2-A), this cam is contoured to conform to the arcs followed by the inboard and outboard propellors. On the B-24 airplane (turret model A-13),

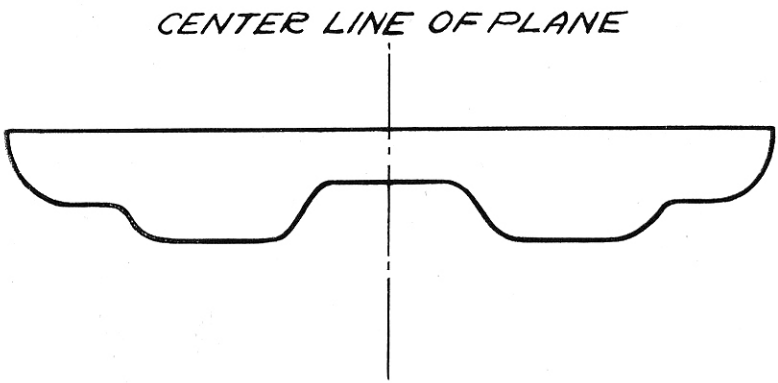


FIGURE 13—Fire Cut-off Cam, Models A-2 and A-2-A

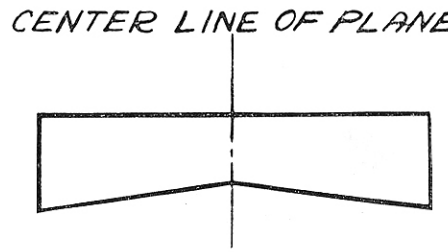


FIGURE 14—Fire Cut-off Cam, Model A-13

only the forward under portion of the fuselage requires protection and the fire cut-off cam on this model is designed to afford such protection. See Figures 13 and 14.

H. ARMOR

For protection of the gunner, armor is provided in the seat and in an Armor Plate Assembly which constitutes a part of the center section of the turret ball structure. Figure 15 is a diagram showing the approximate angles of protection afforded by the armor plate.

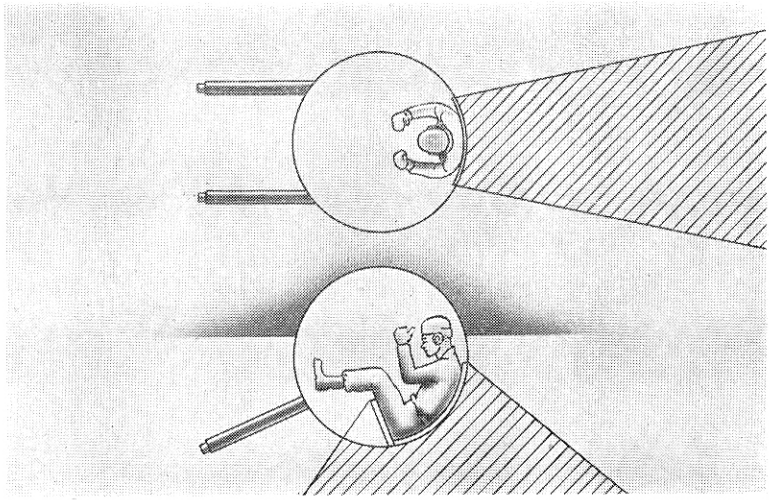


FIGURE 15—Turret Armor Protection Angles

I. OXYGEN AND OTHER EQUIPMENT

The gunner is provided with oxygen for breathing at high altitudes, intercommunication phone connections and switch, and electrically heated suit receptacle and rheostat.

J. HYDRAULIC RETRACTION SYSTEM

The retractable lower ball (model A-13) employs a very simple retraction system. A hydraulic cylinder is secured to a supporting beam in the top of the plane. The entire weight of the turret is supported by a piston riding within this cylinder. Upward movement of this piston is hydraulically controlled by means of a hand pump fastened to the wall of the plane. The pump is operated by the gunner, who retracts the turret after bringing it to a —90 degrees elevation position and 180 degrees azimuth position. The gunner must leave the turret to operate this hand pump. Safety hooks are provided to bear the weight of the turret after it is retracted. The turret is then rotated in elevation (with the outside elevation hand crank) to the —22 degrees position required for stowing the turret in the well of the ship.

Repositioning of a valve in the hydraulic lines permits a reverse flow of oil when the turret is extending. The turret drops of its own weight, no operation of the hand pump being necessary. See Figure 16.

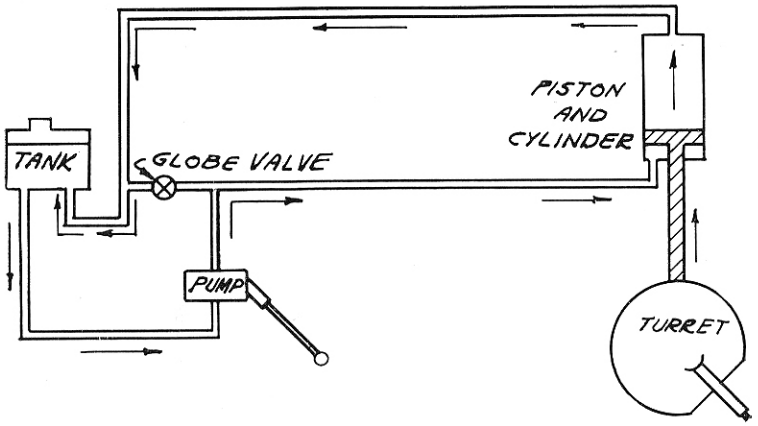


FIGURE 16—Hydraulic Retraction System

NOTES

SECTION III

OPERATION

Examine Figure 17 to become familiar with names applied to operating mechanisms on the outside of the turret before reading the following instructions:

A. EXTENSION AND RETRACTION (Model A-13 only)

The hydraulic Retraction Cylinder applies the force necessary to retract the ball turret. The hydraulic system is independent of other hydraulic systems in the airplane.

In the retracted position the weight of the turret is sustained by the Retraction Safety Hooks.

IN EMERGENCY

If the retraction cylinder should be damaged, the turret may be retracted with the airplane bomb hoist.

Secure the hoist to the fuselage beam over the turret. Two hook-retaining pins are provided on the Retraction Cylinder Guide Flange for emergency retraction. Hook cables to these pins so that turret is lifted evenly.

To Extend Turret

1. Close hydraulic valve.

2. Use hand pump mounted on the airplane fuselage to lift turret enough to release safety hooks.

3. Move safety hooks to open position.

4. Open hydraulic valve. Turret will descend to its extended position.

5. Be sure that turret is properly seated at its lowest position. Tapered bushings are placed on the lower ends of the bolts holding the azimuth ring gear to the retraction mounting ring. The tapered bushings seat in holes provided in the airplane floor ring.

To Retract Turret

1. Upon leaving turret, guns will be down (—90 degrees in elevation).

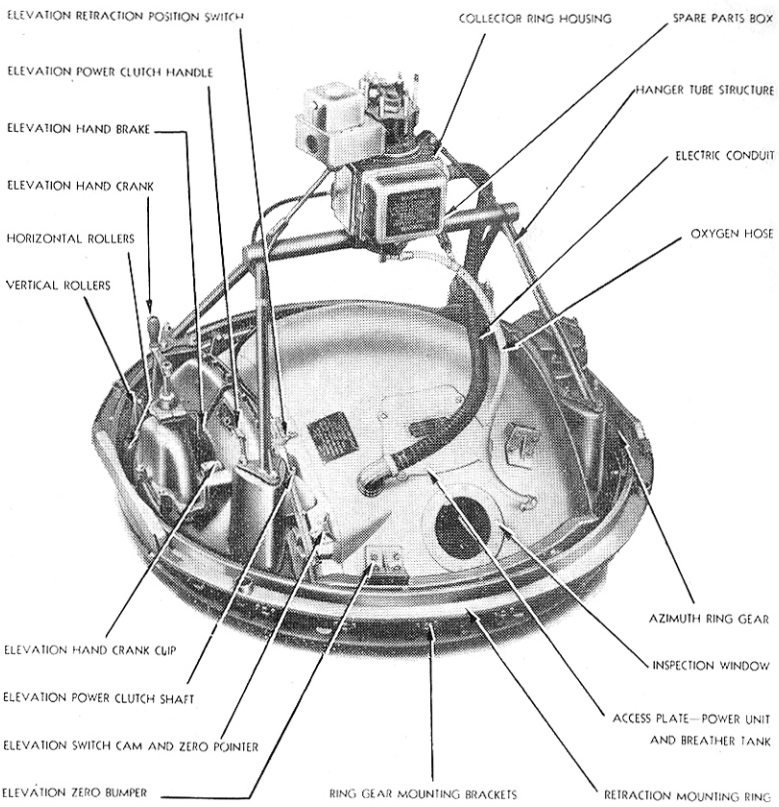


FIGURE 17—Mechanisms Outside Turret Ball

IMPORTANT

Personnel operating or maintaining the Lower Ball Turret must become familiar with the procedure to be followed in operation of the turret. Serious injury and death have resulted from failure to follow the complete instructions.

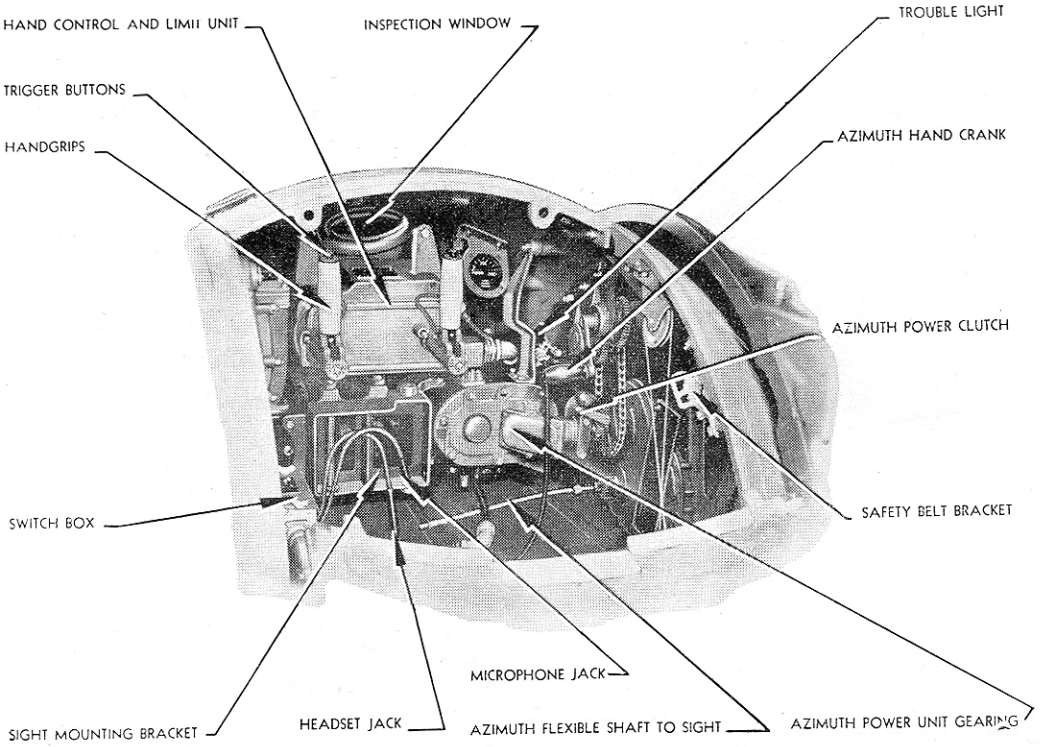


FIGURE 18—Interior of Turret and Operating Controls

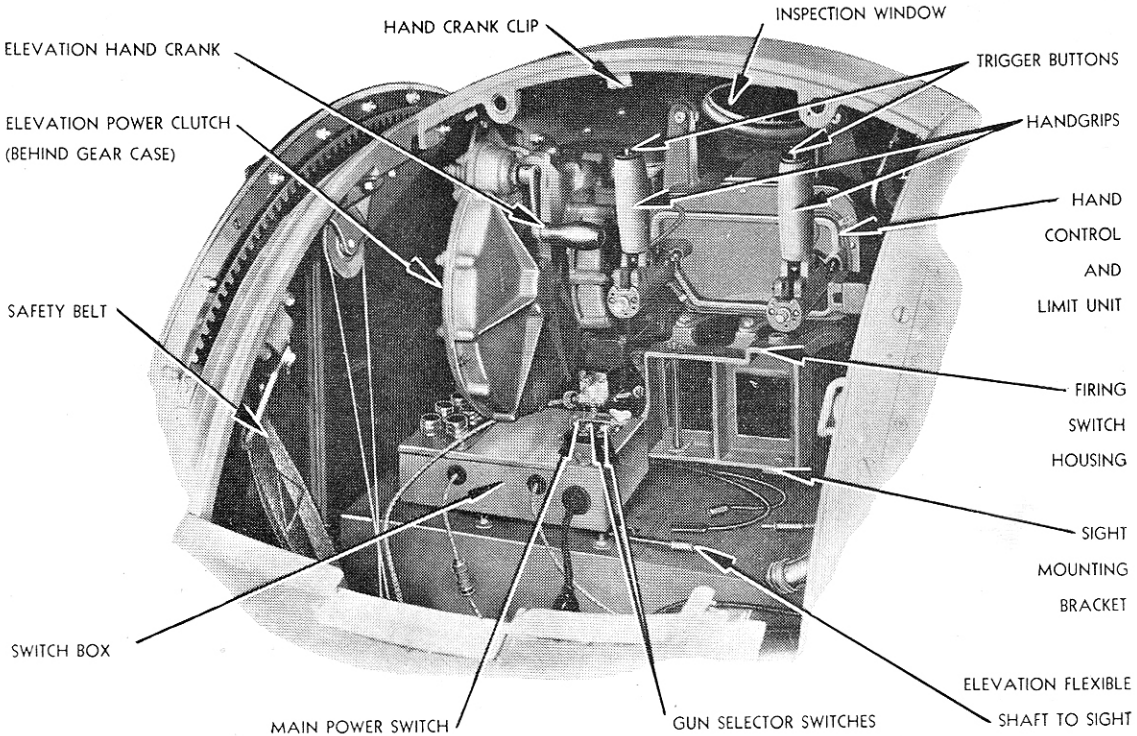


FIGURE 19—Interior of Turret and Operating Controls

2. Close hydraulic valve.

3. Operate hand pump to raise turret until retraction safety hooks may be closed.

4. Close safety hooks to retain turret securely.

5. Move turret by hand in azimuth to 180 degrees as marked on trunnion ring support (guns pointing directly toward tail of airplane). Engage Azimuth Power Clutch to secure turret (see Figure 18).

6. Crank turret in elevation to —22 degrees as indicated by cam closing Elevation Retraction Position Switch.

7. Engage Elevation Power Clutch, using handle provided in the retainer clip on the trunnion ring support. Replace handle in clip.

8. Tighten Elevation Hand Brake. Replace hand crank in clip.

B. ENTERING AND LEAVING TURRET (all three models)

Examine Figures 18 and 19 to become familiar with the controls inside the turret before reading the instructions on entering, leaving, and operating the turret. The procedures which follow *must be strictly adhered to.*

To Enter Turret

1. Remove Elevation Hand Crank from retainer clip on trunnion ring support and place it on the vertical shaft projecting from the Hand Elevation Drive Unit.

2. Holding crank firmly, release elevation brake.

3. Holding crank firmly, move elevation power clutch to OUT position by means of the handle provided in the retainer clip on the trunnion ring support.

It may be necessary to rock the turret slightly with the hand crank to free the power clutch.

4. Remove the clutch handle and replace in retainer clip.

5. Crank the turret in elevation to —90 degrees (guns down) to bring the turret door into accessible position.

6. Holding the crank firmly, open turret door and move the elevation power clutch to IN position. Move hand crank if necessary. Be sure clutch is engaged.

7. Turret is now held in elevation position by power gearing. Remove outside hand crank and place in clip on trunnion ring support.

8. Before entering turret, take a firm grasp on the tubular supporting structure and place one foot on the turret seat to make sure that the turret will not move. Maintain a firm grasp on the tubular structure while entering turret.

9. When inside turret, fasten safety belt and close door securely. Be sure that door latches are completely closed.

To Leave Turret

1. Drive turret to low limit in elevation (—90 degrees).
2. Turn power and sight switches OFF.
3. Disengage *azimuth* power clutch *only*.
4. Open door, unfasten safety belt and leave turret.
5. Attach elevation hand crank.
6. While holding hand crank firmly, disengage elevation power clutch within turret.
7. Tighten elevation hand brake.
8. Close and latch turret door.
9. (Model A-13 only) Retract turret according to instructions given above.

C. OPERATING TURRET

The turret motor should not be operated without an auxiliary source of power in addition to the plane's batteries, as low voltage is likely to damage the motor or the relay in the switch box. During flight, this additional power will be furnished by the generators but on the ground it will be necessary to provide other sources. Most bombing planes are now equipped with auxiliary gasoline generators.

1. Enter turret as per instructions given above.
2. Turn on power switch.
3. Turn on sight switch.
4. Plug heated suit into receptacle beneath seat.
5. Connect oxygen mask to hose from regulator beneath seat.
6. Connect microphone and headset into jacks on cords from switch box.
7. Charge guns twice.
8. Turn on gun selector switches.
9. At high altitudes or low temperatures, operate power unit frequently to keep oil warm and thinned out.
10. When target is observed, set target dimension dial on sight.

11. Operate turret so that reticles stay on target ("tracking").
12. Operate foot range pedal to frame target with sight reticles.
13. Fire guns with either hand grip button.
14. When ammunition is used up, charge guns twice to insure that no live shells are left in the guns.
15. Turn gun selector switches OFF.
16. Leave turret as described above.

IMPORTANT

On B-24 airplanes, during landing or take-off, turret must be retracted, with guns at —22 degrees in elevation and pointing aft. There must be no crew member in the turret.

On B-17 airplanes, during landing or take-off, turret must be at 0 degrees in elevation and guns pointing aft. There must be no crew member in the turret.

NOTES

SECTION IV

TURRET DRIVE SYSTEM

A. HYDRAULIC POWER UNIT

The turret is driven in azimuth and elevation by the Vickers Double Power Unit (see Figure 20) which is mounted within the turret ball. The Power Unit consists of three separate assemblies bolted together:

1. Constant-speed electric motor.
2. Azimuth hydraulic transmission.
3. Elevation hydraulic transmission.

The electric motor is driven by the airplane electric current supply, being turned on or off from within the turret by a Main Power Switch. The motor drives both hydraulic transmissions.

Vickers Units

The azimuth hydraulic transmission and the elevation hydraulic transmission are mounted at each end of the motor, being driven by the two ends of the motor shaft. Operation of the two hydraulic systems, or transmissions, is identical.

Each hydraulic system consists of:

1. A constant-speed, variable displacement pump.
2. A variable-speed, fixed displacement hydraulic motor.
3. A control booster piston and valve assembly (servo unit).
4. A replenishing and control pump.
5. Associated check valves, relief valves, pipe lines, shafts, etc.

Figure 22 is a hydraulic diagram to show the operation of each hydraulic transmission of the double power unit.

The pump, or "A" end of the unit, is driven at a constant speed of approximately 4000 R.P.M. Oil pumped by the "A" end forces the hydraulic motor, or "B" end of the unit, to turn, driving the turret through gearing.

The "A" end is provided with pistons having connecting rods fastened to a disc with universal joints. The pistons operate within cylinder bores in a cylindrical barrel. These parts rotate together. The cylinder barrel is mounted on a bearing to a yoke, permitting the cylinder bores to be tilted relative to the center line of rotation of the piston assembly (see Figure 21).

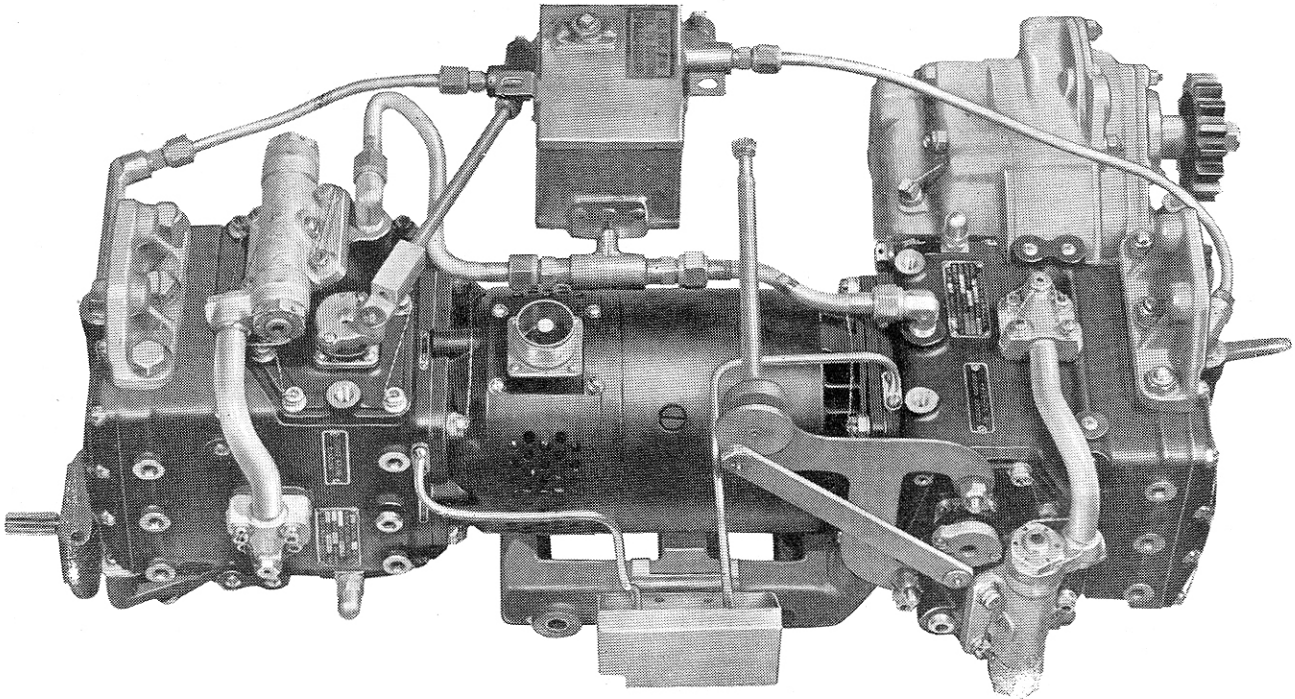


FIGURE 20—Vickers Double Power Unit

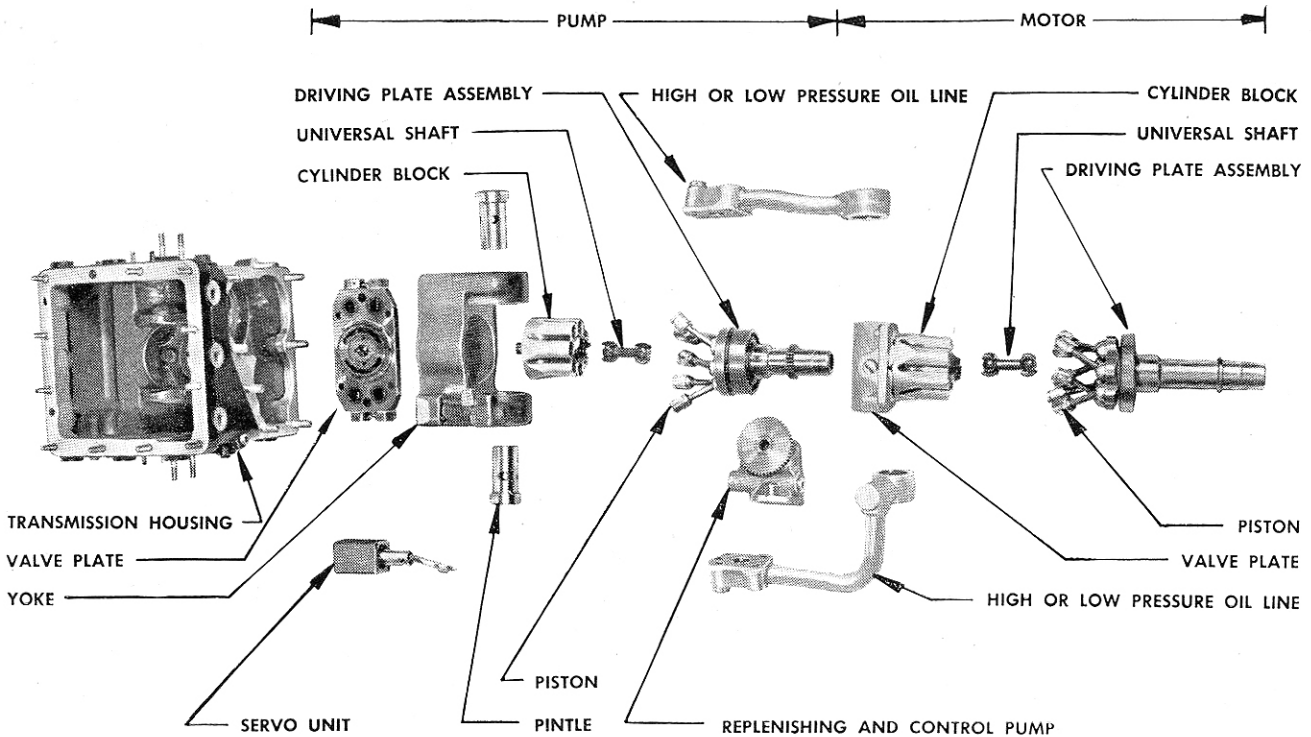


FIGURE 21—Vickers Hydraulic Transmission—Schematic Arrangement

When the pistons and cylinder are rotating at normal speed with the yoke in a neutral position, the pistons do not move in their cylinder bores or displace fluid. When the yoke is tilted, the cylinder bores rotate "off center," but the pistons are retained by their connecting rods to a disc remaining in the same plane as before. Therefore the pistons move relative to their cylinder bores and fluid is pumped in an amount determined by the angle at which the yoke is tilted.

The action is reversible: fluid is pumped in a direction determined by the direction in which the yoke is tilted. The "B" end is driven by the "A" end at a speed and in a direction determined by the amount and direction of displacement of the yoke (see Figure 22).

The yoke is tilted through linkage by a servo unit. The piston of this unit is controlled by a valve operated by a control shaft. This shaft is in turn positioned by the gunner's hand grips on the hand control unit. A small torque applied to the control shaft actuates the servo unit, and displaces or tilts the yoke.

The displacement of the yoke, determining the hydraulic output

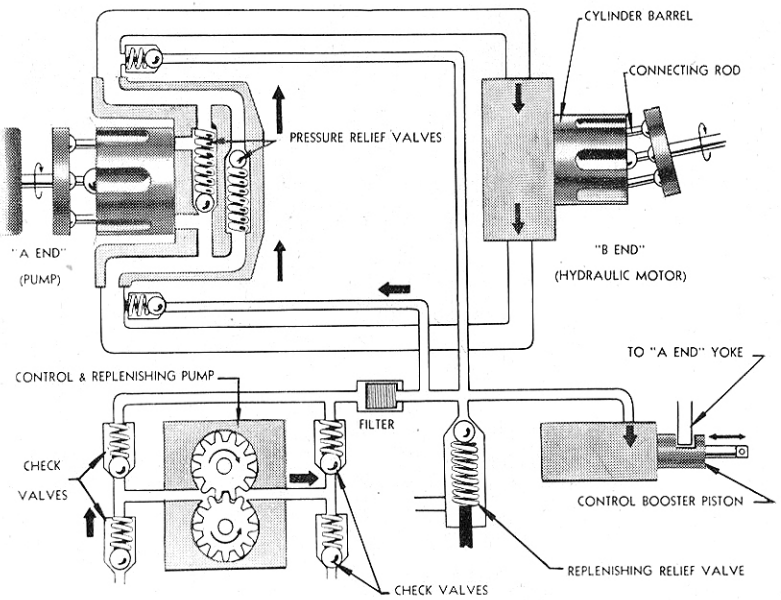


FIGURE 22—Hydraulic Transmission Diagram

of the "A" end, controls very accurately the speed of the "B" end or hydraulic motor which drives the turret. A neutral position of the yoke causes no output from the transmission, so that the turret is stationary although the power unit's electric motor continues to run.

Inasmuch as the hydraulic units for azimuth and elevation are separate hydraulic systems, they are controlled by separate shafts from the hand control unit, so that azimuth and elevation movements may be independently operated.

The replenishing and control pump in each hydraulic unit is driven by the constant-speed electric motor. Replenishing valves are so situated that hydraulic fluid from the housing reservoir will be forced automatically into the "A" end and "B" end system when the pressure in the system falls below a certain limit. The pump also furnishes pressure to drive the control servo unit piston described above.

Pressure relief valves are also provided to protect the system against abnormally high pressures.

The breather or expansion tank is common to the two hudraulic units and permits the addition of hydraulic fluid to the units when required. A fluid gauge is provided, and removable screw plugs are placed in the bleeder tubes to the tank so that air may be removed from the hydraulic systems.

The two hydraulic Vickers Units provide the gunner with power for smooth and easily controlled motion of the turret in elevation and azimuth.

The following is the order of disassembly for either of the hydraulic transmissions:

1. Rear Cover
2. High or Low Pressure Lines
3. Yoke Control Arm
4. Booster Cylinder
5. Control Pump
6. "A" End Valve Plate
7. Pintles and Yoke
8. "A" End Rotating Assembly

9. "B" End Valve Plate
10. Side Cover
11. "B" End Rotating Assembly
12. Bearings and Retainers

The following is the order of reassembly:

1. Booster Cylinder
2. Bearings and Retainers
3. "B" End Rotating Assembly
4. Side Cover
5. "B" End Valve Plate
6. "A" End Rotating Assembly
7. Pintles and Yoke
8. "A" End Valve Plate
9. Control Pump
10. Yoke Control Arm
11. High or Low Pressure Lines
12. Rear Cover

B. TURRET MOVEMENT GEARING

Power from each hydraulic Vickers Unit is transmitted through gearing arranged so that the turret may be moved continuously in azimuth and from 0 to —1600 mils in elevation (0 degrees to 90 degrees downward. Figure 23 is a schematic diagram to show the arrangement of gearing units to permit these movements.

Elevation

Power from the elevation (left hand) Vickers Unit drives the Elevation Power Gearing contained in a gear case bolted to the power unit. This gear case is a part of the complete Power Unit Assembly, and contains an Elevation Power Clutch which may be operated from inside or outside the turret ball.

A projecting shaft is machined to accommodate the inside Elevation Hand Crank, which is normally carried in the clip provided

inside the turret above the door. After engagement of the Elevation Hand Clutch, this crank may be used to move the turret in elevation when the operator is inside the turret.

The power transmitted through the Elevation Power Gearing Assembly turns a pinion projecting through the end bell of the turret ball, engaging the Elevation Quadrant Gear attached to the trunnion ring support assembly, and driving the turret ball in elevation.

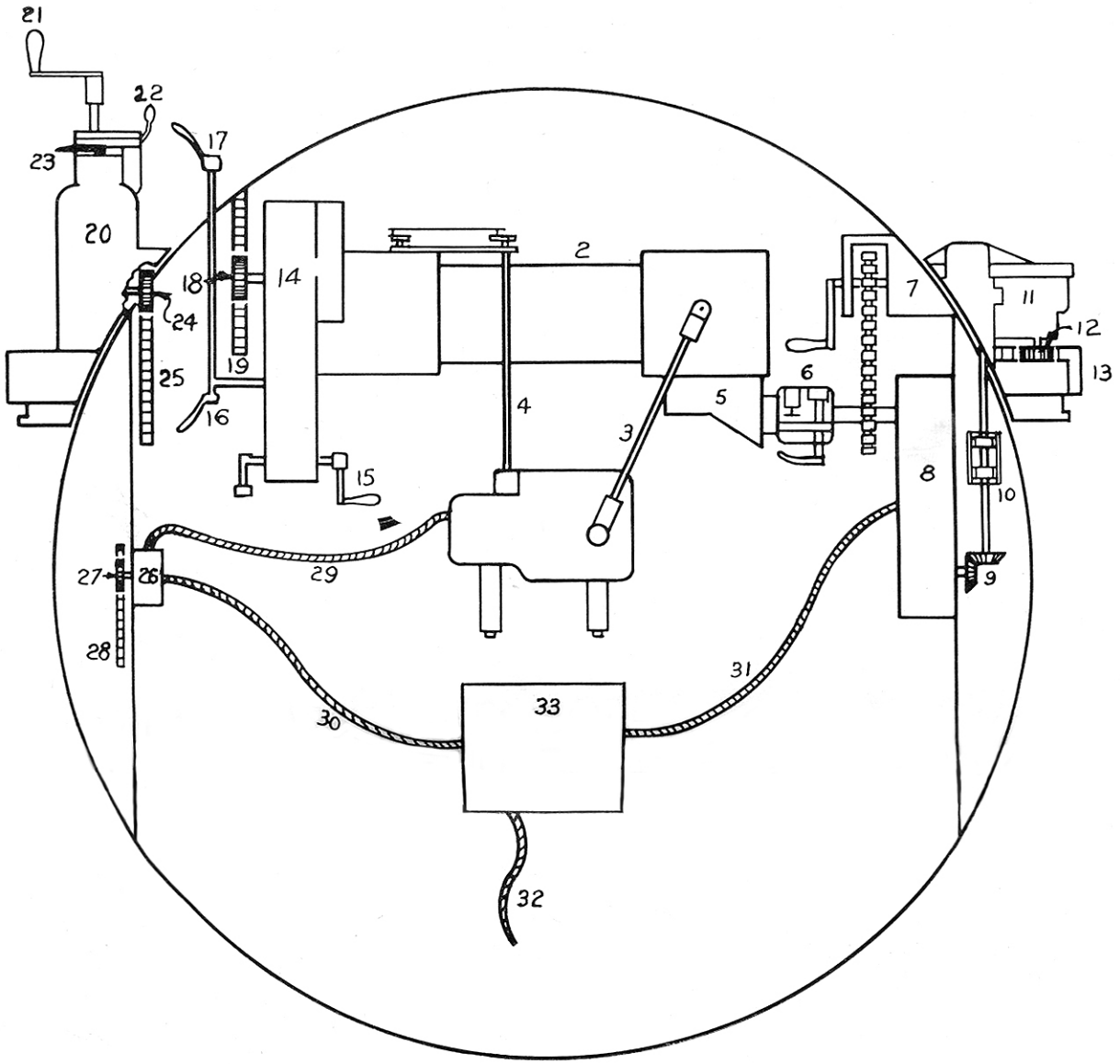
A Hand Elevation Drive Unit is attached to the trunnion ring support so that the turret ball may be moved in elevation from outside the ball. A removable crank operates the turret by turning gears moving a pinion meshed with a gear rack mounted on the turret ball. The crank is normally kept in the spring clip holder mounted on the trunnion ring support.

The elevation power clutch must be disconnected during hand operation. This allows the turret to rotate freely; therefore the hand elevation drive unit is provided with a brake which will hold the turret ball securely in any elevation position.

An Elevation-to-Sight Gear Unit is secured to the left hand end bell within the turret ball. A pinion projecting from this gear box through the end bell meshes with an Elevation-to-Sight Sector Gear mounted on the left hand trunnion support bracket. Flexible shafts are secured to the elevation-to-sight gear unit, rotating as the turret moves in elevation. These shafts carry elevation position and rate information to the computing sight and the elevation limit stop mechanism.

Azimuth

Power from the right hand Vickers unit enters the Azimuth Power Unit Gear Box mounted on the power unit. Motion is transmitted through the Azimuth Power Clutch to the Azimuth End Bell Gearing. This gear unit drives the Azimuth Trunnion Gear Unit mounted in the right hand trunnion support bracket, permitting rotation of the ball in elevation while power is carried up to the Azimuth Pinion Gearing mounted on the trunnion ring support. This gear unit includes a pinion which is meshed with the azimuth ring gear secured to the airplane so that the turret is rotated in azimuth as the pinion turns.



1. Hand Control and Limit Unit
2. Double Power Unit
3. Azimuth Control Shaft
4. Elevation Control Shaft
5. Azimuth Power Gear Assembly
6. Azimuth Power Clutch
7. Azimuth Hand Gear Assembly
8. Azimuth End Bell Gearing
9. Azimuth Trunnion Gearing
10. Azimuth Spline Coupling
11. Azimuth Pinion Gearing
12. Azimuth Pinion Gear
13. Azimuth Ring Gear
14. Elevation Power Gear Assembly
15. Elevation Inside Hand Clutch and Crank
16. Elevation Power Clutch
17. Elevation Outside Power Clutch Shaft
18. Elevation Power Pinion
19. Elevation Quadrant Gear
20. Hand Elevation Drive Unit
21. Elevation Outside Hand Crank
22. Elevation Outside Hand Brake
23. Elevation Outside Hand Clutch
24. Elevation Outside Hand Pinion
25. Elevation Outside Hand Gear Rack
26. Elevation-to-Sight Gear Unit
27. Elevation-to-Sight Gear Pinion
28. Elevation-to-Sight Sector Gear
29. Limit Stop Flexible Shaft
30. Elevation-to-Sight Flexible Shaft
31. Azimuth-to-Sight Flexible Shaft
32. Range-to-Sight Flexible Shaft
33. K-4 Calibre .50 Computing Sight

NOTE: Elevation Outside Clutch (No. 23) has been eliminated on turrets manufactured since early 1943.

FIGURE 23—Complete Turret Gearing Schematic

A geared chain and sprocket (Azimuth Hand Gear Assembly) within the turret and driving the azimuth end bell gearing provides for the attachment of a crank for moving the turret in azimuth by hand (see Figure 18). This crank is stowed in a clip located inside the turret above the door.

Provision is made in the azimuth end bell gearing for the attachment of a flexible shaft which conveys azimuth position and rate information to the computing sight.

In each power gear train there is considerable reduction so that the turret is moved within a speed range suitable for tracking the target. The gear reduction also produces great torque in the turret movement, insuring smoothness of motion.

C. HAND CONTROL AND LIMIT UNIT

To provide the gunner with complete freedom of control over a wide range of speeds in both elevation and azimuth movements, a Hand Control Unit is mounted within the turret ball, bolted to the ball structure and to the power unit (see Figure 18). The hand control unit gives the gunner control over the turret movements by indirectly positioning the control shafts of the elevation and azimuth Vickers hydraulic transmissions.

Control Movements

The hand grips move forward and backward, in a vertical plane, to control the turret in the same plane, or in elevation. The hand grips rotate to right or left to control the turret *left* or *right* in azimuth (see Figure 12). The lower ends of the hand grips point in the direction of gun movements in azimuth and elevation.

A wide movement of the hand grips furnishes high turret speed and a slight hand grip displacement results in a very low turret speed. The amount of hand grip displacement determines turret speed.

An combination of azimuth and elevation speeds may be achieved by displacement of the control unit hand grips forward or back *and* right or left simultaneously.

The two hand grips are mechanically connected; either handle serves to control the turret in azimuth and elevation.

Gun Firing Buttons

Gun Firing Buttons are arranged in the end of each hand grip to operate switches so that pressure of the gunner's thumb fires either or both guns, as selected by switches on the main switch box. Gun firing switches controlled by the hand grip buttons are connected in parallel so that either button will fire either or both guns.

Hand Control Mechanism

The Hand Control Mechanism within the hand control and limit unit is arranged so that right or left displacement of the hand grips moves only the azimuth control assemblies (see Figure 24). A system of gears is used to transfer hand grip movement to an arm on the cover plate of the hand control unit. From this arm an adjustable link rod carries the movement to the Vickers hydraulic power unit control shaft.

Displacement of the hand grips in a vertical plane actuates only the elevation control assemblies, transferring indirectly the hand grip movements through an adjustable coupling to the elevation Vickers unit control shaft.

Centralizing Springs are situated within the hand control unit to return the hand grips to a neutral position, so that when the gunner relieves pressure on the hand grips a neutral, or zero-rate, position of the Vickers unit control shaft is obtained. Centralizing spring assemblies are used in both azimuth and elevation control mechanisms.

Variable Rate Mechanisms are provided in azimuth and elevation control systems within the hand control unit to give the gunner very accurate control over low speed operation of the turret. When tracking a target greatest accuracy of control is required, but it is also necessary to have immediately available a means for quickly rotating the turret, or "slewing."

Initial movement of the hand grips effects very small movement of the Vickers unit control shaft. As the hand grip is moved farther to accelerate the turret operation, the hand grip movement causes a progressively greater movement of the Vickers unit control

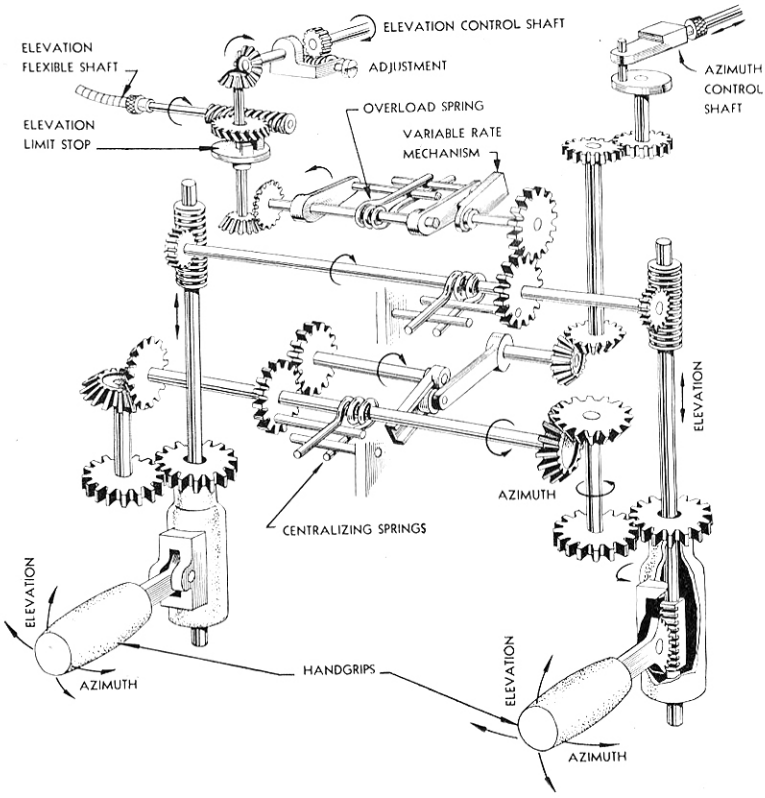


FIGURE 24—Hand Control Gearing Schematic

shaft. Specifically, a constant, or rectilinear, movement of the hand grips is converted within the hand control unit to a progressive, or curvilinear, control characteristic.

This characteristic is provided for by a variable displacement mechanism shown in Figure 24. Hand grips rotate a shaft with a lever having a channel in which rides a roller. The roller is at the end of another lever which rotates the output shaft.

As the channel rotates, the roller causes rotation of the output shaft. As the roller progresses farther in the channel, it moves farther from the center of rotation of the channel, so that the output shaft is displaced in a progressively greater amount because the roller must traverse the longer distance traveled by the outer end of the channel.

Elevation Limit Stop

The hand control and limit unit also contains the Elevation Limit Stop mechanism which restricts travel of the turret to the necessary limits in elevation (0 degrees horizontal to —90 degrees), to prevent the gun bosses from striking the airplane fuselage.

Figure 24 indicates the manner in which this limitation is accomplished. Elevation control movements are transmitted through a shaft to a bevel gear in the hand control unit which in turn drives the elevation control shaft to the Vickers hydraulic unit.

On the shaft carrying the bevel gear in the hand control is mounted a worm wheel free to rotate. A worm gear meshing with this wheel is driven by a flexible shaft to the elevation-to-sight gear unit and, therefore, the worm wheel rotates as the turret moves in elevation.

The worm wheel carries a "dog" or projection. Two similar projections are mounted on discs secured to the shaft carrying the elevation control output bevel gear referred to above (see Figure 33). As the turret approaches a limit in elevation, the worm wheel engages one of the projections secured to the shaft so that the shaft is turned and the Vickers unit control shaft returned to neutral.

This is accomplished regardless of hand grip position because the hand grip control movements are transmitted through overload springs which yield when the limit stop mechanism returns the elevation control shaft to neutral.

Reversing the hand grip causes normal reverse of the turret in elevation because the worm wheel dog does not prevent rotation of the control shaft in a direction to operate the turret away from the restricted position.

SECTION V

ELECTRICAL SYSTEM

The lower ball turret is operated by power from the airplane electrical system. An electrical schematic of the turret system is shown in Figure 27; a complete wiring diagram is shown in Figure 25.

Current Supply

Direct current at a voltage of 27.5 ± 5% is specified for safe operation of the turret. The turret should not be operated on the airplane battery without supply from a generator, as the current drawn may be 90 amperes and, during overload or extreme cold conditions, much higher.

Electrical Components

The turret electrical system consists of the following essential assemblies:

1. Collector Ring Assembly
2. Retraction Position Switches (Model A-13 only)
3. Main Switch Box
4. Power Unit Motor
5. Fire Cut-off Switch
6. Gun Solenoids
7. Gun-firing Switches
8. Computing Sight Connection
9. Heated Suit Receptacle and Rheostat
10. Trouble Light
11. Associated Conduit Assemblies
12. Push-to-talk Switch, Headset and Microphone Connections
13. Oxygen Pressure Signal

Figure 27 shows the schematic connection of the various units in symbol form to aid in understanding the operation of the electrical circuit and its simplicity.

Figure 25 represents the components in diagrammatic form, showing the actual wiring between the units.

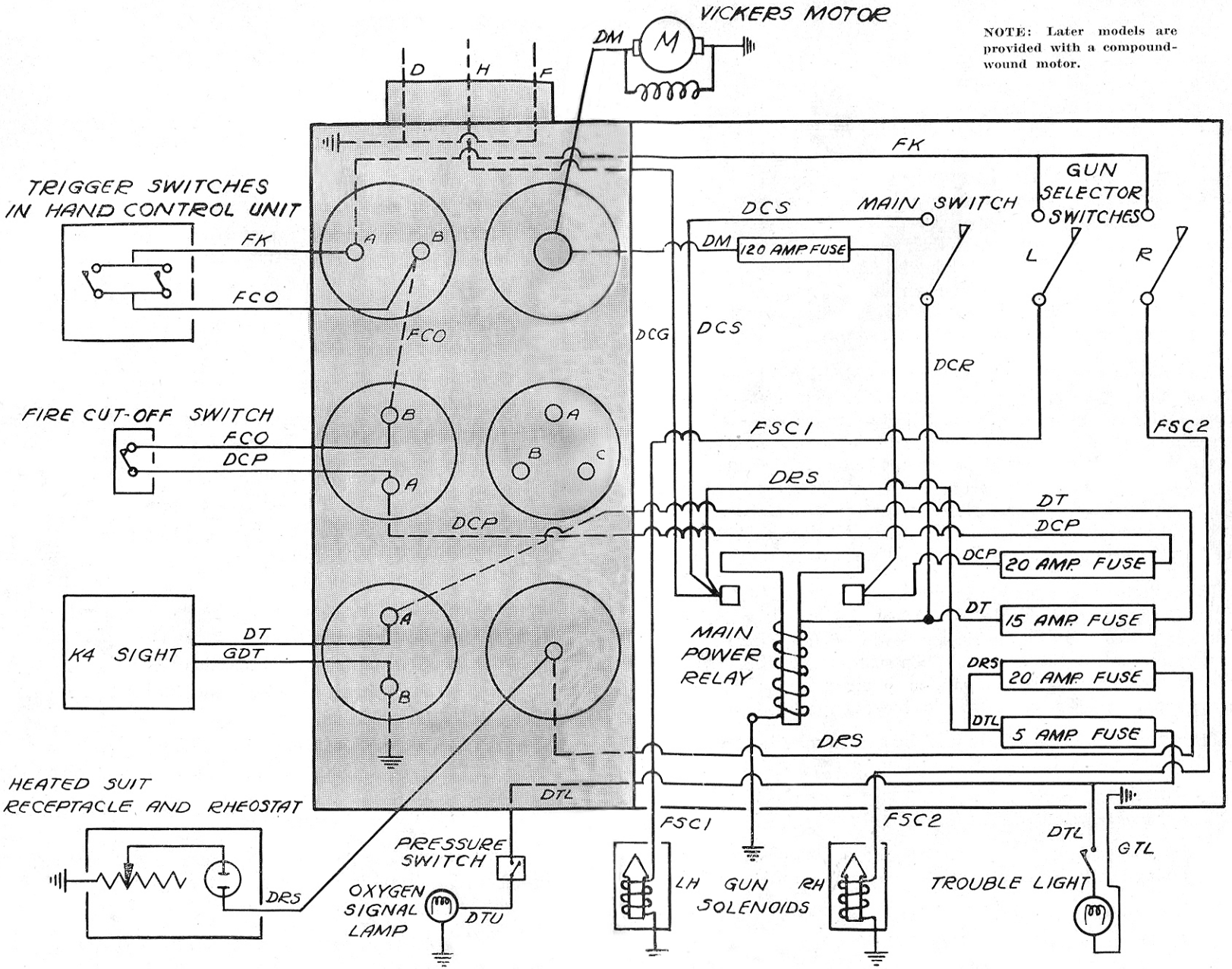


FIGURE 25—Wiring Diagram

Collector Ring Assembly

In order to transfer the various electrical leads from the plane to the turret (from a stationary to a rotating object) a device called the Collector Ring Assembly is used. The collector ring assembly consists of a series of copper rings separated by insulators. This assembly is fastened to the stationary portion of the hanger assembly which is secured to the plane. A housing surrounds these stationary slip rings and contains metal contact brushes. The housing is a part of the rotating portion of the hanger assembly. The brushes, under spring tension, maintain contact with their respective slip rings as the turret revolves in azimuth. Wires coming from the plane are soldered to the inner surfaces of the stationary slip rings. The brushes pick up the current from the rings; wires fastened to the ends of the brushes are concentrated in conduits and carried to the turret switch box.

The collector ring assembly in use on the Model A-2 lower ball turret contains eight slip rings (see Figure 26). Four of these are required for the communication system with two spare rings provided as substitutes in the event one of the communication rings becomes damaged. The two larger rings at the top and bottom of the assembly are for the ground and main power respectively. The ground ring is grounded to the ship's frame and two wires are carried from the ground contact to the switch box in the turret. All electrical circuits in the turret system are thus assured of a definite ground.

The collector ring assembly in use on the retractable (model A-13) and non-retractable (model A-2-A) lower ball turrets is similar in principle but contains 11 slip rings instead of 8 (see Figure 25). Four rings are provided as communication spares and an individual ring is provided for the retraction position circuit on the model A-13. Five rings are provided as communication spares on the model A-2-A.

The spare rings are regularly used by the Royal Air Force in connection with their communication system.

Retraction Position Switches (Model A-13 only)

A Retraction Limit Switch is mounted on the collector ring upper trunnion housing. The switch closes when the turret is fully retracted.

An Elevation Retraction Position Switch is mounted on the trunnion ring support, being closed by a cam on the turret ball when

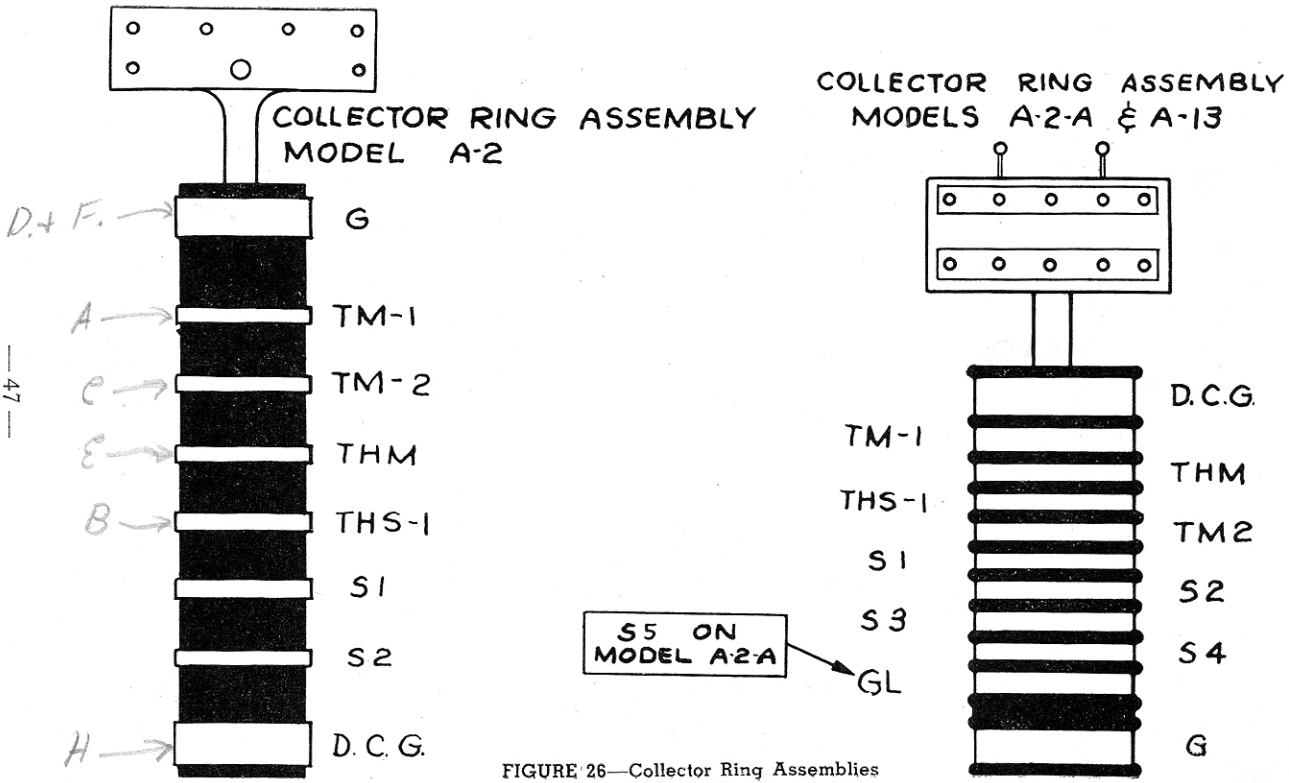


FIGURE 26—Collector Ring Assemblies

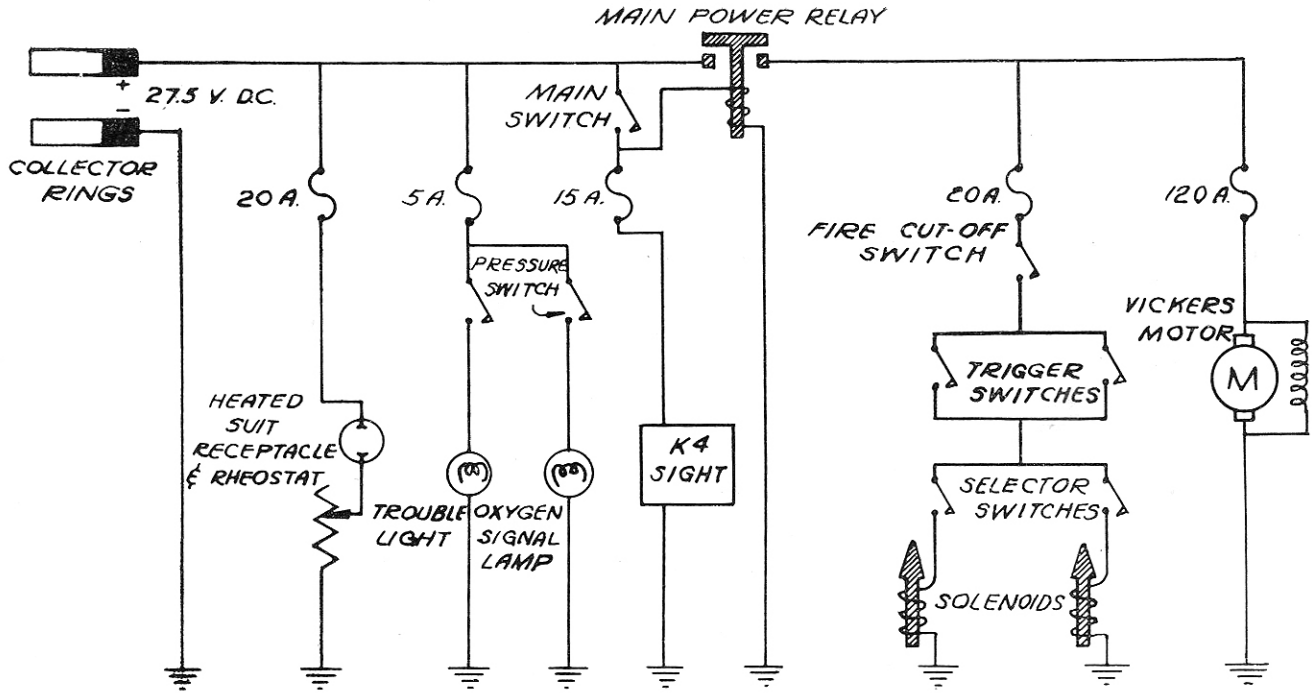


FIGURE 27—Electrical Schematic Diagram

the guns are at —22 degrees in elevation or completely withdrawn into the fuselage wells when the ball is retracted.

These two switches are connected in series so that when both are closed an indicator light on the airplane pilot's instrument panel informs the pilot that the turret is in correct position for landing the airplane. See Figure 28 for the additional circuit on the retractable turret.

Main Switch Box

Within the turret, electrical circuits are led into a Switch Box which contains equipment to give the gunner control of the electrical devices in the turret. The switch box contains:

1. Main Power Switch
2. Main Power Relay
3. Gun Selector Switches
4. Fuses
5. Communication Circuit Terminals
6. Cannon Plug Receptacles
7. Necessary Terminal Blocks, Wiring, etc.

Nearly all electrical connections from the switch box to turret and gun operating equipment are made by means of standard "AN" plugs and receptacles with shielded flexible conduit.

The gunner's head phones and microphone are plugged into jacks at the ends of flexible leads. These leads enter the switch box through rubber grommets and are connected to a terminal strip in the box.

The Main Power Switch is single-pole, single-throw, mounted at the left of the Gun Selector Switches. The switch is moved upward to the ON position, as marked on the switch box cover, and protected by a guard to prevent accidental operation.

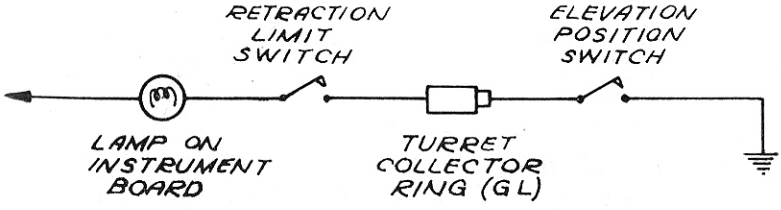


FIGURE 28—Retraction Position Switch Circuit

The Main Power Relay is energized by the main power switch, to operate a set of heavy contact points. These contacts supply turret power and gun-firing circuits with 27.5-volt direct current. The purpose of the relay is to make or break quickly large current-carrying circuits with a minimum of damage from arcing. If the turret is operated at low voltage, current demand on the system may lower the voltage across the energizing coil even further so that the relay contacts are not firmly closed. Burning of contacts and unsatisfactory operation of the relay will result.

Gun Selector Switches are single-pole, single-throw switches at the right of the switch box, permitting the gunner to connect either or both guns to his gun-firing (or hand control trigger) switches.

Fuses protect all individual operation circuits within the turret, in suitable capacities as follows:

1. 120 Amp. for Power Motor
2. 20 Amp. for Gun-firing Circuits
3. 15 Amp. for Computing Sight
4. 20 Amp. for Heated Suit
5. 5 Amp. for Trouble Light and Oxygen Pressure Signal

The four smaller fuses at the right of the box are easily replaced. The power motor fuse is bolted into the box above the relay. Spare fuses are contained in the Spare Parts Box mounted on the hanger support framework.

The switch box cover is provided with Dzus fasteners to be easily removable.

Power Motor

Driving the hydraulic Vickers units is a 2-horsepower, 4000 R.P.M., compound-wound motor, supplied with 27.5-volt direct current through the main power relay. The motor must be protected against excessive oil or moisture under unusual conditions.

Fire Cut-Off Switch

A normally-closed, spring-loaded switch is placed in the circuit supplying current to the gun-firing solenoids. The function of this switch is to prevent firing of the guns by opening the circuit when the guns are pointed so that projectiles would strike any part of the ship.

The Fire Cut-off Switch is mounted inside the front center section of the turret ball, being actuated by a round-nosed Cam Riser Pin projecting forward through the turret wall.

When the guns approach a restricted area the pin encounters a sheet metal cam mounted on the azimuth ring gear, stationary with respect to the airplane. The cam opens the switch by depressing the pin. The cam contour is designed according to the position of air lane parts relative to the turret guns. See Figures 13 and 14.

Gun Solenoids

The calibre .50 M-2 aircraft-type guns are fired by Gun Solenoids (type G-11) mounted on the guns. Each solenoid is connected in series with a gun selector switch in the switch box and the fire cut-off switch. The circuit is completed by either of the hand control trigger switches.

The circuit receives 27.5-volt current through the main power relay. While the solenoids are energized the guns continue firing.

Heated Suit

A receptacle for the gunner's electrically heated suit is placed under the seat in the box containing a rheostat for controlling the current through the suit heating elements. The circuit is separately fused and current is supplied independent of other circuits and fuses.

Trouble Light

A swivel-mounted Trouble Light is provided with an extension cord carrying the switch. The trouble light swivel fitting may be pushed into either of two receptacles mounted within the turret above the door opening. The circuit is independent of switches and fuses other than the 5-amp. fuse in the switch box.

Sight Connection

The Sperry computing sight requires current for operation of a small constant-speed motor and reticle lamp within the sight. A switch is placed on the sight, with a rheostat for controlling intensity of reticle illumination.

The sight receives current from the switch box through a 15-amp. fuse.

Conduits

Conduits are all of the flexible, metal-sheathed type, coated with a protective covering.

Plugs and receptacles are standard "AN" type. Care must be exercised to determine that all plugs are connected all the way into receptacles for safety and proper electrical characteristics.

Push-to-Talk Switch

Two-way communication is provided for the gunner. Connections are made to a terminal strip in the switch box. A normally-open Push-to-talk Switch is located in front of the gunner's right foot rest; the gunner pushes the switch when he wants to use his microphone. The headphones are always connected to the ship's communication system.

Oxygen Pressure Signal

An Oxygen Pressure Signal Switch closes a circuit to the Oxygen Signal Lamp when the pressure of the supply drops below a safe level. This pressure switch receives its current from the same 5-amp. fuse as the trouble light.

NOTES

SECTION VI

DISASSEMBLY AND REASSEMBLY

REMOVAL OF THE DOUBLE POWER UNIT

In order to remove the double power unit, it is first necessary to remove several other parts or sub-assemblies.

1. Remove the computing sight.
   a. Disconnect the sight conduit at the sight.
   b. Disconnect all three flexible shafts at the sight.
   c. Remove the sight mounting pin and carefully lift the sight from the turret.

2. Remove the two machine guns.
   a. Disconnect the gun solenoid wires at the solenoid cannon plugs.
   b. Remove the four Phillips head screws from the right hand gun cover plate (located on the right hand gun boss at the outside front of the turret) and remove the plate.
   c. Remove the cotter pins (at the end of the gun charging cables) from the gun charging cables.
   d. Remove the two stop nuts holding the right hand gun charger pulley bracket to the end bell near the door and remove the pulley bracket.
   e. Remove the belt feed pawl pins from both guns and remove the link ejection chutes which they hold in place.
   f. Remove the two turret windows that are located directly behind the guns.
   g. Remove the small circular access plates from the outside of the ball surface near the front gun openings and remove the front gun mounting support bolts.
   h. Slide the guns through the back window openings.

3. Remove the hand control and limit unit.
   a. Disconnect the limit stop flexible shaft at the elevation-to-sight gearing.
   b. Disconnect the hand control conduit at the hand control.

c. Disconnect the azimuth control linkage at the hand control.
d. Remove the four cap screws holding the hand control unit in place (support the unit while doing this).
e. Carefully break the mesh between the elevation hub dial and the thumbscrew worm by lifting the hand control off the elevation rate shaft.
f. Remove hand control from the turret.

4. Remove the switch box.
   a. Disconnect all cannon plugs from the switch box and make certain that no conduit or wire will interfere with its removal.
   b. Remove the switch box cover and the two mounting screws at the inside right hand of the switch box; *loosen* the other two mounting screws.
   c. Slide the switch box slightly to the right and lift to remove it.

5. Remove azimuth power clutch mechanism.
   a. Remove the two long hexagonal head bolts and two elastic stop nuts.
   b. Remove the clutch actuating mechanism.
   c. Slide the male clutch plate as far to the left as possible.

6. Remove the double power unit.
   a. The following units are still attached to the double power unit when it is removed:
      (1) Azimuth power gear assembly
      (2) Elevation power gear assembly
      (3) Breather tank
      (4) Sight mounting bracket
      (5) Azimuth control shaft
      (6) Elevation control shaft
      (7) Elevation control shaft bracket
   b. Disconnect the left hand air bleeder line at the breather tank so as to permit removal of the power unit without disturbing the main power conduit.
   c. Remove the two cap screws at the breather tank.
   d. Remove the azimuth offset bracket by first removing its two cap screws and two elastic stop nuts.
      Caution: Be certain that the two cap screws removed from the transmission are replaced in the

same locations in reassembly. Failure to do so may cause irreparable damage to the transmission case.

e. Remove the three cap screws at the top of the elevation power gear assembly.

f. With the power unit supported, remove the four remaining cap screws (two at either side) which extend from the outside of the end bells into the brackets attached to the Vickers transmissions.

g. Disconnect the main power conduit at the power unit.

h. Remove the power unit assembly.

Note: Care should be taken in moving the unit to release the left hand bleeder line from behind the power cable, and the bleeder line should be reconnected (hand-tight) before lifting from the turret. Care should be taken at all times in handling the unit so that the weight is not placed at the rear. It should be kept level or tilted forward; failure to observe this precaution will result in damage to the elevation control shaft bracket.

REPLACEMENT OF THE DOUBLE POWER UNIT

The reassembly of the units taken out in the process of removing the double power unit is accomplished by reversing the above procedure. The following precautions should be observed:

1. As the power unit is replaced, make certain that the outside elevation power clutch shaft extends through its hole in the ball.

2. Electrical conduit to the sight must be placed underneath the power unit and the conduit to the hand control must be fed over the top of the azimuth hydraulic transmission.

3. Use care to avoid cross-threading of screws or nuts as, in many instances, this will cause stripping of threads.

4. The four cap screws extending into the brackets at the back of the Vickers transmissions should be replaced first.

5. The double power unit must be properly aligned so as to permit the correct mesh between the male and female halves of the azimuth power clutch before the various cap screws and stop nuts are tightened.

6. Care should be exercised in installing the hand control and limit unit in order to avoid damage to either thumb screw worm on the back of the hand control or to the small hub dial on the elevation control shaft.

7. Safety wire all cap screws, bolts, screws, and castellated nuts.

8. All electrical conduit connections must be tight. These connections can be tightened until a little more than two threads will be left showing, even when tightening is done by hand. Failure to observe this precaution may cause failure of the turret entirely.

9. After completing the reassembly make the creep and limit stop adjustments, boresight the turret, and check the fire cut-off of the guns.

NOTES

SECTION VII

ADJUSTMENTS

The lower ball turret is designed to provide (a) accurate fire at long ranges, (b) the utmost in ease of operation, and (c) safety to the airplane.

The automatic mechanisms provided for achieving these objectives require careful adjustments, which are not difficult to perform. The extent to which the turret fulfills its purpose is determined by the thoroughness and accuracy with which adjustments are performed.

Adjustments must be properly made in order to (a) prevent gun barrels from striking the fuselage, (b) prevent firing at the carrying airplane, (c) insure smooth operation of the turret, (d) insure accurate control in tracking, and (e) provide maximum accurate fire power.

Adjustments are best performed by two men: one man to operate the turret from within and the other to make adjustments outside the turret.

A. CREEP (ZERO RATE) ADJUSTMENTS

Creep is movement of the turret with the hand grips in a neutral position when the turret motor is operating. The cause of creep is lack of synchronization between the hand control unit and the Vickers hydraulic transmission. Creep can occur in either azimuth or elevation. Creep in either azimuth or elevation can be sufficiently serious to cause the turret to be out of control, and unless adjustment is made in the proper manner the equipment can be severely damaged. The method of adjusting creep is to coordinate Vickers units and the hand control unit by means of the adjustments on the rate or control shaft linking the two.

1. With a man in the turret, disengage both azimuth and elevation power clutches and rotate the turret by means of the outside elevation hand gearing to a point where the plate covering the breather tank can be removed, and lock the brake.

2. With the turret motor running adjust the knurled knob on the azimuth control shaft as the man inside the turret uses the trouble light to watch the male half of the azimuth clutch. When the assistant signals that the clutch plate has stopped rotating, turn off the motor.

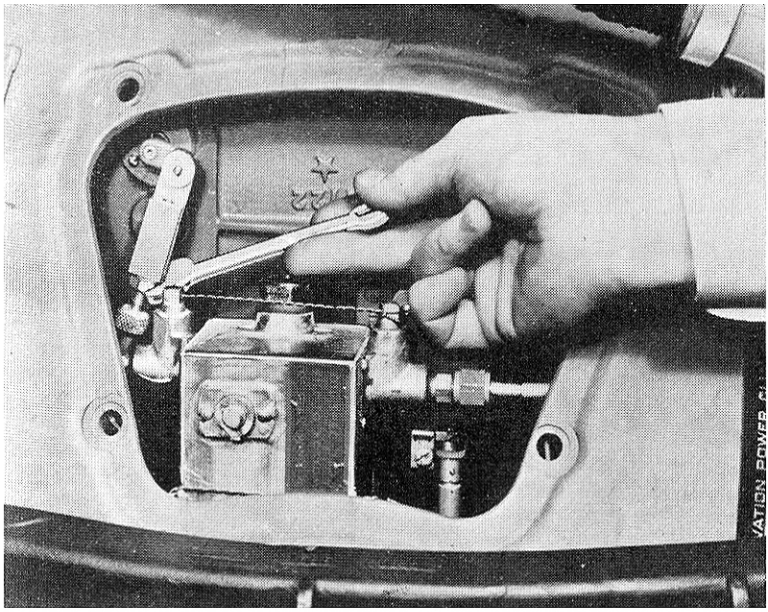


FIGURE 29—Azimuth Creep Adjustment

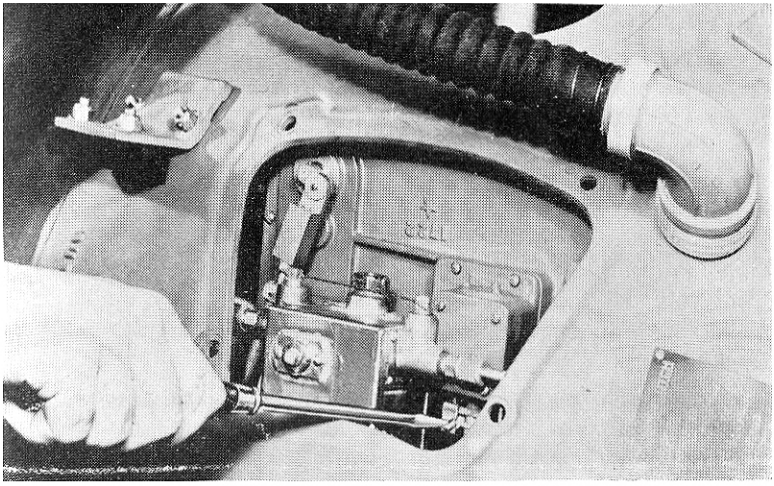


FIGURE 30—Elevation Creep Adjustment

3. Re-engage the azimuth power clutch, turn on the motor, and check the adjustment by running the turret back and forth several times. Remove the remaining creep (if any) by turning the knurled knob on the azimuth control shaft in the same direction that the turret is creeping. Tighten the locknut (see Figure 29).

4. Rotate the turret by hand to an approximate —45 degrees elevation position. Lock the brake.

5. With the motor running and the elevation power clutch still disengaged use a screwdriver to turn the thumbscrew worm on the back of the hand control until the hub dial gear on the elevation control shaft stops turning. Reverse the direction of turning and count the half-turns of the thumbscrew worm until opposite maximum is reached. Turn back half way. This should be the approximate neutral position of the Vickers hydraulic unit (see Figure 30).

6. Turn off the motor and engage the elevation power clutch.

7. Turn the motor switch on and off quickly to determine the amount and direction of creep.

8. Again turn the motor on and, using a screwdriver to turn the elevation thumbscrew worm in the direction of the creep, adjust until a zero rate (no movement) has been reached.

9. Check the adjustment by running the turret back and forth in elevation several times.

Note: It is not always possible to remove all creep. Therefore, a ¼ degree per second tolerance has been established. If necessary to leave azimuth creep in the turret it should be split up as evenly as possible over both directions of travel. If necessary to leave elevation creep in turret, guns should creep upward so as not to interfere with the landing of the plane in the event of an emergency landing.

The complete adjustment procedure given above should be necessary only when replacing the hand control and limit unit after it has been removed. At other times, slight creep can be easily adjusted by merely having the man inside the turret engage the power clutch while the man outside the turret proceeds with the adjustment as given above after engagement of clutches. It is advisable to make each adjustment separately with the other power clutch disengaged during the process.

Caution: Any maladjustment or wear which causes a loose connection between the worm adjusting screw on the hand control and the hub dial on the elevation control shaft will make it difficult or impossible to satisfactorily adjust elevation creep. Such a condition must be corrected at once.

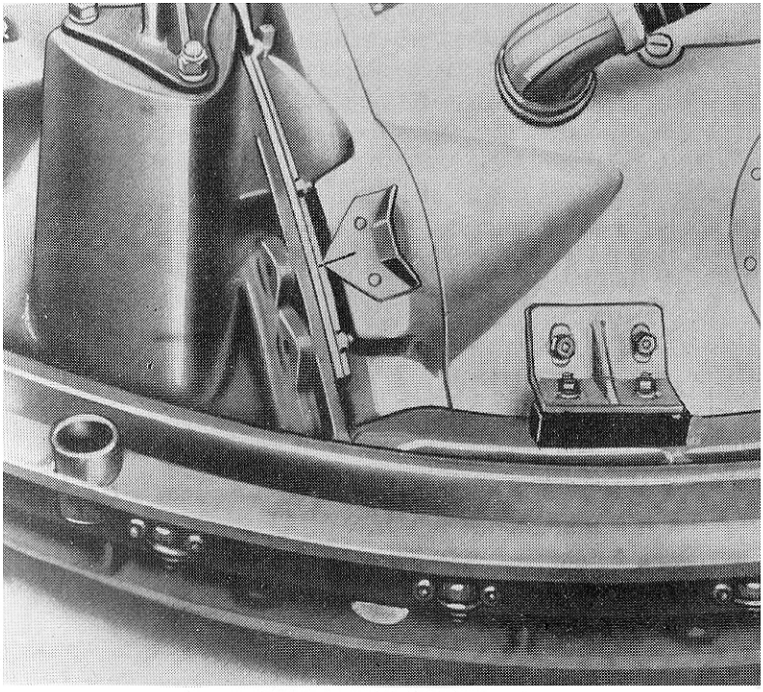


FIGURE 31—Elevation Limit Position of Turret

B. LIMIT STOP ADJUSTMENT

1. Remove all elevation creep from the turret.

2. Disconnect the limit stop flexible shaft at the elevation-to-sight gearing.

3. With a man in the turret, rotate the turret by hand to 0 degrees elevation.

4. The man in the turret turns the limit stop flexible shaft counter clockwise until the dogs in the hand control unit contact each other. Remesh the shaft in the elevation-to-sight gearing and tighten the coupling.

Caution: Never move the turret by hand in elevation with the limit stop shaft engaged until you first check the limit stop setting by operating the turret under power. Failure to observe this precaution can result in serious damage to the hand control unit if stops are set incorrectly.

5. Engage the elevation power clutch and check *under power* to see where the stop takes effect. This should be at 0 degrees elevation as indicated by the pointer and the scribe mark on the brass elevation quadrant gear (see Figure 31).

6. If incorrect, disconnect the limit stop flexible shaft immediately and repeat the above procedure.

If, after repeated trials of the method outlined above, the setting is still unsatisfactory, it is possible to make a finer adjustment by changing the relationship of the elevation-to-sight pinion to the stationary elevation-to-sight sector gear.

This may be done *only before setting inputs to the sight.*

1. Remove left hand end bell cap.

2. Run guns down to approximately -90 degrees elevation. At this position, the elevation-to-sight gear pinion is accessible on the outside of the end bell.

3. Remove two screws holding the sector gear at the end near-

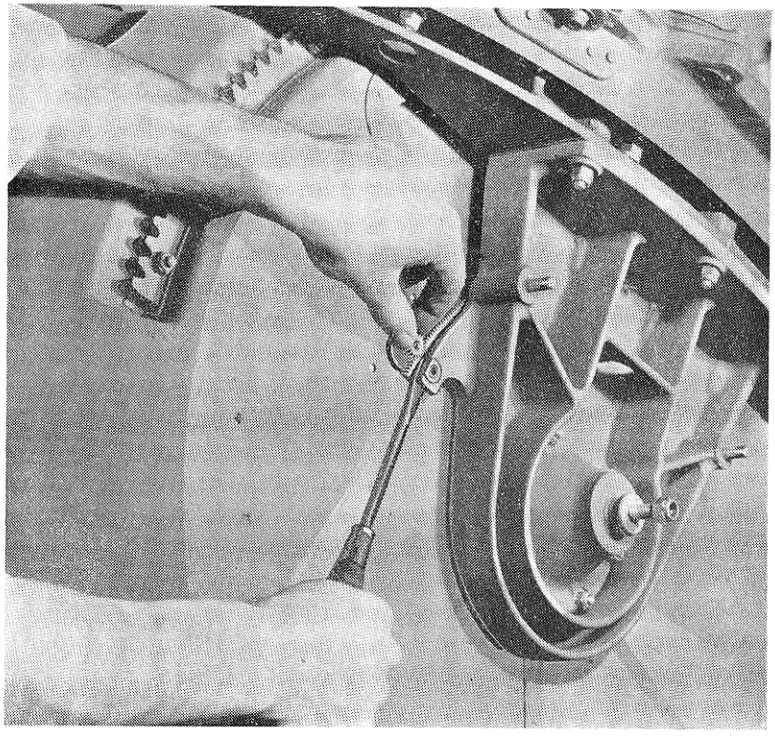


FIGURE 32—Adjusting Elevation Limit Stop Gearing

est the pinion. Carefully pry the sector gear free of the pinion (see Figure 32).

4. If the turret has been running *short of zero,* turn the pinion one tooth *counter-clockwise* and remesh the sector gear. If the turret has been running *beyond zero,* move the pinion one tooth *clockwise* and remesh.

5. Replace the two screws holding the sector.

6. Check turret operation *under power.* Slight additional adjustment may be necessary.

C. ELEVATION TRAVEL LIMIT ADJUSTMENT

After the limit stop adjustment has been made so that the limit stop takes effect at 0 degrees elevation, the turret should be run under power to the lower limit of its travel. The lower limit should be -90 degrees elevation. If the turret travels past -90 degrees elevation or does not travel to -90 degrees, the trouble is probably in the hand control unit. It is necessary to remove the hand control unit from the turret to make the required adjustment.

1. Remove the box and cover from the hand control unit.

Note: Care should be taken to mark the position of the arms on the hand control unit which connect to the azimuth and elevation control shafts. It is necessary that these arms be replace in the same position as before removal of the cover.

2. Place the floating worm wheel dog in contact with either one of the other two dogs (see Figure 33).

3. The measurement across the outside of all three dogs should be 7/8". If it is not, loosen the three set screws and adjust until it is 7/8".

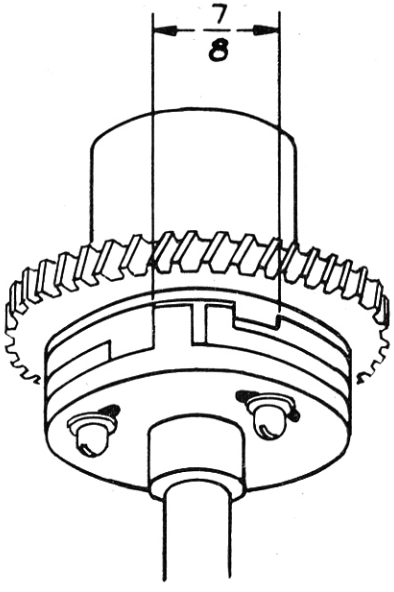


FIGURE 33—Travel Limit Adjustment

4. Tighten the set screws and check the measurement.
5. Replace the box and cover.
6. Replace the hand control unit.

D. AZIMUTH RING GEAR

Adjustment of the azimuth ring gear is occasionally necessary for two reasons. First, to provide clearance for the trunnion support brackets as the turret rotates in azimuth. During this azimuth rotation these trunnion support brackets ride between the top of the fire cut-off cam and the bottom of the ring gear. Improper alignment of the ring gear with the turret could result in damage to or mis-alignment of the fire cut-off cam.

The second reason is to insure a proper mesh between the azimuth pinion gear and the azimuth ring gear.

1. Loosen all Lord shock mountings and, after making sure the center cylinders of the mountings are firmly against the mounting plate or the floor of the plane, adjust the ring gear up or down, measuring at each mounting point, until the top of the azimuth pinion gear is exactly 3/16" above the top of the azimuth ring gear.
2. As each measuring point is passed tighten the Lord shock mounting.
3. Check the trunnion support brackets for proper clearance (minimum, 1/32" above the fire cut-off cam).
4. Check the fire cut-off to be sure that the fire of the guns is cutting out 8" to 11" away from the propeller arcs.

E. HORIZONTAL ROLLERS

Location of the trunnion ring support in the horizontal plane with respect to the ring gear is determined by 20 rollers attached to the trunnion ring support. The rollers are mounted on eccentric shafts so that the horizontal adjustment movement is obtained by turning the shafts. This adjustment is made at the factory and readjustment should seldom, if ever, be required.

1. The roller shafts should not be moved unless the turret is plumb so that the weight of the turret is not against the rollers on one side of the trunnion ring support.
2. Rollers should just touch the ring gear and it should be possible to rotate the rollers with the fingers.
3. Roller shafts may be turned with a wrench after loosening the stop nuts which are accessible through holes in the lower flange of the trunnion ring support.

4. Rotate the turret by hand in azimuth to determine that the azimuth drive pinion does not bind.

F. FIRE CUT-OFF

To protect the airplane, gun-fire is cut off within restricted areas of turret operation. (Refer to Wiring Diagram, Figure 25).

The turret positions at which the circuit is broken are determined by the relationship of the Fire Cut-off Switch Pin on the turret ball to the fire cut-off cam. Because the cam may be bent or dented, it is very important that fire cut-off action be checked carefully.

The fire cut-off cam is bolted and adjusted for location to brackets fixed to the ring gear at the factory. It should not be removed from the ring gear except when absolutely necessary.

Replacement of the cam is an overhaul procedure requiring a special protractor.

1. Carefully examine cam for dents or bent condition.
2. Be sure that the switch pin does not bind in its hole.
3. Check position of the ring gear as outlined above.
4. *Be sure the guns are not loaded.*
5. Connect a gun solenoid to one of the gun conduits. Turn on the corresponding gun selector switch. With clutches disengaged, turn the power switch on; this will energize the gun firing circuit.
6. In an unrestricted area, make sure that the firing buttons operate the solenoid.
7. With the firing button held down to energize the solenoid, move the turret by hand until the switch pin makes contact with the cam at a point directly under one of the cam brackets. As soon as the solenoid clicks off, stop turret movement.
8. Sight through both gun barrels to determine that the gun bores point at least 8 inches from any part of the airplane fuselage or propeller arcs.
9. Repeat steps 7 and 8 at each of the other cam mounting brackets.
10. Check the adjustment at the outside ends of the cam, which are most likely to become bent. If such a condition is found, bend the cam ends back to the correct position as indicated by action of the pin.
11. The radius of curvature of the cam should be constant. At the different positions tested, cut-off should occur at very

nearly the same position on the inclined surface of the cam. This position should be at least 3/16" from either edge of the inclined surface.

If the cam surface is not a constant radius, use shims at cam mounting points until the switch pin does not move in and out while traveling over the smooth portion of the cam as the turret is rotated in azimuth.

12. Adjust the fire cut-off switch pin by loosening the locknut and running the pin *out* to increase the fire cut-off, or restricted area, or *in* to decrease the restricted area.

NOTES

SECTION VIII

MAINTENANCE

A. LUBRICATION

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. All parts of friction should be given a *few* drops of Univis #48 oil.

The Foot Range Control Assembly, Azimuth Hand Gears, Elevation-to-Sight Gear Assembly, and Elevation Hand Drive Unit all require AN-G3 grease.

The self-aligning bearing at the top of the supporting framework and the elevation trunnion bearings are 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 AN-G3 grease.

The Azimuth Power Gear Assembly, Azimuth End Bell Gear Assembly, Azimuth Pinion Gear Assembly, Elevation Power Gear Assembly should be packed with AN-G3 grease. At the present time there are some turrets in the field that have oil in these gear boxes inside the turret. It is not necessary to drain these gear boxes and replace the oil with grease until the boxes are disassembled for other purposes. However, such gear boxes should have the oil checked regularly and replenished as needed with Univis #48 oil.

The azimuth spline coupling should be kept greased at all times with AN-G3 grease, as it is exposed to the weather.

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 the centralizing spring to prevent binding.

Vickers power units should be replenished with Univis #40 (Spec. 3580-C) oil as per instructions.

Note: Grease meeting Specification AN-G3 should be generally available. If not, Penola Beacon M-285 grease may be used.

B. AMMUNITION BOX LOADING

The ammunition boxes should be loaded in accordance with directions indicated in Figure 34. These diagrams are applicable to all three models (A-2, A-2-A, and A-13).

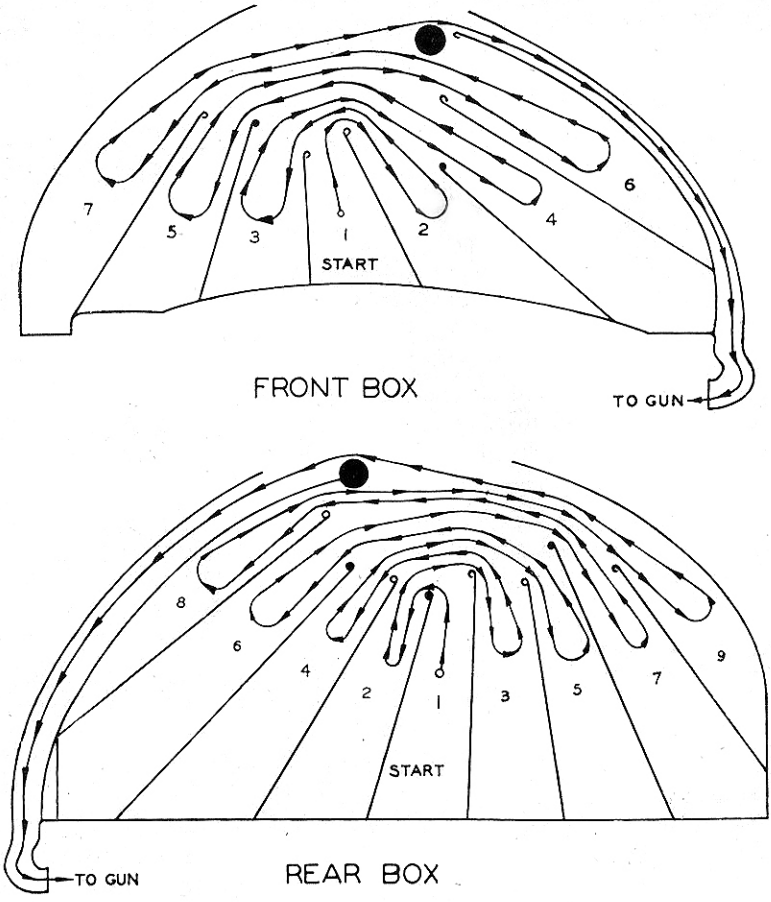


FIGURE 34—Method of Loading Ammunition Boxes

C. OIL REPLENISHMENT PROCEDURE

Oil level in the hydraulic units should be checked before each flight. The motor should be cold and the power unit level when oil is checked or replenished.

1. Rotate the turret enough to remove hydraulic unit cover plate.

2. Place turret in a position to make the breather tank level.

3. Oil should be just visible in the breather tank inspection window when the motor is cold.

4. If oil is required, remove breather tank filler plug and the two bleeder line plugs.

5. Add Univis #40 (Spec. 3580-C) oil until it appears halfway up on the inspection window.

6. Replace one bleeder line plug and blow through the filler opening until air-free oil comes out of the other bleeder line. (Catch the oil in a container or with absorbent material.) Replace the plug.

7. Remove the other bleeder line plug and repeat the bleeding operation, continuing this process until oil is at proper level (just visible in inspection window).

8. Replace and safety wire all plugs.

D. CLEANING

Precautions must be taken to keep dust and dirt out of the turret. Cover plates must be kept in place except when servicing operations are being performed. This work should be done in surroundings as dust-free as possible.

The later ball turrets have been manufactured without a clutch in the outside hand elevation gearing. On these turrets, the pinion of this gearing is constantly in mesh with the elevation gear

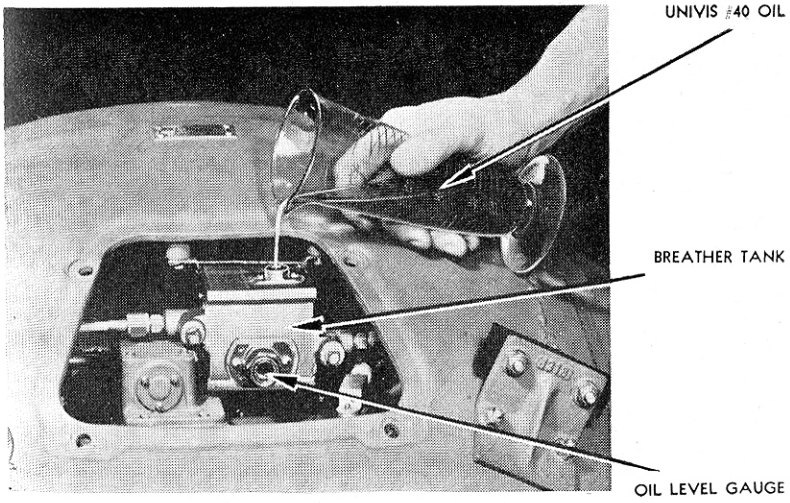


FIGURE 35—Replenishing Oil in Hydraulic Units

rack on the ball. Field reports have indicated that a considerable amount of dirt and mud sometimes becomes lodged in this elevation rack. The result of this is a roughness or sometimes complete failure of the elevation movement of the turret. It is therefore important that this rack be kept clean. Removal of the outside hand elevation gear box from the trunnion ring support will provide easy access to the rack for inspection and cleaning.

Particular care must be taken to prevent the entry of foreign matter into the Vickers hydraulic units. The most common cause of trouble with these units in the presence of lint, dust, or other dirt within the hydraulic systems.

Electrical contacts such as collector rings, brushes, relay and switch contacts, terminals, "AN" plug pins, etc., must be kept free of oil and grease. Clean with *carbon tetrachloride* on a clean cloth. Use *crocus cloth* when necessary.

Plexiglas windows have a soft surface and care must be taken to avoid scratches in service work. Never use dirty or coarse rags.

Wash Plexiglas windows with soap and water and soft sponge or chamois. Naphtha may be used to remove grease.

Do not use solvents such as acetone, lacquer thinner or benzene.

A fogged surface usually results from rubbing with a dry cloth. A good grade of polishing wax helps to restore optical clarity and prevent further scratching. Small scratches may be removed by rubbing with toothpaste or Simoniz cleaner.

E. INSPECTIONS

50-Hour Inspection

After every fifty hours' operation of the *airplane,* the following inspection procedure should be carried out.

1. Make sure that cap screws, castellated nuts, etc., are safety wired.
2. Check retraction system (on model A-13) for operation, tightness of fastenings and tubing.
3. Check oxygen system for operation and condition of hose, tubing, etc.
4. Clean collector rings with carbon tetrachloride on a clean rag and inspect for smoothness. Use crocus cloth if necessary. Replace brushes if necessary.
5. Check items in spare parts box.
6. Examine electrical plug connections for tightness and good contact.

7. Check oil level in hydraulic breather tank. Add clean Univis #40 (Spec. 3580-C) oil only, when required.
8. Bleed air from hydraulic systems.
9. Check grease on exposed gearing. Wipe off excess.
10. Check ring gear and azimuth pinion alignment.
11. Operate turret in elevation and azimuth by hand cranks.
12. See that hand cranks are in proper locations.
13. Examine cover plate fastenings.
14. Operate turret in azimuth and elevation under power. Check control, smoothness, limits, etc.
15. Inspect hinge and latches on door for security. See that safety belt is in commission.
16. Clean safety glass and Plexiglas windows.
17. Inspect screws in window retainers.
18. Check fire cut-off action.
19. Have guns serviced.
20. Check alignment of sight and guns by boresighting.
21. Check tightness of guns in mountings.
22. Operate foot range pedal.
23. Operate heated suit and rheostat.
24. Check operation of firing buttons, solenoids, and gun selector switches.
25. Inspect sight mounting.
26. Check telephone circuit for proper operation.
27. Inspect gun charger cables and pulleys.
28. Check trouble light.
29. Inspect relay contacts. Clean with crocus cloth.

Pre-flight Inspection

The following pre-flight operation check is recommended to insure satisfactory operation of turret during combat:

1. Clean windows.
2. Check oil level in hydraulic breather tank.
3. See that all hand cranks and clutch levers are secured in clips.
4. Turn power switch and sight switch on.
5. Check response of power and control mechanisms by manipulating hand controls, being careful not to cause the guns to strike the ground.
6. Adjust reticle light on sight to desired brilliance.
7. Determine that reticles respond to foot range control.

8. Check roughly alignment of sight and guns by boresighting.

9. Operate oxygen system. Be sure that blinker flow indicator shows oxygen supply through regulator and that pressure remains adequate.

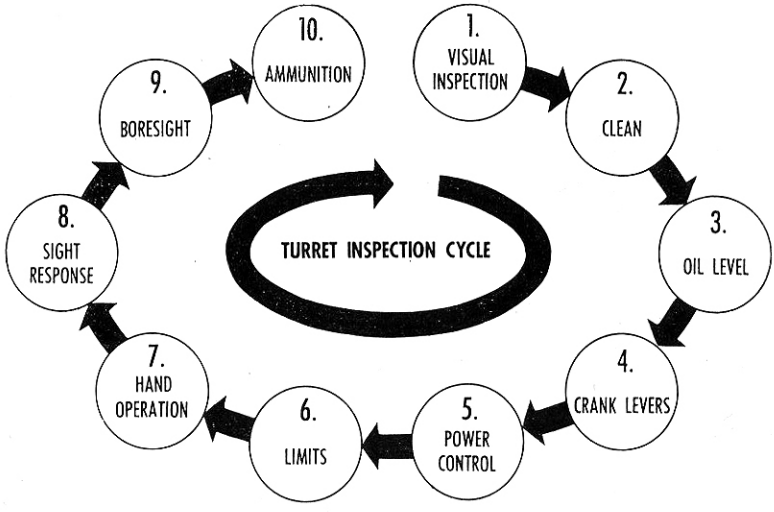
10. Operate heated suit to be sure that it is functioning properly.

11. Operate communications system, depressing foot switch to use microphone.

12. Load ammunition boxes and push ammunition down to guns. Lift each gun cover plate and pull ammunition down, feeding first shell into gun magazine by hand. Close gun cover plates. A hook bent from iron wire may be useful.

F. OXYGEN SYSTEM

Care must be exercised in maintaining the oxygen system. Oil or grease in contact with high pressure oxygen is likely to cause spontaneous combustion and explosion. Water or moisture will freeze at the high altitudes where oxygen is required by the gunner. Any foreign matter may contaminate the oxygen or interfere with the proper functioning of the oxygen system. Thus, it may be seen that extreme cleanliness should be the watchword in working with the oxygen system. Only lubricants which are approved by the Air Corps (Specification 40363-A) should be used anywhere in the oxygen system.



SECTION IX

BORESIGHTING

There are several satisfactory methods depending on the equipment available. Whatever method is used, it is necessary to perform all steps as accurately as possible.

The following procedure is more easily accomplished and is more accurate than the alternative method (chart method). This procedure should be followed whenever possible; that is, when a small distinct target at approximately 1000 yards is available.

Note: The sight must be properly adjusted and preliminary boresighted to align the reticles with the mounting pin holes. When the sight is accurately adjusted and placed in a turret having accurately aligned guns, very little further adjustment should be necessary.

A. ALIGNMENT OF SIGHT TO TARGET

1. Remove the sight by removing sight mounting pin and disconnecting the azimuth and elevation input shafts at the sight, the electrical conduit and the range shafts.

2. Set target dimension knob at 20 ft. and range dial at 1000 yards.

3. Rotate azimuth and elevation inputs to the sight until azimuth and elevation deflection dials read exactly zero. (The range flexible shaft may be removed from the foot control gearing and used for this purpose.)

4. Remove the lamp housing and lamp from the sight. Direct a light (flashlight or turret trouble light) into the opening so that the reticle image can be seen.

5. Move the turret until reticles are centered on a target not less than 1000 yards away, or on the test target sight marking.

Note: The 1000-yard target will align the gun bores to meet at the point selected. The test target will align the gun bores exactly parallel. The theoretical difference of 28 inches at 1000 yards is negligible.

Important: Test Target—If an object at a range of 1000 yards or more cannot be used for boresighting, use a test target only as follows:

1. Target must be laid out according to Figure 35. Test targets used with other turrets having different relative positions of sight and guns are not to be used.

2. Target must be level with respect to turret and two gun bores.

3. Target must be at right angles to gun bores.

Note: When sighting through gun bores be sure that circle at front end of barrel is concentric with circle at rear of barrel, as shown in Figure 36.

B. ALIGNMENT OF GUNS TO SIGHT

1. Align the guns accurately on the target by making lateral and vertical gun trunnion adjustments. (A muzzle boresight tool should be used if available, otherwise sight through gun bores).

2. Tighten adjustment bolts, and replace lamp and lamp housing on sight.

If guns cannot be made to align with sight, the sight should be made to align with guns by the following procedure:

a. Adjust one gun so that the lateral and vertical adjustments are approximately at the midpoint of travel.

b. Tighten adjustment bolts and move the turret so that this gun is aligned on a target at approximately 1000 yards.

c. Adjust other gun to align on same target.

d. Remove the window plate on the sight over the deflection dials.

e. With deflection dials set at zero, with range set at 1000 yards, and target dimension at 20 feet, adjust azimuth and elevation thumbscrews to align reticles on the target. The thumbscrews move the optic head and do not move the computing mechanism.

f. Replace sight and turret parts.

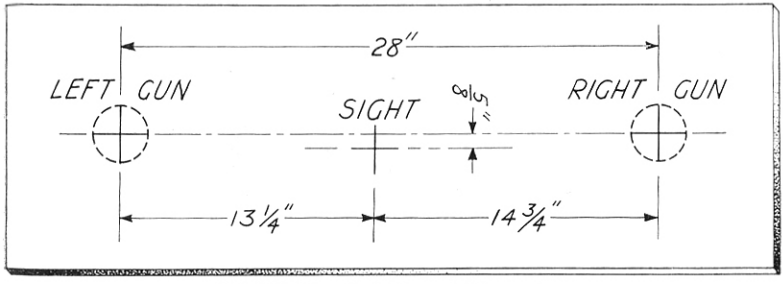


FIGURE 35—Test Target Dimensions

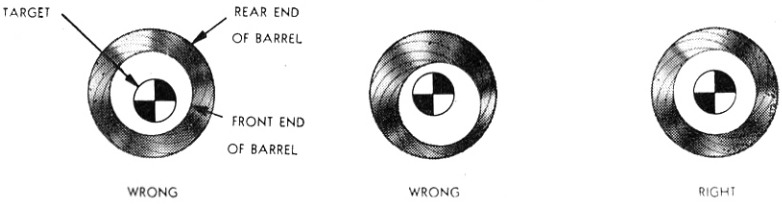


FIGURE 36—Sighting Target Through Gun Bore

C. ALIGNMENT OF SIGHT TO TURRET

After the boresighting operations have been performed, make sight connections to the turret as follows:

1. Run turret exactly to zero azimuth and zero elevation.
2. Remove sight from mounting bracket.
3. Using loose piece of flexible shaft, set sight elevation and azimuth dials at zero. Attach azimuth flexible shaft to sight rather than to turret gearing.
4. Connect "AN" plug into receptacle on sight and replace sight in its mounting bracket. Be sure that azimuth dial is at zero.
5. Connect azimuth flexible shaft into turret azimuth end bell gearing. Connect elevation flexible shaft from elevation-to-sight gear box into sight elevation input.
6. Place sight in position and insert the mounting pin.
7. With range flexible shaft disconnected from foot range control, connect one end to sight range input. Rotate shaft until range dial is as far below zero as possible. The dial should be at approximately —40. (There is no marking on the range dial below zero; this position may be estimated). Back off the shaft an amount corresponding to one tooth on the shaft spline. This position of shaft insures that foot range control stops will limit rotation of shaft so that sight will not be damaged.
8. Connect the flexible shaft to the foot range control. Check travel of the sight range dial while slowly moving the foot pedal. Control should be from below zero to over 1000 yards. Be sure that flexible shaft is free of kinks and bends which will cause binding and jerky action.

Caution: Do not operate turret under power with sight installed unless sight motor is running. Failure to observe this precaution may result in serious damage to sight.

TROUBLES and REMEDIES

POSSIBLE CAUSE	REMEDY
A. SLUGGISH OPERATION	
1. Low oil level in hydraulic power units.	1. Check oil level in breather tank. Bleed air from system.
2. Low voltage.	2. Check voltage. Use power supply at 27.5 $\pm 5\%$ volts.
3. By-passing of oil in Vickers units.	3. With power off, power clutches engaged, and elevation hand brake released, try to move guns in azimuth and elevation by hand. Movement indicates leakage through the Vickers unit replenishing check valves. Remove the two ball and spring valves in each Vickers unit, by taking out the cap screws at the ends of the large tubing assemblies mounted on the unit. A momentary use of the power motor will pump oil out the valve openings, flushing foreign matter away. Be sure valve balls and springs are free of dust or grit and replace them. Again check hydraulic lock by trying to move the guns.

POSSIBLE CAUSE	REMEDY
B. DEAD SPOT IN CONTROL HANDLE MOVEMENT	
1. Low oil level in hydraulic power units.	1. Check oil level in breather tank. Bleed air from system.
2. Backlash in hand control unit and/or control shafts.	2. Check control linkage and remove play. Hand control unit output shafts should rotate more than 19 degrees with full movement of hand grips from neutral. See item "C", below.
3. Low control pressure in hydraulic power units.	3. Test by removing ⅛-inch Allen plug from gear pump. Connect a pressure gauge with copper tubing and suitable fittings. With unit operating, pressure should be about 85 pounds per square inch. Turret will operate at a pressure as low as 20 pounds, but the neutral hand control dead spot will be appreciable and sluggish response will result. To increase pressure, remove acorn nut on gear pump and adjust spring-loaded ball by turning screw. If pressure cannot be sufficiently increased this way, remove four cap screws and pump assembly; clean foreign material from the four ball check valves in the assembly.

C. ELEVATION CREEP CANNOT BE ELIMINATED

1. Worn elevation control shaft spur gear (hub dial) or worn adjustment screw worm.	1. No backlash should exist in this assembly. Replace worn parts.
2. Backlash in elevation control shaft adjusting screw mounting.	2. Bracket holding the adjusting screw worm should be replaced or bent so that the worm will be secure.

D. TURRET FAILS TO OPERATE IN ELEVATION

1. Elevation control shaft spur gear (hub dial) teeth stripped.	1. Replace hub dial.
2. Bevel gear teeth stripped within hand control unit.	2. Replace hand control and limit unit.

E. POWER UNIT DOES NOT RUN WITH SWITCH ON

1. Power fuse blown.	1. Replace 120-ampere fuse in switch box.
2. Brushes not contacting collector rings DCG or G.	2. Check power circuit from connection to turret to brush DCG and airplane ground to brush G. Free the sticking brush or replace. Clean the collector rings.

POSSIBLE CAUSE	REMEDY
3. Relay failure.	3. Check power circuit to relay, main switch and connections. Examine large relay contacts. Clean or replace.
4. Open circuit.	4. Make complete check of power circuit. Refer to Wiring Diagram. Examine motor brushes.

F. TURRET ROTATES IN WRONG DIRECTION

1. Elevation linkage between hand control unit and hydraulic units reversed.	1. Install correctly.
2. Azimuth arm or cover of hand control unit out of location.	2. Hand control unit cover must be removed to relocate arm in correct position.

G. GUN SOLENOIDS DO NOT OPERATE

1. Main power switch off and/or gun selector switches off.	1. Turn switches on.
2. Gun solenoid conduits disconnected.	2. Be sure that all conduits are in place.
3. Guns in restricted area.	3. Move turret to close fire cut-off switch.
4. Fire cut-off switch stuck.	4. Check switch for open circuit.
5. Fuse blown in firing circuit.	5. Replace 20-ampere firing circuit fuse.
6. Firing switches in hand control inoperative.	6. Check switches for open circuit with buttons depressed.

7. Open circuit.	7. Check for power from relay through circuit, using a gun solenoid to detect presence of current, or a continuity test-set.

H. HYDRAULIC UNIT WHINE EXCESSIVE

1. Azimuth clutch yoke misaligned.	1. Remove handle, yoke assembly, and check yoke for wear on one side. Straighten yoke fork.
2. Azimuth clutch misaligned.	2. Move clutch handle to check for binding in different positions of shaft. Relocate power unit on mounting bolts if necessary, checking alignment as bolts are tightened. Do not tighten mounting bolts until all bolts are in place.

I. HYDRAULIC UNIT OPERATION FAULTY

1. Presence of dirt or failure of parts in hydraulic power units causing erratic operation.	1. Vickers hydraulic units must be overhauled only under proper conditions and after proper instruction.

J. SIGHT MOTOR DOES NOT RUN

1. Sight fuse blown.	1. Replace 15-ampere fuse in switch box.
2. Sight motor governor on dead spot.	2. Turn sight switch off, then on.
3. Open circuit in turret.	3. Check for current to the sight "AN" plug on conduit.

POSSIBLE CAUSE	REMEDY
4. Open circuit in sight.	4. Remove sight and test circuit for continuity.

K. POWER UNIT DOES NOT SHUT OFF

1. Relay stuck closed.	1. Disconnect power lead from airplane to turret at noise filter terminal. *Remove quickly* to minimize arcing. Replace relay, or replace relay contacts and examine relay spring tension.
2. Main switch defective.	2. Check switch and replace if necessary.

L. TURRET DOES NOT TRAVEL TO CORRECT LIMITS IN ELEVATION

1. Elevation limit stop not properly adjusted.	1. Follow elevation limit stop adjustment procedure.

GLOSSARY

Aft—Toward the tail of the airplane.

Azimuth—The measurement of rotation in the horizontal plane or simply rotation in the horizontal plane.

Ball, Turret—Spherical structure of the lower turret rotating in azimuth and elevation.

Ballistic Deflection—In the Sperry Computing Sight, deviation in the path of a projectile from a straight line caused by cross wind or gravity or both.

Bevel Gear—Gear having teeth at an angle to its shaft to permit transmission of motion between shafts at an angle to each other.

Booster—See Servo unit.

Boresighting—Aligning guns and sight with each other and with the turret.

Bumper—Bracket with rubber cushion mounted on turret ball to prevent over-travel.

Brush—A spring-loaded member making electrical contact with a collector ring or commutator moving with respect to the brush, to complete an electrical circuit from stationary to moving parts.

Cannon Plug—Trade name applied to a type of electrical connector.

Center Section—In the lower ball turret, cast sections of the spherical turret structure.

Check Valve—In hydraulic systems, a device to permit fluid flow in one direction and prevent flow in the opposite direction.

Collector Ring—A metal ring or disc conducting electricity to a sliding contact or brush to complete an electrical circuit from stationary to moving parts.

Combining Glass—In the Sperry Computing Sight, a glass reflecting the reticle image arranged to rotate so as to combine lateral deflection with vertical deflection. The target is sighted through the glass.

Communication Circuits—In turrets, telephone connections to other members of the airplane crew.

Commutator—In electric motors, a series of metal segments arranged to complete electrical circuits between rotating armature windings and stationary brushes.

Computing Sight—An automatic device to calculate continuously ballistic and prediction corrections required in aiming guns accurately.

Conduit—In electrical systems, a protective pipe or sheathing for wires.

Control Unit—In the lower ball turret, an assembly of mechanisms giving the gunner control over the rate and direction of turret movements.

Crocus Cloth—Cloth coated with fine, non-conducting abrassive.

Cylinder—In hydraulic systems, a closed cylinder permitting the application of fluid pressure to a movable piston.

Dead Spot—Position at which control handgrip movement has no effect on movement of turret or guns.

Deflection—In the Sperry Computing Sight, deviation of line of sight from centerline of gun bores, in a lateral or vertical direction.

Depression—Downward in the vertical plane of gun and turret rotation.

Flexible Shaft—A wire or cable, encased in a sheath or conduit, transferring rotation while bent into a curve.

Direct Current—Electrical energy flowing in one direction continuously when the circuit is completed.

Dog—Projection transferring mechanical motion or force.

Elevation—The measurement of rotation in a vertical plane or simply rotation in a vertical plane.

Filter—In hydraulic systems, a device to remove dirt from the fluid.

Filter Glass—In the Sperry Computing Sight, a tinted glass to reduce glare from the sky.

Filter, Noise—In electrical systems, a device to prevent radio or communication interference.

Fire—Gun-fire.

Fire Cut-Off—Applied to devices interrupting gun-fire to prevent damaging the airplane carrying the turret. Sometimes known as "Fire Interrupter."

Firing Switch—An electric switch with which the gunner operates solenoids which fire the guns.

Fore, Forward—Toward the nose of the airplane.

Fuse—A device which breaks an electrical circuit by melting when the current exceeds safe limits.

Gearing—Any assembly of gears arranged to transfer motion or power from one place to another or to change speed of rotation.

Gun Selector Switch—An electric switch used by the gunner to select the gun or guns to be fired by the firing switches.

Gun Solenoid—An electromagnetic device moving the trigger bar in a machine gun to fire the gun.

Ground—In an electrical system, a return circuit common to one or many devices, usually through the structure supporting the devices.

Hand Crank—In turrets, a crank for moving the turret by hand in azimuth or in elevation.

Headset—Earphones used in communication.

Heated Suit—Suit heated by current from the airplane electrical system.

Horizontal Rollers—Rollers rotating in a horizontal plane.

Hydraulic—Operated by fluid pressure.

Interphone (or intercommunication)—Telephone communication system between stations in the airplane.

Jack—Receptacle for plug connection, usually in communication circuits.

Lateral Deflection—In the Sperry Computing Sight, either or both ballistic and prediction deflections in a lateral plane.

Limit Stop—Mechanism to prevent turret power operation beyond prescribed limits

Microphone, Throat—Electrical device to convert sound vibrations into electrical impulses, picking up voice vibrations by contact with the throat.

Micro-Switch—An electrical switch operated by a small movement and pressure, usually carrying a small current.

Mil—Unit of angular measurement: the legs of an angle of one mil are approximately one yard apart at a distance of one thousand yards. Zero mils elevation is at the horizon when the airplane is level. Zero mils azimuth is toward the nose of the airplane.

Motor, Hydraulic—A device to transform energy of fluid motion into mechanical torque.

Nut, Castellated—Threaded nut having serrations or slots in the top surface through which a cotter pin is placed.

Nut, Elastic Stop—Threaded nut containing a fiber ring to lock the nut in place.

Nut, Spanner—Circular threaded nut having holes or notches in the circumference.

Optic Head—Part of the Sperry Computing Sight through which the gunner sights his target.

Plexiglas—Trade name for clear synthetic thermoplastic material (methyl methacrylate resin).

Prediction Deflection—Angle of "lead" necessary in firing at a moving target; angle between the line of sight and center-line of gun bore required for movement of the target while the bullet is in flight.

Range—Distance from the gun to the target.

Relay—Electric device to complete circuits by remote control or to control heavy currents by means of circuits carrying small currents.

Relief Valve—In hydraulic systems, a device to prevent excessive pressure within parts of the system.

Reticle—Sighting lines in the focus of the eyepiece of an optical instrument.

Retraction—As applied to aircraft gun turrets, the movement of the turret structure and guns to a position within the normal outer surface or skin line of the airplane.

Schematic Diagram—A diagram in which parts are simplified to clarify operating principles.

Servo Unit (Booster)—Hydraulic device affording control of mechanisms by means of small movement or force.

Shim—Flat plate or spacer used to provide adjustment between assemblies bolted together.

Spanner—Wrench used for spanner nut. See "Nut, spanner".

Target—Any object at which guns are aimed.

Torque—Twisting force; force applied about an axis of rotation.

Trajectory—Path of a projectile in flight.

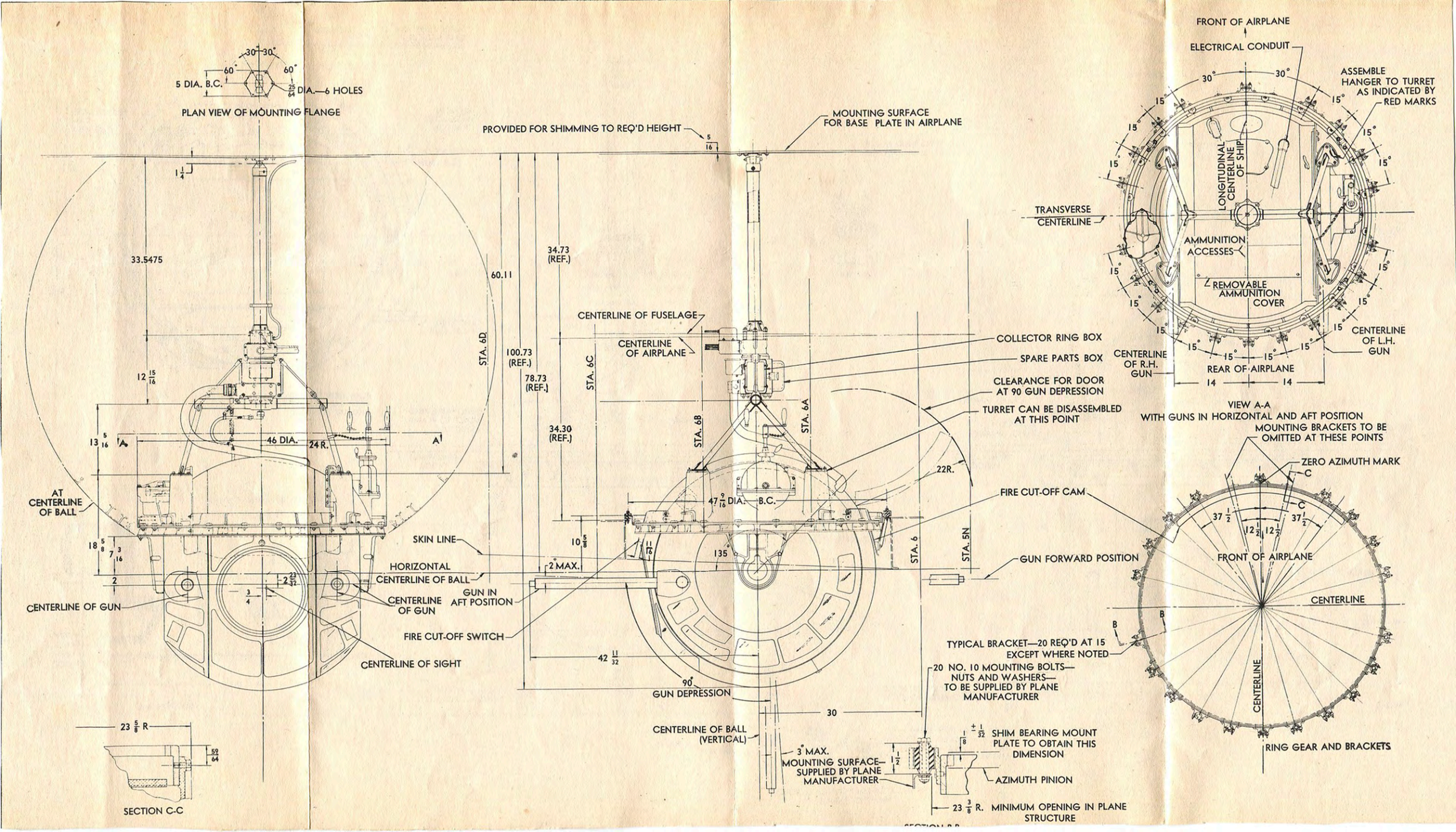
Trunnion—A support permitting rotation.

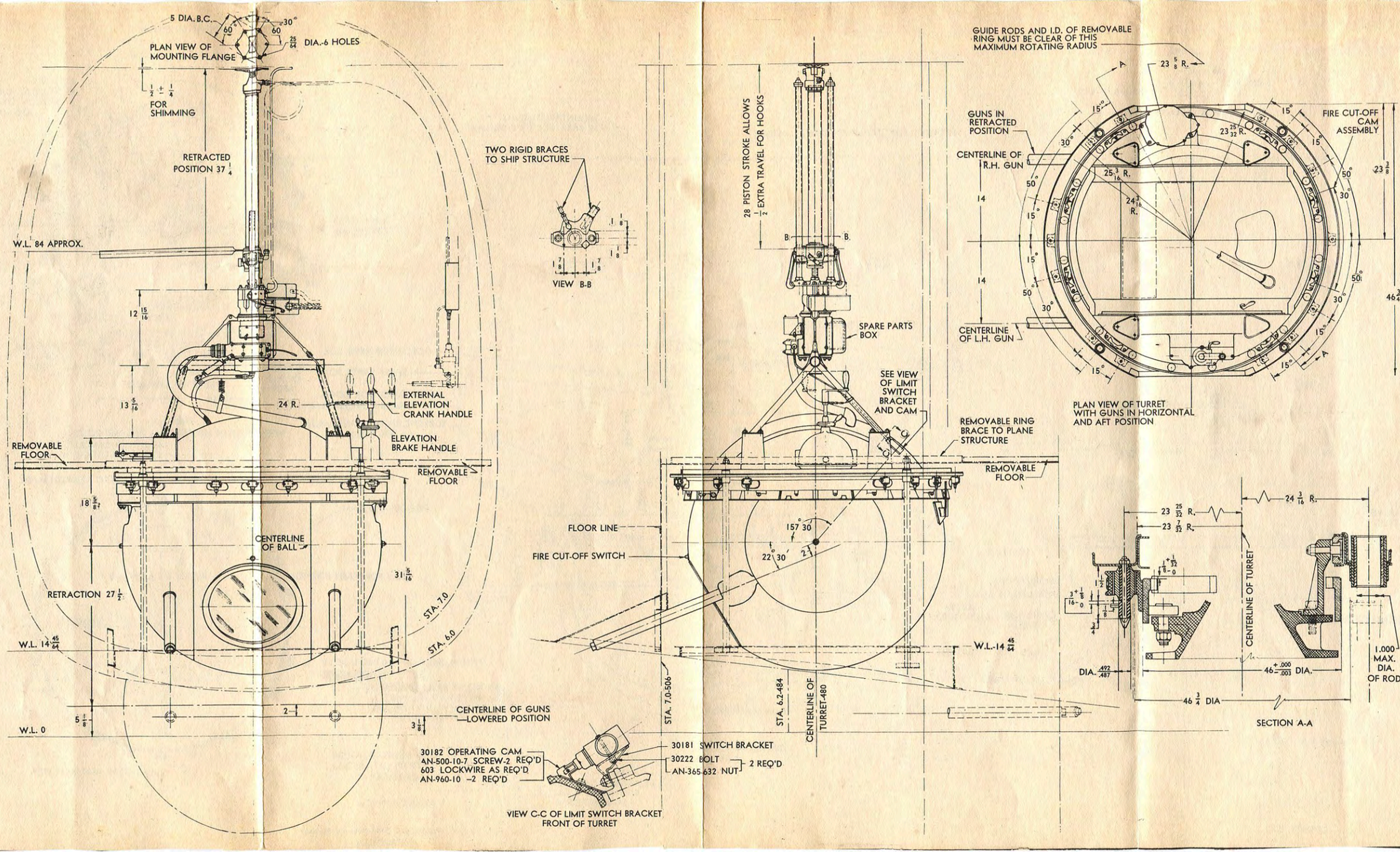
Vertical Deflection—In the Sperry Computing Sight, either or both ballistic and prediction deflections in a vertical plane.

Vertical Rollers—Rollers rotating and bearing a load in a vertical plane.

Worm, Worm Gear—A gear having threads or helical teeth usually meshed with a worm wheel or spur gear designed for the purpose.

NOTES


30° 30°
60° 60°
5 DIA. B.C.
25/64 DIA.—6 HOLES
PLAN VIEW OF MOUNTING FLANGE
PROVIDED FOR SHIMMING TO REQ'D HEIGHT
5/16
MOUNTING SURFACE FOR BASE PLATE IN AIRPLANE
1 1/4
33.5475
12 15/16
13 5/16
A
46 DIA.
24 R.
A'
AT CENTERLINE OF BALL
18 5/8
7 3/16
2
2 23/32
3/4
CENTERLINE OF GUN
CENTERLINE OF SIGHT
SECTION C-C
23 5/8 R
59/64
60.11
STA. 6D
100.73 (REF.)
78.73 (REF.)
34.73 (REF.)
34.30 (REF.)
CENTERLINE OF FUSELAGE
CENTERLINE OF AIRPLANE
STA. 6C
STA. 6B
STA. 6A
STA. 6
STA. 5N
COLLECTOR RING BOX
SPARE PARTS BOX
CLEARANCE FOR DOOR AT 90 GUN DEPRESSION
TURRET CAN BE DISASSEMBLED AT THIS POINT
22R.
47 9/16 DIA. B.C.
FIRE CUT-OFF CAM
GUN FORWARD POSITION
SKIN LINE
10 5/8
11/16
2 MAX.
135°
HORIZONTAL CENTERLINE OF BALL
GUN IN AFT POSITION
CENTERLINE OF GUN
FIRE CUT-OFF SWITCH
42 11/32
90° GUN DEPRESSION
30
CENTERLINE OF BALL (VERTICAL)
3° MAX. MOUNTING SURFACE— SUPPLIED BY PLANE MANUFACTURER
1 1/2
1/8 +1/32 SHIM BEARING MOUNT PLATE TO OBTAIN THIS DIMENSION
AZIMUTH PINION
23 3/8 R. MINIMUM OPENING IN PLANE STRUCTURE
FRONT OF AIRPLANE
ELECTRICAL CONDUIT
ASSEMBLE HANGER TO TURRET AS INDICATED BY RED MARKS
30° 30°
15°
LONGITUDINAL CENTERLINE OF SHIP
TRANSVERSE CENTERLINE
AMMUNITION ACCESSES
REMOVABLE AMMUNITION COVER
CENTERLINE OF L.H. GUN
CENTERLINE OF R.H. GUN
REAR OF AIRPLANE
14 14
VIEW A-A
WITH GUNS IN HORIZONTAL AND AFT POSITION
MOUNTING BRACKETS TO BE OMITTED AT THESE POINTS
ZERO AZIMUTH MARK
C
37 1/2
12 1/2
FRONT OF AIRPLANE
CENTERLINE
B
TYPICAL BRACKET—20 REQ'D AT 15 EXCEPT WHERE NOTED
20 NO. 10 MOUNTING BOLTS— NUTS AND WASHERS— TO BE SUPPLIED BY PLANE MANUFACTURER
RING GEAR AND BRACKETS


5 DIA. B.C.
60°
30°
DIA.-6 HOLES
PLAN VIEW OF MOUNTING FLANGE
FOR SHIMMING
RETRACTED POSITION 37 1/4
W.L. 84 APPROX.
12 15/16
13 5/16
24 R.
EXTERNAL ELEVATION CRANK HANDLE
ELEVATION BRAKE HANDLE
REMOVABLE FLOOR
18 5/8
CENTERLINE OF BALL
RETRACTION 27 1/2
31 5/16
STA. 7.0
STA. 6.0
W.L. 14 45/64
5 1/8
W.L. 0
2
3 1/8
CENTERLINE OF GUNS —LOWERED POSITION
TWO RIGID BRACES TO SHIP STRUCTURE
1 1/8
7/8
VIEW B-B
28 PISTON STROKE ALLOWS 1/2 EXTRA TRAVEL FOR HOOKS
B
SPARE PARTS BOX
SEE VIEW OF LIMIT SWITCH BRACKET AND CAM
REMOVABLE RING BRACE TO PLANE STRUCTURE
FLOOR LINE
FIRE CUT-OFF SWITCH
157° 30'
22° 30'
STA. 7.0-506
STA. 6.2-484
CENTERLINE OF TURRET-480
W.L.-14 45/64
30182 OPERATING CAM
AN-500-10-7 SCREW-2 REQ'D
603 LOCKWIRE AS REQ'D
AN-960-10 -2 REQ'D
30181 SWITCH BRACKET
30222 BOLT
AN-365-632 NUT
2 REQ'D
VIEW C-C OF LIMIT SWITCH BRACKET FRONT OF TURRET
GUIDE RODS AND I.D. OF REMOVABLE RING MUST BE CLEAR OF THIS MAXIMUM ROTATING RADIUS
A
23 5/8 R.
GUNS IN RETRACTED POSITION
CENTERLINE OF R.H. GUN
CENTERLINE OF L.H. GUN
FIRE CUT-OFF CAM ASSEMBLY
23 25/32 R.
25 3/16 R.
24 3/16 R.
23 3/8
46 3/4
14
15°
30°
50°
PLAN VIEW OF TURRET WITH GUNS IN HORIZONTAL AND AFT POSITION
23 25/32 R.
23 7/32 R.
24 3/16 R.
CENTERLINE OF TURRET
DIA. .492 .487
46 +.000 -.003 DIA.
1.000 MAX. DIA. OF ROD
46 3/4 DIA
SECTION A-A