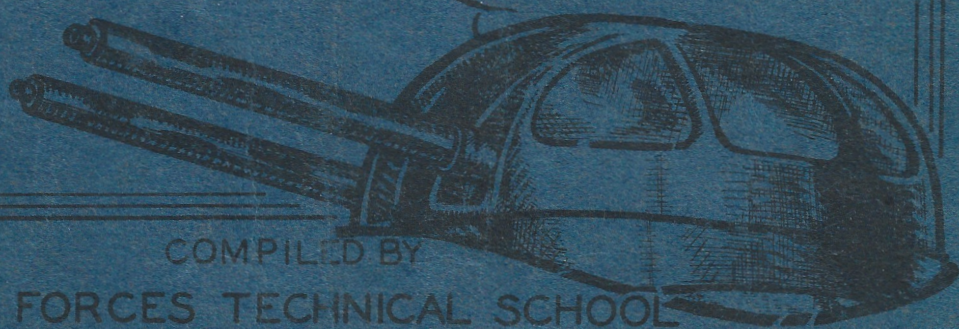


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SPERRY UPPER LOCAL TURRET



COMPILED BY
AIR FORCES TECHNICAL SCHOOL

2ND ECHELON POWER OPERATED GUN TURRET DIVISION

LOWRY FIELD, COLORADO

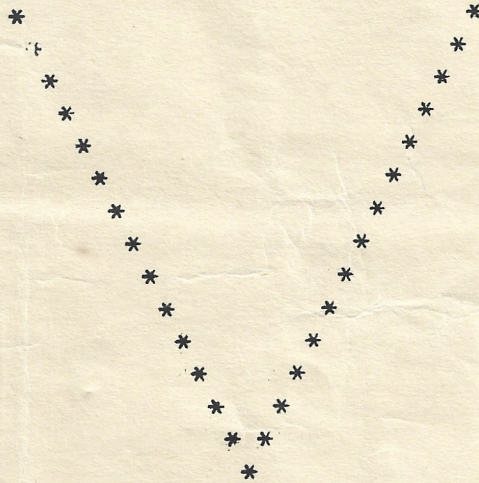
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2ND ECHELON POWER OPERATED GUN TURRETS

SPERRY UPPER LOCAL TURRET

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R E S T R I C T E D

SPERRY TURRETS

INTRODUCTION

The Sperry Upper Local and Lower Ball Turrets are used on the B-17E and B-17F airplanes. Power operated turrets are used because steadier aim as well as faster, more positive operation can be obtained. With these turrets, the Sperry Computing Sight is used, thus sighting efficiency is improved far above that of flexible or fixed gun installations.

Each day the value of power operated turrets is being proven in the fields of action, since they enable heavier bombers to complete their missions in spite of the faster, more maneuverable fighter ships of the enemy.

The field of power operated turrets is comparatively new and constant efforts are being made to bring it to perfection. This text is compiled with a view to helping the student to a clearer understanding of the subject, in order that his work in the field can be of the highest quality.

SPERRY UPPER LOCAL

GENERAL INFORMATION

Mounted between pilot's compartment and bomb bay in upper portion of ship and protrudes from upper skin line 14".

Consists of a fixed azimuth internal ring gear mounted to the ship and a main casting to which guns, ammunition cans, sight, floor plate, adjustable foot rests, safety belt and control and drive units are mounted. This main casting moves within the azimuth ring gear in an azimuth rotation.

Weighs 1015 lbs. complete with guns, ammunition and sight, and entire weight of turret is supported by one thrust bearing mounted under the floor plate of the turret.

Turret is supported laterally by 10 horizontal rollers which are fastened to the azimuth casting and roll against the azimuth internal ring gear.

Mounts two cal. 50 M2 modified Browning Aircraft Machine Guns, 24" between the center lines of bore and 3-1/2" below the line of sight. Guns can be fired from top or rear. They are charged from the inside

manually by cable and pulley arrangement, and are fed from the inside from ammunition cans below the guns

Three ammunition cans for each gun contain approximately 133 rounds per can or 400 rounds per gun. They are loaded and installed in the turret individually, then linked to make a continuous belt. Ammunition is loaded with projectiles pointing toward the outside. Links and brass are recovered in canvas bags hung below the guns and anchored at the bottom to the supporting framework.

Turret is operated electro-hydraulically and controlled locally.

The Sperry K-3 computing sight is mounted on the sight cradle which is linked with the gun cradles so the line of sight is parallel with lines of bore as guns and sight move in elevation.

Turret rotates in azimuth 360° at speeds from 0° to 45° per second.

Guns move in elevation from 0° to 85° at speeds from 0° to 30° per second.

Torque, measured at muzzle end of gun barrel, is 707 foot pounds in elevation and 377 foot pounds in azimuth.

Electrical power is brought into the turret from the ship's system.

LOCATIONS AND PURPOSES OF UNITS

Electrical System.

Terminal Box: Adjacent to thrust bearing. This is means of connecting ship's system to turret's electrical system.

Brush Box and Slip Ring Assembly: Beneath floor plate. Provides means of transferring electrical power from a stationary to a moving object. The slip rings are stationary and insulated from each other. The brushes revolve with the turret in azimuth and provide a continuous flow of power. There are eight slip rings and eight corresponding brushes (carbon), in order from top to bottom: one power, two spares, four intercommunications and one ground brush.

Switch Box: At operator's left, mounted to wall of turret:

1. Main switch: Closes circuit to sight, trouble light, and deadman switches.

2. Selector switches (2): Select gun or guns to be fired.
3. Power relay switch. Closes circuit to power motor and firing circuit.
4. Fuses for each circuit and fuses (spare) are carried in the switch box.

Firing Switches: On hand controls. Operated by index finger of either hand. Are wired in parallel. Either one or both switches close circuit to selector switches.

Deadman Switches: On hand grips. Wired in parallel. Closing either one or both closes circuit to power relay switch.

Fire cut-off Switch: In fire cut-off and elevation limit stop unit. Normally closed unless opened by action of fire cut-off unit.

Solenoids: Mounted on guns and grounded to them. When energized, they fire guns.

Trouble Light: On gunner's right on wall of turret and consists of a spring loaded reel of wire with focusable bulb and housing. Switch is on mounting box.

Sight Switch: Mounted on side of sight housing.

Push to Talk Switch: Near floor plate. Operated by gunner's right foot closing circuit to gunner's microphone.

Electric Power Motor: Between Vickers units. Drives Vickers units. Constant speed, shunt wound, 2 HP, 4000 rpm 27-1/2 volt $\pm 5\%$, approximately 75 amps.

Drive System

Vickers Units: One for azimuth and one for elevation. Units are identical and inter-changeable. The housing of each unit is a reservoir which is filled through a breather cup connected outside the unit. This breather cup is an additional reservoir. The following units are contained within the reservoir of oil inside Vickers Units -

1. Pressure control pump (gear pump): Supplies constant 85# pressure to booster and to two replenishing check valves in the high pressure lines. It rotates at a speed of 2200 rpm. Contains two inlet and two outlet check valves and one pressure control valve which prevents pressure from gear pump from exceeding 85# per square inch.
2. Booster: Strengthens movement of control handles, smooths out their movement and gives more sensitive control in tilting the "A" end.
3. "A" end is a constant speed, variable tilt hydraulic pump which supplies oil flow to the "B" end. It is linked directly to the

SHAFT of the electric motor and rotates at 4000 rpm. It can be tilted from 0° to 8° 51' on either side of the neutral position. It consists of a yoke, head, cylinder block, seven pistons, base and drive shaft.

4. "B" end: is a constant tilt, variable speed hydraulic motor, which converts hydraulic energy into the mechanical energy that drives the turret. It has a constant tilt of 30° and speeds varying from 0 to 1200 rpm, depending on tilt of "A" end and the amount of oil pumped to "B" end, as a result of that tilt.
5. High Pressure relief valves: open when the pressure in the high pressure lines exceeds 1250# per square inch, allowing oil flow to by-pass "B" end and preventing damage to Vickers unit.
6. Replenishing check valves: Open only when the pressure in high pressure lines drops below 85# per square inch.

Azimuth Gear Train

Azimuth gear train is connected directly to "B" end of azimuth Vickers unit which drives turret in azimuth.

Power Clutch: On lower left side of azimuth gear housing. Allows drive shaft to be disconnected from power unit so that the hand crank can be used.

Hand Crank: Below and to left of hand controls. Used for hand operation of turret in azimuth.

Flexible shaft: Geared to azimuth gear train just above azimuth pinion gear. Carries rate indicating azimuth position of guns to sight.

Fire Cut-off Cam Drive Shaft: Next to flexible shaft coupling. Rotates fire cut-off cam at 1 to 1 ratio with azimuth movement of turret.

Elevation Gear Train

Elevation gear train is connected directly to "B" end of elevation Vickers unit which drives the guns in elevation.

Power Clutch: On right and below elevation gear train. Allows drive shaft to be disconnected from power unit so that the hand crank can be used to move guns in elevation.

Elevation Adjustable Cross Shaft: Directly in front of the gunner. Drives on each end of itself, an elevation gear train which in turn drives elevation gun sectors to elevate guns. One rotation of cross shaft = 4-1/2° elevation of guns.

Hand Crank: Located to gunner's right and connected to right hand elevation gear train. Used for manual elevation of guns.

Elevation Flexible Shaft: From left elevation gear train to fire cut-off and elevation limit stop unit and to sight. Carries a rate to these units indicating elevation position of guns.

Control Linkage

Hand Controls: Located in front of operator as he stands in turret. Operation of hand controls on a horizontal axis governs the elevation movement of guns. Operation on a vertical axis controls azimuth movement of the turret.

Range Knob: Located between control handles. Operated by either or both thumbs. Through a flexible shaft, positions reticles of sight for range.

Rate Shafts: Located between control handles and Vickers units to control tilt of "A" end. Azimuth and elevation linkage through rate shafts are identical in operation except the elevation linkage has an extension through the elevation limit stop unit.

Centralizing Springs: Located between horizontal and vertical rate shafts. Tend to return control handles to neutral.

Overload Springs: Between horizontal and vertical rate shafts outside of centralizing springs. Smooth out action of hand controls and take up counter rate from elevation limit stops.

Eccentric Gears: Located in eccentric gear box just in front of fire cut-off unit and above hand controls. Convert linear motion of rate shafts to rotary motion, spread tracking speeds over the maximum part of control handle movement and compress slewing speed into last small portion of control handle movement.

Zero Detents: Located in fire cut-off unit on shaft leading to Vickers unit. Holds "A" end in neutral while making adjustments, and aids in returning rate shafts to neutral when control handles return to neutral.

Fire Cut-off and Elevation Limit Stop Unit: Located in front of operator above Vickers unit.

1. Elevation limit stop unit: Prevents guns from exceeding prescribed elevation limits (0° to 85°). Consists of:
 - a. Fixed disc: positioned by hand controls through rate shafts.
 - b. Floating gear: positioned by elevation movement of guns through flexible shaft.

2. Fire cut-off unit: Prevents firing on propeller arcs, both wing tips, and vertical stabilizer. Fire is cut off below 9° (approximately) in front, and 13° (approximately) in the rear. Consists of:
 - a. Profile cam which rotates at a 1 to 1 ratio with azimuth movement of the turret.
 - b. Rack, rack lever and cam follower pin. Moves toward profile cam as guns are depressed and away from it as guns are elevated.
 - c. Small elevation spiral gear: driven by elevation movement of guns and operates rack.
 - d. Micro switch: opened by the upward movement of the rack lever, opening firing circuit.

Oxygen System

Oxygen tank and mounting brackets: Located in forepart of turret and has two positions, stowing position and operating position. Oxygen tank holds a maximum of 500# per square inch and is suspended in the mounting brackets, with piping connection in forward position. Metal piping connects tank to oxygen regulator.

Oxygen regulator: Located at operator's right shoulder. Has two dials. Top dial indicates altitude and lower dial indicates pressure left in tank. Has valve which, when turned, adjusts flow of oxygen to operator's mask.

ADJUSTMENTS

Zero Rate (Creep) Adjustments

1. Remove covers from eccentric gear box, fire cut-off, and limit stop unit.
2. Loosen screw on elevation and azimuth zero detents. Turn on power to turret and turn azimuth and elevation rate shafts in fire cut-off unit until rates from both the elevation and azimuth variable speed transmissions are zero. Tighten elevation and azimuth zero detents.
3. Loosen locknuts on front ends of pinion shafts in eccentric gear box and set both eccentric gears so that their slots are horizontal.
4. Tighten locknuts securely. Turn on power and check for zero rates, with eccentric gears in horizontal position.
5. With power off, hold vertical rods so that the slots in eccentric gears are still horizontal and then adjust joints on vertical rods so that the centralizing springs are in their vertical position. Turn on power and check for zero rates in both azimuth

and elevation.

6. With power off and the vertical rods and centralizing spring in the zero position, adjust length of linkage rods to the hand control unit so that the yoke of the hand control unit is in its vertical position and the handles are centered in azimuth. The center point of travel between the two stops should line up with the screw heads on the rear of the unit.
7. Now turn on power and check over-all adjustment for zero rates. The turret should not creep in azimuth or elevation if the adjustments have been properly made.
8. Replace covers of eccentric gear box, fire cut-off, and limit stop unit.

Elevation Limit Stop Adjustment

When operating under power, movement of guns should cease automatically at the 0° and 85° limits. If not, readjust as follows:

1. Remove fire cut-off and limit stop unit cover.
2. Loosen three retainer screws on adjustable elevation spiral gear which drives the rack.
3. Loosen the three retainer screws on the large spiral gear on rate shaft to Vickers unit.
4. Run guns slowly to exactly zero elevation, turn elevation rate shaft until guns just begin to move upward.
5. Loosen the three screws on the fixed disc adjustable lug, move lug until screws are at extreme right of their slots.
6. Disengage eccentric gear box, or loosen self locking nut on elevation side of eccentric gear box.
7. Turn large spiral gear forward until lug on fixed disc contacts lug on floating gear.
8. Tighten screws on elevation spiral gear, re-engage eccentric gears and test adjustment, at zero, under power.
9. Run guns up until cross shaft has made 18-3/4 revolutions from 0°.
10. Position adjustable part of fixed disc lug so it contacts lug on floating gear. Tighten the three screws on lug.
11. Check at 0° and 85°, under power.
12. Reset fire cut-off unit.
(Note: Steps #5 and #10 can be omitted unless adjustable lug is set incorrectly).

Fire Cut-Off Unit Adjustment

1. Position turret at 0° azimuth and guns at 9° elevation with back lash removed.
2. Loosen the three clamp screws on profile cam, after removing micro switch and bracket.
3. Place setting fixture #177126 in hole in front of profile cam.
4. Position cam follower pin and cam so that the point of the pin is in the detent in the fixture.

5. Tighten the three screws on profile cam and the three screws on the elevation spiral gear driving rack. Check setting of pin in setting fixture after tightening each set of screws.
6. Replace micro switch and bracket. Check cam pin height.
7. If cam pin height is incorrect, adjust by screwing it down out of rack until it just opens micro switch when point of pin is just at top of 11° slope, but not on level portion of setting fixture. Check for open switch by hooking ohmmeter or continuity tester across terminals of switch. Have turret power off while doing this.
8. Check by boresighting at protected parts of ship, trying to energize solenoids.
9. Replace covers.

INSTALLATION OF TURRET

1. Remove any two opposite flanges from ring gear, take ring gear in through turret hole and replace flanges.
2. Level ring gear (by shimming) with respect to ship with zero scribe mark forward and aligned with center line of ship. Fasten securely with 18 bolts.
3. Remove dome, attach hoist sling to lifting lugs, lift turret above opening and lower slowly into opening in plane - being careful that the azimuth pinion gear meshes with the azimuth internal ring gear as turret is lowered.
4. Shim under thrust bearing mounting flange until bottom of pinion gear is 1/8" below bottom surface of azimuth internal ring gear, checking to see that this dimension is maintained all around the ring gear. Bolt mounting flange through shims.
5. Make electrical connections.

INSTALLATION AND ALIGNMENT OF GUNS

Changes to be made on guns before installation.

1. Arrange both guns to be fed from the inside.
2. Change both cover latch levers to inside.
3. Change both back plate latch locks to outside.
4. Mount charging plates.
5. Install link ejection chutes.
6. Install solenoid adapters and solenoids.
7. Mount edgewater adapters.

Installation and alignment.

1. Fasten Edgewater adapter to front mount.
2. Fasten rear mount by means of sliding rear trunnion.
3. Make electrical connection to solenoid.

Alignment.

Align guns in parallel, vertical planes perpendicular to the horizontal cross axis of the turret. (Lateral adjustment).

1. Run guns to approximately 85° and using a bevel protractor set at 90° ; place protractor on side plate of guns; make lateral adjustment until bubble in protractor is leveled.

Align guns in same horizontal plane. (Vertical adjustment).

1. Run guns to exact zero, with turret at 180° azimuth.
2. Using bevel protractor on top plates, level guns in relation to longitudinal axis of the plane. (All adjustments are made at the rear mounts. Make lateral adjustments first.)

PRECAUTIONS IN OPERATING

1. Do not operate under power unless sure that hand cranks are disengaged.
2. Do not disengage hand cranks until power clutches have been engaged.
3. Do not disengage power clutches until hand cranks have been engaged.
4. Do not operate guns in elevation with flexible shaft to F.C.O. and limit stop unit engaged unless unit is properly adjusted.
5. Do not run guns beyond their limits in elevation.
6. Never operate by power or hand with sight switch off if flexible shafts to it are connected.
7. Do not leave turret with main switch on.
8. Do not stop turret by letting up on deadman switches.
9. Do not operate turret unless ship's motor is running or an auxiliary source of power is provided.

CLEANING AND OILING

Do all servicing in as dust free a place as possible. Carefully remove all dirt, grit and foreign matter from all parts of the turret. DO NOT OVER-OIL. All cover plates should be kept on except during necessary

servicing operations.

1. All switches, terminal blocks, slip rings, relay points, etc., should be cleaned regularly with Carbon Tetrachloride and a clean cloth.
2. Be sure excess oil or grease is removed after servicing operations.
3. Particular care should be taken to prevent any foreign matter from getting into the Vickers units.
4. Filter in Vickers unit can be cleaned with Varsol (A.C.S. P-S-661).
5. Keep breather cups $1/4$ full of Univis 40.
6. Oil all bearings in the fire cut-off and limit stop unit with one drop of Univis No. 48. All points of friction should be oiled with a few drops of Univis No. 48, unless otherwise specified.
7. Beacon M-285 should be used when lubrication is required in various gear boxes.
8. Keep sight mounting pin lubricated with Alcoa thread lubricant.
9. Keep oxygen system free of oil, grease, and all foreign matter. Use no lubricant on oxygen system, but ACS #40363.

TROUBLES AND REMEDIES

1. Sluggish operation on one or both axes:
 - a. Low oil level in Vickers unit = refill breather cups to $1/4$ of capacity.
 - b. Voltage supply low = check voltage.
2. Dead spot in control handles:
 - a. Low oil level in Vickers unit = refill breather cups to $1/4$ of capacity.
 - b. Low control pressure in Vickers unit = test by removing $1/8$ " allen plug located in gear pump. Connect pressure gauge by means of short length of copper tubing and suitable fitting. When unit is operating, pressure should read approximately 55 lbs. Turret will operate with pressure as low as 20 lbs. but dead spot near central position of hand control unit will be appreciable and a slow and sluggish action will result. To increase pressure, remove acorn nut and adjust spring loaded ball by means of screw. If pressure cannot be sufficiently increased in this method, remove gear pump and remove any metal chips or foreign material from four ball check valves in the pump assembly.
 - c. Hand control mechanisms have excessive backlash or loose couplings = check hand controls, centralizing springs and control box.
3. Power unit will not run when main switch is on and deadman switches are operated.

- a. Brush fails to make contact with slip ring - check position and condition of power brush.
 - b. Power relay not operating when safety switches are closed - check for broken lead between power relay and hand control unit.
 - c. Power relay operates correctly, but power motor will not start - check main fuse (120 amp). Replace if blown.
 - d. Open circuit between power relay and power motor - check continuity of leads with ohmmeter.
4. Gun solenoid will not operate when firing key is closed.
- a. Main power switch off, or power relay not operating - operate safety switch and check to see that power relay is operating.
 - b. Either or both fire selector switches off.
 - c. Fuses blown - check 120 amp and 20 amp fuses in switch box.
 - d. Switch in fire cut-off and limit stop unit stuck open - repair or replace.
 - e. Gun is pointing at cut-off area - move turret until sealed switch in fire cut-off and limit stop unit closes.
 - f. With power relay operated, switches in correct positions and fuses all right, firing solenoid still fails to operate - check continuity of leads to fire cut-off and limit stop unit, hand control unit and firing solenoid.
5. Motor of computing sight does not operate.
- a. 15 amp fuse blown in switch box - replace.
 - b. Sight switch on when turret main switch was turned on (motor on dead spot) - turn sight switch off and on again.
 - c. Open circuit between main switch and switch box and computing sight - check continuity of leads with ohmmeter.
 - d. Computing sight motor does not operate after preceding checks and necessary corrections have been made - refer to Sperry instructions 14-226.
6. Hydraulic unit whines, indicating overload.
- a. Power unit improperly aligned - correct alignment.
 - b. Guns strike plane structure - limit stop improperly adjusted - adjust.

INSPECTIONS

Preflight

1. Check oil level in breather tanks to see that they are $1/4$ full.
2. Clean plexiglas panels and domes, using some mild soap as Lux or Drene shampoo.
3. Engage power clutches and disengage the safety hand cranks.
4. Close main switch, sight switch and deadman switches. Allow sight and hydraulic units to warm up.

5. Check turret response to elevation and azimuth controls.
6. Close gun selector switches and firing switches to check operation of solenoids.
7. Adjust reticle light to desired brilliance. (Approximate).
8. Check operation of target dimension mechanism. Operate range knob, observe movement of reticle image on the combining glass.
9. Turn off all switches.
10. Place ammunition in boxes.
11. Place belts in guns, with first round over belt holding pawl. Charge guns once.
12. Check oil buffers for full open position.

DAILY INSPECTIONS

1. Check general condition of turret.
2. Check oil level in breather cups.
3. Check Vickers units for leaks.
4. Check security of gun mounts.
5. Inspect castings for cracks.
6. Inspect flexible electrical conduit.
7. Check shafts to sight.
8. Check turret control shafts.
9. Clean dome panels using mild soap.
10. Check operation of turret and sight.
11. Set turret at 180° azimuth and 0° elevation.

50-HOUR INSPECTIONS

1. Clean dome panels with mild soap.
2. Check tightness of dome fastening studs on top of unit housing.
3. Clean slip rings.
4. Check condition of flexible conduits.
5. Check tightness of cannon plugs and receptacles.
6. Clean points of relay in switch and junction box.
7. Check to see that spare fuses are in clips on inside cover of main switch box.
8. Clean fire cut-off and limit stop unit and put one drop of Univis #48 oil in each bearing.
9. Check tightness of flexible shafts.
10. Check guns for security of mounting.
11. Check condition of guns and service as required.
12. Check condition of charger cables. Tape or replace if badly worn.
13. Check charging operation.
14. Check gun slot shutters and flexible shell case chutes for proper operation.
15. Check condition of ammunition rollers.

16. Check power gears for excess backlash. $1/4$ " movement at muzzle of gun in elevation or azimuth is maximum allowable.
17. Check voltage at turret. Should be $27-1/2$ volts $\pm 5\%$.
18. Check oil levels in breather cups. Should be $1/4$ full. Mirror plate in cap on cup provides means of doing this when dome is in place.
19. Check turret for satisfactory response in operation, by driving at minimum and maximum rates in azimuth and elevation.
20. Check for creep, correcting if necessary.
21. Check alignment of sight and guns. (By boresighting at several different points).
22. Check firing solenoid operation.
23. Check fire cut-off operation.
24. Check operation of oxygen system.
25. Check elevation limit stops by running guns to maximum limits.

